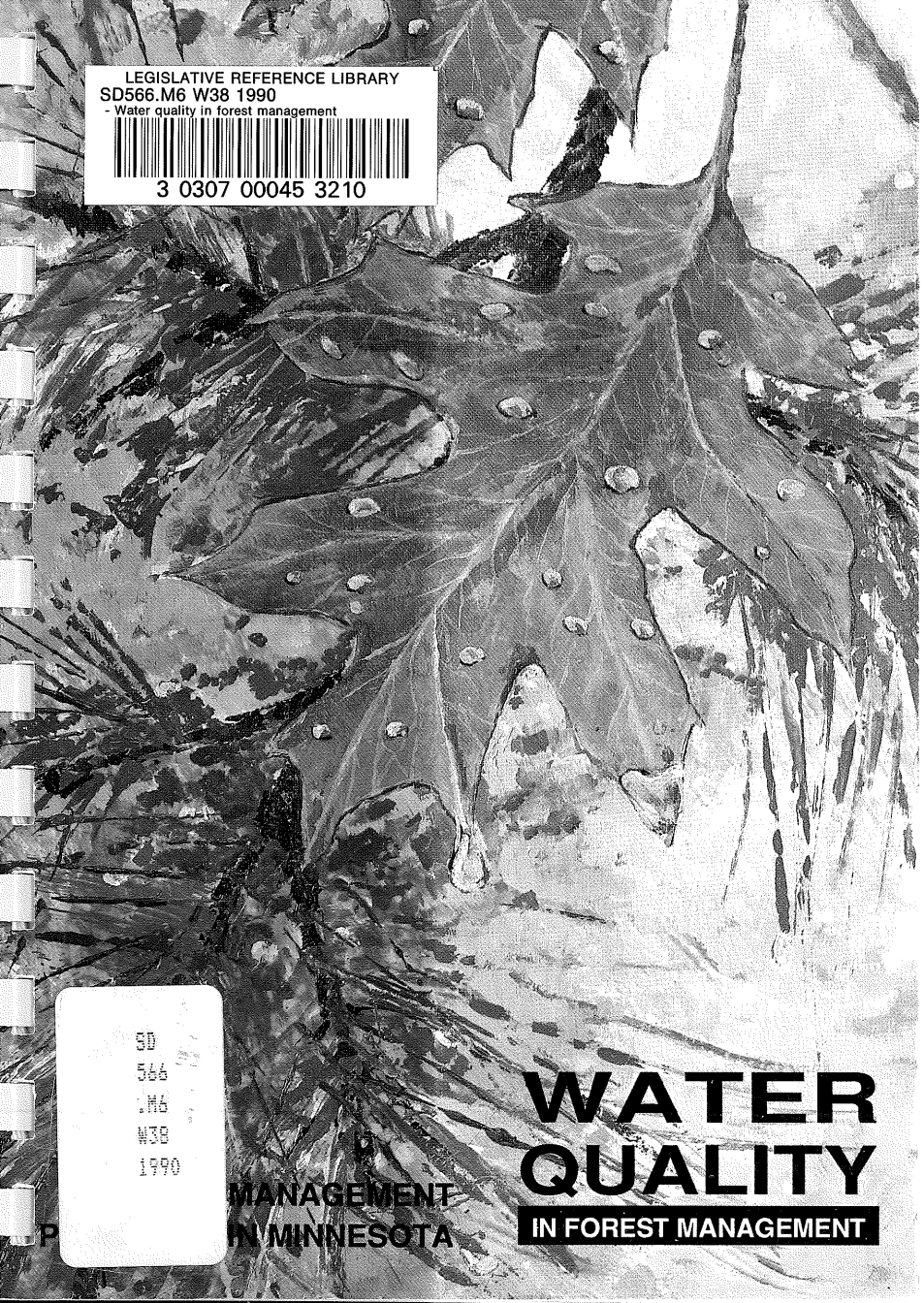


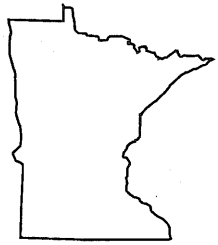
WATER QUALITY

IN FOREST MANAGEMENT

MANAGEMENT

P IN MINNESOTA

Water Quality in Forest Management
"Best Management Practices in Minnesota"



Prepared by the following organizations:

Chippewa National Forest, U.S. Forest Service
Minnesota Association of County Land Commissioners
Minnesota Department of Natural Resources/ Division of Forestry
Minnesota Forest Industries
Minnesota Pollution Control Agency
Minnesota Timber Producers Association
Superior National Forest, U.S. Forest Service
University of Minnesota

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TABLE OF CONTENTS

INTRODUCTION

Minnesota has large acreages of land in forests that support the second largest manufacturing industry in the state, varied recreational opportunities, wildlife habitat, and highly prized watershed values. Clean water is one of Minnesota's greatest resources and much of this water originates in forested areas. Many of the activities related to forest management have the potential to contribute some level of nonpoint source (NPS) pollution to surface water or ground water. Nonpoint source is diffuse pollution that comes from almost everywhere; it even occurs naturally to a certain extent. The amount from any particular spot is small and insignificant, but when combined from over the landscape, can create water quality problems. Although it is unrealistic to expect that all NPS pollution can be eliminated, Best Management Practices (BMPs) can be used to minimize the impact of forestry practices on water quality. A BMP is a practice or combination of practices for preventing or reducing NPS pollution to a level compatible with the water quality goals. These practices must be reasonable, achievable and cost effective. The adoption and use of forestry Best Management Practices will provide the mechanism for attaining the following water quality goals:

- ❑ To maintain the integrity of stream courses.
- ❑ To reduce the volume of surface runoff originating from an area of forest management disturbance and running directly into surface waters.

- To minimize the quantity of logging debris deposited in stream beds.
- To establish filter strips, adjacent to lakes and ponds and along perennial and intermittent stream channels to filter sediment, reduce pesticide concentrations, and maintain water temperature.
- To minimize the movement of pesticides, nutrients, petroleum products and sediment to surface water and ground water.
- To stabilize exposed mineral soil areas through natural or artificial revegetation means.

Forestry NPS is complex, since it is often difficult to identify the source or even whether the pollution is occurring. In general, the impacts of NPS are not obvious, and the principal focus for addressing NPS pollution must continue to be on voluntary preventative practices (i.e. BMPs). This is consistent with the efforts in developing the State 208 plan mandated by the passage of the 1972 Federal Water Pollution Control Act. Section 208 of the Act required each state to develop plans and procedures for controlling NPS pollution to the "extent feasible." In 1987, Congress passed amendments to the Clean Water Act which required the development of a specific NPS control program. Section 319 of the Act mandates the development of BMPs to reduce NPS pollution to the "maximum extent practicable."

6

The Minnesota 208 Plan** studied the relationship of forestry activities to water quality and concluded that water pollution is not generally severe in forested areas. In Minnesota the topography, soils and location of forests are such that instances of forestry-caused water pollution are site specific as opposed to regional problems. The forestry activities that are considered to be of most concern for NPS if improperly conducted are:

- forest road development
- timber harvesting activities
- mechanical site preparation
- pesticide application
- prescribed burning and fireline clearing

The major types of water pollutants that can be generated from forest management disturbances to the forest ecosystem include:

- nutrients
- sediment
- pesticides
- organic matter
- thermal impacts

** Recreation was also identified as an activity that has the potential to adversely affect water quality. The issue, however, is beyond the scope of this guidebook and would be more appropriately addressed separately from the common forest management activities.

Activities related to forest roads pose the greatest potential impact to water quality, in part due to the proximity of these activities to water. The other activities identifed above are likely to have less impact on water quality, since these activities involve much less soil disturbance.

This guidebook is the result of the cooperative efforts of many individuals within the professional forestry community to describe water quality protection measures to those conducting forestry activities. It is designed to heighten the awareness of NPS pollution for individuals and organizations involved in forestry. The guidebook provides basic information related to forestry practices that can be used to help prevent or minimize impacts to water quality. The types of waters affected by the recommendations contained in this document will be:

- ❑ lakes
- ❑ ponds
- ❑ perennial streams
- ❑ intermittent streams
- ❑ ground water

8

Statutes and regulations currently exist for state, federal and local agencies to control water pollution from forestry activities on public forest lands. These include:

- ❑ Local water plans (county boards)
- ❑ Local zoning controls or ordinances
- ❑ Shoreland management regulations
- ❑ National Environmental Policy Act
- ❑ DNR/Division of Water permits as required by law where construction activities impact public waters
- ❑ National Forest Management Act
- ❑ Minnesota Pesticide Control Law
- ❑ 1972 Federal Water Pollution Control Act
- ❑ Minnesota Groundwater Protection Act of 1989

Water and wetland protection measures must be considered part of the land management prescription on a site-by-site basis. These measures must be tailored to site specific conditions as it is not realistic to develop a single set of prescriptions that apply to all situations and all areas. The intent of this guidebook is to target all persons involved in forestry so that informed and appropriate decisions can be made on a site-by-site basis. The solution to forestry water quality problems will reside to a great extent on the attitudes toward, and acceptance of, water quality protection measures by individual loggers, landowners, contractors and forest management personnel.

The first section of the guidebook contains descriptions of practices that can be used to minimize the impact on water quality for the forestry activities identified earlier. Each activity contains a short description, a discussion of planning considerations, and an identification of the BMPs for the activity. The BMPs are not meant to be complete construction standards or engineering specifications and should not be used as substitutes for obtaining professional assistance when needed to achieve management objectives.

The second section is the resource directory, which lists organizations and individuals that can provide information, both technical and regulatory, and services related to the application of forestry BMPs.

The third section provides a list of useful references that address issues related to water quality in Minnesota.

The fourth section of the guidebook contains the glossary of terms identified within the document.

10

GENERAL PRACTICES TO PROTECT WATER QUALITY

I. FUEL, LUBRICANT AND EQUIPMENT MANAGEMENT

DESCRIPTION AND PURPOSE

Activities related to forest management utilize fuels and lubricants with a variety of equipment to accomplish field operations. Precautions are needed to prevent water contamination when using fuels, lubricants and other materials associated with heavy equipment operations.

