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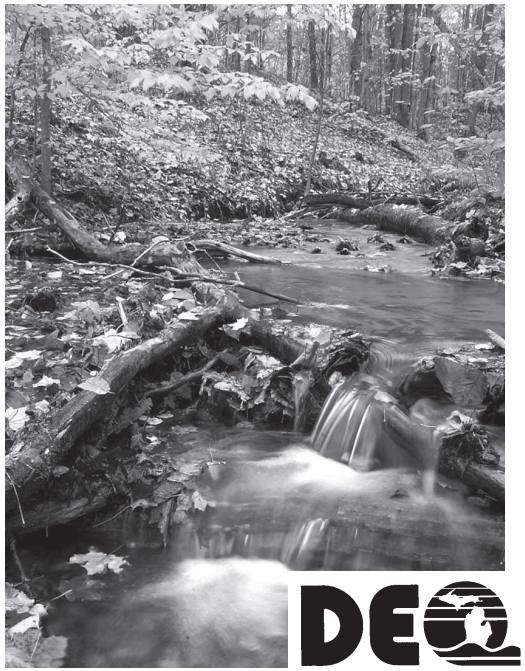
Sustainable Soil and Water Quality Practices on Forest Land



MICHIGAN DEPARTMENT OF NATURAL RESOURCES
AND
MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

IC4011 (Rev. 02/24/2009)

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FOREWORD

Dear Reader and User:

This manual describes the specifications and techniques to properly apply voluntary "Best Management Practices" (BMPs). It also provides information regarding environmental laws and regulations that may apply when forest management activities occur.

This is the first substantial revision of the *Water Quality Practices on Forest Land*, also known as Michigan's Forestry Best Management Practices (BMP) Manual. The original was published in 1994. It has been reprinted with minor changes to adjust for governmental reorganization and re-codification of environmental and natural resource protection laws. This version supercedes all previous versions.

A key influence in revising the original manual has been the development of forest certification standards. These standards emphasize sustainable forestry principles and practices which include protection of water and soil resources. In the United States, there are two primary forest certification systems: The Sustainable Forestry Initiative (SFI) and the set of standards developed by the Forest Stewardship Council (FSC).

The scope and use of the term "Best Management Practices" has been expanded in this manual. The manual describes BMPs in the context of those practices that not only protect surface water quality, but soil quality too. Two new sections have been added: 1) Forest wetland protection practices to use when constructing roads, and 2) guidance to address rutting. The term "buffer strip" has been changed to "Riparian Management Zone" (RMZ). This term provides a more accurate description regarding the activities allowed in the forested area adjacent to a stream or other water body. Forest management activities within an RMZ are allowed, as long as extra precaution is used and the integrity and function of the RMZ is maintained during and after forest management activities (i.e. logging). The manual has also incorporated information on designated trout streams, vernal pools, and bogs to provide information about such areas. However, the focus remains on water and soil quality rather than wildlife or other broader ecological concerns. For the latter types of information, for example on species of greatest conservation need, see the DNR Wildlife Action Plan on the DNR Website, *www.michigan.gov/dnr*.

Please note that the BMPs described in previous editions are incorporated into this manual. The specifications have not been changed nor have the statutes governing them.

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From a legal standpoint, the use of these BMPs is voluntary. However, properly applying these practices enables the responsible party or parties to meet pertinent environmental protection regulations. Voluntarily applying these practices will, under most weather conditions, prevent sediment or other nonpoint sources of pollution from going into a stream or other open water body.

This manual provides recommended guidance and specifications. It does not cover all situations, as conditions vary from site to site. These practices may be modified for specific site conditions in line with protecting soil and site productivity, and water quality resources.

In addition to DNR and DEQ staff, we wish to thank The Nature Conservancy, Michigan Association of Timbermen, the Forest Management Advisory Committee, and the Michigan Forest Products Council for their collaborative, helpful reviews and comments.

Lynne M. Boyd, Chief
Forest, Mineral and Fire Management
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1. INTRODUCTION

Michigan is bordered by four of the Great Lakes, which are the largest group of freshwater lakes on earth, containing 20 percent of the world's freshwater. Forty thousand (40,000) of the 95,000 square miles of Great Lakes are contained within Michigan's boundaries. In addition, Michigan's land mass includes 11,000 inland lakes and 36,000 miles of rivers and streams. Clean water is one of our greatest natural assets.

Management practices on forest lands, by all owners, will determine if the forests remain healthy and productive. Healthy, stable and productive forests are closely associated with the highest quality of surface and ground water. Integrating the water and soil protection practices described in this manual can prevent erosion, sedimentation and soil compaction, an essential part of maintaining a healthy forest and healthy watersheds. Other uses and activities can also have long-term impacts on ground water.

The 19 million acres of forested land in Michigan are a great natural resource asset. The sustainable management of Michigan's forests serves to protect the health of Michigan's waters and communities. These forests, about one-half of the State's land area, are owned by many people. The largest owner group contains approximately 385,000 individuals whose private holdings range from small woodlots to tracts of several thousand acres. Fifty-three percent (53%) of Michigan's forested acres are held by this group. The next largest ownership group is public forest lands (20% owned by the State, and 15% by the Federal government). The forest products industry and timber investment firms own the remaining 12% of forest land.

In forestry operations, poor management practices can degrade surface water and groundwater quality by introducing the following major pollutants: sediment (mineral and organic), nutrients, chemicals, heat and debris. Forest landowners and their agents and contractors are responsible for any damage to streams, lakes, and wetlands resulting from any aspect of a logging or other forest management operation. Environmental degradation is covered by existing laws in Michigan. Violation of those statutes or failure to secure the necessary permits can result in financial penalties to the landowner. The landowner or their designated agent must obtain a permit to cross a stream, construct a road that disturbs more than one acre of soil, or engage in an earth change within 500 feet of water body. **Regular inspection of all roads, bridges, culverts, and preventive actions taken to prevent erosion and the movement of sediment into surface waters, are part of a high quality and sustainable forest management operation**.

The purpose of this manual is to assist the forest landowner and persons who do forest management work on the ground. It provides specific guidance on how to protect water quality, critical habitat, and aquatic resources, while conducting timber harvesting or other forest management activities. It was revised with assistance from staff in the Michigan Department of Natural Resources (DNR) and the Michigan Department of Environmental Quality (DEQ). It takes language extensively from the original 1994 DNR publication, "Water Quality Management Practices on Forest Land". Many of the graphics are courtesy of the Wisconsin Department of Natural Resources' (WDNR) BMP Field Manual. The U.S. Environmental Protection Agency (EPA) document entitled "National Management Measures to Control Nonpoint Source Pollution from Forestry" was also a source of information in developing this manual. This manual provides information and guidance on how to plan, design and implement a system of Best Management Practices that will protect water and soil quality while harvesting timber or engaging other forest management treatments.

In 1987, the federal Clean Water Act of 1972, was amended to address nonpoint source pollution. The Environmental Protection Agency developed new legislation that would require every state to develop sets of "Best management Practices for all major land use activities, such as Agriculture, Forestry, Turf Management, Golf courses, etc. Unlike the regulations regarding point source discharges to surface waters, the amended Act, commonly referred to as Section 319, stated that the use and application of the specifications and guidance stated in the variety of BMPs manuals would be voluntary and not regulated by the states or EPA or any other federal agency. However, these specifications and guidance, such as those stated in this manual, were developed based on federal research activities on how to address the pollution of America's surface waters by nonpoint source pollutants, such as sediment, fertilizers, and pesticides. In Michigan, the Michigan Department of Environmental Quality is the primary agency, working under both state and federal regulations, to ensure protection of Michigan's surface waters and it has determined that proper use and application of the BMPs in this manual will accrue vastly improved water quality across the state.

The guidance described in this manual can be adjusted to the conditions of the site at the time logging or other forest management activities are carried out. The goal is to provide guidance that protects water and soil quality, while allowing for the efficient removal and transport of forest products, as well as allowing for post-harvest treatments such as prescribed burning or site preparation/regeneration practices.

