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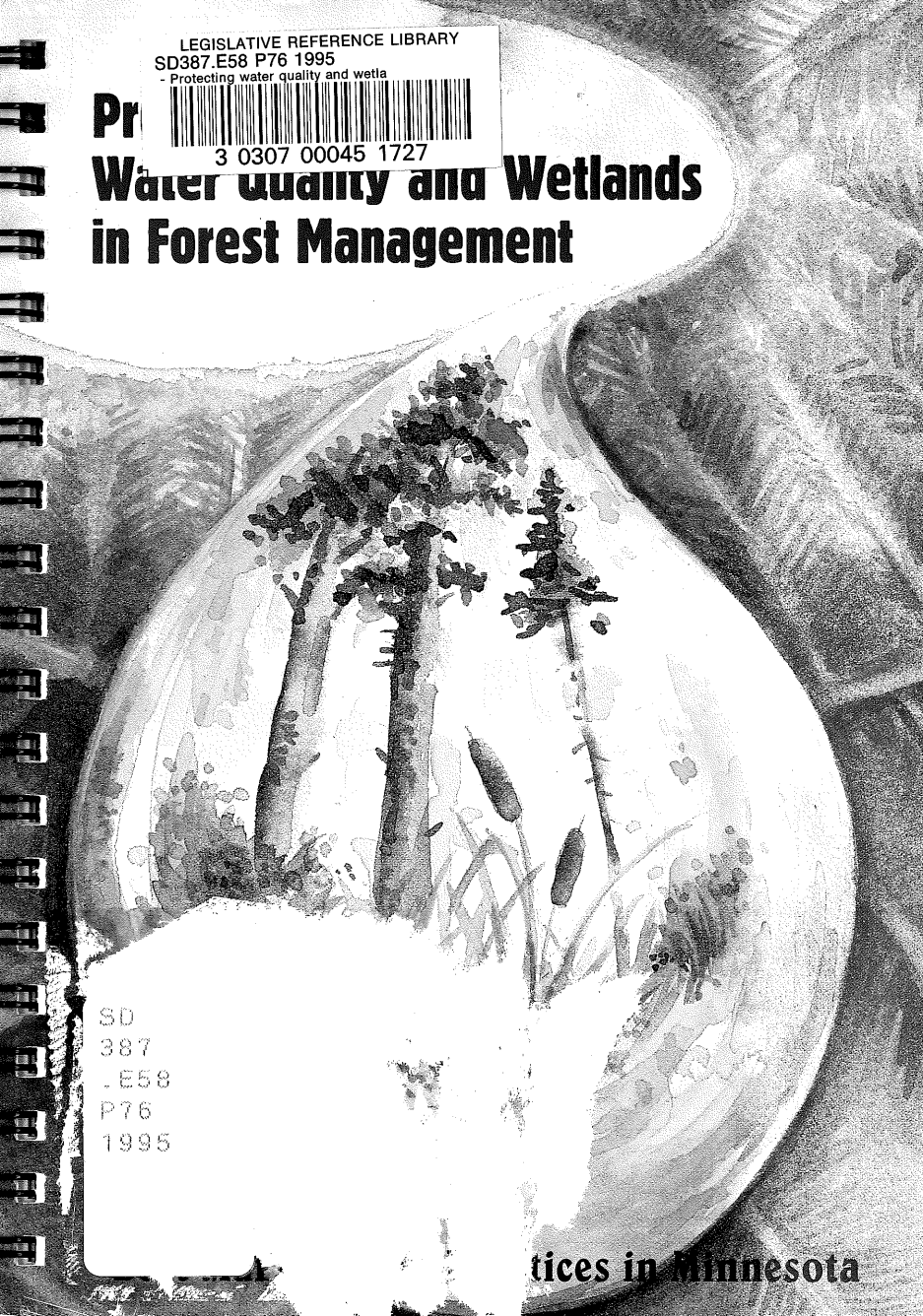

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Protecting Water Quality and Wetlands in Forest Management:

Best Management Practices in Minnesota

1995

Prepared with cooperation of the following organizations:

Associated Contract Loggers
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Minnesota Department of Natural Resources
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    Division of Forestry
    Division of Waters
Minnesota Forest Industries
Minnesota Forestry Association
Minnesota Pollution Control Agency
Minnesota Power
Minnesota Science Teachers' Association
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1995

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FOREWORD

Protecting Water Quality and Wetlands in Forest Management: Best Management Practices in Minnesota is the Best Management Practices guidebook authored by a diverse working group of individuals representing many public and private organizations.

The goal of these recommendations is to heighten awareness of nonpoint source pollution; to provide natural resource managers, loggers, contractors and landowners with the tools to protect water quality and wetlands in forested watersheds; and to provide sufficient information and guidance to assist them in making informed and appropriate management decisions on a site-by-site basis.

Effective protection of water quality and wetlands will depend in great part on the attitude toward—and acceptance of—water quality and wetlands protection measures by individual natural resource managers, loggers, contractors and landowners.

When best management practices are applied in forest management, commercial timber production can occur without compromising the quality of Minnesota's lakes, streams, wetlands and ground water.

CONTENTS

FIGURES

TABLES

INTRODUCTION

Our Clean Water Resource

An abundance of clean water is one of Minnesota's greatest resources. Much of this water originates in forested watersheds. In addition to water, these forested areas provide many other valuable resources and support a variety of human activities.

Natural resource managers, loggers, contractors and landowners attempt to balance a variety of objectives when planning and conducting forest management activities. These activities include the production of timber, the support of recreational uses, the enhancement of scenic beauty, the improvement of wildlife habitat, and the protection of forest ecosystems. When carrying out any forest management activity, care is needed to prevent or minimize nonpoint source pollution impacts on water quality and wetlands, as well as impacts on normal water flow in wetlands.

Impacts of Nonpoint Source Pollution

Nonpoint source (NPS) pollution is diffuse pollution that originates from over the landscape. While the amount from any one particular location may seem insignificant, the combined effects of NPS pollution from throughout a watershed can impact water quality and wetlands.

NPS pollution reaches lakes, streams, wetlands and ground water through leaching, surface runoff and erosion. While some NPS pollution does occur naturally, such as when soil is carried in runoff to surface water, human activity can dramatically increase the potential for NPS pollution. Many forest activities have the potential to contribute NPS pollution to lakes, streams, wetlands and ground water.

Types of water pollutants that can be generated from forest activities include:

- Sediment
- Nutrients
- Pesticides
- Fuels and lubricants
- Organic matter
- Thermal impacts

NPS pollution from forest activities is not severe in most areas of Minnesota, due to the state's topography, soils and forest locations. Forest management activities with the greatest potential for creating NPS pollution include:

- Forest road development
- Timber harvesting activities
- Mechanical site preparation
- Pesticide application
- Prescribed burning and fireline clearing

Of these activities, the building and maintenance of forest roads is generally considered to have the greatest potential to impact water quality and wetlands. This impact is due to the concentration of activity, the extent of area affected, the amount of disturbed and exposed soil, and the relative permanence of a forest road. These effects are of particular concern when activities are close to water.

A Regulatory Umbrella

Statutes and regulations currently exist for federal, state and local agencies to control water pollution and protect wetlands on both public and private forest lands:

- ***At the local level,*** this "regulatory umbrella" includes comprehensive local water plans, local zoning ordinances and shoreland management regulations.

- ***At the state level,*** regulatory involvement includes the Minnesota Groundwater Protection Act, the Minnesota Wetland Conservation Act, the Minnesota Pollution Control Agency Water Quality Standard Rules (Minn. Rule 7050), and the Minnesota Department of Natural Resources Protected Waters Permit Program.

- ***At the federal level,*** regulations include the National Environmental Policy Act, the National Forest Management Act, the Federal Clean Water Act, and the Food, Agriculture, Conservation and Trade Act.

Using BMPs To Protect Water Quality and Wetlands

NPS pollution cannot be eliminated entirely, but the use of Best Management Practices (BMPs) can prevent or minimize the impact of forestry activities on lakes, streams, ground water and wetlands. BMPs are practices (individual or in combination) that provide natural resource managers, loggers, contractors and landowners with the tools to either prevent NPS pollution or ensure that the amount of NPS pollution is kept to a level compatible with state water quality and wetland protection goals.

In addition to protecting water quality, BMPs for wetlands provide the tools to maintain the functions and values of wetlands by protecting normal water flow in wetlands.

BMPs: A Voluntary, Preventive Approach

Some BMPs are required in order to comply with existing statutes and regulations, such as shoreland zoning and the Wetland Conservation Act. Most BMPs, however, are voluntary, and all BMPs are ***flexible recommendations*** that represent a preventive approach to protecting water quality and wetlands.

The specific sources of forestry NPS pollution are sometimes difficult to identify, and the immediate impacts of NPS pollution often are not obvious.

For these reasons, ***a regulatory approach to NPS pollution may not be as effective as active use of voluntary preventive practices,*** such as BMPs. The adoption and use of reasonable, achievable and cost-effective forestry BMPs provide the mechanism for maintaining water quality and protecting wetlands in a manner consistent with the intent of federal and state water quality and wetland protection mandates.

Making BMPs Flexible To Meet Site-Specific Needs

Because one single set of practices cannot effectively address the concerns of all situations and all areas, BMPs need to be flexible enough to address site-specific conditions. This flexibility also allows individual BMPs to be modified to balance water quality and wetland protection with other forest values and management considerations, such as promoting biodiversity and enhancing wildlife and aquatic habitat. Modified approaches may be used ***as long as the alternate practices achieve the same level of protection*** for water quality and wetlands.

Specific BMPs will be altered or expanded as new information becomes available. As discussions continue on riparian management and other water quality-related issues, recommended BMPs may be revised to reflect new information, new perspectives or new priorities.

Using This Guidebook

This guidebook is divided into six major forest activity sections:

- General Practices To Protect Water Quality and Wetlands
- Building and Maintaining Forest Roads
- Timber Harvesting
- Mechanical Site Preparation
- Pesticide Use
- Prescribed Burning

Each section includes a short description of the activity and the need for BMPs, a discussion of planning considerations, and a listing of recommended BMPs. Specific recommended BMPs are indicated by square bullets (❒) throughout the guidebook.

These recommendations ***are not meant to serve as complete construction standards or engineering specifications*** and should not be used as a substitute for obtaining professional assistance when needed to achieve management objectives or meet appropriate engineering standards.

Following the six BMP sections are three appendices:

- ***Appendix I:*** The Resource Directory, which lists sources of information, advice and technical services related to the application of forestry BMPs.

- ***Appendix II:*** Baseline Standards for Development of Best Management Practices To Provide Wetlands Protection

- ***Appendix III:*** The Glossary, which defines terms used throughout the guidebook.

GENERAL PRACTICES TO PROTECT WATER QUALITY AND WETLANDS

Certain Best Management Practices (BMPs) for protecting water quality and wetlands are applicable to many forest management activities. These general practices include managing fuel, lubricants and equipment; using filter strips and shade strips; protecting wetlands; and conducting followup evaluations of protective measures.

MANAGING FUEL, LUBRICANTS AND EQUIPMENT

Why BMPs Are Needed

Forest management activities often require the use of fuels and lubricants in a variety of equipment during field operations. These operations typically occur at remote locations, with maintenance activities taking place onsite. Precautions are needed to prevent water and wetland contamination when using fuels, lubricants and other materials associated with heavy equipment operations. Proper planning will help prevent or minimize spills of fuels, lubricants or other materials.

Common sense, care, proper planning and the anticipation of problems can eliminate or reduce potential water quality problems arising from spills. Routine maintenance of equipment, including regular checks of hoses and fittings for leaks or wear, is the key to protecting lakes, streams, wetlands and ground water from the impacts of fuel and lubricant spills and leaks.

Recommended Practices

The following precautions related to managing fuel, lubricants and equipment should be adopted for each of the specific forestry activities described in the guidebook:

- ❒ Designate a specified area for draining lubricants from equipment during routine maintenance. The area should allow all waste lubricants to be collected and stored until transported off-site for recycling, reuse or disposal at an approved site.

- ❒ Locate fuel and maintenance areas away from open water at locations where a potential spill can be contained and properly treated with minimal risk of surface water or ground-water contamination.

- ❒ Locate fuel and maintenance areas on upland sites whenever practical. When operating on wetland areas, an upland site may also be the preferred location for fueling and maintenance.

- ❒ Provide maintenance vehicles with the equipment necessary to collect and store lubricants drained during repair activities. Breakdowns could require lubricants to be drained from equipment at locations away from the designated collection area. ***It is illegal to burn the residues or to drain these materials directly onto the ground (Minn. Rule 7045.0065).***

- ❒ Provide waste containers in maintenance areas or vehicles for collecting solid wastes, such as oil containers, grease tubes, oil filters and other trash.

- ❒ Recycle or properly dispose of collected solid waste materials at an approved solid waste site. ***It is illegal to burn these wastes (Minn. Statute 88.171).***

- ❒ Report all petroleum spills of five or more gallons. Direct all reports to the Minnesota Duty Officer. The two 24-hour phone numbers are (612) 649-5451 (in the metro area) and (800) 422-0798 (in greater Minnesota). The Minnesota Duty Officer will contact the appropriate state agencies.

- ❒ Thin-spread any soil contaminated by spills of petroleum products of less than 5 gallons.

FILTER STRIPS ADJACENT TO LAKES, STREAMS AND OPEN WATER WETLANDS

Why Filter Strips Are Needed

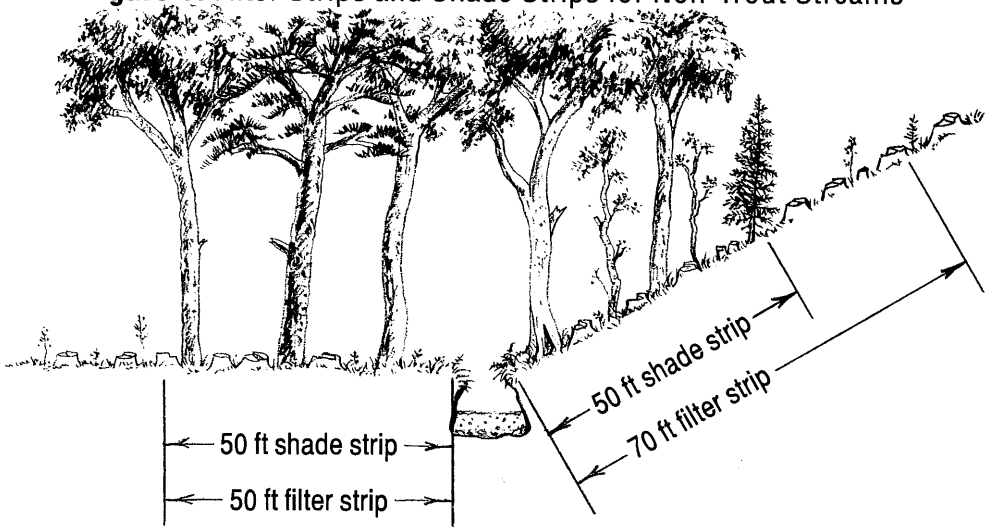
Managing land to control NPS pollution near surface water and wetlands is important. Timber harvesting activities, mechanical site preparation, prescribed burning and road construction increase the potential for sedimentation due to mineral soil exposure.

Maintaining a filter strip between the water body and the forest disturbance can protect surface water. Filter strips (Figure 1) are areas adjacent to lakes, perennial and intermittent streams, and open water wetlands that help minimize the runoff of sediment, debris, nutrients and pesticides into these water bodies. Filter strips provide a zone of infiltration that protects surface water by allowing residual vegetation and the forest floor to trap sediment from adjacent land areas.

Recommended Practices

Forest management activities are allowed in filter strips as long as the integrity of the filter strip is maintained. These activities should produce minimal exposure of mineral soil.

Figure 1. Filter Strips and Shade Strips for Non-Trout Streams



Shade strips represent minimum filter strips in all situations.
The filter strip may be wider dependent on slope.

The following practices will help minimize the runoff of sediment, debris, nutrients and pesticides into lakes, streams and open water wetlands:

- ❒ Limit mineral soil exposure to less than 5%, well distributed throughout the filter strip.
- ❒ Avoid concentrating disturbance in the filter strip, to prevent concentration of flows across the filter strip.
- ❒ Establish filter strip widths based on percent and length of slope (Table 1). They should border and parallel the edge of lakes, perennial and intermittent streams, and open water wetlands.

Table 1. Filter strip width guide

Slope of land between activity and water body	Recommended width of filter strip (slope distance)*
0-10%	50 feet
11-20%	51-70 feet
21-40%	71-110 feet
41-70%	111-150 feet

**For roads, distance is measured from the edge of soil disturbance. For fills, distance is measured from the bottom of the fill slope.*

SHADE STRIPS ADJACENT TO LAKES, STREAMS AND OPEN WATER WETLANDS

Why Shade Strips Are Needed

Retaining and perpetuating vegetation along lakes, perennial streams and open water wetlands is important for providing shade. Shade helps maintain moderate water temperatures and serves the needs of aquatic species. Shade also minimizes warming of the water body itself, as well as warming of flow entering the water body.