PLANNING CONSIDERATIONS

The remote locations that are typical of most forestry operations result in many on site maintenance activities. If proper planning is not used, these activities

could result in spills of fuels, lubricants or other materials. Proper equipment maintenance, including routine checks of hoses and fittings, is the key to protecting surface water and ground water resources from the impacts of fuel and lubricant spills and leaks.

RECOMMENDED PRACTICES

The routine maintenance of equipment is a necessary part of most forestry operations. Common sense, care, proper planning and the anticipation of problems that may occur can eliminate or reduce potential water quality problems arising from spills. The following precautions should be adopted for each of the 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.

- ❑ 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 drain these materials directly onto the ground (Minn. Rules 7045.0065, subp. 1a., item B).

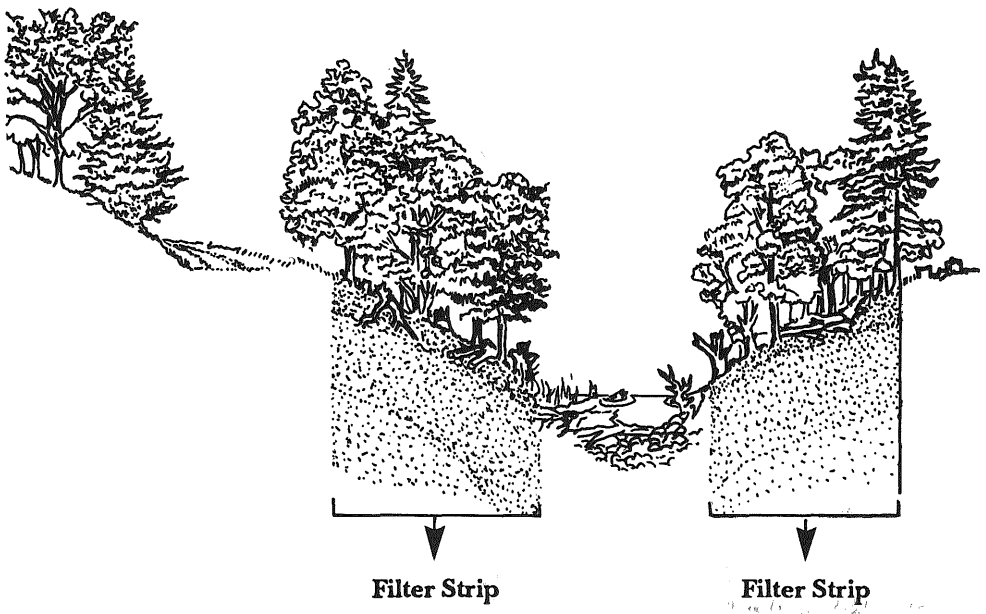
- Provide receptacles in maintenance areas or vehicles for collecting solid wastes such as empty grease tubes, oil filters and other trash. The materials collected in these receptacles must be disposed of properly at an approved solid waste site. Empty oil barrels should be recycled or properly disposed of as solid waste at an approved land fill.

- Locate fueling areas away from water at locations where a potential spill can be contained and properly treated with a minimum chance of surface water or ground water contamination.

II. FILTER STRIPS

Managing land to control NPS pollution near surface water is important. Timber harvesting activities, site preparation, prescribed burning, and road construction increase the potential for sedimentation due to mineral soil exposure. Protection of surface water is afforded by maintaining a filter strip between the water body and the forest disturbance. Filter strips (Figure 1) are areas adjacent to lakes, perennial streams, intermittent streams, and ponds that help minimize the runoff of sediment, debris and other pollutants into these water bodies. Forest management activities are permitted in filter strips, providing the integrity of the filter strip can be maintained. These activities should

Figure 1. Filter Strip Area



produce minimal exposure of mineral soil so that the residual vegetation and the forest floor can adequately trap sediment and provide an infiltration zone for surface waters from the adjacent area.

Filter strip widths will vary according to soil, and percent and length of slope. They should border and parallel the ordinary high water mark. Recommendations for filter strip widths are given in Table 1.

Table 1. **Filter strip width guide**

Slope of land between road and stream (percent)	Recommended width of filter strip (slope distance in feet)*
0 - 1	25
2 - 10	30 - 50
11 - 20	50 - 70
21 - 40	70 - 110
41 - 70	110 - 170

*Distance is measured to the edge of soil disturbance, or in the case of fills, from the bottom of the fill slope.

III. FOLLOW-UP EVALUATIONS

Where structures or other protection measures are used to minimize impacts to water quality, follow-up visits to the area are encouraged to assure that no later water degradation occurs.

RECOMMENDED PRACTICES FOR

FOREST ROADS

IN MINNESOTA WITH RESPECT TO WATER QUALITY

15

DESCRIPTION AND PURPOSE

Forest roads connect the most remote parts of the forest lands to the existing transportation infrastructure of township, county, and state roads and highways. Forest roads are managed to provide adequate access to forest lands for timber management, fish and wildlife habitat improvement and a variety of dispersed and developed recreational activities. Generally, these are low volume roads that must carry heavy loads for short periods of time during their service life. The potential for adverse impacts from forest roads exists in areas which have steep slopes, erodible soils, or where forest roads are located near water.

The recommendations contained in the roads section are to be considered as guides to reduce potential water quality impacts for incorporation in the overall road project design. The landowner may need the services of a forester or engineer to provide a complete design with construction specifications. Further assistance is available from the DNR/Division of Forestry, Soil and Water Conservation Districts (SWCD), industrial foresters and consultants.

PLANNING CONSIDERATIONS

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. The value of the resources served and site characteristics will influence the choice of road construction standards and maintenance activities. The following recommendations should be considered when planning the design of a road:

- ❑ Examine existing access routes to determine if they are the best routes to improve. Consider if relocation will provide a better long-term access route.
- ❑ Minimize the total road mileage required to meet

the landowner's objectives by coordinating with adjacent landowners.

- ❑ Minimize the number of water crossings and the ground disturbance.

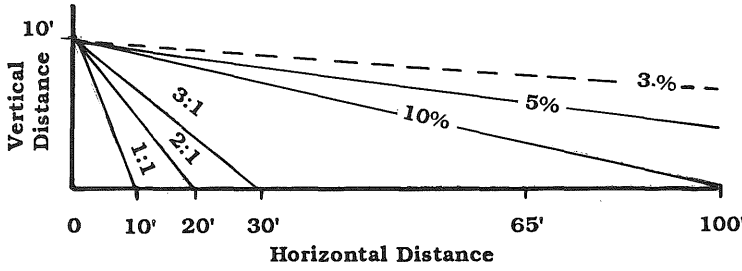
DESIGN RECOMMENDATIONS

1. Alignment

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

- ❑ Provide for maximum cross-drainage and minimum down-road flow. Construct roads with a slight grade of 1% or 2% where feasible. Grades in excess of 10% to 12% should be avoided in most cases. In erodible soils, maximum grades of 5% are recommended (Figure 2).
- ❑ Locate roads to lay lightly on the land, which minimizes the amount of soil disturbance (cut and fill) and the number of water crossings.
- ❑ Contact utility owners when crossing pipelines or other underground utilities. The utility owner must be consulted for safety and design needs.
- ❑ Avoid locations below the ordinary high water mark whenever possible (Figure 3).
- ❑ Locate roads away from lakes, ponds, creeks and draws, where possible, to provide adequate vegeta-

Figure 2. Slope and Bank Chart



1:1 2:1 3:1 Conversion for inslopes and backslopes

% Conversion for Road Grades

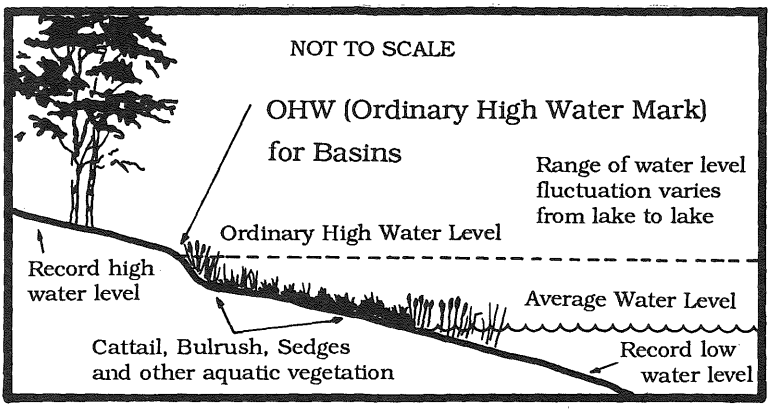
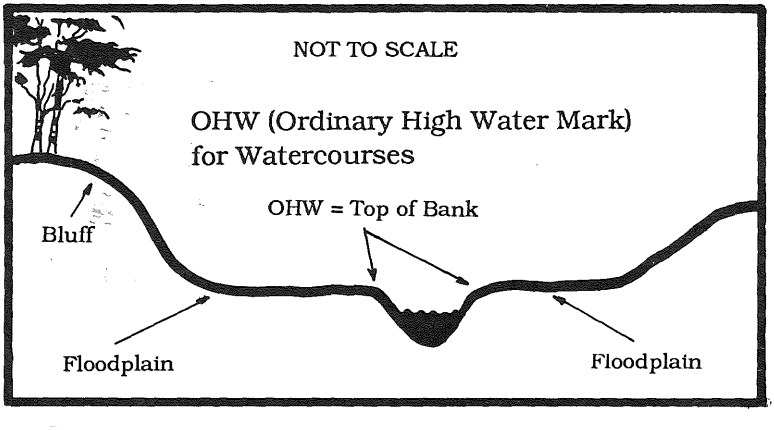


Figure 3. Ordinary High Water Mark



tive filters that minimize siltation potential from the roads. See Table 1 for recommended filter strip widths.

2. Water Crossings

Roads should cross waterways a minimum number of times. Permanent crossings are recommended when long term use is expected or when the crossing will be used frequently over the short term. Bridges and culverts should be used for roads that have regular use or where the crossings are often wet. Fords and low water crossings (Figure 4) are to be used only in locations where the subgrade contains large amounts of rock (this may be hauled in) with few fine particles and water is not expected to be present during any of the road use cycles. The following guidelines should be included in the design for water crossings to help protect water quality:

- ❑ Maintain crossings as close to a 90 degree angle as possible to the streambed.
- ❑ Give preference to crossing locations where:

  a. construction will disrupt a minimum amount of natural stream channel.
  b. streambed and banks are composed of firm cohesive soils or are armored with rock.
  c. approaches to stream banks have low percent slopes and short slope lengths.