If you see questionable forestry practices, you may report them to the Michigan Sustainable Forestry Initiative (SFI) Implementation Committee which maintains an "Inconsistent Practices Hotline" at 800-474-1718. If you see forest practices that are threatening water quality, you may report them to the DEQ Pollution Emergency Alerting System (PEAS) at 800-292-4706 (within Michigan) or 517-373-7660 (outside of Michigan).

To ensure clarity between legal requirements and voluntary soil and water protection practices and guidance described in this manual, the following has been used:

Legal requirements are denoted by the symbol "⚖".

2. LAWS AND PERMITS

In addition to the BMPs and other types of management practices described in this manual, loggers, land managers and landowners should be aware of existing regulations relating to forest management and water quality protection. Most of these laws and regulations are listed in Appendix C, List of Applicable Laws in Michigan. This chapter summarizes certain permits related to water quality. For more information, please contact your local DEQ office. To contact your local DEQ office, please visit the DEQ online at www.michigan.gov/deq and select DEQ locations. You may also call the DEQ Environmental Assistance Center toll-free at 800-662-9278.

⚖ Stream Crossings

When constructing a new or upgrading an existing stream crossing, there are three specific statutes of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), that always apply. These are: Part 31, Water Resources Protection; Part 91, Soil Erosion and Sedimentation Control; and Part 301, Inland Lakes and Streams. For each part, there are a legal set of rules and regulations that apply. In certain cases, Part 303, Wetlands Protection and Part 305, Natural Rivers, may also apply, if a stream crossing occurs in a wetland environment or on a stream within the watershed boundary of a legally designated Natural River system.

To be in compliance with Parts 31, 301 and 303, the responsible party must complete the DEQ/United States Army Corps of Engineering (USACE) "Joint Permit Application" (JPA) package. The JPA covers permit requirements pursuant to State and Federal rules and regulations for construction activities where the land meets the water and including streams and wetlands. These types of areas are often referred to as the land/water interface.

The JPA is available electronically for on-line submittal through the Michigan Timely Application and Permit Service (MITAPS). Visit: www.michigan.gov/jointpermit for more information about MITAPS, to download or view the JPA.

If you have questions regarding completing the JPA, contact your local DEQ office. A DEQ office location map and staff contact information can be viewed at www.michigan.gov/deq.

Please note that a Part 91 permit, Soil Erosion and Sedimentation Control (see below) is usually required before constructing any roads or landings. Landowners or their designated representative should also note that a permit from the DNR, under Part 305, Natural Rivers, may also be required, if conducting forest management activities within one of the16 designated Natural River systems.

⚖ Soil Erosion and Sedimentation Control Regulations

Part 91, Soil Erosion and Sedimentation Control (SESC), of the Natural Resources and Environmental Protection Act, PA 451, 1994, as amended (NREPA), has the primary intent of protecting the waters of the State from the deposition of sediment and wind erosion as the result of earth change activities during construction. Specifically, a Part 91 permit is required for those activities involving earth changes that are one or more acres in size or within 500 feet of a lake or stream.

When enacted, Part 91 was considered legislation that was primarily applied to regulate construction activities to protect the waters of the State. Section 9115 (1) states a person engaged in the logging industry is not required to obtain a permit under this part. However, all earth changes associated with the activities listed in this section shall conform to the same standards as if they required a permit under this part. Generally, landings will not be an issue as their size can often be kept to under an acre. However, access roads and landings **outside** the logging

or harvest area in excess of an acre or that are within 500 feet of a lake or stream require a permit.

Part 91 permit applications are obtained by contacting your local county enforcing agency (CEA). Such agencies may include the county drain commissioner's office, county building department, or county conservation district office. In some counties, there are multiple municipal enforcing agencies (MEA) that can issue Part 91 permits. To locate the appropriate CEA or MEA for the county you are interested in through the internet, visit: http://www.deq.state.mi.us/sesca.

A public agency that has been designated by DEQ as an Authorized Public Agency (APA) does not need to obtain a Part 91 permit for earth change activities from a CEA or MEA but must comply with Part 91, follow approved procedures and maintain an APA status with training and other requirements. DNR, Michigan Department of Transportation and numerous county road commissions are Authorized Public Agencies.

Wetlands and Floodplains

Per Part 303, Wetlands Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), specified silvicultural and timber harvesting activities are exempt from obtaining a wetlands permit. Construction or maintenance of forest roads, or temporary roads for moving forestry equipment, is exempt, providing the roads are constructed and maintained in a manner to assure that any adverse effect on the wetland will be otherwise minimized. However, grading or "land balancing" in wetlands associated with a forestry operation requires a permit because it is dredging and filling. It should also be noted that a permit is required for tree clearing if the purpose of the activity is to subject the land to a use to which it was not previously subject (i.e., preparation for development). In sum, typical forestry operations in wetlands including standard cultivation activities and even plantations are exempt, but the exemption does not permit land alterations to convert wetlands.

Any construction, fill or alteration of a floodplain of a river, stream, or drain which has a drainage area greater than or equal to 2 square miles, will require a State floodplain permit under Part 31, Water Resources Protection, of the Environmental Protection Act, 1994 PA 451, as amended (NREPA). With respect to forest management, such projects include placement of fill for road construction, or installing a culvert or

bridge. The applicant uses the JPA package (described in the previous stream crossings section) to obtain a floodplain permit.

Other Laws Affecting Forest Management

Michigan's forests are not only valued for their production of wood products, but also because they contain vital cultural and archaeological resources. They also provide critical habitat for rare, threatened and endangered plants and animals.

With respect to cultural and archaeological resource protection, Michigan's Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), contains legislation that reserves for the State the exclusive right and privilege of exploring, surveying, excavating and regulating through its authorized officers, agents and employees, all aboriginal records and other antiquities, including mounds, earthworks, forts, burial and village sites, mines or other relics, and abandoned property of historical or recreational value found upon or within any of the lands owned by or under control of the State.

An archaeological site is a place where remnants of mankind's past are sealed in the soil. The scientific and historic value of a well-preserved archaeological site is far greater than the value of the artifacts found there. The exact location of artifacts in the ground, their spatial relationships to other artifacts, to soil composition, to bits of charcoal, bone or chemically distinct areas of soil are all clues that archaeologists can translate into a more complete picture of the past. Archaeological sites also preserve items that are fragile and can be easily recognized only by a specialist. These include tiny fragments of burned plant remains, pollen, charcoal suitable for radiocarbon dating, deteriorated bits of pottery or leather, and the traces left in the soil by hearth fires, refuse pits or privies.

Proper management of archaeological sites is guided by one overriding principle: avoid disturbing the soil. The following guidance cover some common situations that land managers should keep in mind:

1. Grading or bulldozing of the site should be avoided whenever possible.
2. Pulling stumps, planting trees, laying utility lines and other activities requiring excavation of soil should be avoided.
3. Activities that will involve only the surface of the site, such as lawn seeding or laying woodchip trails, are acceptable.

4. Erosion control measures, if done carefully, will benefit the site, as long as soil disturbance is minimized.
5. In the case of historic foundation walls and similar structures, careful trimming of saplings and other vegetation growing within them will aid preservation of the site. In such cases, the roots should be left in place because attempts to remove them can damage fragile masonry.
6. Vandalism is a common cause of damage to sites. Sites in isolated locations should not be marked in any way. Unless a site is under responsible, direct care, anonymity is the best protection. In such cases, the site's exact location should be known only to the land manager or others directly responsible for the site. Sites in public view that can be checked regularly can be marked and interpreted for the public. In these cases, the combination of public inspection and public awareness minimizes the chances of serious damage to the site. An example of an isolated location is a forest accessible only by a two-track road.

Sand Dunes Protection and Management, Part 353 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA) regulates use in 'critical sand dune' areas including developmental, silvicultural and recreational activities. Information on the location of critical dune areas as well as the permitting agencies (DEQ or a local unit of government) can be found the DEQ website, www.michigan.gov/deqland.