Recommended Practices

To perpetuate vegetation, forest management is allowed within the shade strip. The following practices may be modified to accommodate other management considerations, such as promoting biodiversity, promoting shade-intolerant species and producing large woody debris:

For trout waters

❒ Maintain a 100-foot-wide shade strip on both sides of all designated trout streams, including their tributaries, and trout lakes (Minn. Rule 6262.0400). *For sources of listings of designated trout streams and trout lakes, see Resource Directory, page 117.*

❒ Maintain between 60 and 80 square feet of basal area per acre of trees in the shade strip where trees provide the primary shade to trout streams, their tributaries, and trout lakes.

❒ Minimize disturbance to other vegetation (such as brush or grass) where such vegetation provides primary shading.

❒ Maintain a minimum of 25 square feet of basal area per acre within a shade strip where the future forest management goal is to manage for shade-intolerant species. No individual harvest segment bordering the water body should exceed 600 feet in length.

For other perennial waters

❒ Maintain a 50-foot-wide shade strip along both sides of all other lakes, perennial streams and open water wetlands (Figure 1, page 13).

❒ Maintain a minimum of 60 square feet of basal area per acre of trees in the shade strip where trees provide the primary shade to all other lakes, perennial streams and open water wetlands. This minimum should provide about 50% of full shade.

❒ Minimize disturbance to other vegetation (such as brush or grass) where such vegetation provides primary shading.

❒ Maintain a minimum of 25 square feet of basal area per acre within a shade strip where the future forest management goal is to manage for shade-intolerant species. No individual harvest segment bordering the water body should exceed 600 feet in length.

WETLAND PROTECTION

Why Protection Measures Are Needed

Wetlands are highly productive sites for a variety of ecologic functions, as well as for the enhancement of water quality. All management operations in or adjacent to wetlands should be planned and conducted in a manner that protects these functions.

State and federal wetland regulations provide an exemption for silvicultural activities in wetlands. To qualify for an exemption for silvicultural activities in a wetland under the Minnesota Wetland Conservation Act, an individual or organization:

- Must use appropriate erosion control measures to prevent sedimentation of water.
- Must not block fish activity in a watercourse.
- Must comply with all other applicable federal, state and local requirements, including Best Management Practices and water resource protection requirements.

The wetland BMPs were developed to meet the intent of federal regulations (33 CFR, Section 323.4, and 7 CFR, Part 12). These sections were 1) modified to allow flexibility of implementation where appropriate, and 2) broadened to cover the activities listed in the Wetland Conservation Act. The federal criteria that served as the standard for much of the forestry BMP development are listed in Appendix II, page 125.

Recommended Practices

The first planning priority should be to avoid operations in wetlands. Where avoidance is not practical, however, the natural resource manager, logger, contractor or landowner should minimize impacts by limiting the extent of wetland activities and using BMPs.

Soil information to assist the natural resource manager, logger, contractor or landowner in planning activities in wetlands may be available from county soil and water conservation district (SWCD) offices or local USDA Natural Resources Conservation Service (NRCS) offices. Specific requirements may apply to operations in special management areas, such as Scientific and Natural Areas.

Use of a site map or onsite review indicating the location of wetlands on the proposed site can be an effective tool for communicating planning considerations.

Conducting silvicultural operations when the ground is frozen will minimize damage on all wetland types. In addition, seasonally flooded basins and flats may be operated on if soil conditions are firm enough to support the type of equipment being used.

Susceptibility to compaction and rutting on mineral soil wetlands is dependent on several factors, including level of equipment trafficking, type of equipment used, soil type (mineral soil or peatland), soil water content at the time the silvicultural activity is conducted, and season of activity. In general for mineral soil wetlands, compaction and rutting increase as soil texture becomes finer and soil water content increases. In unfrozen peatland, deep rutting can bring muck to the surface and block normal water flow.

The following practices can help minimize the impact of silvicultural operations on the function and value of wetlands:

❒ Conduct silvicultural activities in wetlands when frozen or when firm enough to support equipment being used. Evaluate the site based on weather conditions to ensure adequate support for equipment to prevent or minimize rutting. Examples of weather conditions that could be cause for concern include heavy rain, flooding, significant snow before frost, and three consecutive nights above freezing. Operations may resume following a return to freezing or dry conditions.

- ❒ Mark springs and maintain a filter strip (Figure 1, page 13, and Table 1, page 14).

- ❒ Avoid disturbances such as ruts, soil compaction and addition of fill, which can interrupt or redirect the flow of water through a wetland. Such disturbances can also impact the depth of the water table or the extent of flooding or draining that occurs in all or a portion of a wetland, significantly altering the plant and animal community in that wetland.

- ❒ Plan for removal of equipment and cut material from the wetland area at the end of the winter season prior to thawing, or leave it until the next winter.

CONDUCTING FOLLOWUP EVALUATIONS OF PROTECTION MEASURES

Where structures (such as culverts or water bars) or other protection measures (such as seeding of bare areas) are used to minimize impacts on water quality and wetlands, followup visits to the area can help assure that the protection measures remain functional.

BUILDING AND MAINTAINING FOREST ROADS

Why BMPs Are Needed

Forest roads are managed to provide adequate access to forest lands for timber management, fish and wildlife habitat improvement, and a variety of recreational activities. The potential for forest roads to impact water quality and wetlands exists in areas with steep slopes or erodible soils, and in areas where forest roads are located near water or wetlands.

A forest road system connects the most remote parts of forest lands to existing township, county and state roads and highways. A well-planned access system is a sound method of reducing erosion and sedimentation in areas requiring frequent or temporary access. Proper location and construction of roads will provide for safety, longer operating periods, lower maintenance and operating costs, and minimal impacts to water quality and wetlands.

The following recommendations should be considered as guides for incorporation in the overall road project design to prevent or minimize potential water quality and wetland impacts. The landowner may need the services of a forester or engineer to provide complete design and construction specifications. *For sources of technical assistance, see Resource Directory, page 115.*

Why Additional BMPs Are Needed To Protect Wetlands

BMPs can minimize the potential impact of wetland roads on water quality and alterations to normal water flow patterns. While the quality and character of forest roads will vary depending on the design standard of the road, the impacts of placing fill materials and structures in wetlands are still present regardless of the road type.

Incorporating the following recommendations into the overall road project design should reduce potential impacts on water quality and wetlands.

PLANNING CONSIDERATIONS FOR ALL FOREST ROADS

General Considerations

Effective road construction techniques minimize the disturbance to the natural flow of water over the landscape and ensure the structural integrity of the road embankment. The goal is to provide a simple road structure of adequate strength to support heavy vehicle traffic and provide drainage structures to pass water at its normal level through the road corridor.

Choices regarding road construction standards and maintenance activities will be influenced by site

characteristics and the value of the resources served. Culverts and ditches may be necessary with any road construction technique. Structural features of an upland road are shown in Figure 2.

To reduce costs and minimize road mileage, coordination with adjacent landowners may be desirable.

Selecting Type of Road

Permanent roads are intended for long-term use. They include all-season roads and seasonal roads.

- ***All-season roads*** are designed for use ***all year long***, though there may be some restrictions on vehicle weight at times during spring breakup or wet periods. There is a great range in design standards and road surfacing in this type of road, depending on the traffic load anticipated.

- ***Seasonal roads*** are designed for ***long-term periodic*** use, such as during dry and frozen periods. These roads are built to lower engineering standards and have minimal material surfacing.

Temporary roads are generally minimum-standard roads designed for ***short-term*** use during a specific project, such as a timber harvest. Many of these temporary roads are little more than a bladed lane pushed into the harvest site (Figure 3). Use of these roads is typically limited to dry or frozen conditions to minimize rutting and compaction.

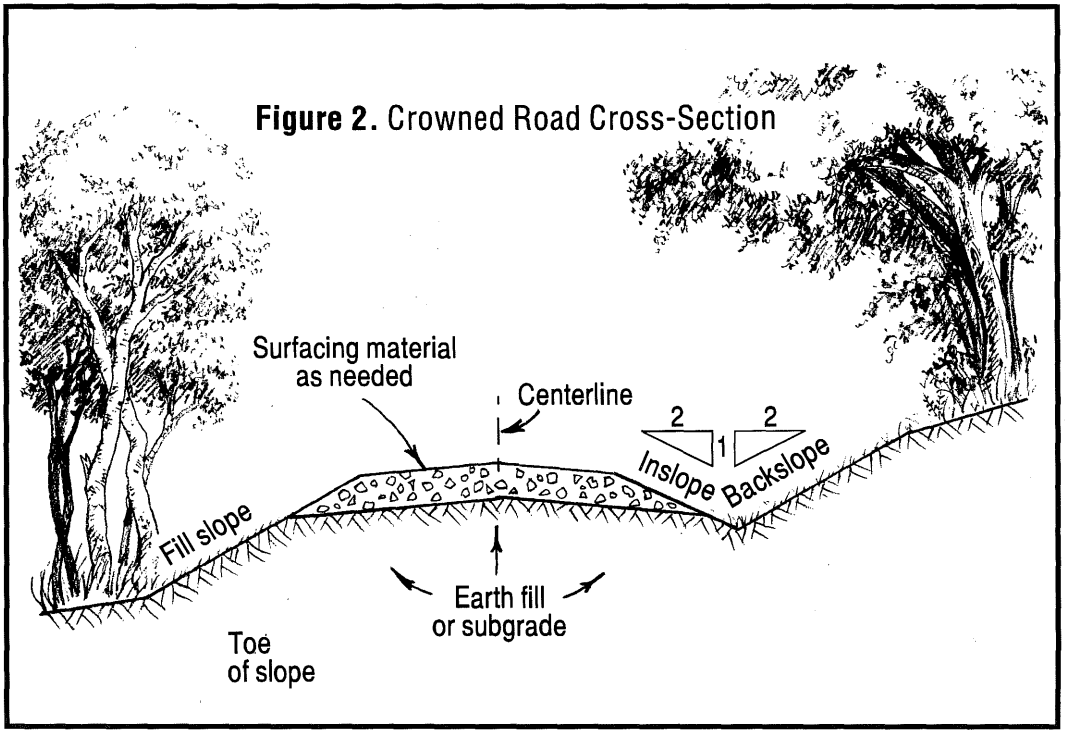
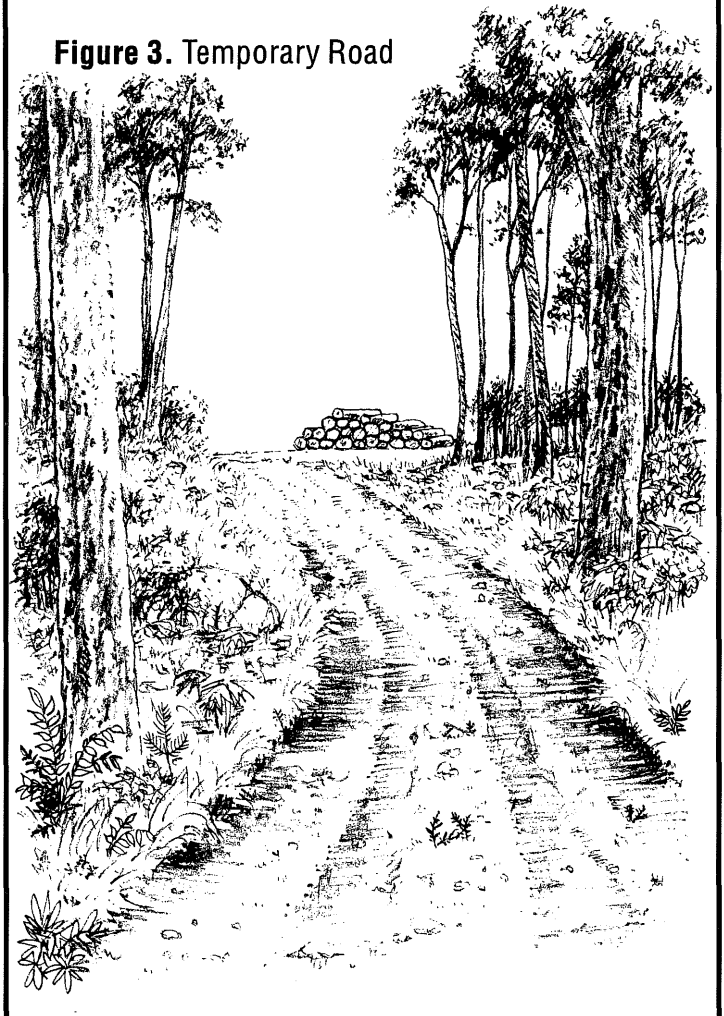


Figure 2. Crowned Road Cross-Section

Figure 3. Temporary Road



DESIGN RECOMMENDATIONS FOR UPLAND FOREST ROADS

The following recommendations should be considered when planning the design of a road:

- ❒ Examine existing access routes to determine whether they are the best routes to improve. Consider whether relocation would provide a better long-term access route.

- ❒ Minimize total road mileage and ground disturbance required to meet the landowner's objectives.

- ❒ Minimize the number of water crossings.

- ❒ Establish appropriate stabilization, drainage and erosion control measures, to be applied on a daily basis during all phases of an operation.

Alignment and Location

The proper alignment and location of roads will reduce the potential for NPS pollution. The following recommendations should be incorporated in the road design:

- ❒ Locate roads to minimize the amount of cut and fill and the number of water crossings.

- ❒ Locate roads away from lakes, streams and open water wetlands whenever possible, to provide adequate filter strips (Table 1, page 14).

- ❒ Avoid locations below the high water mark of lakes, streams and wetlands whenever possible (Figure 4).

- ❒ Avoid locating roads on unstable slopes subject to slumping or creep whenever practical.

- ❒ Avoid constructing roads with grades in excess of 10%. On highly erodible soils, maximum grades of 5% are recommended (Figure 5).

- ❒ Minimize down-road flow and ponding by constructing roads with a slight grade of 1% or 2% and with appropriate ditches where practical.

- ❒ Contact utility owners or Gopher State One Call at (800) 252-1166 or (612) 454-0072 when crossing pipelines or other underground utilities.

Water Crossings

Water crossings present a high risk to water quality and should be avoided when practical. Bridges or culverts are preferred for road crossings that are used frequently or for extended periods. Fords should be used for infrequent crossings and for short-term operations.

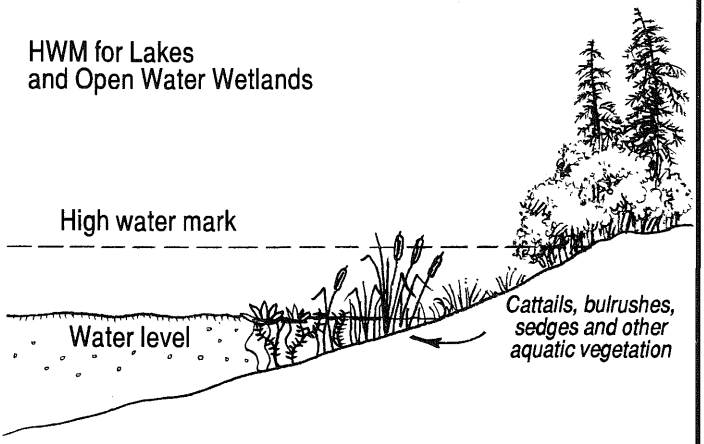


Figure 4. High Water Mark (HWM)

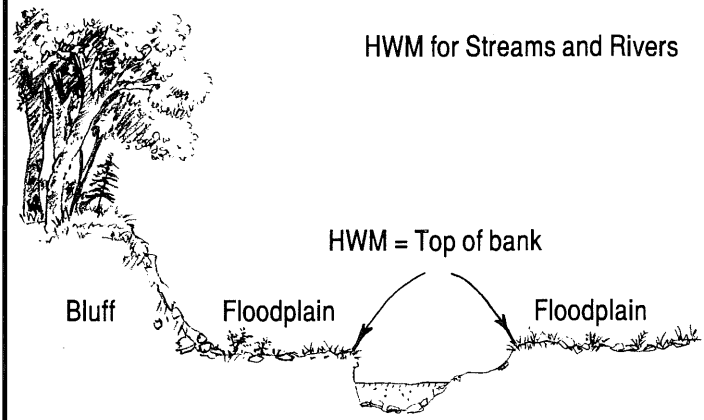
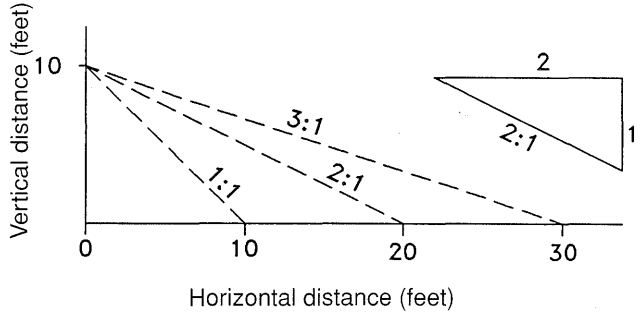
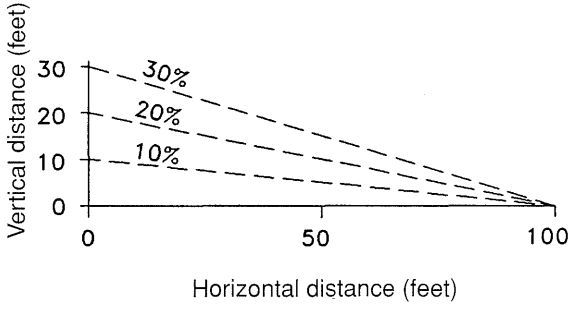
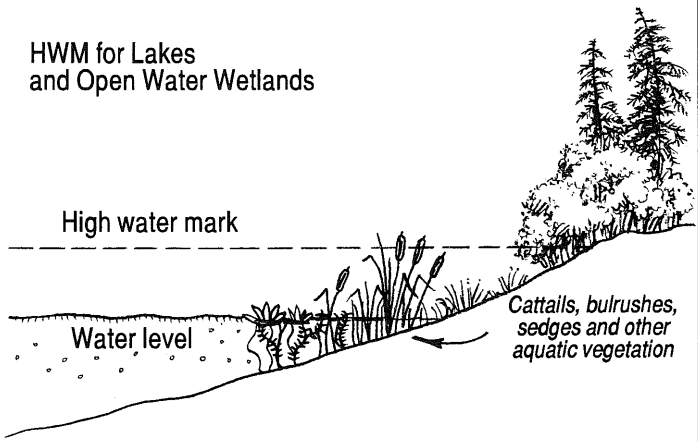