- ❑ Design culverts and bridges for minimal impact on water quality and sized to accommodate the 25 to 50 year flood frequency. Putting in culverts and drainage structures that are too small could result in the road washing out. Contact a local SWCD office, Minnesota DNR engineer, or local Minnesota Department of Transportation (MN DOT) office or local road authority for assistance.
- ❑ Construct crossings so that they do not 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. An example of the use of riprap is shown in Figure 4.
- ❑ Minimize construction disturbance to the natural flow of water.
- ❑ Restrict activity in the water to periods of low flow.
- ❑ Provide cross drainage for water when crossing swamp or peat ground to ensure that surface and subsurface water is equalized on both sides of the road. It is best to leave surface drainage installation until late in the construction phase after some settlement has occurred.
- ❑ Contact a Minnesota DNR region or area hydrologist to determine if the proposed road will cross a public water or protected wetland. If so, obtain the appropriate permit (MN Statute 105.42).

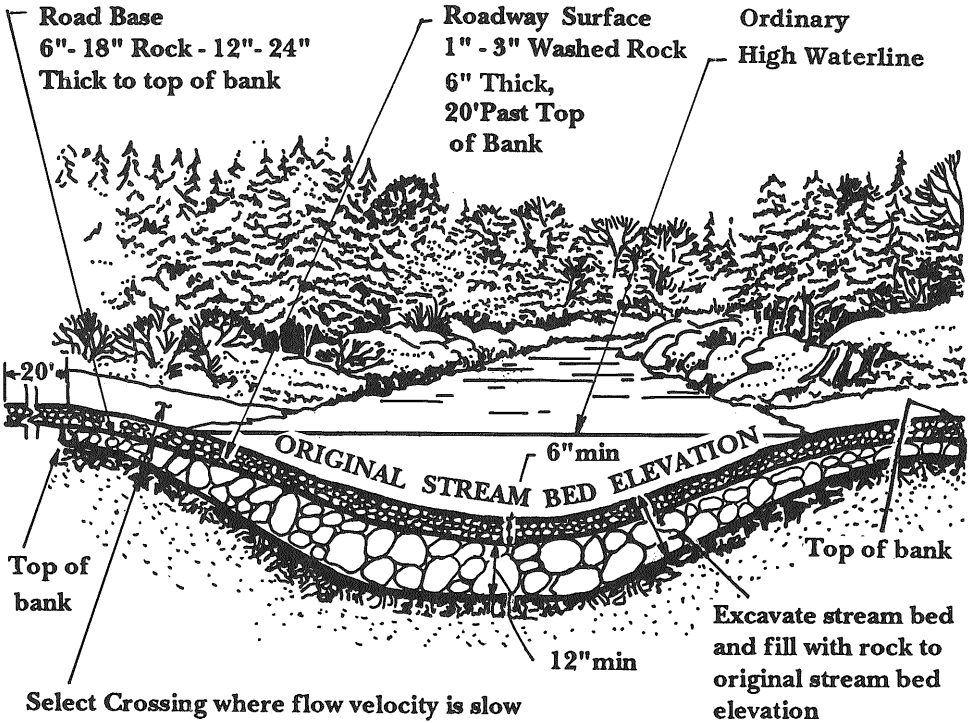


Figure 4. Use of Riprap in a Stream Channel

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

3. Winter roads

Winter roads and trails provide access under frozen ground conditions for timber harvesting and other timber management activities. Properly constructed winter roads are recognized as an important component of timber management. For example, it is estimated that from 55% to 60% of timber harvesting on state forest land occurs during the months of January, February and March. To minimize the impacts to water quality during spring breakup, the following recommendations should be included in the design of winter roads:

- ❑ Consider using culverts or bridges to cross definite drainages where winter roads are to be used for five years or more.
- ❑ Construct temporary crossings on winter roads using proper drainage structures so that there will be no more than a minimal increase in the natural, expected sediment load of the area.

- ❑ Consider the placement of native log materials across the waterway when practical alternatives to frozen water crossings do not exist.
- ❑ Avoid the use of mineral soil as fill over the logs or directly in the crossing.
- ❑ Construct winter road crossings on level terrain where practical. Where adjacent ground slope generally exceeds 3%:

  a. organic materials may not be placed in winter crossings.
  b. temporary winter crossings must be removed prior to breakup.

4. Drainage

Water entering on or adjacent to the road must be diverted 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:

- ❑ Design roads to minimize erosion (Figure 5).
- ❑ Install grade rolls or dips, where practical, to reduce the down-road flow of surface water. See Figures 6 and 7 for recommended design, and Table 2 for spacing of cross drain culverts and dips.

Figure 5. Typical Road Designs for Drainage and Stability

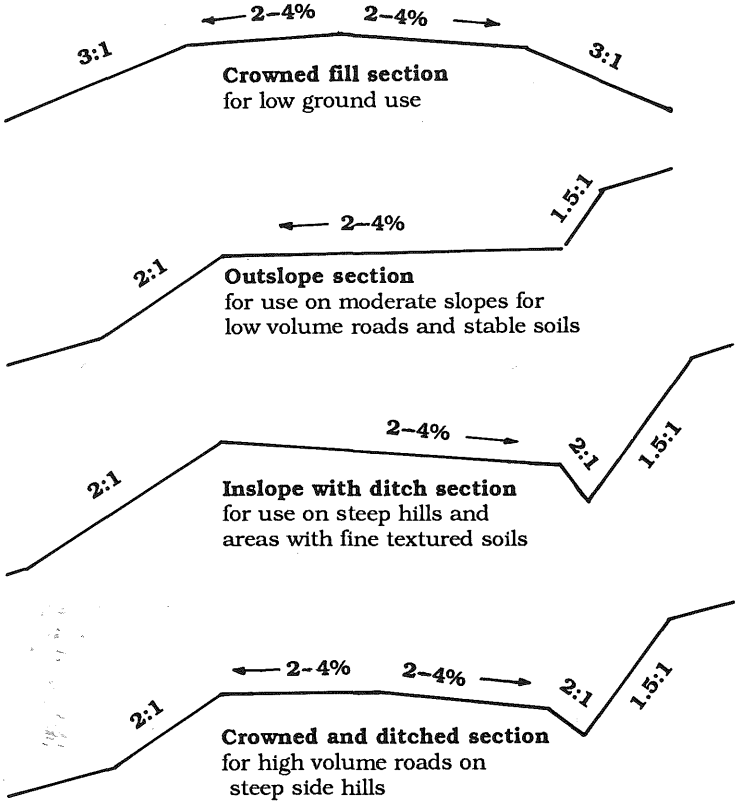
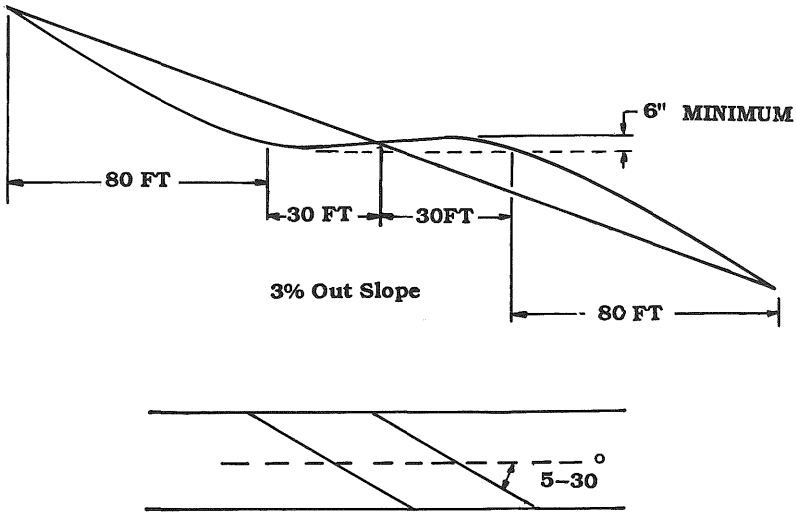


Figure 6. Broad-Based Drain Dip Typical Drawing



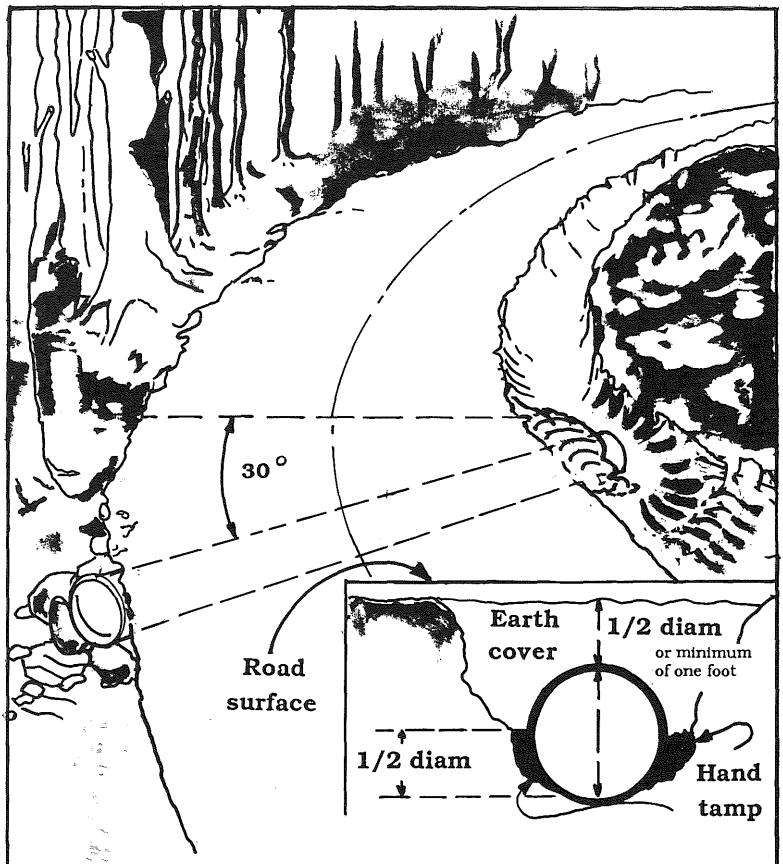


Figure 7. Design and Installation of Pipe Culverts

- ❑ Use open-top culverts to remove surface water from temporary or occasional use roads. These can be difficult to keep clean if they are too narrow (Figure 8).
- ❑ Do not drain surface water diverted from roads directly into open water. Drain the water into the filter strip or vegetative draw.
- ❑ Install cross drains, culverts and lead-off-ditches to avoid carrying water long distances in roadside ditches (Figure 9 and Table 2).