In Michigan, threatened and endangered species are protected on both public and private lands. Endangered Species Protection, Part 365 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA) states an individual may not harm or take threatened and endangered species. When it is uncertain if a threatened or endangered species occupies the area to be harvested, or timber harvest impacts are unclear, the landowner or other responsible party should contact the DNR and request an environmental review. Removing uncertainty may reduce impacts and clarify appropriate operational procedures. The process can be initiated in two ways: 1) The DNR Wildlife staff receives a written request for review of a proposed project; or 2) a proposed project site can be reviewed on the Endangered Species Assessment website, www.mcgi.state.mi.us/esa/. In both cases, the location of the proposed project is compared with Michigan Natural Features Inventory (MNFI) data for known locations of endangered or threatened species and other natural features (special concern species, exemplary natural communities, and geologic features).

If a threatened or endangered species will be taken or harmed, an Endangered Species Permit, issued by the DNR, is required.

Those using the Endangered Species Assessment website can perform their own preliminary review and request a formal review (if necessary) directly on the website. Others can request an environmental review by sending a written request with the following information:

- Brief description of the proposed project
- Brief description of the location (town, range, section, county)
- What is there now (buildings, type of vegetation, recent disturbance)
- Map of location clearly marked with major roads for reference

A written response to a formal review request may take approximately 3 to 4 weeks. Reviews are processed in the order they are received. **The DNR cannot give out location data or conduct reviews over the phone; all requests must be received in writing**. There is no charge for this service. Mail requests to:

ENDANGERED SPECIES SPECIALIST
WILDLIFE DIVISION
MICHIGAN DEPARTMENT OF NATURAL RESOURCES
PO BOX 30444
LANSING MI 48909-7944
PHONE: 517-373-1263; FAX: 517-373-6705

3. FUELS, LUBRICANTS AND SPILLS

Chemical releases in Michigan are potentially reportable under one or more of twenty-six different State and Federal regulations. Determining which regulations apply to a specific release can be an overwhelming task. The "Release Notification Requirements in Michigan" table, compiled by the DEQ Environmental Science and Services Division, is designed to help owners and operators of facilities in Michigan, including vehicles and farms, determine their potential notification and reporting requirements, in the event of a chemical release. Check your permits, licenses, registrations, pollution prevention plans, and local ordinances for additional release reporting requirements. Visit the DEQ website at www.michigan.gov/deq and type “spill/release reporting” in the Search field.

The remote locations that are typical of most forestry operations result in many on-site maintenance activities. The equipment operator must constantly guard against spills of fuels, lubricants or other toxic 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.

Common sense, care, proper planning, and the anticipation of problems that may occur can eliminate or reduce potential water quality problems arising from spills.

Spill Prevention Best Management Practices

The following BMPs/precautions should be adopted for all activities requiring equipment operations:

- A contingency plan for accidental spills should be developed for every operation. This may be a generic plan with customized conditions for particular sites or jobs. Also, at least one spill kit, as recommended by DEQ, should be available on every job site.

- Provide receptacles in maintenance areas or in 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 bodies and drainage structures and at locations where a potential spill can be contained and properly treated. This will minimize the chance of surface water or groundwater contamination. Where a spill does contaminate soil, the contaminated material must be removed from the site and deposited at a facility licensed for that purpose.

- 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. Maintenance activity should not occur while equipment is located in water bodies, flood plains or wetlands.

- 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.

Spills

When spills of fuels or lubricants do occur, if the spill is large, an emergency situation may exist. An operator or any member of a logging crew must be prepared to take action to keep the spill from spreading and entering the water courses on the site. Any emergency spill should be reported to the **Pollution Emergency Alerting System (PEAS) at (800) 292-4706**. Additional contacts may be necessary or desirable, depending on the location and spill situation. It is recommended that each logging site have a completed Spill Response Plan that is available to all members of the crew.

4. TIMBER HARVEST PLANNING

Timber harvesting includes felling, forwarding, sorting, loading and hauling of timber products. Harvest operations require haul roads, log landings and skid trails to be developed and maintained. Timber harvesting, and other silvicultural treatments such as tree planting, soil scarification, and herbicide application, are vital and integral parts of management of forest resources. The treatments contribute to a healthy and vigorous forest. These practices perpetuate the land use which has the greatest potential for protecting surface water quality.

Pre-Harvest Planning

Pre-harvest planning may help minimize potential soil and water quality problems. Pre-harvest planning is the collection of information about the area to be harvested and the use of this information to determine the best time and method to harvest while protecting water and site quality. The planning includes deciding where current and new roads and skid trails are located. Consideration should be given to water quality protection measures and appropriate BMPs. Large forest operations tend to use checklists and timber sale proposal specifications which address these.

Pre-harvest planning helps the logger or forest resource professional in developing a timber sale contract that protects water quality, as well as soil and site productivity. This may include a map (may not be drawn to a specific scale) identifying such concerns as:

- Property boundaries
- Streams and drainage areas
- Soils
- Slope
- Approximation of proposed main haul road and skid trail locations
- Potential log landings
- Stream crossings
- Riparian management zone designations
- Vernal pools or open water wetlands

Figure 1 is an example of a harvest site map with BMPs mapped out accordingly. Note that this is an example only. The use of topographical maps may be of use in forested areas having variable and sloping terrain.

A narrative may also be part of the planning in which road and trail specifications, along with amount and size of machinery for harvest and removal of timber products, are identified. Timing of harvest and timber sale contract conditions may be included as well.

Harvest Site Map

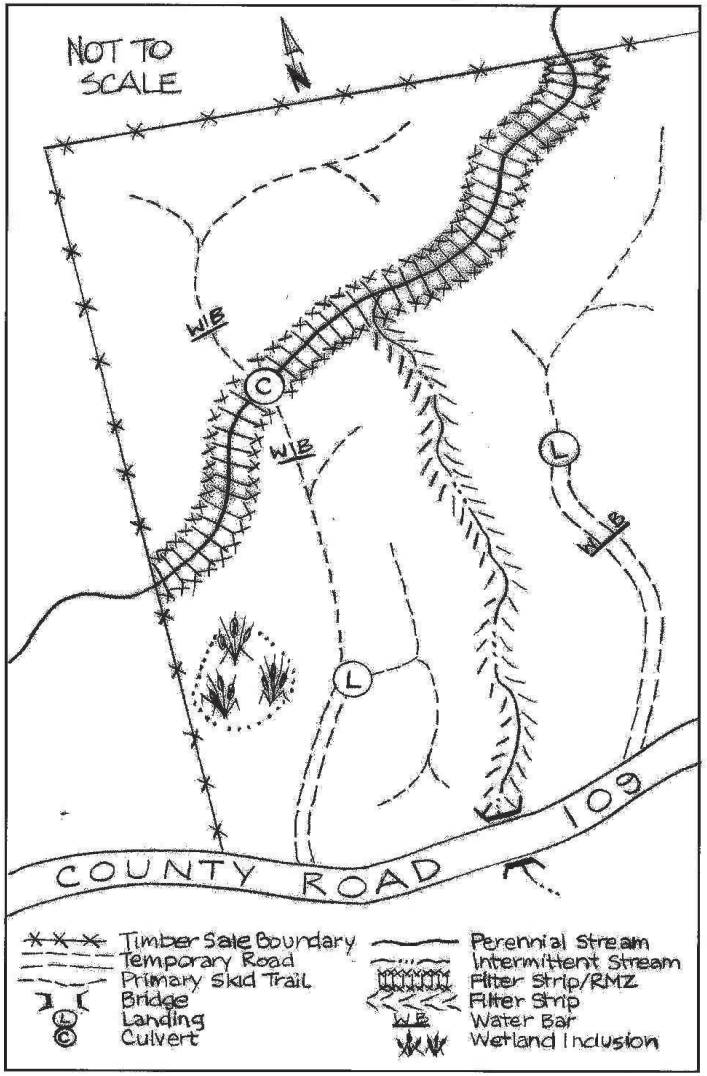

Figure 1. Pre-Harvest Site and BMP Plan Map

5. RIPARIAN MANAGEMENT ZONES (RMZs)

Riparian Management Zones (RMZs) are sometimes called buffer strips, filter strips, or streamside management areas or zones (see Figure 2). An RMZ occurs on both sides of perennial or intermittent streams and around the perimeter of bodies of open water (e.g. open water wetlands or lakes) where **extra precaution** is used in carrying out forest management practices including timber harvesting activities.