Figure 5. Representations of Typical Slope and Grade







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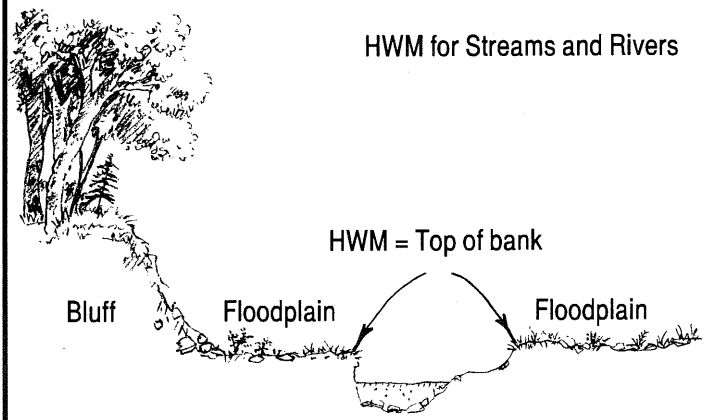

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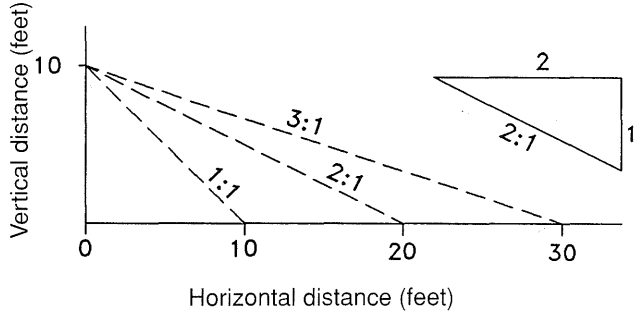
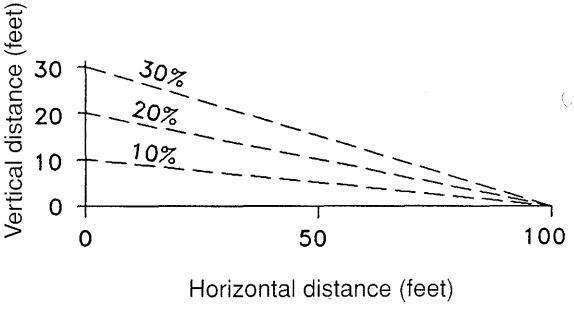




Fords should have a firm base (or a firm based installed) to minimize potential impacts to water quality or wetlands.

The following practices should be included in the design of water crossings to help protect water quality:

❒ Contact a DNR regional or area hydrologist to determine whether the proposed road will cross any water or wetland designated on the Protected Waters Inventory maps. ***If so, obtain the appropriate permit (Minn. Statute 103G.245).***

❒ Give preference to crossing locations where:

- Streambed and banks are composed of firm cohesive soils or rock.

- Approaches to streambanks have low-percent slopes and short slope lengths.

- Construction will disrupt a minimum amount of natural stream channel.

❒ Maintain crossings as close to a 90-degree angle as possible to the streambed.

❒ Construct crossings so that they do not change the cross-sectional area of the stream channel or impede fish migration.

- ❒ Construct low-water crossings with materials that will not degrade water quality. These materials include (but are not limited to) concrete, coarse rock, riprap and gabions.

- ❒ Minimize construction disturbance to the natural flow of water.

- ❒ Restrict activity in the water to periods of low flow.

- ❒ Design culverts and bridges for minimal impact on water quality. Permanently installed culverts should be at least 12 inches in diameter for ease of maintenance. Putting in culverts and drainage structures that are too small could result in the road washing out. *For sources of information on sizing culverts, see Resource Directory, page 115.*

- ❒ Install culverts and bridges using materials within the stream that are clean, non-erodible and nontoxic to aquatic life. These include compacted fill, riprap, concrete and treated timbers. When using chemically treated timber below or near the water level, it should be reasonably dry and free of excessive surface oils when installed.

- ❒ Anchor temporary structures at one end to allow the structure to move aside during high-water flows.

- ❒ Remove temporary fills and structures to the extent practical when use is complete.

Winter Roads

Winter roads provide access under frozen ground conditions for timber harvesting and other timber management activities. Like all other roads, winter roads need to have provisions for adequate drainage to prevent or minimize erosion and sedimentation into wetlands and open water. With much of the timber harvesting in Minnesota occurring during January, February and March, properly constructed winter roads are an important component of timber management.

To minimize the impacts on water quality during spring breakup, the following recommendations should be included in the design of winter roads:

- ❒ Construct temporary crossings for winter roads where practical. Examples of preferred temporary crossings include ice bridges, temporarily installed culverts and bridges (including use of native log materials), and timber mats. ***Soil fill should not be used*** on these temporary structures.

- ❒ Construct crossings to prevent water from backing up.

- ❒ Consider using culverts or bridges to cross defined drainages where winter roads are to be used for five years or longer. *For sources of information on sizing culverts, see Resource Directory, page 115.*

❒ Anchor temporary structures at one end to allow the structure to move aside during high-water flows.

❒ Install all temporary structures that could potentially block water flow in such a manner that they can be easily removed prior to breakup.

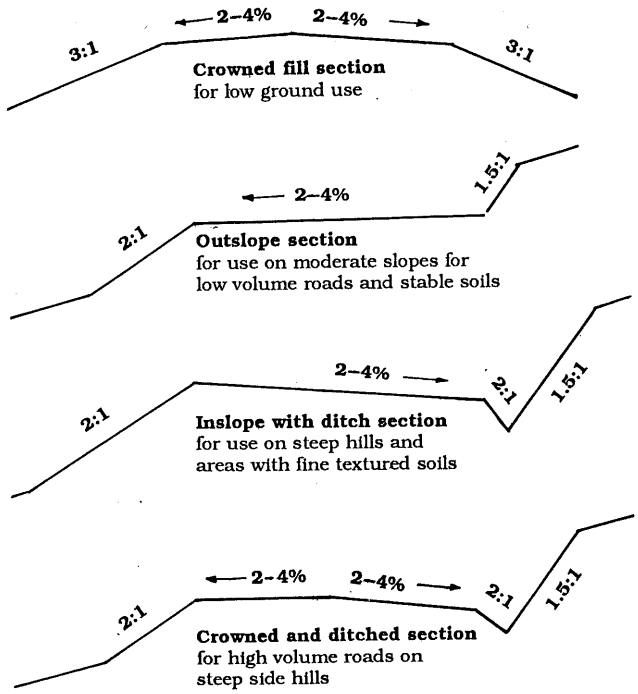
Drainage

Water entering onto or adjacent to the road must be diverted away from the road before gaining sufficient flow and velocity to cause significant erosion of the road and ditch. The following recommendations should be used to minimize erosion and siltation of adjacent waters:

❒ Control down-road flow of surface water by using a combination of the appropriate road cross-section (Figure 6) and appropriate water diversion structures within the roadbed itself, such as broad-based dips or grade rolls (Figure 7), open-top culverts and water bars (Figure 8). Table 2 gives proper spacing for broad-based dips and upland culverts, and Table 3 gives proper spacing for water bars on roads and skid trails.

❒ Avoid draining surface water that is diverted from roads directly into lakes, streams or open water wetlands. Instead, drain the water into the filter strip or vegetative area (Figure 9).

Figure 6. Typical Road Profiles for Drainage and Stability



❒ Install cross drains and lead-off ditches to avoid carrying water long distances in roadside ditches. Cross drains may include open-top culverts, pipe culverts and bridges. An engineer can provide additional design recommendations to protect against erosion and sedimentation for high-use roads.

CONSTRUCTION RECOMMENDATIONS FOR UPLAND FOREST ROADS

Clearing

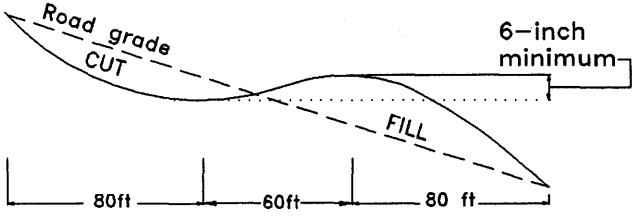
Clearing widths will vary depending on the needs of both the owner and the user of the road. Consideration should be given to the necessity for roadway drying, as well as to the safety, cost and aesthetics of narrow rights-of-way. Cleared material should be disposed of properly using the following recommendations:

❒ Place clearing debris in a manner that will not impede water flow or potentially increase sedimentation of waters.

❒ Provide periodic breaks in the windrows of clearing debris to allow for free movement of water.

❒ Avoid placing excess excavated material or clearing debris in filter strips.

Figure 7. Broad-Based Dip Installation



Numbers for illustrative purposes only. Dimensions will vary.

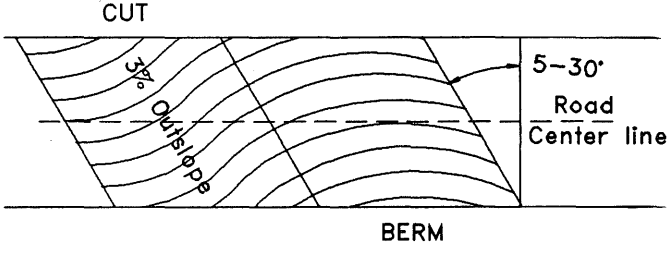
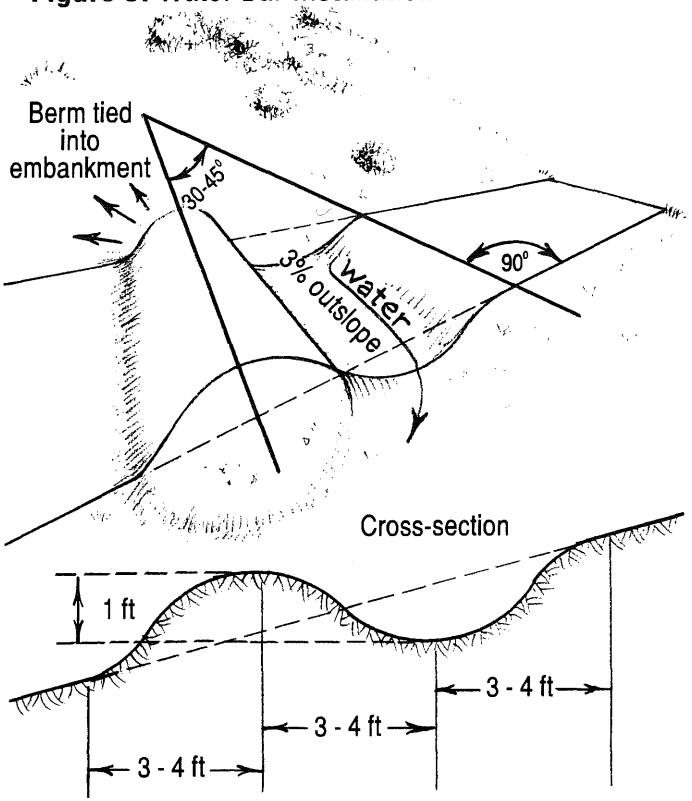


Figure 8. Water Bar Installation



Numbers for illustrative purposes only. Dimensions will vary.

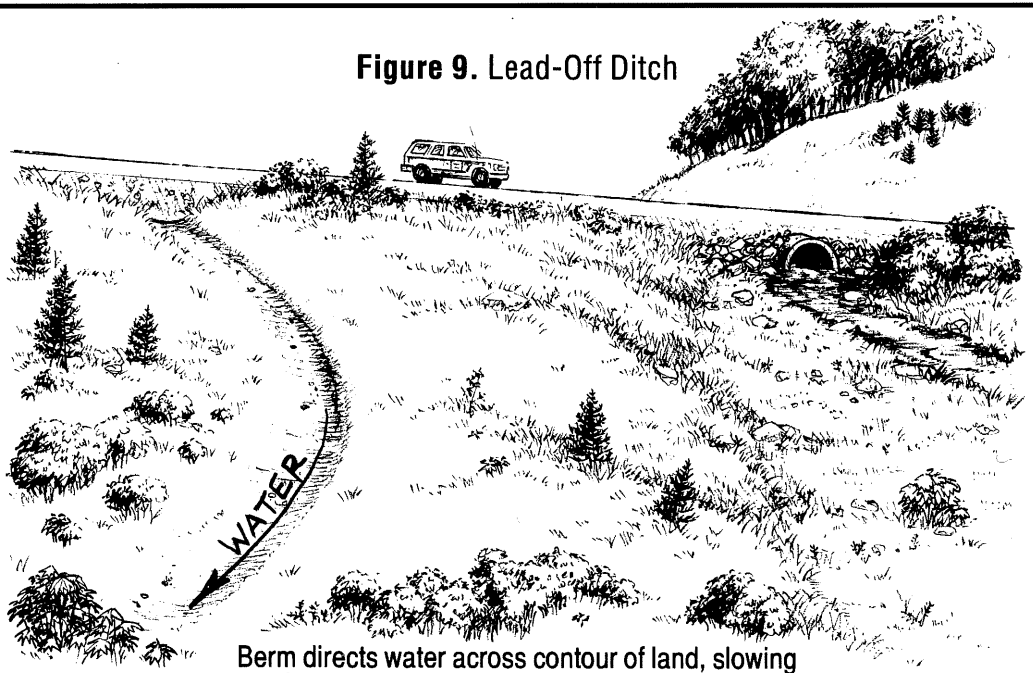
Table 2. Cross-drain spacing for broad-based dips and upland culverts

Grade	Spacing between dips or upland culverts
0-2%	500 feet
3-4%	300 feet
5-7%	180 feet
8-10%	150 feet
11-15%	130 feet
16%+	110 feet

Table 3. Water bar spacing

Grade	Spacing between water bars
2%	250 feet
5%	130 feet
10%	80 feet
15%	50 feet
25%+	40 feet

Figure 9. Lead-Off Ditch



Berm directs water across contour of land, slowing flow and keeping water away from stream.

Excavation

In most cases, material must be brought in to provide an adequate road for even a minimal amount of hauling. Such material should be obtained from the closest available source, which is often the ditch.

During work on new projects, loose exposed mineral soil is the most critical factor affecting siltation of waters. Care should be taken to drain the site during construction.

Recommended methods for placement of materials associated with road construction include the following:

- ❒ Place excavated material in a manner that will not impede water flow or potentially increase sedimentation of waters.
- ❒ Avoid placing excavated material in filter strips.
- ❒ Shape inslopes and backslopes to promote revegetation and soil stabilization. Slopes of 1½:1 or flatter are preferred if terrain permits (Figure 5, page 29).
- ❒ Compact fill material to reduce entry of water, increase load-carrying capacity and minimize settling.
- ❒ Deposit excess material in stable locations above lakes, streams and wetlands.

❒ Shape and stabilize borrow pits and excess material.

❒ Limit the area excavated to that which can be properly shaped and compacted within a day, with provisions for storm drainage and sedimentation control.

Surfacing

Surfacing can be the major cost of low-volume road construction. Alternatives should be evaluated according to expected use and potential impact on sediment load. Where grades make the potential for surface erosion significant, the road should be surfaced with materials that will minimize potential water quality impacts (such as crushed rock, compacted gravel, sod or asphalt).

Drainage

Site drainage and cross-drainage are important for controlling sedimentation. Proper handling of water during construction will minimize potential impacts on water quality. These recommendations should be followed to reduce possible impacts:

❒ Install drainage structures as construction proceeds.

- ❒ Install culverts at grades 2% more than the ditch grade and angled at least 30 degrees from perpendicular to the flow of water to improve inlet efficiency (Figure 10).