CONSTRUCTION RECOMMENDATIONS

1. Clearing

Clearing widths will vary depending on the needs of the owner and 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. The cleared material should be disposed of properly as recommended below:

- ❑ Place and locate 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.

Figure 8. Open Top Culverts

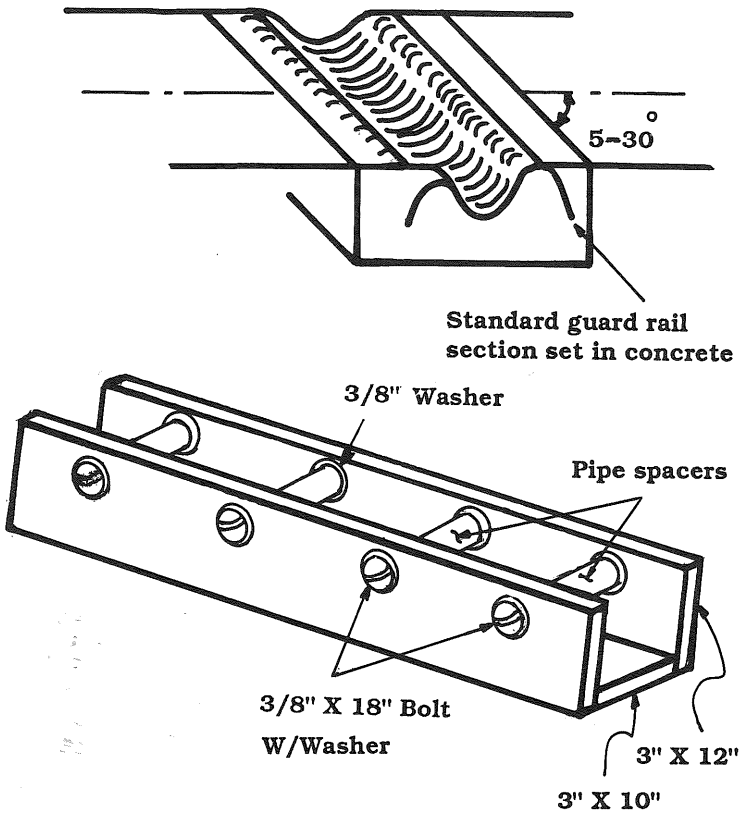
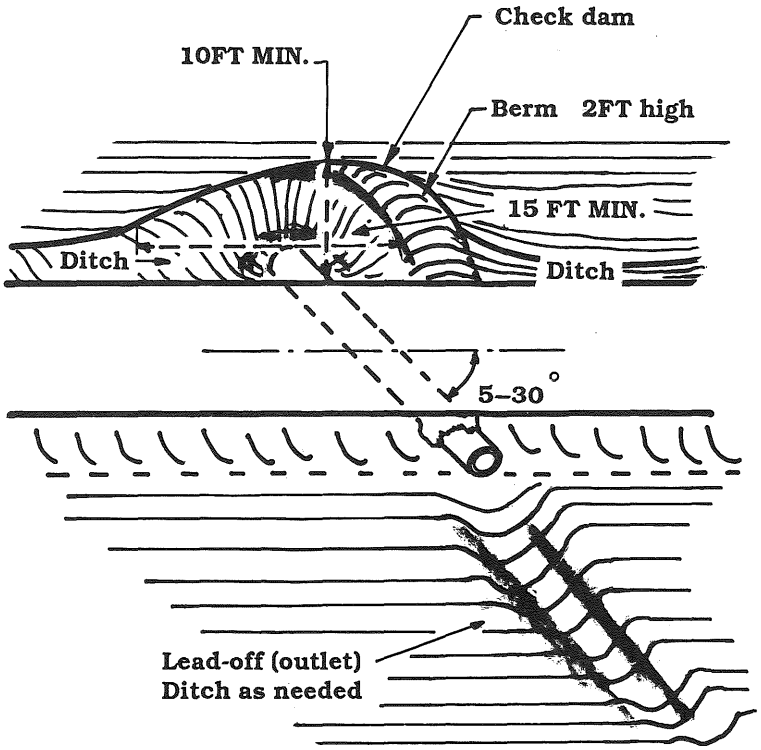


Figure 9. Crossdrain Culvert and Catchbasin Construction



2. Excavation

In most cases, material must be moved to provide an adequate road for even a minimal amount of hauling. It is recommended that this material be obtained from the closest available source, which is often the ditch. When working 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. Some recommended methods to consider for placement of this material associated with road construction are given below:

- ❑ Place and locate clearing debris in a manner that will not impede water flow or potentially increase sedimentation of waters.
- ❑ Shape inslopes and backslopes to be 1 1/2:1 or flatter in order to be stable (Figure 2).
- ❑ Compact material to reduce the entry of water, to increase the load carrying capacity, and to minimize the settling of fill material.
- ❑ Use filter materials (geotextiles) or other subgrade support (corduroy) in areas of peat or bog to minimize siltation by keeping the subsoils from mixing with the fill material.
- ❑ Deposit excess material in stable locations above the ordinary high water mark (Figure 3).
- ❑ Shape and stabilize borrow pits to avoid sedimentation of adjacent waters.

Table 2. **Cross drain spacing on forest roads for broad based dips and culverts**

Road grade (percent)	Spacing (feet)
0 - 2	500
3 - 4	300
5 - 7	180
8 - 10	150
11 - 15	130
16+	110

3. Surfacing

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

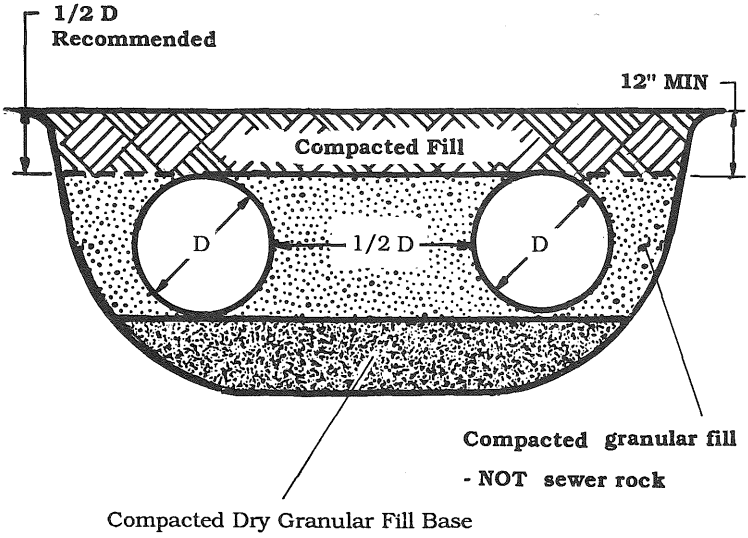
4. Drainage

Site drainage and cross drainage are important for controlling sedimentation. Proper handling of water

during design and construction will minimize the potential impact. These recommendations should be followed to reduce possible impacts:

- ❑ Install drainage structures on streams as soon as feasible.
- ❑ Install culverts on a dry surface of compacted granular material. The fill material should be firmly compacted around the culvert, particularly under the lower half of the culvert (Figure 10). Cover the top of the culverts with fill to a depth of one half of the pipe diameter or at least 12 inches, whichever is greater. Culvert lengths should reach to the toe of the fill without changing the sideslopes of the fill.
- ❑ Provide adequate drainage for road grades during construction to minimize erosion of unconsolidated materials.
- ❑ Retain outslope drainage and remove all berms on the outside edge during construction operations, except those intentionally constructed for protection of road grade fills.
- ❑ Provide dips, water bars and cross drainage where needed on all temporary roads (Figures 6, 7 and 11).
- ❑ Provide subsurface drainage (e.g. porous fill, perforated tubes) to help stabilize the ground where areas of slope instability are encountered.
- ❑ Consider armoring culvert inlets and outlets, where necessary, to reduce bank and channel erosion and sedimentation.

Figure 10. Culvert Installation Procedures



- ❑ Construct or install culverts and other drainage structures that will accommodate the 25 to 50 year flood frequency. Putting in culverts and drainage structures that are too small could result in washing out of the road. Contact a local SWCD office for size and design recommendations.
- ❑ Install silt fences as an option during construction in sites where roads and water have close contact for long periods.

5. Soil protection

Slopes should be finished in a timely manner to minimize erosion potential. The following long-term measures are recommended before leaving the project:

- ❑ Stabilize bare soil areas to reduce erosion. A sod cover is desirable along all roadsides. Disturbed soil should be seeded as soon as practical after construction. Recommendations for seed mixes and fertilizer use may be obtained from the local offices of the SWCD, U.S. Forest Service (USFS), DNR/ Division of Forestry, MN DOT, or county extension.
- ❑ Install siltation barriers such as straw bales or mulch to help stabilize soils prior to establishment of vegetative cover.

MAINTENANCE RECOMMENDATIONS

Maintenance should ensure that the original measures to minimize impacts on water quality are working and continue to work for the life of the road.

1. All Roads

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

- ❑ Clean debris and windfalls from culverts, ditches, dips and other structures prior to periods of peak flow to diminish the danger of clogging and the possibility of washouts. This material should be placed above the ordinary high water mark (Figure 3).
- ❑ Keep traffic off roads during wet periods and spring breakup to reduce maintenance requirements.
- ❑ Place a barrier to traffic such as a berm, and post "Road Closed" signs at the beginning of the road when closing roads that are not to be used again.

2. Active Roads

Roads that are open for use require more maintenance than roads that are closed to vehicular travel. The amount of use will determine the amount of surface maintenance required during a given period.

- ❑ Fill in ruts and holes that develop during road use with a suitable material (e.g. gravel, compacted fill) as soon as possible to reduce the erosion potential.
- ❑ Grade the road surface periodically to maintain proper surface drainage and eliminate small wheel ruts.
- ❑ Minimize berms along the edge of the road that will trap the water on the road surface. Feather material out on the road surface.
- ❑ Apply dust control agents (e.g. calcium chloride, road oil), in a manner that will minimize entry of these compounds 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.