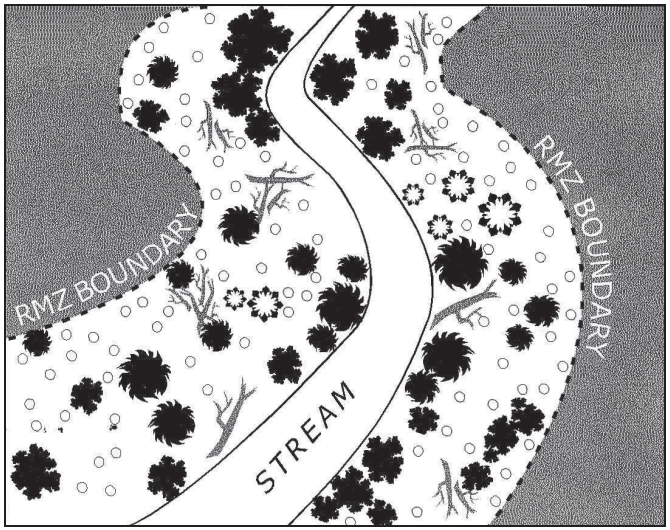

Figure 2. Example of a Riparian Management Zone

One of the purposes of a management zone is for water quality protection to provide an area of vegetation to interrupt water flow and to trap and filter out suspended sediments, nutrients, chemicals, and other polluting agents before they reach the body of water. An RMZ also provides shade to small streams, thus reducing thermal pollution.

The part of the zone nearest the stream bank can also provide an important contribution to the aquatic food chain. As trees die within the RMZ, all or portions of them may fall over into the adjacent stream. This dead material provides aquatic habitat known as large woody structure (LWS). Naturally occurring LWS in lakes and streams provides essential areas of shaded cover for fish, amphibians and aquatic insects and can

provide important isolated platforms for reptiles and small mammals. In developing a management plan for the RMZ, consider leaving some late successional trees (both coniferous and deciduous) within the RMZ that have the potential to provide LWS to a lake or stream.

Forest Management Activities within the Riparian Management Zone

Michigan's BMPs do allow for forest management activities within the RMZ. These include equipment operation and timber harvesting. The key is ensuring the water quality protection function of the RMZ is maintained (see Section "RMZ Water Quality Function Factors") throughout and after the harvesting operation.

The RMZs should be maintained along all perennial and intermittent streams, lakes or ponds where nearby management activities result in surface/soil disturbance, earth changes and where erosion and sediment transport occur during rain events. An example of this is a newly constructed forest road where the base consists entirely of compacted soil and the road begins eroding after a rain event.

The RMZs are critical to watersheds, wildlife, fish, trees, and people for many different reasons. Adequate vegetation in a RMZ helps filter and trap pollutants such as sediment, excess nutrients, and other contaminants before they reach surface waters. Excessive disturbance of the forest floor within the RMZ minimizes its ability to prevent nonpoint source pollutants from reaching a stream or other water body. In fact, such disturbance might lead to the transport of sediment directly from the RMZ to the water body adjacent to it.

Site Specific Factors to Consider

Landowners considering forest practices in or near a RMZ must plan carefully to assure that the water quality functions of the RMZ are maintained. Those unsure of the water quality impacts of a planned activity should either seek the advice and assistance of foresters or other natural resource professionals familiar with RMZ functions, or leave the RMZ undisturbed. The following are site-specific factors to consider prior to harvesting or conducting other management activities in the RMZ:

- Water body characteristics.
  - DNR designated trout stream
    - Greater than 50 feet in width (typical beaver dam building activity not a concern on these streams).

    - Less than 50 feet in width (typical beaver dam building activity is a concern on these streams and aspen regeneration within 300 feet of the stream may be a concern).
- Legally Designated Natural River (There are specific rules and regulations for each designated Natural River system).
- Slope
- Soils
- Aesthetics
- Existing vegetation
- Shade requirements to maintain water temperature
- Time of year activity is scheduled to occur
- Availability of large woody structure for the adjacent water body
- Recent precipitation
- Extent of soil saturation

Riparian Management Zone Water Quality Function Factors

The water quality function of RMZs can be maintained by using the following specifications:

- When setting up a timber sale, make sure the forester or logger establishes a minimum RMZ. Michigan's standard RMZ minimum width is 100 feet or 30 meters measured from the top of the bank of the lake or stream or the ordinary high water mark. The RMZ width should be increased as slope percentages increase above ten percent (see Table 1).

- Zone width may have to be increased along State designated "Natural Rivers" and federally designated "Wild and Scenic Rivers" as designated in their management plans.

- Minimize disturbance of the forest floor in the RMZ (a recommended goal is to have less than 10% of the soil disturbed).

- Harvesting/cutting specifications should be modified to retain a sufficient number of trees (60-80 basal area is often used as a benchmark) to maintain shading of streams and to leave a relatively stable and undisturbed forest floor (less than 10 percent bare soil exposure).

- Trees growing along the stream bank should not be cut.

- Do not leave felled trees, limbs or tops in streams and open water wetlands; spread them on the ground, unless corrective action would create more damage to the site or stream. This biomass is considered a source of “unnatural” organic debris that impacts aquatic habitat, for example, by lowering levels of dissolved oxygen required to maintain healthy coldwater fisheries.

- Limbs and tops from trees that are cut within the RMZ should be left on the ground in the RMZ.

- Felled trees, limbs and tops harvested outside the RMZ should not be placed within the RMZ.

- Locate haul roads outside of RMZs. Where a road must cross a stream, it should do so at right angles. A permit from DEQ to construct a stream crossing is required.

- Locate equipment storage and maintenance sites and landings outside all RMZs.

- Harvesting activities in the RMZ should minimize scarification and soil compaction. Skidding or dragging logs in the RMZ should be avoided. Skidders should not be operated in RMZs when soils are saturated, as the soil easily compacts and runoff is not easily absorbed by the soils in the RMZ. If cutting must occur in the RMZ, every effort should be used to remove timber from the zone with techniques such as tracked equipment with knuckleboom cranes (see Figure 3) to ensure equipment is not negatively impacting the RMZ’s soil base. Even if the soil is not scarified, compaction will decrease the ability of the soil to absorb runoff.

- All roads, cuts and fills in the RMZ must be stabilized. Use appropriate seeding and mulching procedures (see Appendix E). Energy dissipaters (e.g. rock ranging from 3-12 inches in diameter) should be installed at inlets and outlets of cross-drainage culverts located underneath roads approaching a stream.

- Drainage structures such as culverts, diversion ditches, conveyor belt water bars, and broad-based dips should be installed according to BMP specifications (see section 7) prior to roads and primary skid trails entering the boundary of a RMZ.

Figure 3. An Example of a Knuckleboom Harvester.

(Note the boom allows for removal of timber from a RMZ with little soil disturbance.)

Riparian Management Zone Widths

Michigan's standard RMZ minimum width is 100 feet or 30 meters measured from the top of the bank or the ordinary high water mark of a lake or each side of a stream. This is the zone in which extra precaution should be used in harvesting timber or for other forest management activities. It is generally the minimum distance needed to protect water and aquatic habitat quality when conducting forest management activities adjacent to a water body, especially if the activity provides a source of sediment (e.g. a dirt-based forest road). A wide range of riparian management zone widths (from less than 50 feet to over 500 feet) has been proposed in water quality research. If management objectives include protecting wildlife habitat or controlling beaver activity on smaller streams, widths larger than 100 feet may be appropriate. Activity within the RMZ is acceptable where there is little chance of significant soil disturbance, no chance of water sedimentation, and only select trees are being removed.