- ❒ Size culverts and other drainage structures large enough to minimize impacts on water quality. Putting in culverts and drainage structures that are too small could result in washing out of the road. *For sources of technical assistance, see Resource Directory, page 115.*

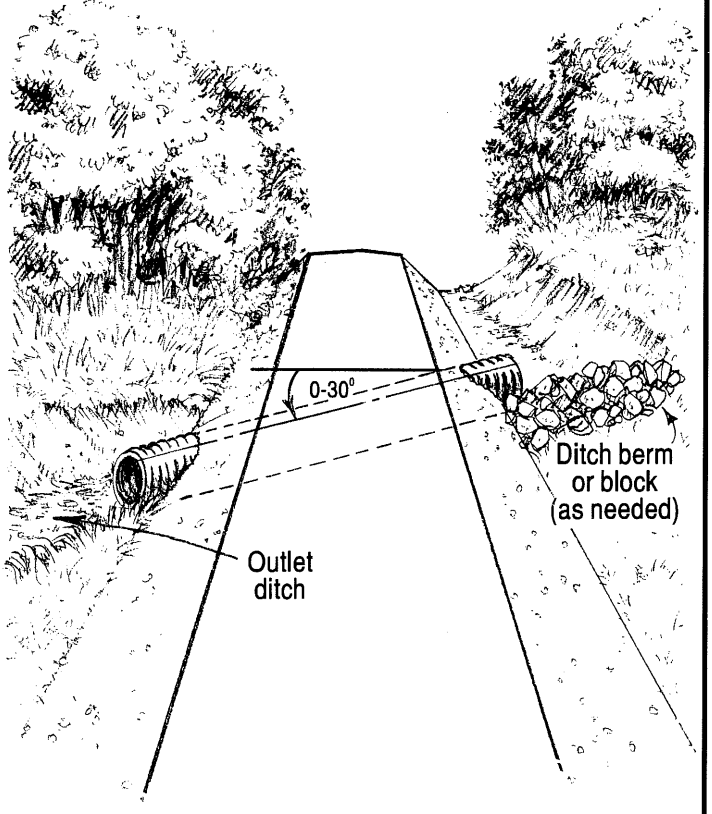
- ❒ Compact fill firmly around culverts, paying special attention to the sides and lower portion (Figure 11). Cover the top of culverts with fill to a depth of one-half the pipe diameter or 12 inches, whichever is greater. Culvert lengths should reach to the toe of the fill without changing the sideslopes of the fill.

- ❒ Armor culvert inlets and outlets to reduce bank and channel erosion and sedimentation where appropriate.

- ❒ Provide adequate drainage for road grades during construction to minimize erosion of unconsolidated materials.

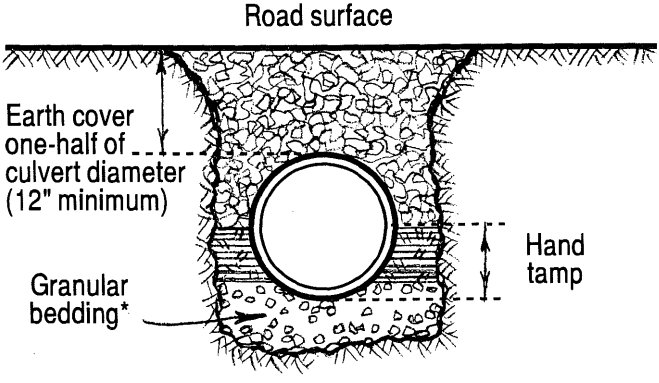
- ❒ Retain outslope drainage and minimize berms on the outside edge during construction operations, except those intentionally constructed for protection of road grade fills.

Figure 10. Typical Upland Cross-Drainage Culvert



Angle of culvert placement for low-velocity flows may be less than 30°.

Figure 11. Typical Culvert Installation for Uplands and Mineral Soil Wetlands



Not required if appropriate base exists (free of large rocks and voids)

❒ Provide temporary cross-drainage structures (such as water bars) during construction where needed (Figure 8, page 37, and Table 3, page 38).

❒ Install siltation barriers, such as silt fences and straw bales, during construction in sites where roads and water have close contact for long periods.

Soil Protection

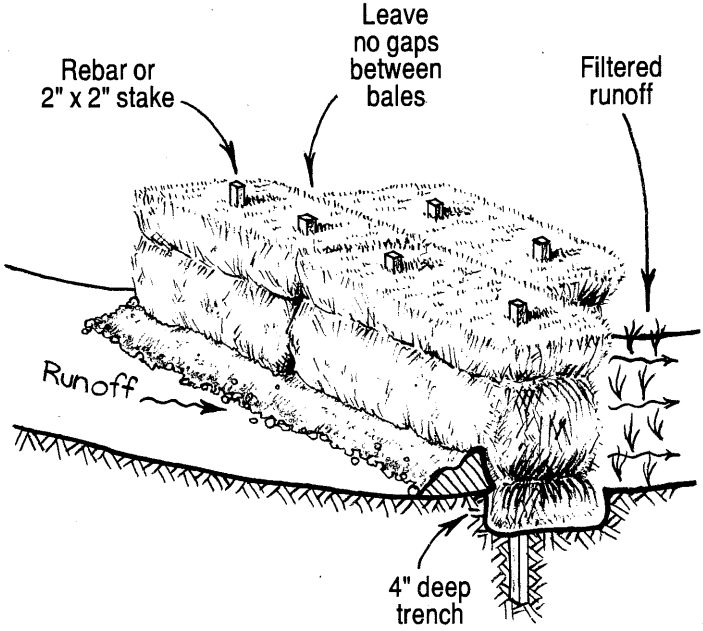
Disturbed areas should be shaped and stabilized as soon as possible to minimize erosion potential. ***The greatest potential for soil erosion occurs immediately after construction.*** The following measures are recommended:

❒ Stabilize bare soil areas to reduce erosion. A vegetative cover is recommended along all roadsides. Where necessary, disturbed soil should be mulched and seeded as soon as practical after construction. *For sources of recommendations for seed mixes and fertilizer use, see Resource Directory, page 121.*

❒ Install temporary erosion control devices, such as straw bales, mulch or woody debris, to help stabilize soils prior to establishment of vegetative cover (Figure 12).

❒ Inspect and repair erosion control measures on a regular basis to ensure that they remain functional.

Figure 12. Installation of Straw Bales



DESIGN RECOMMENDATIONS FOR WETLAND FOREST ROADS

The landowner/operator is strongly advised to utilize the services of a forester and a professional engineer to develop complete design and construction specifications. This professional assistance is particularly important when constructing permanent all-season roads. *For sources of professional assistance, see Resource Directory, page 115.*

General Planning and Design Recommendations

The following general recommendations apply when planning the design of all roads across wetlands:

❒ Avoid crossing wetlands.

❒ Minimize total wetland road mileage when wetlands must be crossed, while still meeting landowner objectives.

❒ Determine the type and depth of wetland subsoils to ensure proper design and construction.

❒ Contact a county SWCD office or DNR regional or area hydrologist to determine whether the proposed road will cross a water or wetland designated on the Protected Waters Inventory maps.

If so, secure the required permit from the Division of Waters to work in public waters (Minn. Statute 103G.245). *For a listing of DNR regional offices, see Resource Directory, page 116.*

❒ Contact a county SWCD office to determine whether the local government unit requires a certificate of exemption for forest roads for silvicultural practices.

❒ Minimize width of roads consistent with maintaining safety and road design considerations. Provide turnouts, as appropriate, placed at intervals to accommodate two-way traffic. On deep peat wetlands, road fill slopes should be 3:1 or flatter to spread out road loading and minimize failure (Figure 5, page 29).

❒ Construct all road embankment fills with clean fill or other suitable native materials.

❒ Design upland road approaches to wetlands so that surface runoff carrying potential sediment is diverted before entering the wetland.

❒ Anchor temporary structures at one end to allow the structure to move aside during high-water flows.

❒ Remove temporary fills and structures to the extent practical when use is complete.

❒ Employ sediment control techniques (such as silt curtains) to prevent movement to open water when placing fill during construction.

❒ Provide adequate cross-drainage by employing one or both of the following techniques: 1) Use construction methods that allow free water flow throughout the entire roadbed (Figure 13); or 2) Place culverts or other cross-drain structures at each end of each wetland crossing and at intermediate low points. Space culverts or other cross-drain structures at maximum 300-foot intervals to ensure adequate cross-drainage through the roadbed (Figure 14).

CONSTRUCTION RECOMMENDATIONS FOR WETLAND FOREST ROADS

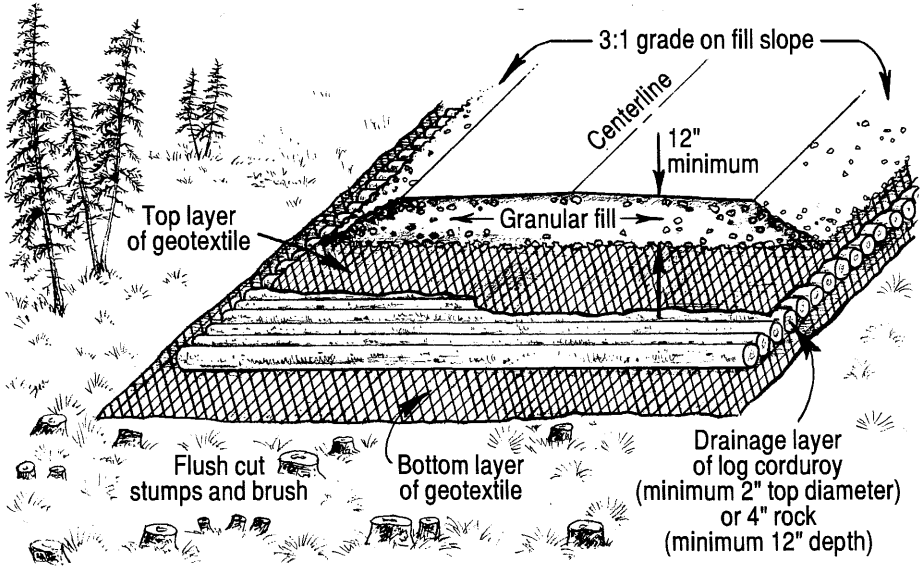
General Considerations

Choosing the appropriate road construction technique will depend on a knowledge of water table position, zone of water flow, type of wetland soils, and the strength of wetland soils. With any road construction technique, culverts or ditches (or both) may be necessary.

Follow these recommendations when constructing ditches on wetland roads:

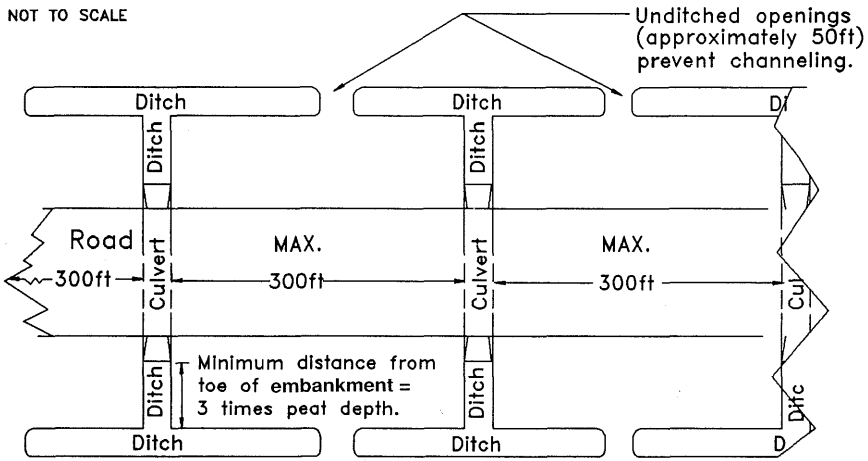
❒ Construct ditches in wetland crossings, where necessary, to intercept and carry surface and subsurface water (the top 12 inches) to, through, and away from the culverts. Unditched breaks should be left midway between culverts (Figure 14).

Figure 13. Road Design for Peat Wetlands with Continuous Cross-Drainage



Drainage layers may be used as an alternative to culverts, or in combination with culverts, to provide adequate cross-drainage.

Figure 14. Deep Peat Wetlands Culvert and Ditch Spacing



Culverts may be used as an alternative to drainage layers, or in combination with drainage layers, to provide adequate cross-drainage. When needed, parallel ditches should be spaced as shown.

❒ Avoid having ditches create additional outlets that will result in drainage of the wetland.

Additional ditching practices are listed below under specific guidelines for various wetland types.

The following guidelines address four different kinds of construction approaches: 1) crossing mineral soil wetlands; 2) crossing shallow peat wetlands; 3) crossing deep peat wetlands; and 4) crossing wetlands in winter.

Guidelines for Crossing Mineral Soil Wetlands

Wetlands with mineral soils include those wetlands having fine-textured (clay or silt), slowly permeable soils to sandy soils overlaying impervious subsoils or hardpans. Road building across these wetland types employs conventional road construction techniques for road fill and drainage structures.

Weak mineral soils can be excavated and backfilled with clean granular soils, or they can be filled over with clean granular fill and allowed to compress and displace. Additional fill is added to keep the road bed at the desired grade.

Culverts and ditches are installed to minimize disruption of normal water flow across the landscape and transport it through and away from the roadbed.

Fill areas in floodplains should be designed to allow high flows to pass unimpeded.

❒ Install culverts of sufficient size to handle hydrologic flows for the site and for long-term maintenance needs. If ditches are needed, construct them immediately adjacent to the toe of the fill slope. *For sources of technical assistance, see Resource Directory, page 115.*

Guidelines for Crossing Shallow Peat Wetlands

Wetland crossings of shallow peat less than 4 feet deep may be constructed using conventional road construction methods:

- The conventional road construction method consists of excavating the shallow peat and then backfilling with clean granular backfill material. The excavated peat can be used to flatten the roadbed fill slope. Excess peat should be hauled away and disposed of at an approved upland disposal site.

- Another accepted road construction method involves placing granular fill material directly onto the peat surface. The weight of the fill material displaces (or pushes aside) the weaker peat until

the strength of the subsoils is sufficient to bear the weight of the fill material and vehicle loadings. As final settling occurs, additional fill may be needed to maintain the desired road grade.

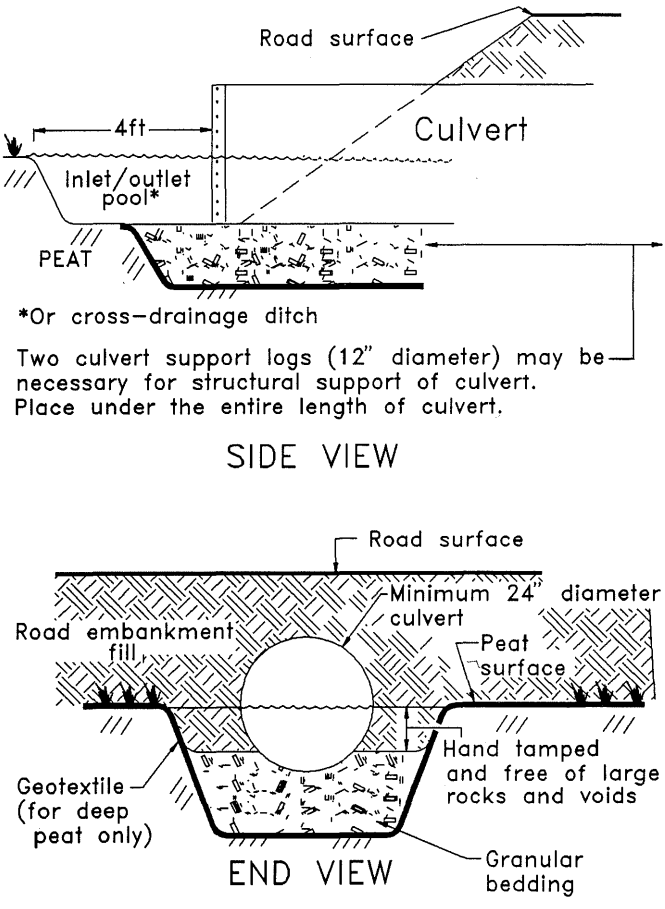
With both methods, the installation of culverts and ditches intercepts surface and subsurface water flow, transporting it through and away from the roadbed. (Most subsurface flow occurs in the top 12 inches of the peat.)

Follow these recommendations when placing culverts:

- ❒ Install culverts that are a minimum of 24 inches in diameter buried halfway below the soil surface (Figure 15). The upper half will handle surface storm flows and the lower half will handle normal subsurface flows. Failure to bury the lower half of the culvert will cause subsurface water to pond on the upstream side of the road and kill trees.

- ❒ Place culverts at the low points of the wetland to pass surface water flows through the road embankments. If ditches are needed, construct them immediately adjacent to the toe of the fill slope. *For sources of technical assistance, see Resource Directory, page 115.*

Figure 15. Wetland Culvert Installation



Guidelines for Crossing Deep Peat Wetlands

Crossing wetlands with peat soils greater than 4 feet deep can be done using special road construction methods that do not require excavation and backfill. These methods make use of geotextile fabrics, special embankment structures (such as lightweight road fills, extra-wide road bases or log corduroy layers), and the inherent strength of the underlying peat layers to resist slip failure and resultant road failure (Figure 13, page 50).

Such failures can range from the gradual sinking to the sudden loss of the road into the wetland. When such failures occur, the peat water flow through the wetland is greatly disturbed, which can result in large areas of flooding.

These methods generally specify that a layer of geotextile be placed on the peat surface. Road fill is then placed over the geotextile. To provide additional strength and adequate cross-drainage, special materials such as log corduroy, chunkwood, wood chips or drainage rock may be added in the lower portion of the fill (Figure 13, page 50).