3. Inactive roads

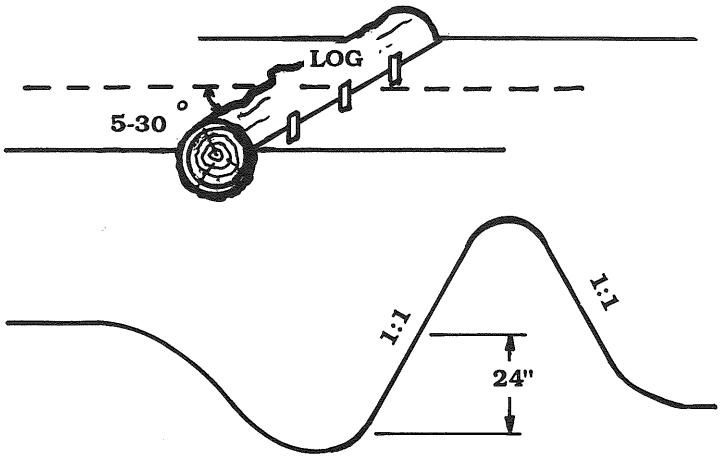
Even closed roads require occasional work to reduce potential damage to waters of the state.

- ❑ Ensure that the road surface remains in a stable condition by blading it occasionally or seeding the surface of unsurfaced roads.
- ❑ Maintain drainage structures in working order.
- ❑ Place water bars, where necessary, before roads are abandoned (Figure 11 and Table 3).

Table 3. **Water bar spacing for closed roads**

Road grade (percent)	Spacing between water bars (feet)
2	250
5	130
10	80
15	50
25+	40

Figure 11. Water Bars for Closing Temporary Roads and Skid Trails



3% Outslope

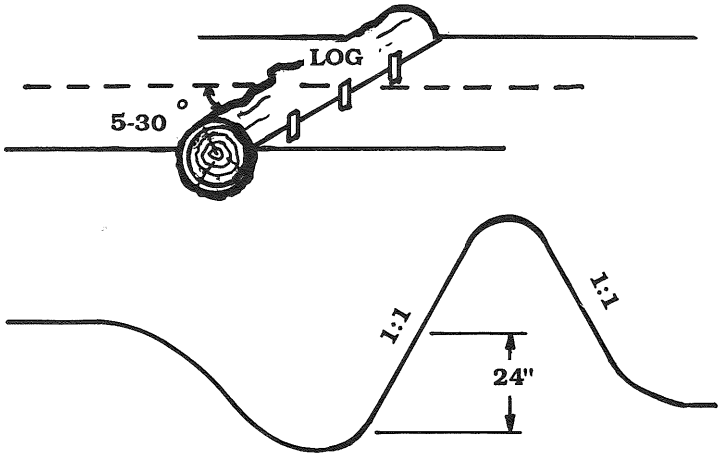
40

RECOMMENDED PRACTICES FOR TIMBER HARVESTING IN MINNESOTA WITH RESPECT TO WATER QUALITY

DESCRIPTION AND PURPOSE

Timber harvesting, an integral part of forest management, involves cutting trees and removing them from the forest. Timber harvesting includes the activities of felling, forwarding, sorting, loading, and developing skid trails and landings. These operations temporarily disturb the environment at and around the harvesting area. Best management practices for harvesting activities will minimize sediment, chemical, nutrient and debris movement into surface water or ground water, and minimize thermal (heating) impacts on surface waters.

Figure 11. Water Bars for Closing Temporary Roads and Skid Trails



3% Outslope

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RECOMMENDED PRACTICES FOR

TIMBER HARVESTING

IN MINNESOTA WITH RESPECT TO WATER QUALITY

DESCRIPTION AND PURPOSE

Timber harvesting, an integral part of forest management, involves cutting trees and removing them from the forest. Timber harvesting includes the activities of felling, forwarding, sorting, loading, and developing skid trails and landings. These operations temporarily disturb the environment at and around the harvesting area. Best management practices for harvesting activities will minimize sediment, chemical, nutrient and debris movement into surface water or 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 protection in all operations. Those who have not had any experience with timber harvesting need to contact a professional forester for assistance. This assistance is available through the Minnesota DNR Private Forest Management program, consulting foresters, and forest industries' private forest assistance programs. The Resource Directory provides a list of contacts for professional assistance.

1. Reconnaissance

An "on-the-ground" evaluation should be done for all land being considered for timber sales regardless of who owns the land. It is extremely important to have this first hand knowledge of the area being considered for harvesting. A variety of tools are available to assist in evaluating property and developing a plan for timber harvesting and other land management activities:

- ❑ Aerial photographs
- ❑ Topographic maps
- ❑ Soil surveys

Refer to the Resource Directory for a list of contacts to obtain these items.

Familiarity with soils in the area being considered for harvesting will assist the landowner in choosing appropriate timber harvesting methods while providing water quality protection. Many counties have completed soil surveys. Contact a local Soil and Water Conservation District (SWCD) office for information about obtaining or using county soil surveys.

If professional assistance is obtained, walk over the property with the forester and establish objectives for timber harvesting and forest regeneration. Consider water quality concerns as objectives are established. When contractors are used for harvesting, include provisions for water protection in the timber sale contract.

2. Timber Sale Plan

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

- ❑ location of surface water (streams, lakes, ponds) and wetlands.
- ❑ location of stream crossings.
- ❑ number and location of landings, roads, and skid

trails needed to meet objectives (refer to Forest Roads section).

- ❑ location of other areas that may require special attention (e.g. steep slopes, rock outcrops, spring seeps).
- ❑ compatibility of the timing of harvesting operations with soil, topography and weather conditions.

Consider limiting site disturbance by accomplishing as many management objectives as possible through a single timber harvesting operation.

3. Design and layout

Determine the timber sale size and duration and the anticipated season and method of harvest. Where necessary to protect water quality, the following should be specified:

- ❑ Roads (see Forest Roads section)
- ❑ Landings
- ❑ Skid Trails
- ❑ Filter Strips (see General Practices section)
- ❑ Shade Strips

In addition, the recommendations given below should be incorporated in the design and layout of the timber sale:

Landings

Size landings to the minimum required for the acres to be harvested, the equipment to be used and the products to be cut. Where necessary to protect water quality, the harvesting agreement should specify the landing location(s).

- ❑ Locate landings away from low or poorly drained areas, preferably on level or gently sloping, stable ground.
- ❑ Consider the flow of water to, across, and from landing areas. Control measures may be necessary to reduce the erosion potential.
- ❑ Avoid locating landings and yarding areas on open water wetlands. Landings can be placed on other wetlands during frozen conditions. However, concentrations of harvesting slash from upland timber harvesting areas should not be deposited in wetland areas unless no practical alternative exists. Extra caution is necessary with equipment maintenance and when fueling equipment on wetland landings.
- ❑ Deposit debris from upland landing construction above the ordinary high water mark (Figure 3).

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Skid Trails

Refer to the BMPs in the Forest Roads section for drainage specifications that are also applicable to skid trails.

- ❑ Install bridges, culverts or use 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 (see Forest Roads section, page 21).
- ❑ Avoid locating skid trails in filter strips.
- ❑ Minimize long, straight skid trail stretches through careful siting, or adequately drain using broad-based dips, lead-off ditches or waterbars where there is the potential for erosion.

4. Harvesting and follow-up

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 problems in the future. Application of these practices should be used to provide long-term protection to water quality:

- ❑ Establish filter strips adjacent to perennial streams, intermittent streams, lakes and ponds.

- ❑ Minimize soil disturbance and mineral soil exposure within the filter strip. When an area of soil is exposed within the filter strip and it is likely to result in sedimentation, or when management objectives preclude the use of a filter strip and sedimentation is likely to occur, additional stabilization measures will be necessary. Suitable measures may include the use of lopped brush, straw bale barriers, mulch, and silt fences.
- ❑ Locate landings and skid trails outside the filter strips.
- ❑ Avoid felling timber into nonforested 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 streams, lakes and wetlands except in cases where residue placement is specifically prescribed for fish or wildlife habitat.
- ❑ Winch logs off of steep slopes, whenever possible, if erosion and sedimentation would result from conventional skidding.
- ❑ Consider erecting traffic barriers to prevent off-road vehicles from disturbing recently stabilized areas.
- ❑ Seed, fill in ruts, and install water bars and erosion barriers, where appropriate, to prevent erosion and sedimentation from roads, skid trails and landings into surface waters. Seeding and fertilizing recommendations can be obtained from county SWCD offices. Recommended water bar construction and

spacing specifications can be found in the Forest Roads section.

- ❑ Restore water courses to approximate their natural condition by removing temporary drainage structures and stabilizing the soil along the banks.
- ❑ Inspect erosion barriers periodically. These barriers should be maintained or removed as needed.

5. Shade strips

Vegetation adjacent to designated trout streams should be managed to minimize increases in stream temperature.

48

RECOMMENDED PRACTICES FOR MECHANICAL SITE PREPARATION IN MINNESOTA WITH RESPECT TO WATER QUALITY

DESCRIPTION AND PURPOSE

Mechanical site preparation on forest land includes practices to alter conditions to favor the establishment, survival and growth of a desired tree species. The purpose of mechanical site preparation is to facilitate planting, direct seeding and natural regeneration, and to provide 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. The potential for impacts on water quality from mechanical site preparation exists in areas that have steep slopes, erodible soils, and where the prepared site is located near water.

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 for potential water quality impacts prior to implementation of site preparation operations. Recommendations on site preparation practices should be related to specific site characteristics including:

- ❑ soil
- ❑ topography
- ❑ vegetation
- ❑ access
- ❑ distance to surface waters
- ❑ depth to ground water

Possible resources to assist in this evaluation include soil survey manuals and their forestry supplemental publications, soil scientists from the DNR and SWCD, or other qualified soil scientists. Practices that cause 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.

RECOMMENDED PRESCRIPTIONS

The following specifications should be applied to mechanical site preparation practices to protect water quality:

1. General Recommendations

- ❑ Use mechanical site preparation techniques that will cause minimal disturbance to the site in order to achieve the objective of establishing crop trees.
- ❑ Provide adequate filter strips (Table 1).
- ❑ Avoid operations during periods of saturated soil conditions that may cause rutting or accelerate soil erosion.
- ❑ Manage vegetation adjacent to designated trout streams to minimize increases in stream temperature.