Table 1 illustrates the minimum recommended widths for RMZs based on slope. Note that these widths are for overland sheet flows only.

Nonpoint source pollutants transported via concentrated flows into a RMZ will usually require additional measures such as using nonwoven geotextile fabric overlain by riprap or large sized rock, ranging from 3-12 inches in diameter, for a width of 3 feet and a length of 5 feet (Michigan Department of Transportation, 2003).

When measuring for a proper width of a RMZ, take into account the natural variablility of the landscape and widen the RMZ accordingly. Slope can be estimated ocularly or calculated by several methods, including using a string and line level or through the services of a professional surveyor. Remember that it takes years for deposited sediment to be cleansed from a stream, so the landowner or the land manager should err on the side of caution when establishing the width of a RMZ.

Table 1. Minimum Riparian Management Zone Width Adjusted for Slope.

Slope of Land Above Water Body or Stream (%)	Minimum Width of Riparian Management Zone (Feet)
0-10	100
10-20	115
20-30	135
30-40	155
40-50	175
50 +	Timber removal is not advised due to the high potential for erosion and sediment transport.

The RMZ width shown in Table 1 may need to be increased where domestic water supply could be impacted.

In addition to slope influencing sedimentation, different soils or soil textures have differing amounts of susceptibility to erosion. Table 2 displays the susceptibility of different soil textures at the soil surface to erosion. When developing an effective RMZ, consider the soils near the lake or stream.

Table 2. Soil Erosion Susceptibility.

Surface Soil Texture	Susceptibility to Erosion *(1=highest)*
Silt, silt loam, loam, very fine sandy loam	1
Sandy clay loam, silty clay loam, clay loam	2
Clay, silty clay, sandy clay, very fine loamy sand	3
Sandy loams, loamy sands, sands	4

(Re-printed courtesy of the Minnesota Forest Resources Council.)

Designated Trout Streams and Management Within the Riparian Management Zone

Certain streams are designated by the DNR as "Trout Streams". For these designated streams, the DNR has the authority to require only lures or baits for fishing and may prescribe the size and number of fish that may be taken (Per Act 451, MCL Section 324.48701). The DNR Director's Order FO-210 lists all designated trout streams, and is available upon request (43 pages) from the DNR Fisheries Division (517-373-1280), or online at www.michigan.gov/dnr.

Excess erosion of sand sediment into streams is broadly regarded as a serious threat to the viability of trout streams. Research has demonstrated that relatively small increases in sand erosion into streams can greatly reduce spawning habitat and habitat for the food supply (e.g. caddis fly or mayfly larva). When topography is relatively flat, sediment can stay in a stream for several decades. A functional RMZ should be maintained to prevent sediment from reaching trout streams.

The Sustainable Soil and Water Quality Practices on Forest Land recommends generally using the DNR designated trout streams as a guide for additional protection with respect to RMZs. Trout are sensitive to changes in habitat requirements and require a clean gravel bed, along with large woody structure and cool water temperatures to sustain their population. Because of these narrow population sustaining requirements, forest management activities may be different in a trout stream RMZ than what is "typical" practice for a non-designated trout stream RMZ. This may be tempered by considerations of other factors, such as management for species of greatest conservation need as identified in the DNR's Wildlife Action Plan.

Designated Trout Stream Width and RMZ Management

In the section "Site Specific Factors to Consider**",** a distinction is made between DNR- designated trout streams greater or less than 50 feet in width. The reason for this distinction is that beaver do not generally build beaver dams on streams greater than 50 feet in width. In contrast, designated trout streams smaller than 50 feet in width have a higher occurrence of beaver dam construction when a beaver population's food and construction supply (e.g. aspen) is within 300 feet of the stream. Beaver dams are considered a serious source of damage to these trout streams. Beaver dams will increase stream temperatures and prevent free passage of trout and anadromous fish species. Consequently, the dammed up stream will not support a viable population of trout or other coldwater fish species.

If the objective is to minimize beaver impacts on designated trout streams smaller than 50 feet in width, forest managers or landowners are encouraged to consider widening the RMZ beyond the standard 100 feet and manage this RMZ to discourage aspen regeneration within it. By widening the RMZ to 300 feet, beaver habitat will be reduced and related stream impacts can be minimimized, but this needs to be evaluated on a case-by-case basis as other site conditions and values may come in to play; for example, riparian zones are key habitats for terrestrial species of concern such as woodcock. Possible management options within an RMZ that favor trout and associated coldwater aquatic habitat are: 1) leaving large super-canopy trees within 50 feet of the stream bank as a source of shade and large woody structure (wood that is four inches or greater in diameter), 2) managing to promote the health and vigor of longer-lived coniferous (e.g. white pine and hemlock) and deciduous (e.g. sugar maple) species, and 3) only harvesting trees that are 50 feet away from the stream and that can be transported out of the RMZ without disturbing the soil (see Figure 3 as an example of a piece of harvesting equipment that might be employed).

For designated trout streams greater than 50 feet in width, implement the RMZ widths (e.g. starting with a minimum width of 100 feet) as stated in table 1 and design an RMZ management plan which considers site specific factors as well as water quality (pages 18-21).

Management for Shade Intolerant Species within the RMZ

In general, landowners, loggers and land managers should consider if the amount of timber harvest removal is compatible with the ecology of the stream (e.g. warmwater or coldwater), and if the DNR has the

adjacent stream listed as a designated trout stream. For streams that are not designated for trout, landowners may consider that managing for shade intolerant species, such as aspen, within an RMZ may be desirable to meet wildlife management goals.

Warmwater rivers or streams may be appropriate for this type of management. With the help of a forester, creative silvicultural and harvesting methods can be employed to allow for multiple goals. While large scale clearcuts should be avoided in the RMZ, it is possible to regenerate species like aspen using other harvesting methods. For example, small clearcuts ¼ to ½ acre in size, spaced appropriately throughout the RMZ, may be an option. Cuts like these mimic natural disturbances such as blowdowns.

Another example is to leave a higher residual basal area (BA) in the RMZ than what would occur outside the RMZ. In contrast to traditional clearcuts outside of the RMZ, leaving 20 to 25 BA would still provide enough sunlight to promote regeneration of aspen or other shade intolerant species. Also consider leaving a higher basal area (e.g. 60-80 BA) or clusters of mature longer-lived trees within 25 to 50 feet of the stream bank for shade, soil and bank stabilization and a source of large woody structure. Refer to Appendix A-Glossary for the definition of basal area.

Natural River Regulations

There are currently 16 legally designated Natural River Systems in Michigan. Part 305, Natural Rivers, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), *provides the DNR with the legal authority for managing these river systems and regulating all land management or construction activities occurring on these river systems*. Note that in all the management plans, the term “vegetative buffer strip” is used instead of the term Riparian Management Zone. However, for the purposes of this document, the term “RMZ” will be used to avoid confusing the reader.

All forest management activities within a legally designated Natural River RMZ are regulated. A permit is required before any activities can take place. A Natural River management plan has been developed for each designated river. Each plan includes use and development standards for private and public lands. The State is required to manage its lands and programs in accordance with the approved Natural River plan. Each state designated Natural River has it own standards

regarding RMZs (buffer widths) for both private and public ownerships (see Appendices F and G).

The minimum RMZ for each Natural River is codified in its approved plan and promulgated rules. In general, the RMZ requirements are wider for public lands than private lands. For example, the Au Sable Natural River Management Plan has a 150-foot RMZ for both mainstreams and tributaries. On private lands, the management plan has a minimum 75-foot RMZ on the mainstream and 50-foot RMZ on tributaries.