The specific road structure needed depends on the strength of the peat layers below the road. The determination of shear strength is critical in designing a sound, safe and economical road crossing. The landowner or natural resource manager is strongly advised to consult the services of a registered civil engineer to accurately determine shear strengths, conduct field testing and provide design specifications.

Some deep peat wetlands with peat layers that are too weak to support a roadbed will require traditional excavation and backfill methods. Because of the high cost of traditional construction methods, as well as environmental effects, it is best to avoid building on these weak peat wetlands.

Cross-drainage through the roadbed in a deep peat wetland is normally slowed or halted as a result of the compression of the peat layers by the road embankment, equipment rutting of the peat surface, or road failure. This can cause flooding on the upslope side of the wetland and drying on the downslope side. Cross-drainage can be maintained by the proper installation of culvert and drainage layers. In all cases, the construction objective is ***to provide a stable road surface while maintaining the free flow of water through the roadbed.***

The following techniques can prevent or minimize impacts to deep peat wetlands:

❒ Construct road embankments across wetlands with deep peat subsoils when the peat is frozen. Construction on frozen peat avoids rutting and other damage of the topmost root mat layer, which normally contains considerable shear strength. Such damage can greatly reduce the strength of the upper peat layers and reduce the ability of the wetland subsoils to hold up the weight of the roadbed and vehicle loads.

- ❒ Install culverts that are a minimum of 24 inches in diameter buried halfway below the soil surface (Figure 15, page 55). The upper half will handle surface storm flows, and the lower half will handle everyday subsurface flows. Failure to bury the lower half of the culvert will cause subsurface water to pond on the upstream side of the road and kill trees

- ❒ Maintain a separation between the toe of the embankment fill slope and the ditch when constructing ditches parallel to the roadway. The separation distance should be at least three times the depth of the peat (Figure 14, page 51), which will prevent or minimize disturbance of the inherent strength of the top layer of peat containing the root mat.

- ❒ Provide ditches to facilitate flow into and out of culverts.

- ❒ Construct ditches using flotation devices (such as timber mats) or schedule construction to occur during frozen conditions, to prevent or minimize impacts on wetlands and minimize damage to construction equipment.

- ❒ Obtain professional engineering advice on design of cross-drainage ditches for permanent roads across deep peat wetlands.

Specific design techniques for crossing deep peat wetlands

Roadbeds that use geotextile fabrics should be prepared to protect the woody root mat by flush-cutting trees and brush and leaving non-merchantable material in place. The first geotextile fabric should be laid loosely over the cut material. Then proceed with one of the following wetland road construction techniques:

Corduroy

- Place trees parallel to each other, side by side and perpendicular to the roadbed direction.

- Cover as needed with clean road fill or gravel.

- If log corduroy is to be used for cross-drainage, apply geotextile both above and below the corduroy. If log corduroy is not to be used for cross-drainage, other cross-drainage structures should be considered (Figure 13, page 50).

Rock drainage layer

- Place 12 inches of rock (4 inches or less in diameter) over the geotextile, followed by another layer of geotextile. The rock layer will settle into the top 12 inches of the wetland,

providing the pore space for water passage through the roadbed.

• Place clean road fill or gravel on top (typically 18 inches deep).

Lightweight road fills

Lightweight materials may be incorporated into the core of the road embankment fill to lessen the total weight of the road embankment when constructing on weak peat wetlands.

Lightweight materials include chunkwood, wood chips and sawmill residues, among other materials. Materials with known potential to leach toxic substances (such as construction debris, treated wood, tires, asphalt or other petroleum-laden materials) are not suitable for use.

• Place the lightweight materials over the fabric to form the core of the road embankment fill, followed by another layer of geotextile fabric over the lightweight materials.

• Cover the core with at least 18 inches of granular sand or gravel road fill.

• Install culverts and ditches, if necessary, to pass surface and subsurface waters through the road embankment (Figure 14, page 51).

Guidelines for Crossing Wetlands in Winter

Roads across wetlands are often designed to take advantage of frozen ground conditions. Follow permanent road BMPs if permanent structures or minimal fill are necessary. Use the following recommendations to design roads across all wetland types:

- ❒ Plan the layout to maximize operating efficiency and minimize site disturbance.
- ❒ Select the shortest routes practical that minimize potential problems with drifting snow and the crossing of open water.
- ❒ Tramp and pack the wetland area wider than needed for the driving and working area if sufficient frost is not present. This additional space will allow for turnouts, snow removal and parking.
- ❒ Avoid crossing open water or active springs. If unavoidable, temporary crossings are preferred. These can be ice bridges, temporarily installed bridges or culverts, or timber mats.
- ❒ Avoid using soil fill.
- ❒ Install all structures that block water flow so that they can be easily removed prior to breakup. If the streams are navigable or require a DNR permit to cross, removal may be necessary at the end of each winter of operation, not just at the end of the timber contract.

- ❒ Use planking, timber mats or other support alternatives to improve the ability to support heavy traffic where conditions are inadequate to stay within the stated guidelines. If removal would cause more damage than leaving them in place, these areas may be left as permanent sections on frozen roads.

- ❒ Anchor temporary structures at one end to allow the structure to move aside during high-water flows.

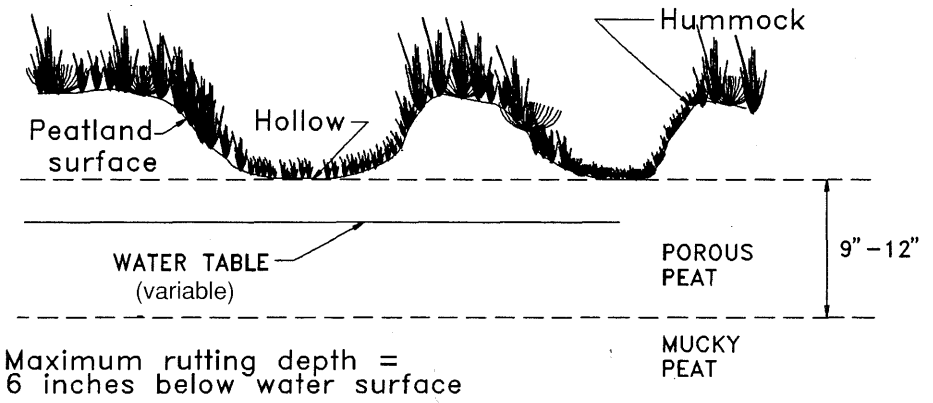
- ❒ Remove temporary fills and structures to the extent practical when use is complete.

- ❒ Avoid clearing practices that result in berms of soil or organic debris building up on either side of the road clearing. Such berms can disrupt normal water flow.

- ❒ Provide adequate filter strips near open water (Figure 1, page 13, and Table 1, page 14).

- ❒ Cease equipment operations on any portion of the road where rutting exceeds 6 inches in depth for continuous distances greater than 300 feet (defined in Figure 16). Resume operations only when conditions are adequate to support equipment. This practice will minimize blockage of cross-drainage and prevent or minimize down-road channelization.

Figure 16. Peat Wetland Surface in Relation to Water Table



The water table (solid line) is near the bottom of the hollows (upper dotted line). Operations should stop when ruts reach 6 inches below the water table or 6 inches below the bottom of the hollows, whichever is lower. Peat is usually still porous 9 inches below the hollows, and ruts will heal in 2 to 3 years. Deep ruts (more than 12 inches below the hollows) will bring up well-decomposed, mucky peat and may take more than 20 years to heal.

MAINTENANCE AND CLOSURE RECOMMENDATIONS FOR ALL FOREST ROADS

The purpose of maintenance procedures is to ensure that measures taken to minimize impacts on water quality and wetlands are working and will continue to work for the life of the road.

Maintenance Measures for All Roads

To reduce impacts on water quality, the following maintenance measures are recommended:

- ❒ Clean debris from culverts, ditches, dips and other structures as needed to diminish the danger of clogging and the possibility of washouts. Any debris should be placed away from the watercourse and stabilized, if necessary.

- ❒ Restrict use of roads during wet periods and spring breakup appropriate to their construction and surfacing to reduce maintenance requirements.

Maintaining Active Roads

Roads that are open for use require more maintenance than roads that are closed to vehicular travel. Surfacing materials and the amount of use will determine the level of maintenance required.

The following maintenance measures are recommended:

- ❒ Fill in ruts and holes that develop during road use. Use a suitable material (such as gravel or compacted fill), and fill as soon as possible to reduce the potential for erosion.

- ❒ Grade road surface periodically to maintain proper surface drainage and eliminate small wheel ruts.

- ❒ Minimize berms along the edge of the road that will trap water on the road surface. Feather material out on the road surface.

- ❒ Minimize entry of dust control agents (such as calcium chloride or road oil) into water. For example, do not apply an excess of these chemicals to the road that could potentially be transported to surface water through erosion and surface runoff.

Closing Inactive Roads

An inactive road is one that is currently not in use. Inactive roads, whether closed temporarily or permanently, require occasional work to reduce potential impacts on lakes, streams and wetlands.

For temporary closure, these recommendations apply:

❒ Control access to minimize maintenance requirements.

❒ Ensure that the road surface is in stable condition when the road is closed. Seed and fertilize disturbed surfaces as necessary. *For sources of recommendations for seeding and fertilization, see Resource Directory, page 121.*

❒ Install appropriate drainage structures as necessary and maintain in working order.

❒ Place a barrier to traffic, and post "Road Closed" signs at the beginning of the road when closing roads.

❒ Provide periodic inspection and maintenance of road surfaces as necessary.

For permanent closure, these recommendations apply:

❒ Place a barrier to traffic, such as a berm, and post "Road Closed" signs at the beginning of the road when closing roads.

❒ Place water bars where necessary (Figure 8, page 37, and Table 3, page 38).

- ❒ Remove structures that would require continuing maintenance (such as culverts and bridges) even after a road is abandoned.

- ❒ Reshape stream crossings to approximate original channel contour when removing water crossing structures, and stabilize the structure site.

- ❒ Provide breaks in extended fills in flood-prone areas at intervals no greater than 300 feet to accommodate high flows and debris.

- ❒ Ensure that the road surface is in stable condition when the road is closed. Seed and fertilize disturbed surfaces as necessary. *For sources of recommendations for seeding and fertilizing, see Resource Directory, page 121.*

TIMBER HARVESTING

Why BMPs Are Needed

The most common forest management activity is timber harvesting. It involves cutting trees, skidding them to a landing, sorting and loading, and transporting them to a mill. The resulting soil disturbance, disruption of vegetative cover, and activity in close proximity to lakes, streams and wetlands can result in an increase in NPS pollution.

Using BMPs for these harvesting activities will minimize the potential for sediment, chemical, nutrient and debris movement into lakes, streams, wetlands and ground water, and minimize thermal (heating) impacts on surface waters.

PLANNING CONSIDERATIONS

Timber harvesting activities should follow a well-thought-out plan that incorporates water quality and wetland protection in all operations. Those who have not had any experience with timber harvesting should contact a forestry professional for assistance. *For sources of professional assistance, including cost-sharing and technical support, see Resource Directory, page 116-117 and 121-124.*

Conducting a Preliminary Site Evaluation

An "on-the-ground" evaluation should be conducted for all land being considered for timber sales, regardless of who owns the land. It is important to have this firsthand knowledge of the area being considered for harvesting.

A variety of tools can provide assistance in evaluating property and developing a plan for timber harvesting and other land management activities. These tools include aerial photographs, topographic maps and soil surveys. *For sources of these tools, see Resource Directory, page 114.*

Familiarity with soils in the area will assist natural resource managers or landowners in choosing appropriate timber harvesting methods while also providing water quality and wetland protection. Many counties have completed soil surveys. *For information about obtaining or using county soil surveys, see Resource Directory, page 114.*

Walk over the property to identify areas of special concern (such as surface water, small wetlands, snags or nesting sites), and establish objectives for timber harvesting and forest regeneration.

Consider water quality concerns as objectives are established. Include provisions for water protection in the timber sale contract.

The information gained in the preliminary evaluation needs to be conveyed to the logger, operator and landowner. Where a map is developed or provided (Figure 17), it should be of sufficient size to adequately depict sensitive areas.

During the actual timber harvest, the logger or operator should also avoid sensitive areas not previously identified.

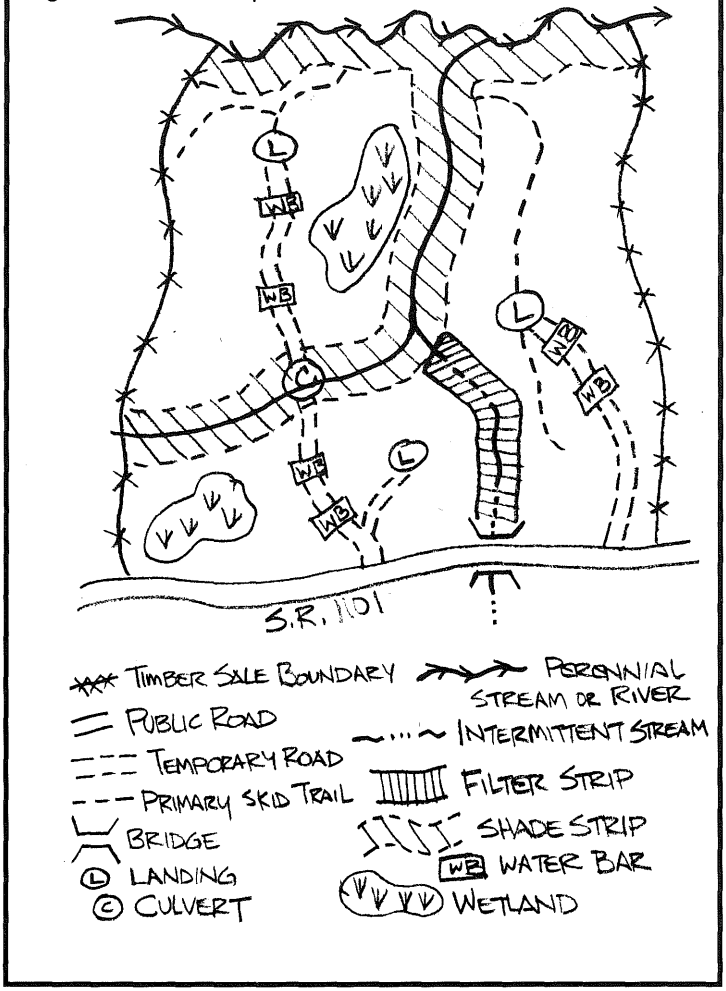
Developing a Timber Sale Plan

Determine size and duration of the timber sale, and the most appropriate season and method of harvest. Limit site disturbance by using BMPs and incorporating other management objectives in the timber harvest plan.

Consider the following water quality protection factors in developing a timber sale plan:

- Location of perennial and intermittent streams, lakes and wetlands.
- Location of stream crossings.
- Location of roads and road standards.
- Number and location of landings and skid trails needed to meet objectives.
- Location and width of filter strips and shade strips.

Figure 17. Site Map



- Location of other areas that may require special attention (such as steep slopes, rock outcrops, springs, unstable soils and sinkholes).
- Regeneration and site preparation methods.
- Appropriate methods of harvest.
- Limitations of soil type, topography and weather conditions on timing of harvest operations.

Special Precautions in Sensitive Areas

Special soil conditions and topographic features make some areas of the state more sensitive than others to disturbance. These localized sensitive areas are found throughout the state. Two primary examples are the blufflands of southeastern Minnesota and the Nemadji River Basin south of Duluth.

When working in such areas, the landowner, resource manager or operator needs to increase the intensity of planning compared to other forested regions of the state. Planning should address long-term development and maintenance needs.

Careful consideration needs to be given to the following precautionary measures:

❒ Incorporate water diversion devices, where needed, during construction rather than as a remedial activity.

❒ Avoid construction of roads and skid trails on highly erodible soils located on slopes steeper than 50% (Figure 5, page 29).

❒ Employ harvesting techniques that minimize the need to operate equipment on steep slopes (such as winching logs off steep slopes or cable yarding).

DESIGN RECOMMENDATIONS FOR UPLAND TIMBER HARVESTING

Landings

❒ Size landings to the minimum required for the acres to be harvested, the equipment to be used and the products to be cut.

❒ Locate landings outside of filter strips (Table 1, page 14).

❒ Locate landings on stable ground.

❒ Avoid landings in locations that will concentrate runoff from the surrounding area onto the landing.

❒ Divert concentrated surface flow from a road or skid trail before it enters the landing.

Skid Trails

Many BMPs for forest roads are also appropriate for skid trails. Refer to the BMPs in the Forest Roads section for drainage specifications that are also applicable to skid trails. Appropriate BMPs include the following:

❒ Install bridges, culverts or other appropriate structures as necessary to prevent repeated soil and streambank disturbance where no practical alternative exists to crossing a stream. This may require a permit from the DNR.

❒ Avoid locating skid trails in filter strips (Table 1, page 14).

❒ Minimize long, straight skid trails that channel water. If long stretches cannot be avoided by careful siting, provide adequate drainage to avoid concentration of surface water flow. Divert water by proper shaping of the trail surface and by using broad-based dips, lead-off ditches or water bars (Figures 7, 8 and 9, pages 36-39).