2. Shearing and raking

- ❑ Avoid concentrating residues from shearing and raking operations in wetland areas. These residues should be deposited in stable locations above the ordinary high water mark.
- ❑ Design shearing and raking practices to avoid direct runoff of sediment into water.
- ❑ Locate windrows and piles to minimize interference with natural drainage patterns.

- ❑ Locate windrows outside the filter strips.
- ❑ Give preference to locating windrows along contours to mitigate the effects of overland flow.
- ❑ Minimize incorporation of soil material into windrows and piles by equipment operators. Two examples of preferred practices would be (1) shearing and raking under frozen soil conditions, and (2) light raking which would only remove slash.
- ❑ Avoid shearing and raking operations on organic soils except under frozen soil conditions.

3. Disking

- ❑ Avoid disking on terrain that results in an increase in the direct runoff of sediment into water.
- ❑ Follow the land contours with proper consideration given to equipment operator safety.

4. Patch and row scarification

- ❑ Use patch or row scarification as the preferred mechanical site preparation method for artificial regeneration where terrain or soil type necessitate minimum soil disturbance.
- ❑ Follow the contours of the land as long as operator safety is maintained.

5. Other methods

- ❑ Use other methods of mechanical site preparation as appropriate. However, all site preparation work should be carried out in such a way as to minimize impeding drainage, possible erosion and runoff into water.

ALTERNATIVE RECOMMENDATIONS

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. Additional alternative methods of site preparation include grazing and manual techniques.

RECOMMENDED PRACTICES FOR

PESTICIDE USE

IN MINNESOTA WITH RESPECT TO WATER QUALITY

53

DESCRIPTION AND PURPOSE

Pesticides are used as intentional additions of chemicals or biological agents to forest lands to facilitate meeting forest management, utility and rights-of-way objectives by reducing, controlling or eliminating insect, disease, animal or weed problems. The purpose of a pesticide application is to promote the establishment, survival, growth or maintenance of a desired species or condition.

PLANNING CONSIDERATIONS

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.

1. Integrated pest management

Consider the use of pesticides as part of an overall program to control pest problems. Integrated Pest Management (IPM) strategies have been developed to control forest pests without a total reliance on chemical pesticides. These strategies incorporate a judicious combination of chemical, biological and cultural activities to control forest pests. IPM is an approach which utilizes all available techniques, including chemical and non-chemical control methods. To be effective, IPM requires an extensive knowledge of the pest and the ecology of the system in question. A good IPM program has four steps: (1) identifying problems, (2) selecting tactics, (3) considering economic factors, including whether it pays to use pesticides, and (4) evaluating the program.

Examples of IPM activities include the following:

Bark beetle control

- ❑ Thin, prune or do other kinds of disturbances in pine areas only from September 1 to February 1.
- ❑ Place trap trees in areas of past and/or current bark beetle activity; destroy the beetles before they emerge by burning, burying or spraying with an insecticide.

Gypsy moth control

- ❑ Place pheromone traps annually throughout hardwood areas, particularly in recreational areas to monitor for the presence of gypsy moth.
- ❑ Use insecticides to control limited populations of gypsy moth in high value forested communities such as those located in urban areas.
- ❑ Risk and hazard rate hardwood areas and concentrate pre-outbreak harvesting in the high risk areas to reduce risk.
- ❑ Scrape off egg masses and destroy.

Saratoga spittlebug control

- ❑ Survey plantations to risk rate based on the shrub composition in the plantation.
- ❑ Use herbicides to control the shrubs that serve as alternate host for the spittlebug if surveys indicate high risk.

Selective vegetation control

- ❑ Establish sod cover to keep out brush.
- ❑ Consider using a selective herbicide (e.g. Garlon) as opposed to disking.

Information on IPM programs can be obtained from the DNR regional insect and disease specialists and by contacting the Forest Pest Management Unit, U.S. Forest Service, State and Private Forestry, St. Paul.

Additional methods to consider for managing the resource include:

- ❑ silvicultural practices that encourage a variety of species and avoid monocultures
- ❑ mechanical techniques
- ❑ manual techniques
- ❑ prescribed burning
- ❑ biological controls
- ❑ grazing
- ❑ mulching
- ❑ planting disease and insect resistant varieties

2. Use of licensed pesticide applicators

Pesticides should only be applied by applicators licensed by the Minnesota Department of Agriculture.

3. Pesticide selection

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 Minnesota Department of Agriculture. Prior to using any pesticide, carefully read and follow all label directions. Maintain current labels and Material Safety Data Sheets (MSDS). The MSDS is a source of cautionary information and data. For additional information on registered pesticides, contact the Minnesota Department of Agriculture.

When selecting among pesticide options, more than effectiveness and cost should be evaluated. Consideration should be given to site factors, pesticide characteristics, application conditions, delivery systems and application techniques that can influence impacts to water quality.

Site factors include:

- ❑ vegetation height
- ❑ target pest
- ❑ adsorption to soil organic matter
- ❑ persistence or half-life
- ❑ toxicity
- ❑ type of formulation

Application conditions include:

- ❑ timing
- ❑ weather conditions

Delivery systems include:

- ❑ aerial
- ❑ ground
- ❑ bombardier
- ❑ skidder
- ❑ handheld
- ❑ spotgun
- ❑ hypo-hatchet
- ❑ mist blower

Application techniques include:

- ❑ broadcast
- ❑ basal bark
- ❑ stump
- ❑ injection
- ❑ strip
- ❑ patch

Three main pesticide characteristics can greatly affect a pesticide's potential to contaminate surface or ground water.

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.

Adsorption is the inherent ability of a pesticide to bind with soil. Some pesticides stick very tightly to soil while others are easily dislodged. A greater adsorption means a pesticide will remain longer in the surface soil and thus be less likely to leach down into the ground water before it has degraded. Adsorption increases as soil organic matter increases. An index or measure of soil adsorption is expressed by the Koc value (Table 4).

Breakdown rate or *half-life* is the time it takes a pesticide to degrade or break down into other chemical forms. 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. Table 5 lists the characteristics of some common pesticides and a rating for possible leaching into ground water or loss to surface water.

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: USEPA pesticides in ground water. Background document.USEPA. Washington D.C. 1986.

In a given situation, pesticides with the highest water solubilities, greatest persistence, lowest affinities for adsorption to organic matter, and highest application rates have the greatest potential for movement in surface water or to ground water. Pesticides with high affinities for adsorption (Koc values in excess of 1000, Table 5) are recommended for soils with the following characteristics:

- ❑ coarse textures
- ❑ low organic matter (≤2%)
- ❑ shallow depth to ground water
- ❑ poor drainage

An alternative means of minimizing the potential movement of a pesticide is to select a non-broadcast application technique for the same pesticide that reduces the amount of the chemical applied directly to the soil.

4. Response 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 reaching ground water. If a spill occurs, it must be properly treated. Be prepared to respond appropriately. The Private Pesticide Applicator's Training Manual from the Minnesota Extension Service provides information on proper actions to take in the event of a spill. A summary of those actions are:

- ❑ 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.

An adequate spill and cleaning kit should be maintained 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

The Minnesota Department of Agriculture must be contacted whenever a spill occurs. You can call the Department of Agriculture directly at (612) 297-5387 during work hours or call the Department of Public Safety, Division of Emergency Services, at (612) 649-5451 in the metro area or 1-800-422-0798 outstate. The number is answered 24 hours a day. The Minnesota Pollution Control Agency (MN PCA) must also be notified. If you call either of the above numbers, the MN PCA will also be notified.

PROCEDURES FOR PESTICIDE USE

Proper pesticide management practices make efficient use of chemicals while preventing contamination of surface water or ground water. Residues of pesticides used in forestry can affect water quality at several phases of the pesticide use cycle. These phases are: (1) transportation, (2) storage, (3) loading and mixing, (4) application, (5) equipment cleanup, and (6) container and waste disposal. To minimize potential impacts on water quality, use of the following practices is encouraged.

1. Transportation

- ❑ Use common sense and care when transporting pesticides.
- ❑ Inspect all containers prior to loading and ensure all caps, plugs and bungs are tightened.
- ❑ Handle containers carefully when loading them onto vehicles.
- ❑ Secure containers properly to prevent shifting during transport.
- ❑ Check containers periodically enroute.
- ❑ Limit access to containers during transport to prevent tampering.
- ❑ Consider potential impacts on water quality when selecting transportation routes.
- ❑ Educate and inform the driver of the proper transportation precautions.
- ❑ Never transport pesticides unless arrangements have been made to receive and store them properly.

2. Storage

- ❑ Store pesticides in their original containers with labels intact.
- ❑ Do not store pesticides for extended periods in buildings that will not contain a complete spill from the largest container being stored.

- ❑ Check containers prior to storage and periodically during storage to ensure that they are properly sealed.
- ❑ 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 big enough to contain the contents of the largest container stored in the buildings.
- ❑ Ensure that storage facilities can be secured under lock and key.
- ❑ Post storage areas with a list of chemicals and quantities stored, and notify local fire departments about storage.
- ❑ Do not store pesticides, if possible, 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.
- ❑ Consider security measures when pesticides are unattended.
- ❑ Educate and inform drivers of proper storage precautions.

3. Mixing-Loading

- ❑ Review the label before opening the container to ensure familiarity with current use directions.
- ❑ Exercise care and caution during mixing and loading, because pesticides are handled in their most concentrated forms.
- ❑ Mix the lowest rate of pesticide possible within the label directions to achieve the desired level of pest control.
- ❑ Do not mix near wells or where pesticide spills could enter streams, lakes or ponds.
- ❑ 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.
- ❑ Do not introduce pesticides into mixing or application equipment until after filling the equipment from the water sources. This restriction does not apply to clean water holding containers.
- ❑ Replace pour caps and close bags or other containers immediately after use.
- ❑ Do not leave 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.

- ❑ Do not fill pesticide mixing or application equipment directly from a public water supply unless the public water supply is equipped with a backflow prevention device.
- ❑ Do not fill pesticide mixing or application equipment directly from surface water unless the equipment contains proper and functioning anti-back-siphoning mechanisms.
- ❑ Do not mix more than is needed to accomplish the task.
- ❑ Do not store mixed pesticides in the tank overnight or over the weekend without adequate security.
- ❑ Triple rinse all empty plastic and metal pesticide containers and add the rinse water to the spray solution.