In general, as the Natural Rivers designation program progressed through the years, more and more research indicated that wider RMZs were better for the health of the stream. On public lands, RMZs may range from 50 feet (the Flat River in the southern lower peninsula) to 200 feet wide (on the Fox River) on each side of the river or tributary. Private land RMZs also vary, but are statutorily limited to a width of no more than 100 feet on each side of the river. Dead, diseased, unsafe and fallen trees, as well as noxious plants, can be removed within the RMZ.

For more detailed information and the listing and location of all 16 Natural Rivers, visit the DNR Natural Rivers website at www.michigan.gov/dnrnaturalrivers.

In addition, all public agencies must comply with the Rules for Utilities and Publicly Provided Facilities, adopted as mandated by Part 305. These rules include standards related to road/stream crossings, erosion control, management of vegetation in utility corridors and others.

Natural River plans typically include standards related to public access site development, campgrounds, land and stream alteration, motorized vehicle use and vegetative buffer requirements. Thirteen of the 16 rivers also have State zoning rules based on the plans that contain private land development standards for residential development and limited commercial activity such as campgrounds, canoe liveries and rental cabins. Most rivers also have local zoning ordinances in effect based on Natural River plans.

The RMZs are maintained to provide fisheries and wildlife habitat, filter runoff, provide shade to maintain cool water temperatures, prevent streambank erosion and sedimentation of the Natural River system, screen new developments, and maintain the aesthetic qualities of the Natural River system. Under a permit issued by the DNR, trees and shrubs may be selectively pruned or thinned for timber harvest, habitat improvement or to maintain public utility facilities. Clearcutting is not usually permitted within the RMZ.

Other development standards for public land are designed to maintain the natural character of the river corridor, limit the impacts of recreational use and help prevent resource damage. New campgrounds have development standards such as setbacks for campsites and associated structures. New access site standards may restrict sites to “walk-in” only and include setbacks for parking areas. Within 400 feet of the river, motorized vehicle use is usually restricted to designated public roads and access roads to permitted areas. Land alteration is prohibited in areas of high groundwater.

Wild and Scenic Rivers

The Wild and Scenic Rivers Act, (Pub. L. 90-542 as amended; 16 U.S.C. 1271-1287) is legislation enacted by Congress and establishes federal protection for designated free-flowing rivers throughout the country. They are designated as “Wild and Scenic Rivers.” This designation regulates the management and control of development on these river systems.
In Michigan, there are 16 Wild and Scenic River systems. The management and regulations for these river systems occur strictly within the administrative boundaries of Michigan’s three National Forests. Each component of the Wild and Scenic rivers system is administered to protect and enhance a variety of values, and certain uses of a designated river are limited. Emphasis is given to protecting its aesthetic, scenic, historic, archaeological, and scientific features and values.

For more information, such as the listing and location of those river systems within Michigan, visit the website: http://www.nps.gov/ncrc/portals/rivers/index.htm.

Vernal Pools, Seeps, and Intermittent Streams

Vernal pools are small (usually less than an acre), temporary bodies of water in depressions that lack perennial inlet or outlet streams and have no permanent fish populations. They appear after snow melt and gradually dry up as the summer progresses. During the wettest seasons of the year, vernal pools are small bodies of water, while in dry seasons they may only be recognizable as an isolated depression on the forest floor. This unique forest feature provides habitat for a variety of aquatic invertebrates, a breeding and feeding site for many amphibians and reptiles, an attractive feeding and resting spot for songbirds, a source of food and water for many mammals, and unique microhabitats for plants.

Some animals will live their entire life cycle in a vernal pool. Fairy shrimp and clam shrimp are suited to a watery environment that varies widely in temperature and dries up annually. They produce thick shelled eggs that survive in the dried up pool until the next spring’s thaw when they hatch in the newly hydrated pool. Therefore, when harvesting occurs, there should be no disturbance to the vernal pool depression. All equipment, trees and tops should be kept out of this area. Within 100 feet or at least one tree length of the pool, it is especially important to avoid deep ruts which can interfere with the movement of salamanders to and from the pools. Equipment should generally only be used when the soil is in a dry or frozen condition to keep rutting to a minimum in this area. Timber harvesting can occur in the area, but the canopy closure should not be reduced to less than 70% to minimize the affect of sun and wind.

A seep, also called a spring seep or just a spring, is a permanent or intermittent discharge of water that emerges from the ground and flows across the soil surface without defined bed and banks. The limits of the seep are demarked by the extent of surface water, water-stained leaves, or other signs of hydrology. Avoid soil and leaf litter disturbance within the known area of the surface water. Limit harvest activity to dry or frozen conditions, when possible.

Intermittent streams have definable beds and banks, but water does not flow through the channel all of the time. Crossing an intermittent stream requires a permit. In contrast, ephemeral streams only occasionally have water flowing and do not typically have defined beds and banks. Use of motorized equipment should be limited near the streams and forest floor disturbance should be minimized. Avoid these areas when laying out skid trails and remove felled tree tops. It is strongly encouraged that skid trails, roads, site-preparation, and other soil-disturbing activities be minimized in the ephemeral streams to avoid erosion and sedimentation of stormwater runoff that will flow downstream into streams or other water bodies.

Fens and Bogs

Fens are wetlands that receive much of their water and nutrients from groundwater rich calcium and magnesium carbonates. They accumulate peat and have relatively high pH and nutrient levels. As a result, fens support a high diversity of grasses, wildflowers, and insects. The high water table, in combination with periodic disturbances such as beavers and seasonal fire, discourages growth of trees and shrubs within fens.

In contrast to fens, bogs are acidic, nutrient poor wetlands that receive most or all of their water from precipitation. They often contain rare, threatened or endangered plants or animals. They also do not tend to contain much in the way of commercially desirable trees.

Harvest activity immediately adjacent to fens or bogs may encounter weak soils that are highly susceptible to rutting. When timber harvesting occurs near fens or bogs, ground disturbance within the wetland area should be avoided. To prevent sedimentation or excessive nutrient delivery into a fen or bog, timber harvests should be avoided along slopes immediately above and leading into a fen or bog.

6. FOREST ROADS

Forest roads are that part of a forest land road system, either temporary or permanent, designed and maintained for the transportation of timber products and often maintained and used for access for resource protection and recreation activities. They are usually minimum standard roads, i.e., single lane with turnouts, surfaced with locally available materials or just the underlying bare soil that is compacted and graded after the vegetative cover is removed. Commercially processed gravel underlain by geotextile is good for use in critical erosion areas. Properly laid, constructed and maintained forest roads provide safe operations over longer periods at desirable vehicle speed. Operating and maintenance costs, as well as sedimentation runoff, are reduced because of proper construction (this includes installation of BMPs), placement and regular maintenance.

Planning and Forest Road Placement

Use of Soil Surveys

When constructing new forest roads or upgrading old ones, knowing the soil types that exist where the road(s) will be placed can be essential to knowing how to construct the road itself to minimize soil erosion. Most of the counties in Michigan have completed soil surveys.

Contact the local Conservation District, Natural Resource Conservation Service, or the County Extension Office for information about obtaining or using a soil survey. The description of a particular soil covers the nature and limitations of the soils, erosion hazard, rock outcrops, construction, and engineering properties of each soil series. Please note that these surveys are general guides and actual soil conditions should be checked in the field.

Other Factors in Road Placement

Reconnaissance of the property generally should be done before constructing a road or roads. This consists of looking at the property with a road plan in mind and developing an idea of where roads should or should not be built. Consider the following points during road reconnaissance:

- Remember to acquire a Part 91 permit, if outside of the sale boundary.
- Terminal Points – Where is the system going to start and end? Where is the best access from public roads? Where are the landings going to be?
- Grades – Roads designed with a slope of 10% or less are usually the easiest to maintain. If any segments exceed 10%, they should not exceed 300 feet.
- Topography – Roads on moderate side hills are easiest to build and drain.
- Obstacles – Note springs, seeps, wetlands, poor drainage areas, ledges, and rocky areas. Design the road system to go around them. If one is encountered after work has begun, move the road away from it.
- Distance from streams – The goal is to avoid placing a road within the RMZ, unless it is for the purposes of crossing a stream.
- Stream crossings – Cross at a 90 degree angle, if possible; if not, follow the stream contour. Approach the stream at as gentle a slope as possible. Keep the number of crossings to a minimum.
- Avoid placing roads in valleys, if possible.
- Old roads – Consider using existing or abandoned roads or trails to lessen soil disturbance. However, if they are located in areas where road drainage is difficult or the potential for erosion or rutting is high, it is better to construct a new road to the construction specifications stated in this manual.