OPERATIONAL RECOMMENDATIONS FOR UPLAND TIMBER HARVESTING

Harvesting operations should be carried out in a manner that protects water quality. It is also critical to leave harvested forest land in a condition that minimizes future problems. Application of these practices should be used to provide long-term protection to water quality and wetlands:

- ❒ Establish filter strips adjacent to perennial and intermittent streams, lakes and open water wetlands (Figure 1, page 13, and Table 1, page 14).

- ❒ Minimize soil disturbance and mineral soil exposure within the filter strip. Additional stabilization measures will be necessary 1) when an area of soil is exposed within the filter strip and it is likely to result in sedimentation; or 2) when management objectives preclude the use of a filter strip and sedimentation is likely to occur. Suitable measures may include the use of brush, straw bale barriers, mulch and silt fences.

- ❒ Avoid felling timber from upland areas into wetlands. Where unavoidable, trees felled into these wetlands should be pulled back into the harvest area prior to harvest completion.

- ❒ Keep logging residue out of all lakes, streams and open water wetlands, except in cases where residue placement is specifically prescribed for fish or wildlife habitat.

DESIGN RECOMMENDATIONS FOR WETLAND TIMBER HARVESTING

Landings

❒ Size landings to the minimum required for the acres to be harvested, the equipment to be used and the products to be cut.

❒ Specify the number and location of landings as part of the harvesting agreement as necessary to protect water quality and wetlands.

❒ Locate landings on upland areas whenever practical.

❒ Avoid locating landings and yarding areas on open water wetlands.

Skid Trails

Locate, design, construct and maintain skid trails to minimize damage to the residual stand, minimize rutting, maintain surface and subsurface water flows in the wetland, and reduce erosion and sedimentation. Refer to the BMP recommendations in the Forest Roads section for specifications that are also applicable to skid trails.

❒ Plan the layout of skid trails to maximize operating efficiency and minimize site disturbance.

❒ Minimize the crossing of intermittent or perennial streams and open water wetlands. Install bridges, culverts, snow or ice bridges, fords or other means, if necessary, to prevent repeated soil and streambank disturbance where no practical alternative exists to crossing a stream. This may require a permit from the DNR.

❒ Approach water crossings at or near right angles to the stream direction, and use measures to minimize streambank disturbances.

❒ Prepare skid trails for the anticipated traffic needs to avoid unnecessary maintenance or relocation of trail. Techniques can include packing of snow or ground cover to ensure freezing or the use of appropriate wetland road construction methods to provide a stable trail surface.

OPERATIONAL RECOMMENDATIONS FOR WETLAND TIMBER HARVESTING

The following timber harvesting practices are intended to provide long-term protection to water quality and wetland functions:

❒ Establish filter strips when harvesting adjacent to open water wetlands, intermittent and perennial streams, or lakes (Figure 1, page 13, and Table 1, page 14).

❒ Minimize rutting by conducting wetland harvest activities on firm or frozen ground that can support the equipment used. This recommendation may require such techniques as:

• Packing the snow or ground cover on a large portion of the harvest area with lightweight equipment to enhance freezing and permit off-trail operation of equipment.

• Using designated skid trails to minimize amount of area impacted by skidding.

• Using specialized low-ground pressure equipment.

❒ Shift harvest operations to a stable portion of the harvest area or alter operating techniques to prevent repeated rutting deeper than 6 inches (Figure 16, page 63). Alternative operating techniques include:

• Employing low-ground pressure equipment.

• Using slash on skid trails as a driving surface.

• Minimizing the amount of off-trail equipment operation to reduce the area disturbed by heavy equipment.

- ❒ Cease operations if existing or alternative techniques cannot avoid repeated rutting deeper than 6 inches.

- ❒ Make reasonable efforts to remove slash or woody vegetation that originates from outside the wetland or from upland areas contained in the wetland. Slash or woody vegetation that originates from outside the wetland is considered fill.

- ❒ Keep logging residue out of all streams and open water wetlands, except in cases where residue placement is specifically prescribed for fish or wildlife habitat.

- ❒ Avoid crossing small wetland inclusions where practical.

POST-HARVEST CONSIDERATIONS

- ❒ Place traffic barriers where appropriate to prevent off-road vehicles from disturbing recently stabilized areas. Barriers should be visible and well marked, and they should not present a safety hazard.

- ❒ Fill in ruts, and install water bars and erosion barriers, where appropriate, to prevent or minimize erosion and sedimentation from roads, skid trails and landings into surface water. Figure 8 (page 37) and Table 3 (page 38) provide recommended water bar construction and spacing specifications. Seed and fertilize as appropriate. *For sources of recommendations for seeding and fertilization, see Resource Directory, page 121.*

- ❒ Restore watercourses to approximate their natural condition by removing temporary drainage structures and stabilizing the soil along the banks.

- ❒ Inspect erosion control measures periodically and maintain or remove as needed.

MECHANICAL SITE PREPARATION

Why BMPs Are Needed

Mechanical site preparation on forest land is the practice of altering site conditions to favor the establishment, survival and growth of a desired tree species. Mechanical site preparation accomplishes two goals:

- It facilitates planting, direct seeding and natural regeneration.

- It provides partial initial control of vegetation competing with crop trees for light, water and nutrients.

Common mechanical site preparation techniques include patch scarification, row scarification, shearing, raking and disking.

Mechanical site preparation can potentially affect water quality and wetlands in areas that have steep slopes or erodible soils, and in areas where the prepared site is located adjacent to open water or wetlands.

PLANNING CONSIDERATIONS

Properly planned harvest operations should include consideration of mechanical site preparation needs. Site preparation methods that minimize the potential for surface erosion should be evaluated prior to implementation of site preparation operations.

Recommendations for site preparation practices should be related to specific site characteristics, including soil, topography, vegetation, access, distance to surface water and depth to ground water.

Practices that result in exposure of mineral soil or soil compaction on erodible slopes should not be used where surface erosion or runoff is likely to result in sedimentation of water or wetlands.

For sources of information and planning assistance, see Resource Directory, page 118.

DESIGN AND OPERATIONAL RECOMMENDATIONS

❒ Use mechanical site preparation techniques that will cause minimal disturbance to the site while achieving the objective of establishing desired trees.

❒ Provide adequate filter strips and shade strips (Figure 1, page 13, and Table 1, page 14).

- ❒ Avoid operations during periods of saturated soil conditions when such operations may cause rutting or accelerate soil erosion.

- ❒ Avoid placing residues from operations on upland sites into wetland areas. Residues should be deposited in stable upland locations.

- ❒ Design practices to avoid direct runoff of sediment into water and wetlands.

- ❒ Locate windrows and piles to minimize interference with natural drainage patterns.

- ❒ Locate windrows outside filter strips and shade strips (Table 1, page 14).

- ❒ Give preference to locating windrows along contours to mitigate the effects of overland flow.

- ❒ Minimize incorporation of soil material into windrows and piles. Preferred practices include 1) shearing and raking under frozen soil conditions; and 2) light raking (which only removes slash).

- ❒ Avoid shearing and raking operations on organic soils except under frozen soil conditions.

- ❒ Operate equipment following the contours of the land as long as operator safety is maintained.

❒ Use patch or row scarification as the preferred mechanical site preparation method for artificial regeneration when terrain or soil type necessitates minimal soil disturbance.

When mineral soil exposure is not essential to establishment of the tree species to be seeded or planted, nonmechanical methods of site preparation should be considered:

- Harvesting operations can be utilized for site preparation. For example, full tree skidding can be used for preparation of black spruce (*Picea mariana*) or jack pine (*Pinus banksiana*) seed beds and can eliminate the need for raking on steep slopes.

- Chemical treatments, prescribed burning and hand scarification should be given serious consideration as alternatives to mechanical site preparation on steep slopes and highly erodible soils.

- Grazing and manual techniques are additional alternative methods of site preparation.

PESTICIDE USE

Why BMPs Are Needed

The purpose of a pesticide application is to promote the establishment, survival, growth or maintenance of a desired species or condition.

Pesticides are intentional additions of chemicals or biological agents to forest lands. Pesticides facilitate meeting forest management, utility and rights-of-way objectives by reducing, controlling or eliminating insect, disease, animal or weed problems.

Proper pesticide management makes efficient use of chemicals while ***minimizing contamination*** of surface water and ground water. Residues of pesticides used in forestry can affect water quality during all phases of the pesticide use cycle.

Planning is the essential first step in reducing pest problems in an efficient manner that produces no adverse impacts on the environment. The maintenance of water quality is an important consideration in all aspects of pesticide operation planning.

RECOMMENDED PRACTICES

Incorporating Integrated Pest Management Strategies

❒ Employ integrated pest management (IPM) strategies.

Pesticide use should be considered as ***part of an overall program to control pest problems.*** Integrated pest management (IPM) strategies have been developed to control forest pests without relying solely on chemical pesticides. These strategies incorporate a judicious combination of chemical, biological and cultural activities to control forest pests.

A good IPM program has four steps: 1) Identify problems; 2) select tactics; 3) consider economic factors, including whether it pays to use pesticides; and 4) evaluate the program.

For sources of information on IPM programs, see Resource Directory, page 118.

Selecting Pesticides

When the decision is made to use pesticides, choose products suitable for use on the target species and registered for the intended uses.

- ❒ Use only pesticides registered by the Environmental Protection Agency and the Minnesota Department of Agriculture.

- ❒ Read and follow all label directions carefully prior to using any pesticide.

- ❒ Maintain current labels and Material Safety Data Sheets (MSDS). The MSDS is a source of cautionary information and data.

- ❒ Evaluate other factors besides effectiveness and cost when selecting among pesticide options. Factors that influence potential impacts on water quality include site characteristics, pesticide characteristics, application conditions, delivery systems and application techniques.

For additional information on registered pesticides, see Resource Directory, page 119.

Characteristics Affecting Contamination Potential

The three main pesticide characteristics that can greatly affect a pesticide's potential to contaminate surface or ground water are solubility, adsorption and half-life.

• ***Solubility*** is the ability of a pesticide to dissolve in water. The greater the solubility, the greater the chance that the pesticide will leach to ground water or move in solution in surface water. Pesticides with very low water solubilities tend to remain at the soil surface and potentially move to surface water attached to sediment carried in runoff.

• ***Adsorption*** is the inherent ability of a pesticide to attach to soil particles. Some pesticides stick very tightly to soil, while others are easily dislodged:

- The greater its ability to adsorb to soil particles, the less the potential for the pesticide to move (except by soil erosion in surface runoff).

- Conversely, the lower its ability to adsorb to soil particles, the greater the potential for the pesticide to leach to ground water or move in solution in surface runoff.

Adsorption increases as soil organic matter increases. An index or measure of soil adsorption is expressed by the Koc value.

• ***Half-life*** is the time it takes for a pesticide in soil to be degraded so that its concentration decreases by one-half. Each pesticide will have successive half-lives that will continually decrease concentrations by one-half.

The ***persistence*** of the pesticide in soil is the time it takes for the pesticide to degrade to the point where

it is no longer active. Pesticides that do not break down quickly can be a hazard if they move to ground water or surface water in toxic forms.

Table 4 provides information on pesticide characteristics that influence the potential for the chemicals to leach to ground water. In a given situation, pesticides with the highest water solubilities, greatest persistence, lowest affinities for adsorption to soil particles, and highest application rates have the greatest potential for movement in surface runoff and for leaching to ground water.

For sources of assistance in evaluating pesticide alternatives and determining potential pesticide loss due to surface runoff or leaching, see Resource Directory, page 119.

Table 4. Pesticide characteristics influencing leaching potential

Characteristic	Threshold value for high leaching potential*
Water solubility	30 mg/liter or greater
Adsorption to soil organic matter (Koc)	Less than 300-500
Field dissipation half-life	Greater than 3 weeks

**No one value will indicate leachability.*

Source: U.S. EPA 1986

Responding to Spills

Forestry pesticides that are spilled can enter surface water or ground water. Spills near wells or in geologically sensitive areas have a high probability of a portion of the spill reaching ground water.

❒ Contact the Minnesota Duty Officer whenever a spill occurs. Phones are answered 24 hours per day.

- Metro area (612) 649-5451
- Greater Minnesota (800) 422-0798

The Minnesota Duty Officer will contact the appropriate state agencies.

❒ Treat spills properly. Recommended actions steps include the following:

- Act quickly.
- Protect yourself.
- Control the spill (stop the leak).
- Contain the spill (keep it from spreading).
- Guard the site.
- Notify the authorities.
- Clean up the spill.

❒ Maintain an adequate spill and cleaning kit that includes:

- Detergent or soap
- Hand cleaner and water
- Activated charcoal, adsorptive clay, vermiculite, kitty litter, sawdust or other adsorptive materials
- Lime or bleach to neutralize pesticides in emergency situations
- Tools such as a shovel, broom, dustpan and containers for disposal
- Proper protective clothing and equipment

Managing All Phases of the Pesticide Use Cycle

Proper pesticide management practices make efficient use of chemicals ***while preventing or minimizing contamination*** of surface water or ground water. Residues of pesticides used in forestry can affect water quality during all phases of the pesticide use cycle: transportation, storage, loading and mixing, application, equipment cleanup, and container and waste disposal.

Of the many BMPs related to proper pesticide management, the following BMPs represent those practices that directly apply to protecting water quality and wetlands:

Transportation of pesticides

❒ Inspect all containers prior to loading, and ensure that all caps, plugs and bungs are tightened.

❒ Select transportation routes to minimize the impact of a potential spill on water quality.

Storage of pesticides

❒ Avoid storing pesticides for extended periods in buildings not equipped to contain a complete spill from the largest container being stored.

❒ Locate pesticide storage facilities at sites that minimize the possibility of impacts on water quality in case accidents or fires occur.

❒ Use storage buildings that have floors constructed of concrete or other impermeable materials, so that spills are easy to clean up. Storage buildings should contain drains or sills with sumps large enough to contain the contents of the largest container stored in the buildings.

❒ Avoid storing pesticides on or adjacent to treatment areas. Where impractical, select unloading and operational storage locations where spills resulting from accidents or vandalism will not have impacts on water quality.

Mixing and loading operations

❒ Review the label before opening the container to ensure familiarity with current use directions.

❒ Exercise care and caution during mixing and loading of pesticides.

❒ Avoid mixing near wells or where pesticide spills could enter open water or wetlands.

❒ Mix and load pesticides outside of filter strips and shade strips (Table 1, page 14).

❒ Transport and store hoses used to fill pesticide application equipment in a manner that prevents direct contact with pesticide, gasoline or oils, or surfaces on which these substances have been spilled.

❒ Avoid introducing pesticides into mixing or application equipment until after filling the equipment from the water sources.

- ❒ Replace pour caps and close bags or other containers immediately after use.
- ❒ Avoid leaving a spray or mix tank unattended while it is being filled.
- ❒ Provide an air gap between the water source and the mixture surface to prevent backsiphoning.
- ❒ Avoid filling pesticide mixing or application equipment directly from a public water supply unless the outlet from the public water supply is equipped with a backflow prevention device.
- ❒ Avoid filling pesticide mixing or application equipment directly from surface water unless the equipment contains proper and functioning anti-backsiphoning mechanisms.
- ❒ Triple rinse all empty plastic and metal pesticide containers and add the rinse water to the spray solution.

Application of pesticides

- ❒ Refer to label directions before applying a pesticide.
- ❒ Check all application equipment carefully, particularly for leaking hoses and connections and plugged or worn nozzles.

❒ Calibrate spray equipment periodically to achieve uniform pesticide distribution and rate.

❒ Avoid applying pesticides directly to water except where specifically labeled for application to water. For pesticides not labeled for aquatic or ditchbank use, filter strips or shade strips should be left adjacent to all lakes, streams, ponds and ditches that contain water at the time of application (Table 1, page 14).

❒ Consider nonbroadcast application of pesticides where appropriate.

❒ Avoid broadcast application methods within filter strips. Appropriate treatments within filter strips include:

- Use of pesticides labeled for aquatic use
- Manual or mechanical treatments
- No treatment
- Spot, banded, stump, basal bark, hack and squirt, frill, or injection treatments.
- Use of less soil-mobile pesticides
- Increasing filter strip width when using toxic to highly toxic insecticides

- ❒ Prohibit aircraft transporting pesticides from crossing lakes or ponds. Aircraft also should not fly down the course of any recognizable stream. Where stream crossings cannot be avoided, they should be made at right angles to the stream course. Chemical application should be shut off during turns and over water.

- ❒ Select potential heliport or helipad locations with consideration for two conditions that could affect water quality: 1) flight patterns in relation to water bodies; and 2) locations adjacent to water bodies.

- ❒ Mark the boundaries of the area for treatment.

- ❒ Select a nozzle type that produces the largest drops at a given rate and pressure appropriate to the chemical being applied.

- ❒ Employ the lowest reasonable equipment pressure when applying pesticides.

- ❒ Avoid applying pesticides when the likelihood of significant drift exists.

- ❒ Use a drift control agent where appropriate.

- ❒ Consider applying pesticides near dawn or dusk, when wind speeds are generally lowest.

❒ Apply pesticides when wind speeds are 6 mph or less for aerial application and 10 mph or less for ground broadcast application.

❒ Limit broadcast applications (both aerial and ground) to appropriate temperature and relative humidity conditions. High temperatures enhance loss of volatile pesticides and the rate of evaporation of droplets. Relative humidity also influences the rate of evaporation, with the rate increasing with decreases in humidity.