4. Application

- ❑ Refer to label directions before making a pesticide application.
- ❑ 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.

- ❑ Never apply pesticides directly to water except where specifically labeled for application to water. For pesticides not labeled for aquatic or ditchbank use, filter strips (Table 1) should be left adjacent to all lakes, streams, ponds and ditches that contain water at the time of application.
- ❑ Avoid the use of broadcast application methods within the filter strips. Treatments within the filter strips may include:

  1. use of pesticides labeled for aquatic use.
  2. manual or mechanical treatments.
  3. no treatment.
  4. spot, banded, stump, basal bark, hack and squirt, frill, or injection treatments.
  5. use of less soil-mobile pesticides (Koc> 1,000, Table 5).
  6. increasing filter strip width when using toxic to highly toxic insecticides.

- ❑ Apply pesticides under favorable weather conditions. Never apply a pesticide when there is a likelihood of significant drift.

Drift control measures include:

- ❑ consideration of alternative application methods.
- ❑ use of the lowest reasonable pressure.
- ❑ use of a nozzle type that produces the largest droplets at a given rate and pressure.
- ❑ use of a drift control agent.
- ❑ application under wind speed conditions that reduce the potential for drift. Lowest wind speeds generally occur near dawn and dusk. Consider use of the following wind speeds for broadcast application:

wind speeds:	aerial	1- 6 mph
	ground	1-10 mph

- ❑ application under the appropriate temperature and relative humidity conditions. High temperatures enhance losses 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. For broadcast applications, consider the use of the following limits on temperature and relative humidity.

temperature (°F)	minimum relative humidity (%)
35	25
45	30
55	35
65	40
75	45
85	50

- ❑ Prohibit aircraft loaded with pesticides from crossing lakes or ponds. Aircraft also should not fly down the stream course of any recognizable stream. Where stream crossings cannot be avoided, they should be made at right angles to the stream course. Be sure to shut off the chemical application during turns and over water.
- ❑ Consider two conditions which involve water quality when identifying potential heliport/helipad locations:

  a. flight patterns in relation to water bodies.
  b. locations adjacent to water bodies.

- ❑ Consider marking the boundaries of the area for treatment.

5. Equipment Cleanup

- ❑ Clean equipment where pesticide residues will not enter streams, lakes or ponds.
- ❑ 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.
- ❑ Do not clean pesticide application equipment in surface waters.

6. 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 and must be handled and disposed of in accordance with hazardous waste regulations. For more information about proper management of waste pesticides, contact the Minnesota Department of Agriculture or the Minnesota Pollution Control Agency.
- ❑ Triple rinse all empty plastic and metal pesticide containers and add the rinse water to the spray solution.

To properly triple rinse containers:

- ❑ Empty the pesticide into the spray tank and allow the pesticide container to drain.
- ❑ Fill the container 10% to 20% with water (or solvent in some cases), rinse, and pour the rinse water into the spray tank.
- ❑ Repeat step 2 two more times and apply rinsate to the spray site.
- ❑ Apply all leftover solutions and rinsates to the treatment area.
- ❑ Puncture and flatten containers or otherwise render useless, so they cannot be used unless they are to be returned to the manufacturer.
- ❑ Dispose of triple rinsed containers:

1. as ordinary solid waste at a landfill licensed by the Minnesota Pollution Control Agency.
2. by recycling through scrap metal dealers willing to accept them. A list of dealers who recycle these containers is available from your county extension office.
3. by returning to the manufacturer when allowed.

Table 5. **Pesticide characteristics**

Pesticide	Trade name(s)	Solubility in water (mg/L)	Half life (days)	Koc	Surface loss* potential	Leaching** potential
Herbicide						
Atrazine	AAtrex Atrazine	33	60	160	M	L
Dalapon soluble sodium salt	Dalapon	800000	30	1	S	L
Dicamba soluble salt	Banvel	800000	14	2	S	L
Dichlobenil	Casoron, Norosac	18	30	224	M	M
Dichlorprop ester (2,4-DP ester)	Weedone	50	10	1000	M	S
Fosamine ammonium soluble salt	Krenite	1790000	7	10000	M	S
Glyphosate amine soluble salt	Roundup, Accord	1000000	30	10000	L	S
Hexazinone	Velpar, Pronone	33000	60	11	S	L
Imazapyr acid	Arsenal	10000	90	5	S	L
Imazapyr soluble amine salt	Arsenal, Chopper	1000000	90	15	S	L

Pesticide	Trade name(s)	Solubility in water (mg/L)	Half life (days)	Koc	Surface loss* potential	Leaching** potential
Linuron	Lorox	75	60	863	L	M
Metsulfuron-methyl	Escort	2000	120	61	M	L
Oxyfluorfen	Goal	0.1	30	100000	L	S
Picloram soluble salt	Tordon	200000	90	16	S	L
Simazine	Princep	3.5	75	138	M	L
Sulfometuron-methyl	Oust	10	60	171	M	L
Tebuthiuron	Spike	2500	360	4	S	L
Triclopyr ester	Garlon	23	46	780	L	M
2,4-D ester	Weedone	50	10	1000	M	S
Insecticides						
Acephate	Orthene	650000	3	100	S	S
Azinphos-methyl	Guthion	29	40	1000	L	S
Carbaryl	Sevin	40	7	229	M	S
Carbofuran	Furadan	350	30	29	S	L
Chlorpyrifos	Lorsban	2	30	6070	L	S

Pesticide	Trade name(s)	Solubility in water (mg/L)	Half life (days)	Koc	Surface loss* potential	Leaching** potential
Diazinon	D.Z.N. Diazinon	40	30	85	M	L
Diflubenzuron	Dimilin	0.2	10	6790	L	S
Dimethoate	Cygon	25000	7	8	S	M
Fenvalerate	Pydrin	0.1	50	100000	L	S
Lindane	Lindane	7	90	1100	L	M
Malathion	Malathion	145	1	1797	S	S
Fungicides						
Benomyl	Benlate	2	100	2100	L	S
Ferbam	Carbamate	120	20	300	M	M
Triadimefon	Bayleton	260	21	273	M	M

L=Large M=Medium S=Small

*Surface loss potential indicates the tendency of a pesticide to move with sediment in runoff. The values should not be considered precise.

**Leaching potential indicates the tendency of a pesticide to move in solution with water and leach below the root zone. Values are estimates.

Sources: USDA-ARS, Interim pesticide properties data base by R.D. Wauchope, August 1985, and surface loss and leaching potentials from USDA Soil Conservation Service, field office technical guide, section 1-5.

76

RECOMMENDED PRACTICES FOR PRESCRIBED BURNING IN MINNESOTA WITH RESPECT TO WATER QUALITY

DESCRIPTION AND PURPOSE

Prescribed burning is used in forest management to: eliminate the hazard of destructive wildfires by reducing fuel accumulations; facilitate site preparation for tree planting or direct seeding by reducing logging debris and other organic matter; release nutrients for growth of seedlings or trees; eliminate unwanted vegetation competing with crop trees for sunlight, moisture, and nutrients; improve wildlife habitat; maintain scientific and natural areas; maintain unique or critically fire dependent ecosystems; and control insects or diseases.

Used systematically to reduce fuel accumulations leading to unpredictable, uncontrollable and potential erosion causing ravages of wildfire, the act of prescribed burning can be viewed as a Best Management Practice. The potential impact of prescribed burning on water quality is related to the following factors:

- ❑ size and intensity of the burn
- ❑ degree of surface soil exposure resulting from the burn
- ❑ topography of the burn area
- ❑ soil type in the burn area
- ❑ distance between the burn area and adjacent water resources
- ❑ soil moisture conditions on the burn area

Although Best Management Practices listed below were developed to provide reasonable guidance for protecting water quality from the impacts of prescribed burning, they are also recommended for use in appropriate 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 the desired results and minimize impacts on water quality. The following are key considerations in planning a prescribed burn to minimize water quality impacts:

- ❑ Clearly identify the objectives of the burn.
- ❑ Obtain a burning permit from the DNR/Division of Forestry.
- ❑ Consider fuel, weather, soil, and topographic conditions in the burn area.
- ❑ Carefully 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 PRESCRIPTIONS

- ❑ Locate firelines on the contour, whenever possible, and avoid straight uphill-downhill placement. For prescribed fires, do not construct firelines such that drainage is directly into a water body.

- ❑ Use natural or in-place fire barriers (e.g. roads, streams, lakes, wetlands) as an acceptable way to minimize the need for fireline construction in situations where artificial construction of firelines will result in excessive erosion and sedimentation.

- ❑ 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. Minimum filter strip widths should be 50 to 100 feet.

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

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

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

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

- ❑ Avoid placement of piles for burning in sensitive areas adjacent to lakes and streams or in drainage channels (e.g. where a hot burn is likely to result in organic layer destruction and lowered infiltration rate).

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

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

- ❑ Do not clean retardant application equipment in lakes or streams. Do not allow fuels or oil from pumper units to drain or drip into lakes or streams.

- ❑ Consult with MN DNR field stations for technical advice and assistance in prescribed burning.

- ❑ Give special consideration when planning burns in marsh or wetland areas to avoid impacts on natural hydrologic functioning of the wetland.

MAINTENANCE (AFTER FIRE)

- ❑ Maintain erosion control measures as needed on firelines. Seeding and fertilizing recommendations can be obtained from your county SWCD office. Recommended water bar construction and spacing specifications can be found in the Forest Road section.

- ❑ Close water wells excavated for wildfire suppression activities as soon as practical following control, or at the completion of mop-up activities.

RESOURCE DIRECTORY

The resource directory provides additional information and identifies resources to contact for assistance with forest management and nonpoint source pollution control. The directory is organized by topic with a brief description of what is available from various organizations and individuals.

For general information about nonpoint source pollution in Minnesota, contact the Minnesota Pollution Control Agency (PCA), Division of Water Quality, 520 Lafayette Road, St. Paul, MN 55155, (612) 296-6300 or tollfree 1-800-652-9747, or contact any of the five regional PCA offices located in Brainerd, Detroit Lakes, Duluth, Marshall, and Rochester.