- Size and duration of a timber sale and the anticipated season of harvest.

- The location and potential impact on flood plains and wetlands.

When planning forest roads to the harvest area, sketch the tentative location of the roads, landings, major skid trails, and the approximate RMZs on the plan map. An enlarged topographical map of where forest harvesting is to occur may be helpful.

Planning on paper helps to pinpoint potential problems, to develop alternative routes, and to consider what erosion and sedimentation control measures are necessary. Have RMZs identified prior to road placement to prevent locating roads or major skid trails in these sensitive areas.

Reducing Water Volume and Velocity on the Forest Road System

The first priority for constructing a road system is to keep the road surface as free of water as possible. Surface water running over exposed soil builds up momentum, as the slope and distance increase. The running water picks up soil particles then transports them down hill, causing soil erosion. Road drainage is the single most important factor in keeping the road passable and in minimizing erosion and sedimentation.

Various structures for water control and erosion control are discussed in the section, *Water Control Devices and Forest Roads*. Construct roads on side hills for good cross-drainage, while avoiding seeps, springs, and swampy areas. If a stream, spring, or seep cannot be avoided, plan to use proper water control structures (see pages 37-43).

The landowner and the person planning the road system should walk the proposed route of the road system and decide on matters affecting the owner's objectives and construction costs, while striving to preserve water quality and wetlands.

Road Grades

A road grade of 2% to 10% is desirable. A hand level should be used to avoid problem areas and maintain the desired grade of the road. Grade

and slope are expressed as the amount of vertical rise, divided by the horizontal distance traveled, multiplied by 100. Check the grade frequently with the hand level. A single stretch that is too steep or a flat area that will not drain may result in road erosion. Where the terrain is relatively flat, the person laying out the road should strive to maintain a minimum 2% slope to maintain adequate drainage of runoff. Also, roads in low topography areas should be crowned (as shown in Figure 4), to allow for water to drain off the road, to lessen the chance of rutting and ponding.

Where absolutely necessary, grades of 15% to 20% may be used for short distances, (i.e., less than 300 feet). Where a steep grade is necessary, at least 300 feet of road above and below should be less than 10% grade, to reduce the amount and velocity of water on the steep area. On those portions of the road with such steep grades, special surfacing such as 3 inches of gravel may be necessary to avoid erosion and rutting.

BMP Construction Specifications for Protection of Water Quality

According to Environmental Protection Agency (EPA) estimates (EPA, 1999), over 90% of the sediment entering forested streams comes from the forest road system. Therefore, the entire road system should be designed to the best standards possible before any road construction begins. This process may take more time, but the road system will be more efficient, less costly, and easier to maintain, and ensure minimum negative impact on water quality.

Study the area, noting the lay of the land. Pay particular attention to steep slopes, flat areas, streams, spring seeps, boulders, rock outcrops, and other potential obstacles. Roads built on south-facing slopes tend to stay drier than those on north-facing slopes. Be sure to look at these problem areas during the walk-through of the area.

- The key to constructing a good “pro-water quality” road system is to have the entire road system follow the contour of the land and keep road grades consistently between 2% to 10%.

- Construct roads to break or change grade frequently. This will result in less erosion than roads that have long, straight continuous gradients.

- Gradients up to 20% are permissible for distances up to 300 feet.

- On soils with severe erosion hazard (see Table 2), grade should be 8% or less. Grades up to 12% are acceptable, if the length of this section is less than 150 feet.

- Water diversion by cross drainage culverts (interception of surface water on the road, up slope from the top of steep slopes) is often needed to keep excess water off the steeper grades.

- Cross all water courses as close to a right angle to the stream as possible. Size structures so that stream flow is not impeded, and in keeping with good drainage practices.

- Roads approaching stream crossings should have reduced gradients to disperse surface water at least 50 feet from the watercourse.

- Roads should be located (with the exception of stream crossings) a minimum distance of 100 feet from a lake or stream. Stabilize stream bank approaches with rock or gravel.

- Outslope (see Figure 4) the entire width of the road where road gradients will permit.

- As a safety precaution, inslope the road toward the bank on sharp turns, road gradients of 15% or greater, and on clay and/or slippery soils (see Figure 4).

- Where roads are insloped (see Figure 4), cross drain runoff 25 feet up-grade of any short stretches of road where gradients exceed 10%.

- Avoid locating roads on level ground, along ravine bottoms, or on a flood plain where drainage away from the roadway is difficult to establish.

- In areas having little or no slope, road drainage is often a problem. Crown these sections of road (see Figure 4) to get the water off and away from the roadway.

- During wet conditions, apply a layer of geotextile fabric covered with 3 inch crushed rock or coarse aggregate at a depth of at least 3 inches (6 inches is optimal), at least 50 feet before reaching the highway.

- Provide a minimum essential width of 12 to 14 feet for a single track road. Increase width as necessary at curves and turnouts. Note that logging trucks used for transporting wood chips may need road widths greater than 14 feet to operate safely and properly. Consider if trimming along the road is necessary and appropriate.

- Road-bank cuts should be sloped and seeded to prevent erosion as necessary.

- Ensure good road drainage with properly constructed and spaced turnouts, broad-based dips, and cross-drainage culverts. Construct turnouts so waterflows are dispersed and will not cut channels across buffer zones.

- Install riprap or rock having a range of 3 to 12 inches in diameter, with a minimum length of 3 feet (MDOT, 2003) at the outlets of cross-drainage culverts to slow the velocity and diminish the erosive force of these channelized flows. Channelized flows coming from cross drainings are known to have enough output velocity and volume to transport sediment across an entire RMZ. Hence, the need for energy dissipating rock at a culvert outlet.