Equipment cleanup

❒ Clean equipment in areas where pesticide residues will not enter lakes, streams, wetlands or ground water.

❒ Clean all mixing and loading equipment thoroughly after each use.

❒ Rinse mixing apparatus at least three times.

❒ Apply rinsate in spray form to the area to be treated.

❒ Avoid cleaning pesticide application equipment in surface waters.

Container and waste disposal

❒ Dispose of pesticide wastes and containers according to state and federal laws. Some pesticide wastes are specifically identified as hazardous wastes by law; these must be handled and disposed of in accordance with hazardous waste regulations. *For sources of information about proper management of waste pesticides, see Resource Directory, page 119.*

❒ Rinse all empty plastic and metal pesticide containers three times and add the rinse water to the spray solution. To properly triple-rinse containers:

1) Empty the pesticide into the spray tank and allow the pesticide container to drain.

2) Fill the container 10% to 20% full with water (or solvent, in some cases), rinse, and pour the rinse water into the spray tank.

3) Repeat Step 2 two more times and apply rinsate to the spray site.

4) Apply all leftover solutions and rinsates to the treatment area.

❒ Puncture and flatten containers not intended for return to the manufacturer.

❒ Dispose of triple-rinsed containers in one of two ways:

• By recycling through an approved program. A list of dealers or locations who recycle these containers is available at county extension offices.

• As ordinary solid waste at a landfill licensed by the Minnesota Pollution Control Agency.

Refer to the product label for additional information on proper disposal.

Using Pesticides on Wetlands

The following recommendations related to pesticide use will help protect wetlands and water quality:

❒ Consult state and federal lists for endangered species, threatened species, or species of special concern that may exist in sites proposed for pesticide applications. To protect listed species, select appropriate pesticides, application methods, equipment and formulations when applying pesticides to those areas. *For sources of assistance on threatened and endangered species and species of special concern, see Resource Directory, page 120.*

- ❒ Select only pesticides labeled for aquatic use on sites where surface water is present at the time of application.

- ❒ Select pesticides, application methods, equipment and formulations that 1) minimize the potential for pesticide drift; and 2) minimize pesticide residue movement to surface water and ground water.

- ❒ Mix pesticides in upland areas, where practical.

- ❒ Apply pesticides in accordance with the product label.

- ❒ Avoid applying pesticides on small wetland inclusions in upland areas unless that application is part of the management objective. If unable to avoid pesticide use in these areas, select only pesticides labeled for aquatic use when surface water is present at the time of application.

- ❒ Avoid discharge of rinse water in wetland areas that are not part of the application site.

PRESCRIBED BURNING

Why BMPs Are Needed

Prescribed burning is used in forest management for a variety of reasons, including:

- Eliminating the hazard of destructive wildfires by reducing fuel accumulations.
- Facilitating site preparation for tree planting or direct seeding by reducing logging debris and other organic matter.
- Releasing nutrients for growth of seedlings or trees.
- Eliminating unwanted vegetation competing with crop trees for sunlight, moisture and nutrients.
- Improving wildlife habitat.
- Maintaining Scientific and Natural Areas.
- Maintaining unique or critically fire-dependent ecosystems.
- Controlling insects or diseases.

Like other forest management activities, prescribed burning has the potential to affect water quality. The exposure of mineral soil from the burning of organic matter and from firelane construction, the release of plant nutrients following burning, and increased post-burn surface temperatures can increase NPS pollution.

The following BMPs were developed to provide reasonable guidance for protecting water quality from the impacts of prescribed burning. They are also recommended where appropriate for use in wildfire situations.

PLANNING CONSIDERATIONS

A prescribed burn is specifically located, confined in area, carefully timed, and regulated in intensity. Careful prescribed burn planning and adherence to specified weather, time of year and fuel conditions will help achieve desired results and minimize impacts on water quality.

Key considerations in planning a prescribed burn to minimize water quality impacts include the following:

- Identify clear objectives for the burn.

- Obtain a burning permit from the DNR Division of Forestry.

- Evaluate fuel, weather, soil and topographic conditions in the burn area.

- Plan fireline location to protect water quality.

- Plan post-fire erosion mitigation.

- Use adequately trained and experienced personnel to plan prescribed burns and direct wildfire suppression.

RECOMMENDED PRACTICES

General Practices

❒ Consult with local DNR offices for technical advice and assistance in prescribed burning.

❒ Consider such alternatives as herbicide use, mowing or other non-erosion-causing practices for firebreak maintenance on areas where prescribed fire will be used on a recurring basis.

❒ Sensitize fire crew bosses to the potential water quality impacts of mop-up activities.

❒ Conduct burns so that the minimum amount of forest floor is consumed consistent with meeting the objectives of the burn.

- ❒ Establish filter strips (unburned zones containing no firelines) to protect water quality in situations where steep slopes, heavy erodible soils, or the likelihood of substantial organic matter removal are present (Figure 1, page 13, and Table 1, page 14).

- ❒ Use natural or in-place fire barriers (such as roads, streams, lakes and wetlands) where appropriate as an acceptable way to minimize the need for artificial fireline construction.

- ❒ Control the pattern and timing of burn ignition by evaluating existing or developing conditions on the ground.

- ❒ Locate firelines on the contour whenever possible, and avoid straight uphill-downhill placement.

- ❒ Avoid construction of firelines for prescribed fires that result in drainage directly into a water body.

- ❒ Construct firelines only deep enough and wide enough to control the spread of the fire.

- ❒ Consider the use of retardant in place of plowed firelines where fireline construction would result in unacceptable soil erosion and water quality degradation.

❒ Prevent or minimize runoff of fire-retardant chemicals into water by keeping filter strip areas off-limits to retardant use.

❒ Avoid cleaning fire-retardant application equipment in lakes or streams.

❒ Prevent the release of fuel or oil from pumper units into lakes or streams.

❒ Avoid placement of piles for burning in sensitive areas adjacent to lakes, streams and wetlands or in drainage channels where a hot burn is likely to result in organic layer destruction and lowered infiltration rate.

Special Considerations for Prescribed Burning on or Adjacent to Wetlands

When planning burns in wetland areas, special considerations are necessary to avoid impacts on natural hydrologic functioning of the wetland.

❒ ***Obtain a DNR permit prior to burning as required under Minn. Statute, Chapter 88.17.***

❒ Use fireline construction methods in wetlands that do not expose bare soil whenever practical. These may include wet lines, existing constructed or natural

barriers, foam or retardants. If techniques result in exposure of bare soil, such areas must be restored if wetland hydrologic functions are impacted.

❒ Provide adequate filter strips when constructing firelines that expose bare soil near wetlands.

❒ Employ suitable water diversion structures on firelines.

❒ Seed firelines when natural revegetation will not be adequate.

❒ Follow manufacturer recommendations when using foam or retardants in wetland areas.

Post-Fire Maintenance

❒ Maintain erosion control measures as needed on firelines. *For sources of seeding and fertilizing recommendations, see Resource Directory, page 121.* Figure 8, page 37, and Table 3, page 38, provide recommended water bar construction and spacing specifications.

❒ Restore water source sites used for wildfire suppression activities as soon as practical following control, or at the completion of mop-up activities.

APPENDIX I: Resource Directory

The Resource Directory provides additional information and identifies resources to contact for assistance with forest management, nonpoint source pollution control and wetlands protection. The directory is organized by topic, with a brief description of assistance available from various agencies, organizations and individuals. Telephone numbers are provided for many of the agencies and organizations listed. Where they are not provided, the numbers of many of the local agencies and departments may be obtained from the government pages of local telephone books.

The following acronyms are used throughout the Resource Directory:

BWSR:	Minnesota Board of Water and Soil Resources
CFSA:	Consolidated Farm Service Agency
COE:	U.S. Army Corps of Engineers
DNR:	Minnesota Department of Natural Resources
LGU:	Local government unit
MDA:	Minnesota Department of Agriculture
MES:	Minnesota Extension Service
MGS:	Minnesota Geological Survey
MNDOT:	Minnesota Department of Transportation
MPCA:	Minnesota Pollution Control Agency
NRCS:	Natural Resources Conservation Service
SWCD:	Soil and Water Conservation District
USDA:	U.S. Department of Agriculture
USFS:	U.S. Forest Service
USF&WS:	U.S. Fish and Wildlife Service
USGS:	U.S. Geological Survey

Resource Directory Contents

GENERAL INFORMATION

Nonpoint source pollution in Minnesota: Contact the MPCA Division of Water Quality at (612) 296-6300 or (800) 657-3864; TDD (612) 282-5332 or (800) 627-3864 for the hearing impaired; and regional offices:

Brainerd	(218) 828-2492
Detroit Lakes	(218) 847-1519
Duluth	(218) 723-4660
Marshall	(507) 537-7146
Rochester	(507) 285-7343

Wetland protection in Minnesota: Contact LGUs, county SWCD offices, BWSR offices or COE offices. A listing of LGUs is available from BWSR and county SWCD offices.

Contact BWSR in St. Paul at (612) 297-5615, or BWSR regional offices:

St. Paul	(612) 282-9969
Duluth	(218) 723-4752
Bemidji	(218) 755-4235
Brainerd	(218) 828-2383
New Ulm	(507) 359-6074
Rochester	(507) 285-7458
Marshall	(507) 537-6060

Contact COE in St. Paul at (612) 290-5375, or COE field offices:

Brainerd	(218) 829-2711
Grand Rapids	(218) 327-2554

Information and educational publications on natural resource management: Contact MES at (612) 625-1915, or county extension offices linked to the University of Minnesota's College of Natural Resources.

Information and educational materials on the wise use of natural resources are also available from the Minnesota Forestry Association at (612) 290-6266; or the DNR Information Center (St. Paul) at (612) 296-6157 or (800) 766-6000; TDD (612) 296-5484 or (800) 657-3929 for the hearing impaired.

PLANNING TOOLS

Erosion control, soil survey use and soil interpretations: Contact county SWCD offices or local NRCS offices.

Aerial photographs: Contact the USDA Aerial Photo Field Office, Salt Lake City, Utah, at (801) 524-5856; USGS, EROS Data Center, Sioux Falls, South Dakota, at (605) 594-6151; or the DNR, Division of Forestry, Resource Assessment Unit, Grand Rapids, Minnesota, at (218) 327-4449.

Topographic maps: Contact the MGS at (612) 627-4782.

National Wetland Inventory (NWI) maps: NWI maps may be viewed at county SWCD offices. They may be purchased at Minnesota's Bookstore, Ford Building, 117 University Avenue, St. Paul, Minnesota 55155. For more information, call (612) 297-3000 or (800) 657-3757.

PETROLEUM SPILLS

Notification of petroleum spills: Contact the Minnesota Duty Officer for petroleum spills of 5 gallons or more. Phones are answered 24 hours a day:

Metro area	(612) 649-5451
Greater Minnesota	(800) 422-0798

The Minnesota Duty Officer will contact the appropriate state agencies.

FOREST ROADS

Proper design and location of roads: Contact the DNR Division of Forestry (Grand Rapids) at (218) 327-4449, county SWCD offices, local NRCS offices, USFS offices, industrial foresters, the Minnesota Association of Consulting Foresters, county highway departments or local road authorities, or the COE.

Listing of consulting foresters: Contact local DNR Division of Forestry offices.

Listing of industrial foresters: Contact the Minnesota Forest Industries at (218) 722-5013.

WATER CROSSINGS

Design standards; installation of bridges and culverts: Contact county SWCD offices, local NRCS offices, county highway departments or local road authorities, or local MNDOT offices.

Permit requirements: Permits are required for work in waters and wetlands designated by the DNR in the Protected Waters and Wetlands Inventory.

For permit requirements, contact DNR Division of Waters regional or area offices. In some instances, further review is required by the COE or local ditch authority. Regional DNR Division of Waters offices:

Bemidji	(218) 755-3973
Grand Rapids	(218) 327-4416
Brainerd	(218) 828-2605
New Ulm	(507) 359-6053
Rochester	(507) 285-7430
St. Paul	(612) 772-7910

TIMBER HARVESTING

Developing timber harvesting plans: The DNR Division of Forestry provides harvest planning assistance through its Private Forest Management Program. For assistance, contact area or regional DNR Division of Forestry offices. Regional DNR offices:

Bemidji	(218) 755-2891
Grand Rapids	(218) 327-4418
Brainerd	(218) 828-2616
Rochester	(507) 285-7428
St. Paul	(612) 772-7925

Assistance is also available from the Minnesota Association of Consulting Foresters or forest industries' private forest assistance programs.

Listing of consulting foresters: Contact local DNR Division of Forestry offices.

Listing of industrial foresters: Contact the Minnesota Forest Industries at (218) 722-5013.

Timber harvesting practices to maintain or improve fish and wildlife habitat: Contact the DNR Division of Fisheries and Wildlife at the following numbers: Fisheries Section, (612) 296-0789 or (612) 297-2804, and Wildlife Section, (612) 296-1325; or regional or area DNR Fisheries or DNR Wildlife offices:

	Fisheries offices	***Wildlife offices***
Bemidji	(218) 755-3959	(218) 755-3958
Grand Rapids	(218) 327-4415	(218) 327-4413
Brainerd	(218) 828-2624	(218) 828-2615
New Ulm	(507) 359-6000	(507) 359-6000
Rochester	(507) 285-7427	(507) 285-7435
St. Paul	(612) 772-7950	(612) 772-7942

Information is also available from MES, the Minnesota Association of Consulting Foresters or forest industries' private forest assistance programs.

For a listing of designated trout streams and trout lakes, contact the DNR Division of Fisheries and Wildlife or the DNR Division of Waters.

MECHANICAL SITE PREPARATION

Contact county SWCD offices, local NRCS offices, or DNR Division of Forestry area or regional offices. DNR Division of Forestry regional offices:

Bemidji	(218) 755-2891
Grand Rapids	(218) 327-4418
Brainerd	(218) 828-2616
Rochester	(507) 285-7428
St. Paul	(612) 772-7925

Additional information is available from the DNR Division of Forestry (St. Paul) at (612) 296-4482 or (612) 297-3513.

Vegetation management recommendations: Contact the University of Minnesota Forest Vegetation Management Cooperative (Cloquet) at (218) 879-0850.

Grazing methods for vegetation management: Contact the USFS Superior National Forest (Duluth) at (218) 720-5322, or the USFS Chippewa National Forest (Cass Lake) at (218) 335-8600.

PESTICIDE USE

Integrated Pest Management: Contact the USFS Forest Pest Management Unit at (612) 649-5262; MES at (612) 625-1915; the MDA Plant Protection Division at (612) 296-8578; or DNR regional insect and disease specialists:

Bemidji	(218) 755-2891
Grand Rapids	(218) 327-4115
Brainerd	(218) 828-2616
Rochester	(507) 285-7428
St. Paul	(612) 772-7567

Regulation of forestry-applied pesticides in Minnesota: Contact the MDA at (612) 296-6121.

Licensing of certified applicators: Contact the MDA at (612) 296-6121.

Proper pesticide use: Contact MES at (612) 625-1915, MDA at (612) 296-6121, or the University of Minnesota Forest Vegetation Management Cooperative (Cloquet) at (218) 879-0850.

Recommendations on rates and applicability of various pesticides: Contact MES at (612) 625-1915, MDA at (612) 296-6121, or the University of Minnesota Forest Vegetation Management Cooperative (Cloquet) at (218) 879-0850.

List of dealers who recycle pesticide containers: Contact MES at (612) 625-1915, MDA at (612) 296-6121, or the University of Minnesota Forest Vegetation Management Cooperative (Cloquet) at (218) 879-0850.

Proper use of specific pesticide products: Contact pesticide company representatives or MES at (612) 625-1915.

Applicator training and licensing for state certification: Contact MES at (612) 625-1915 or MDA at (612) 297-2746.

Pesticide certification workshops: Contact Minnesota Pesticide Information and Education at (612) 447-1187 or MDA at (612) 297-2746.

Disposal of waste pesticides: Contact the MDA Pesticide Collection Program at (612) 297-5296.

Notification of pesticide spills: Contact the Minnesota Duty Officer whenever a spill occurs. Phones are answered 24 hours a day:

Metro area	(612) 649-5451
Greater Minnesota	(800) 422-0798

The Minnesota Duty Officer will contact the appropriate state agencies.

Endangered or threatened species in Minnesota: Contact the DNR Natural Heritage Program, Section of Wildlife, at (612) 296-3344.

Pesticide use as it pertains to endangered and threatened species in Minnesota: Contact the Endangered Species Protection Program, MDA Agronomy Services Division, at (612) 297-7279.

Federal Endangered Species Act, federally listed species or the endangered species listing process: Contact the Office of Endangered Species, USF&WS at (612) 725-3276.

Species of special concern: Contact local NRCS offices or the DNR Natural Heritage Program, Section of Wildlife, at (612) 297-2276.

PRESCRIBED BURNING

Obtaining a burning permit: Contact local DNR Division of Forestry offices, state fire wardens, USFS district offices and fire wardens, LGUs or other designated county authorities.