ROADS

Assistance in properly designing and locating roads: DNR/Division of Forestry, Soil and Water Conservation Districts, U.S. Forest Service/Zone Engineering offices, industrial foresters, the Minnesota Association of Consulting Foresters, and the U.S. Army Corps of Engineers. A list of consulting foresters can be obtained from your local DNR/Division of Forestry office. A list of industrial foresters is available from the

Minnesota Forest Industries or local DNR/Division of Forestry offices.

WATER CROSSINGS

Information and assistance in designing and installing bridges and culverts: Soil and Water Conservation Districts, Minnesota DNR engineers, and local Minnesota Department of Transportation offices.

Permits are required for work in protected waters and wetlands. To determine whether a permit is required for a particular water body or wetland, contact any DNR/Division of Waters region or area office. In some instances, further review is required by the U.S. Army Corps of Engineers or local ditch authorities.

TIMBER HARVESTING

Assistance in developing timber harvesting plans: Minnesota DNR Private Forest Management program, the Minnesota Association of Consulting Foresters, and forest industries' private forest assistance programs.

Technical assistance to woodland owners on erosion control and soil interpretations: local Soil and Water Conservation District offices and Soil Conservation Service District Conservationists.

Information and educational publications dealing with natural resource management: County Extension offices which are linked to the University of Minnesota's College of Forestry. The Minnesota Forestry Association, 220 First Ave. N.W., Room 210, Grand Rapids, MN 55744 (218-326-4200) also provides educational materials and information on the wise use of natural resources.

Aerial photographs: U.S. Department of Agriculture, Aerial Photo Field Office, 2222 W., 2300 S., Salt Lake City, UT 84130, (801) 524-5856; or U.S. Geological Survey, EROS Data Center, Sioux Falls, SD 57198, (605) 594-6151.

Topographic maps: Minnesota Geological Survey, 2642 University Avenue, St. Paul, MN 55114, (612) 627-4782.

Soil survey use and interpretations: local Soil and Water Conservation Districts.

Advice on timber harvesting practices to maintain or improve fish and wildlife habitat: DNR Division of Forestry; DNR Division of Fisheries and Wildlife;U.S. Forest Service, State and Private Forestry; University of Minnesota Extension Service; Minnesota Association of Consulting Foresters; and forest industries' private forest assistance programs.

MECHANICAL SITE PREPARATION

Many of the contacts listed above can provide recommendations on site preparation practices. Landowners can contact soil scientists from the Minnesota DNR or Soil and Water Conservation Districts for assistance.

Recommendations on vegetation management: University of Minnesota Forest Vegetation Management Cooperative, 175 University Road, Cloquet, MN 55720, (218) 879-4528.

Advice on grazing methods of weed control: U.S. Forest Service, Superior and Chippewa National Forests.

PESTICIDE USE

Information about Integrated Pest Management: Forest Pest Management Unit, U.S. Forest Service, State and Private Forestry; Minnesota DNR regional insect and disease specialists; and the Minnesota Extension Service.

Regulation of forestry applied pesticides in Minnesota and licensing of certified applicators: Minnesota Department of Agriculture, 90 W. Plato Boulevard, St. Paul, MN 55107, (612) 297-4506.

Information on proper pesticide use including recommendations of the rates and applicability of various pesticides, and a list of dealers that recycle pesticide containers: Minnesota Extension Service, Minnesota Department of Agriculture, and the University of Minnesota Forest Vegetation Management Cooperative, 175 University Road, Cloquet, MN 55720, (218) 879-4528.

Advice about the proper use of specific pesticide products: Pesticide company representatives.

Training of applicators for state certification: Minnesota Extension Service.

Workshops for pesticide certification: Contact Minnesota Pesticide Information and Education, 2916 South Shore Drive, Prior Lake, MN 55372, (612) 447-1187.

Information about disposal of waste pesticides: Minnesota Pollution Control Agency, (612) 296-6300.

Notification of pesticide spills: Contact the Minnesota Department of Agriculture at (612) 297-5387 during work hours or contact the Department of Public Safety, Division of Emergency Services at (612) 649-5451 in the metro area or 1-800-422-0798 outstate.

The Minnesota Pollution Control Agency must also be notified and can be called at a 24-hour spills hotline (612) 296-8100.

PRESCRIBED BURNING

Obtaining a burning permit: Minnesota DNR/Division of Forestry field stations and area offices, and state fire wardens.

Technical assistance and advice on establishing goals and conducting prescribed burns: Nature Conservancy, DNR/Division of Forestry offices, DNR/Division of Wildlife offices, Sharp-tail Grouse Society, Rough Grouse Association, and Minnesota Deerhunter's Association.

FERTILIZING AND SEEDING

Fertilizer and seed mixture recommendations for exposed soil: Local Soil and Water Conservation District offices, U.S. Forest Service, Minnesota DNR/Division of Forestry, and Minnesota Department of Transportation.

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 over one acre. Contact the local USDA Agricultural Stabilization and Conservation Service (ASCS) office or the local DNR/Division of Forestry office.

Forestry Incentives Program (FIP): provides approximately 65% reimbursement of establishment costs for plantings over 10 acres. Timber is the main goal. Contact the local USDA Agricultural Stabilization and Conservation Service (ASCS) office or the local DNR/Division of Forestry office.

Minnesota Forestry Incentives Program (MNFIP): provides funds for projects such as fencing, gopher control, and firebreaks. Contact the local Soil and Water Conservation District office or the local DNR/Division of Forestry office.

Conservation Reserve Program (CRP): provides 50% of establishment costs and 10 annual payments as an incentive to retire highly erosive cropland. Contact the local USDA Agricultural Stabilization and Conservation (ASCS) office or the local DNR/Division of Forestry office.

Reinvest in Minnesota (RIM): similar to CRP above except that it is targeted for areas that will benefit wildlife. Contact the local Soil and Water Conservation District office or the local DNR/Division of Forestry or Division of Wildlife office.

Private Forest Management (PFM): provides technical assistance to landowner participants in state and federal cost-share programs. Contact the Minnesota DNR, PFM Program, 500 Lafayette Road, St. Paul, MN 55155-4044 or the local Area or Field Station DNR/ Division of Forestry office.

State Cost-Share Program: assists landowners in the installation of permanent non-production 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 the local Soil and Water Conservation District office or the Minnesota Board of Water and Soil Resources, Suite 104, 155 S. Wabasha St., St. Paul, MN. 55107, (612) 296-3767.

The exact requirements and availability of these programs might vary with time and location. Consult your local forester, Agricultural Stabilization and Conservation Service Office, or Soil and Water Conservation District for current details.

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GLOSSARY

Access road: A temporary or permanent access route for vehicles into forestland.

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

Angle of repose: The maximum slope or angle at which a material such as soil or loose rock remains stable.

Barriers: Obstructions to pedestrian, horse, or vehicular traffic. They are intended to restrict such traffic to a specific location.

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 (BMP's): Implies a practice or combination of practices, that is 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 gener-

ated 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.

Check dam: A small dam constructed in a gully or other small watercourse to decrease the streamflow velocity, minimize channel scour and promote deposition of sediment.

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

Culvert: A conduit through which surface water can flow under roads.

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

Dips: Economical, relatively trouble free structures for providing effective drainage of woods roads. Dips are

considerably lower in cost than culverts, so time spent in careful construction is well justified.

Disking: A site preparation system where a heavy harrow with large disks is pulled over a site in order to eliminate competing vegetation.

Diversion ditch: A channel with a supporting ridge on the lower side constructed across a slope for the purpose of intercepting surface runoff.

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

Felling: The process of severing trees from stumps.

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 entering surface waters. Harvesting and other forest management activities are permitted in the 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 constructed by removing fuel or rendering fuel unflammable by use of water or fire retardants.

Ford: Submerged stream crossing where tread is reinforced to bear intended traffic. A place where a perennial or intermittent stream may be crossed by vehicle.

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

Forwarding: The operation of moving products from the stump to a landing for further transport.

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 fibres manufactured in a woven or loose non-woven manner to form a blanket-like product.

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.

Harvesting: The felling, loading, and transportation of forest products, roundwood or logs.

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 only in direct response to precipitation. It is dry for a large part of the year.

Landing: A place where trees and logs are gathered in or near the forest for further 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 the road to a vegetated area.

Loading: The act of placing material on a vehicle for further transport.

Logging debris (slash): That unwanted, unutilized, and generally unmarketable accumulation of woody

material in the forest such as limbs, tops, cull logs, and stumps, that remain as forest residue after timber harvesting.

Mulching: Providing any loose covering for exposed forest soil, using organic residues, such as grass, straw or wood fibers to protect exposed soil and help control erosion.

Narrow based dips: Diversions appropriate on temporary roads which carry relatively low volumes of water or on roads and skid trails which will be closed following logging operations.

Nonpoint source pollution: Pollution that enters a water body from an illdefined or diffuse origin on the watershed and does not result from discernable, confined, or discrete conveyances.

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. Substances necessary for the growth and reproduction of organisms. In water, those substances that promote growth of algae and bacteria; chiefly nitrates and phosphates.

Ordinary high water mark: An elevation which marks the boundary of a lake, marsh or streambed. It is 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.

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

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

Prescribed burning: Skillful application of fire to natural fuels that will allow confinement of the fire to a predetermined area and at the same time will produce certain planned benefits.

Rake: A site preparation tool normally mounted on the front of a crawler tractor, used to remove trees, stumps roots and slash from a future planting site.

Riprap: A layer of boulders or shot rock fragments placed over a 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.

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.

Sediment: Solid material that is in suspension, is being transported, or has been moved from its site of origin.

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

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 expresses the capacity of a given area to grow timber or other vegetation.

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. Skidding may be accomplished by tractors, horses, or specialized logging equipment.

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

Turnout: A widened space in a road to allow vehicles to pass one another and which slopes away (downhill) from the road. Also, a drainage ditch which drains water away from roads.

Water bar: A diversion ditch and/or 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 pollution: Any introduction of foreign material into water or other impingement upon water which produces undesirable changes in the physical, biological, or chemical characteristics of that water.

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

Waters of the state: Any surface or underground waters, except those surface waters which are not

confined but are spread and diffused over the land. This includes all lakes, ponds, marshes, rivers, streams, ditches, springs and waters from underground aquifers, regardless of their size or location.

Wetlands: Geographic areas characteristically supporting hydrophytes, hydric soils and some saturation or flooding during the growing season.

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

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

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