Establishing goals and conducting prescribed burns: Contact the Nature Conservancy, local DNR Division of Forestry offices, DNR Division of Fish and Wildlife offices, USFS, Sharp-Tail Grouse Society, Ruffed Grouse Society, or Minnesota Deerhunters Association.

FERTILIZING AND SEEDING

Fertilizer and seed mixture recommendations for exposed soil: Contact county SWCD offices, local NRCS offices, USFS, local DNR Division of Forestry offices, MES or MNDOT.

FORESTRY ASSISTANCE PROGRAMS

Landowners wishing to install conservation practices or otherwise retire their land may receive assistance through a variety of local, state and federal programs. Many of these programs are available to help private landowners plant trees and shrubs.

Agriculture Conservation Program (ACP): Provides approximately 75% reimbursement of establishment costs for plantings greater than one acre. Contact local CFSA offices, local NRCS offices, or local DNR Division of Forestry offices.

Forestry Incentives Program (FIP): Provides approximately 65% reimbursement of establishment costs for tree plantings greater than 10 acres. Timber management is the main goal. Contact local NRCS offices, or local DNR Division of Forestry offices.

Minnesota Forestry Incentives Program (MNFIP): Provides both technical and cost-sharing assistance to non-industrial private forest landowners. Funds are available for road construction, fencing, pocket gopher control, firebreak establishment and other special projects. Reimbursements are available for up to 65% of actual cost (50% for roads). Contact county SWCD offices or local DNR Division of Forestry offices.

Conservation Reserve Program (CRP): Provides 50% of establishment costs and 10 annual payments as an incentive to retire highly erosive cropland. Contact local CFSA offices or local DNR Division of Forestry offices.

Reinvest in Minnesota (RIM): Similar to CRP (above), except that RIM is targeted for areas that will benefit wildlife. Provides 75% of actual cost for 20-year easements and 100% of actual cost for perpetual easements. Contact county SWCD offices, local DNR Division of Forestry offices, or local DNR Wildlife Section offices.

Stewardship Incentives Program (SIP): Provides up to 75% cost-share assistance to non-industrial private forest landowners for management activities that enhance fish and wildlife habitat, provide recreation opportunities, improve the aesthetic quality of forests, or increase the supply of timber and other forest products. An approved Forest Stewardship Plan is required and is designed to enhance and increase the diversity of forest land benefits. Contact local DNR Division of Forestry offices.

Wetland Establishment and Restoration Program (WERP): Allows landowners to apply to their LGU for up to 50% state cost-share assistance to establish or restore a wetland in a designated high-priority wetland area. A permanent conservation easement must be granted by the landowner as part of the restoration procedure. Contact county assessors' offices or county SWCD offices.

Wetlands Reserve Program (WRP): Provides payments for conservation easements and cost-share assistance for wetland restoration and protection. Landowners are reimbursed up to 75% of actual cost for perpetual easements. Contact local CFSA offices, local NRCS offices, or local USF&WS offices.

Private Forest Management (PFM): Provides technical assistance to landowner participants in state and federal cost-share programs. Contact the DNR Private Forest Management Program at (612) 296-5970, or local DNR Division of Forestry offices.

State Cost-Share Program: Assists landowners in the installation of permanent nonproduction-oriented soil and water conservation practices. Cooperators are eligible to receive up to 75% cost-sharing of specified erosion control and water quality practices. Contact county SWCD offices or BWSR at (612) 297-5615.

Tree Farm Program: Provides recognition and certification for quality forest management of non-industrial private forest lands. Sponsored by the American Forest Council. For more information, contact local DNR Division of Forestry offices, industry foresters or consulting foresters.

The exact requirements and availability of these programs may vary with time and location. Consult local foresters, local CFSA offices, or county SWCD offices for current information.

APPENDIX II: Baseline Standards for Development of Best Management Practices To Provide Wetland Protection

Land use activities in wetlands, which are operating under an exemption in the Minnesota Wetland Conservation Act, should be guided by the following principles to ensure that the activities do not contribute to the loss or diminishment of wetland values and functions. Impacts to wetlands should be avoided if practical alternatives exist.

When impacts cannot be avoided, landowners, managers and operators should implement all practical measures to minimize impacts. Best Management Practices designed to meet these baseline standards will provide the necessary protection while operating in or adjacent to wetland areas and reduce the risk of being in violation of the Minnesota Wetland Conservation Act.

BMPs developed through this process do not supercede federal regulations (33 CFR, Section 323.4 and 7 CFR, Part 12).

1. The activities should minimize impacts to the hydrologic regime of wetlands.

2. The activities should not take or jeopardize the continued existence of state (Minn. Statute, Chapter 84.0895; Minn. Rule, Chapter 6134) and federal (16 USC, Sections 1531-1544; 50 CFR, Section 17) threatened or endangered species, or adversely modify or destroy the critical habitat of such species.

3. Activities in breeding and nesting areas for migratory waterfowl and spawning areas in wetlands should be avoided if practical alternatives exist.

4. The activities should minimize impacts to species of special concern under Minn. Statute, Chapter 84.0895 and Minn. Rule, Chapter 6134 where their existence is known within the activity area.

5. In designing, constructing and maintaining roads, vegetative disturbance in wetlands should be kept to a minimum.

6. Permanent roads, temporary access roads and trails in wetlands should be held to the minimum feasible number, width and total length consistent with the management objectives, and local topographic and climatic conditions.

7. All roads, temporary or permanent, should be located sufficiently far from streams or other water bodies (except for portions of such roads which must cross water bodies) and designed to minimize impacts to wetland functions and values.

8. Discharges of dredged or fill material into wetlands to construct a road fill should be made in a manner that minimizes the encroachment of trucks, tractors, bulldozers or other heavy equipment within wetlands that lie outside the lateral boundaries of the fill itself.

9. The design, construction and maintenance of the road crossing should allow the migration or other movement of those species utilizing the wetland.

10. Road fill should be bridged, culverted or otherwise designed to prevent the restriction of everyday surface and subsurface water flows and expected flood water flows.

11. Fill should be properly stabilized and maintained during and following construction to prevent erosion.

12. Borrow material should be taken from upland sources whenever feasible.

13. All temporary fills should be removed in their entirety and the area restored to its original elevation unless removal will have a greater impact on water quality than leaving in place.

14. Material placed or discharged in wetlands should consist of suitable material free from toxic pollutants in toxic amounts.

APPENDIX III: Glossary

Adsorption: The inherent ability of a pesticide to bind to surfaces of soil particles. The greater the ability of a pesticide to adsorb to soil particles, the less the potential for the pesticide to move in solution.

Alignment: The horizontal route or direction of an access road. It is made up of straight line tangent sections and curves.

All-season road: A permanent road designed for use all year long, though there may be some restrictions on vehicle weight at times during spring breakup or wet periods. There is a great range in design standards and road surfacing for this type of road, depending on anticipated traffic load.

Barriers: Obstructions to pedestrian, horse or vehicular traffic intended to restrict traffic.

Basal area: A measure of the cross-sectional area taken up by trees at 4.5 feet above ground level.

Berm: A low earth fill constructed in the path of flowing water to divert its direction, or constructed to act as a counter-weight beside the road fill to reduce the risk of foundation failure.

Best Management Practices (BMPs): A practice or combination of practices determined by a state or designated areawide planning agency, after problem assessment, examination of alternative practices and appropriate public participation, to be the most effective, practicable (including technological, economic and institutional considerations) means of preventing or reducing the amount of pollution generated by nonpoint sources, thus maintaining a level compatible with water quality goals.

Borrow pit: That area from which soil is removed to build up the road bed, sometimes directly adjacent and parallel to a road.

Broad-based dip: A surface drainage structure specifically designed to drain water from an access road while vehicles maintain normal travel speeds.

Certificate of exemption: A document from the local government unit describing activities exempt from provisions of the Minnesota Wetland Conservation Act.

Corduroy: Logs placed over a wetland to reinforce the natural root mat, for the purpose of minimizing the risk of settlement or foundation failure.

Culvert: A metal, wooden, plastic or concrete conduit through which surface water can flow. Includes pipe culverts and open-top culverts.

Cut-and-fill: Process of earth moving by excavating part of an area and using the excavated material for adjacent embankments or fill areas.

Dip: An economical, relatively trouble-free structure for providing effective drainage of forest roads. Dips are considerably lower in cost than culverts, so time spent in careful construction is well justified.

Disking: A mechanical method of scarifying the soil to reduce competing vegetation and prepare a site to be seeded or planted.

Ditch: An open channel to conduct water.

Drainage structure: Any device or land form constructed to intercept or aid surface water drainage.

Drift: The movement of pesticides through the air to nontarget areas, either as solid or liquid particles, or as vapor.

Erosion: The process by which soil particles are detached and transported by water, wind and gravity and deposited downslope or downstream.

Felling: The process of severing trees from stumps.

Fill: Any solid material added to or redeposited in a wetland that would alter its cross-section or hydrological characteristics, obstruct flow patterns, change wetland boundaries, or convert the wetland to a nonwetland.

Filter strip: An area of land adjacent to a water body which acts to trap and filter out suspended sediment and chemicals attached to sediment before it reaches the surface water. Harvesting and other forest management activities are permitted in a filter strip as long as the integrity of the filter strip is maintained and mineral soil exposure is kept to a minimum.

Fireline: A barrier used to stop the spread of fire that is constructed by removing fuel or rendering fuel unflammable by use of water or fire retardants.

Fire retardant: Any substance that by chemical or physical action reduces the flammability of combustibles.

Floodplain: The area adjacent to a watercourse or water basin that has been or may be covered by a regional flood.

Ford: A place where a perennial or intermittent stream may be crossed by a vehicle. It may be necessary to reinforce the stream crossing to bear intended traffic.

Forest floor: All dead vegetable matter on the mineral soil surface in the forest, including litter and unincorporated humus.

Forest road: A temporary or permanent road connecting the most remote parts of the forest land to existing public roads. Forest roads provide access to forest lands for timber management, fish and wildlife habitat improvement, fire control and a variety of recreational activities.

Formulation: The pesticide product as purchased, usually consisting of a mixture of active and inert ingredients.

Gabion: A woven wire basket filled with stones of minimum size that will not pass through the openings in the basket. Individual baskets are laid in place like building blocks, and then filled to form retaining walls and erosion-resistant surfaces.

Geotextile: A product used as a soil reinforcement agent and as a filter medium. It is made of synthetic fibers manufactured in a woven or loose non-woven manner.

Grade: The slope of a road or trail expressed as a percent of change in elevation per unit of distance traveled.

Ground water: The subsurface water supply in the saturated zone below the level of the water table.

Half-life: The time it takes for a pesticide in soil to be degraded so that its concentration decreases by one-half.

Harvesting (or timber harvesting): The felling, skidding, processing, loading and transporting of forest products, roundwood or logs.

Highly erodible soil: Soil on slopes greater than 35% that is considered to be in the severe category for potential erosion.

High water mark: The highest level at which the water has remained long enough to leave its mark upon the landscape. Generally, it is the point where the natural vegetation changes from predominantly aquatic to predominantly terrestrial.

Impact: A loss in quantity, quality or biological diversity.

Integrated pest management (IPM): An ecological approach to pest management in which all available necessary techniques are consolidated into a unified program so that pest populations can be managed in such a manner that economic damage is avoided and adverse side effects are minimized.

Intermittent stream: A stream or portion of a stream that flows in response to precipitation. It is dry for a large part of the year.

Label: The information printed on or attached to the pesticide container or wrapper.

Landing: A place where trees and logs are gathered in or near the forest for further processing or transport.

Leaching: Downward movement of a pesticide or other soluble material through the soil as a result of water movement.

Lead-off ditch: A ditch to remove water from a road or skid trail to a vegetated area.

Local government unit: A city council, town board, county board of commissioners, or watershed management organization.

Material Safety Data Sheet: The basic hazard communications tool that provides details on chemical and physical dangers, safety procedures and emergency responses for a particular chemical.

Mulching: Using organic residues (such as grass, straw or wood fibers) or commercially available alternatives as a covering for exposed forest soil. This mulch covering protects exposed soil, helps control erosion and facilitates revegetation.

Nonpoint source pollution: Diffuse pollution that enters a water body from over the landscape. Nonpoint source pollution reaches lakes, streams, wetlands and ground water through leaching, surface runoff and erosion.

Nutrients: Mineral elements in the forest ecosystem, such as nitrogen, phosphorus or potassium, that are naturally present or may be added to the forest environment by forest practices such as fertilizer or fire retardant applications. Nutrients are necessary for the growth and reproduction of organisms. In water, nutrients are those substances that promote growth of algae and bacteria; chiefly nitrates and phosphates.

Open water wetlands: Shallow to deep fresh marshes generally having readily observable surface water. Water depth varies from a few inches to less than 10 feet.

Peat: Unconsolidated material consisting of organic matter accumulated under conditions of excessive moisture.

Perennial stream: A stream that maintains water in its channel throughout the year.

Permanent road: A forest road intended to be left in place for the long term.

Persistence: The time it takes for a pesticide in soil to degrade to the point where it is no longer active.

Pesticides: Chemical compounds or biological agents used for the control of undesirable plants, animals, insects or diseases.

Prescribed burning: The controlled application of fire to wildland fuels, in either their natural or modified state, under specified environmental conditions. These conditions allow the fire to be confined to a predetermined area while at the same time producing the fireline intensity and rate of spread required to attain planned resource management objectives.

Raking: A mechanical method of removing stumps, roots and slash from a future planting site.

Riprap: A layer of boulders or rock fragments placed over soil to protect it from the erosive forces of flowing water.

Runoff: In forest areas, that portion of precipitation that flows from a drainage area on the land surface or in open channels.

Ruts: Depressions made by the tires of vehicles such as skidders, log trucks and pickup trucks, usually under wet conditions.

Scarification: The process of removing the forest floor or mixing it with the mineral soil by mechanical action preparatory to natural or direct seeding or the planting of tree seedlings.

Scientific and Natural Area: An area established to protect and perpetuate in an undisturbed natural state those natural features which possess exceptional scientific or educational value.

Seasonal road: A permanent road designed for long-term periodic use, such as during dry and frozen periods. Seasonal roads are built to lower engineering standards and have minimal material surfacing.

Sediment: Solid material in suspension, being transported, or moved from its original location by air, water, gravity or ice.

Shade strip: An area of land of variable width adjacent to a lake, perennial stream or open water wetland where sufficient vegetation is maintained to provide shade that prevents or minimizes increases in water temperature. Shade strip width will vary depending on the classification of the water body. Harvesting is allowed within the shade strip. The volume of timber removed will depend on the tree species to be managed.

Shearing: The operation of cutting off trees and brush at ground level by pushing a bulldozer blade along the frozen surface in winter. The stems and trunks are sheared off at ground level.

Silt curtain: Filter fabric weighted at the bottom and attached to a flotation device at the top. A silt curtain is used to isolate an active construction area within a lake or wetland and prevent silt-laden water from migrating out of the construction zone.

Silt fence: A temporary barrier made of geotextile and installed to prevent the off-site movement of silt material.

Silviculture: The scientific management of forest trees.

Site: An area evaluated as to its capacity to produce a particular forest or other vegetation based on the combination of biological, climatic and soil factors present.

Site preparation: A forest activity to remove unwanted vegetation and other material, and to cultivate or prepare the soil for reforestation.

Skidding: The act of moving trees from the site of felling to a loading area or landing.

Skid trail: A temporary pathway over forest soil to drag felled trees or logs to a landing.

Slash: The unwanted, unutilized and generally unmarketable accumulation of woody material in the forest, such as limbs, tops, cull logs and stumps, that remain in the forest as residue after timber harvesting.

Slope: Degree of deviation of a surface from the horizontal, measured as a numerical ratio, as a percentage or in degrees.

Solubility: The ability of a pesticide to dissolve in water or other solvent. The greater the solubility in water, the greater the chance that the pesticide will leach to ground water or move in solution to surface water.

Temporary road: Generally a minimum-standard road designed for short-term use during a specific project, such as a timber harvest. Use of temporary roads is typically limited to dry or frozen conditions to minimize rutting and compaction.

Toxicity: A measure of the capacity of a pesticide to cause injury.

Turnout: A widened space in a road to allow vehicles to pass one another and which slopes away (downhill) from the road.

Water bar: A ditch and hump across a trail or road tied into the uphill side for the purpose of carrying water runoff into the vegetation, duff, ditch or dispersion area so that it does not gain the volume and velocity which causes soil movement and erosion.

Water quality: The chemical, physical and biological characteristics of water, usually in respect to its suitability for a particular purpose.

Water table: The upper surface of the ground water, generally referred to in terms of linear depth below soil surface.

Watershed: The surrounding land area that drains into a lake, river or river system.

Wetland function: The physical, chemical and biological processes in a wetland.

Wetland value: Wetland characteristics that are beneficial to society. Public benefits include water quality protection, floodwater retention, public recreation and commercial uses.

Wetlands: Lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or where the land is covered by shallow water. Wetlands must have the following three attributes: 1) a predominance of hydric soils (soils that result from wet conditions); 2) inundation or saturation by surface water or ground water at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation (plants adapted to wet conditions); and 3) under normal circumstances, a prevalence of hydrophytic vegetation.

Wildfires: Uncontrolled fires occurring in forestland, brushland and grassland.

Windrow: Slash, residue and debris raked together into piles or rows.