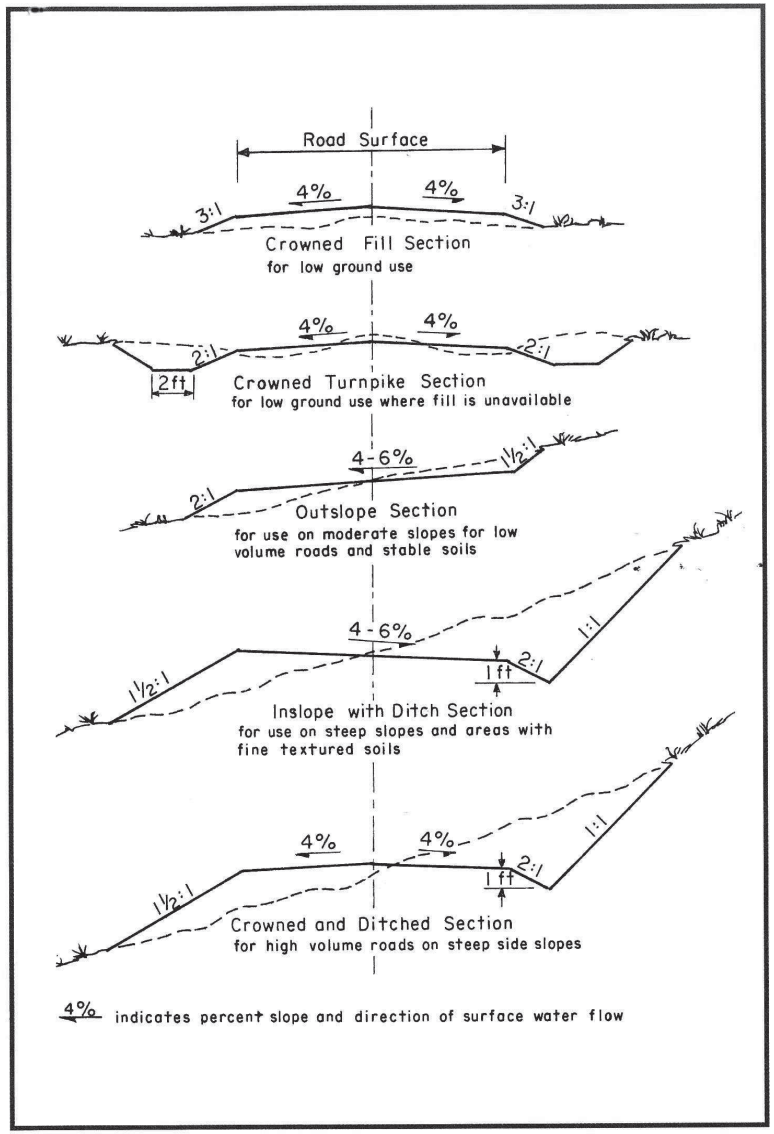

Figure 4. BMP Construction Road Techniques Based on Slope and Soils.
(Re-printed courtesy of the United States Forest Service)

Winter Roads

Winter roads are often used during the harvesting of forested wetland areas. They provide access during frozen ground conditions for timber harvesting and other timber management activities. Properly constructed, winter roads are recognized as an important component of forest management.

- Consider using culverts or bridges to cross definite drainages where winter roads are to be used for several years. Note: a DEQ permit is required for crossing streams and most drainage areas.
- Ice bridges can provide acceptable temporary access across streams during winter. Ice bridges are made by pushing and packing snow into streams and applying water to freeze the snow. Their use is limited to winter under continuous freezing conditions. A permit from DEQ is necessary before an ice bridge crossing can be built. Generally, ice bridges are best used for streams with low flow rates, thick ice, or dry channels during winter. Ice bridges might not be appropriate on large water bodies or areas prone to high spring flows. PVC bundles may be an alternative to facilitate water flow; make sure to anchor one corner of the bundle.
- Place winter roads on level terrain where practical.
- Based on the conditions of your DEQ permit, you may have to remove any culverts and bridges placed in the stream or other drainage way before spring thaw.

Road Management Measures on Active Sales for Permanent and Temporary Roads

- Avoid using roads for timber hauling or heavy traffic during wet or thaw periods on roads not designed and constructed for these conditions.

- Evaluate the future need for a road and close roads that will not be needed. Leave closed roads and drainage channels in a stable condition to withstand storms.
- Remove all drainage crossings such as cross-drainage culverts from temporary roads.
- Following completion of harvesting, close and stabilize temporary spur roads and seasonal roads to control and direct water away from the roadway. Remove all temporary stream crossings including any fill material.
- Inspect roads at regular intervals to determine the need for structural maintenance. Perform maintenance when conditions warrant, including cleaning and replacement of deteriorated structures and erosion and sedimentation control structures. This may include re-grading and seeding and mulching of roads no longer required for access. In certain cases, stabilize slopes or road fills where necessary to maintain structural integrity of the road.
- Perform maintenance activities such as dust abatement, so that chemical contaminants or pollutants are not introduced into surface waters, to the extent practical.
- Properly maintain permanent stream crossings and associated fills and approaches to reduce the likelihood that: (a) the stream overflow will divert onto roads, and (b) fill erosion will occur, if the drainage structures become obstructed.
- After significant rain events, look for possible problems and schedule corrective work as needed.
- Keep roadway and water control structures free of windfalls, logging debris and other obstructions.
- Ensure the free flow of water in the road drainage system, especially during logging operations.
- For permanent roads used during logging operations, periodically grade the road surface to reshape it so that it sheds water. Water should be able to freely flow off the road after grading.
- Fill in ruts and holes when they develop, as necessary.

Road Closure and Retirement

To protect soil and water resources, access roads should be closed to vehicular traffic, unless the forest landowner has other management objectives. This can be done on a seasonal or semi-permanent basis. The reduction of traffic and associated maintenance work will mean a significant reduction in cost, as well as reduction in the source of erosion and sedimentation impacts on the water resource.

When several years between major treatment activities are anticipated, roads should be retired and closed. This involves using temporary soil stabilization materials and revegetating the road (see Appendix E for information regarding the proper methods to stabilize and revegetate roads and other areas having bare soil). Any road(s) no longer required for forest operation use or access should be closed and retired. If the newly or upgraded roads resulted in disturbing one or more acres of soil, or built within 500 feet of a water body, Part 91 requirements are in effect. These mandate that the road be revegetated, regardless of slope or erosive potential.

For those portions having a grade greater than 10%, periodic inspection, especially after rain events, is necessary to ensure erosion is not occurring. The following actions are recommended to retire a section of road:

- Smooth and shape all road and landing surfaces to aid in draining water off the surface of the road or landing.
- If cross drainage culverts are removed, replace them with water bars (see Figures 6 or 7). If properly-sized culverts are covered by more than 2 feet of fill and inlets and outlets are effectively stabilized, leave them in place, if it is less costly than removing them. However, cross drainage culverts left in place will require an established and committed inspection and maintenance schedule to prevent culvert blockage.
- Remove all temporary stream crossings, as required by law.
- Use native seed mixtures wherever possible (refer to Appendix E for specific directions) for erosion control and revegetating retired roads and landings.

- Whenever temporary soil stabilization methods are required to protect recently applied grass seed, install silt fence (see Figure 5), as required.

- The use of brush, slash or wood chips mulch over grass seed may be used, as long as it ensures that the site is permanently revegetated.

- Block the entrance of the closed road using metal structures, large boulders or large tree stumps.

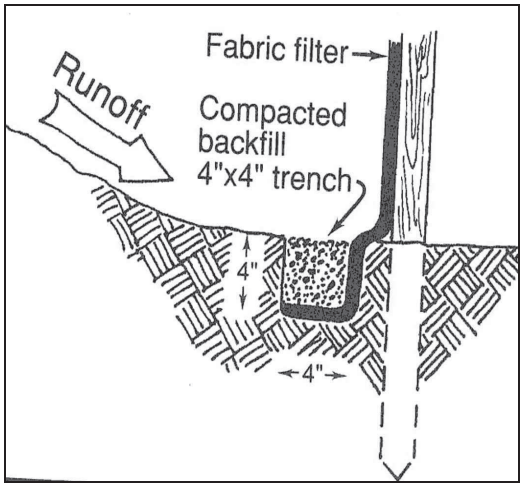

Figure 5. Proper Installation of a Silt Fence.

7. WATER DIVERSION DEVICES

Earth Berm Water Bars

Earth-berm water bars are narrow, earthen ridges built across roads or trails. They divert water off and away from roads or trails into vegetated areas before it causes erosion. When properly built, they prevent exposed soil from moving, protecting the area until grass vegetation is firmly established. Earth-berm water bars are recommended when forest management operations have ceased and the road is closed to further traffic.

- **Earth Berm Water Bar Installation Guidance.**

  - The first water bar should be placed at the top of the slope.

  - Where multiple water bars are required, properly space water bars according to Table 3.

  - As shown in Figure 6, the water bar should be placed at an angle of 30 to 45 degrees, relative to the road, to allow for runoff to drain from the inlet, through the trench, and into the adjacent forest floor or vegetation.

  - Dig a trench, 12 to 18 inches below the surface of the road or trail, and extend it beyond both sides of the road or trail to prevent runoff from bypassing the water bar.

  - The uphill end of the water bar should extend beyond the side ditch of the road and into an earth-berm to fully intercept any ditch flows.

  - The outflow end of the water bar is to be fully open and extended far enough beyond the edge of the road or trail to safely disperse runoff water onto the undisturbed forest floor.

  - After construction, seed and mulch the entire surface of the water bar to prevent erosion.

  - Earth berms and water bars are not meant to be used for active skid trails.

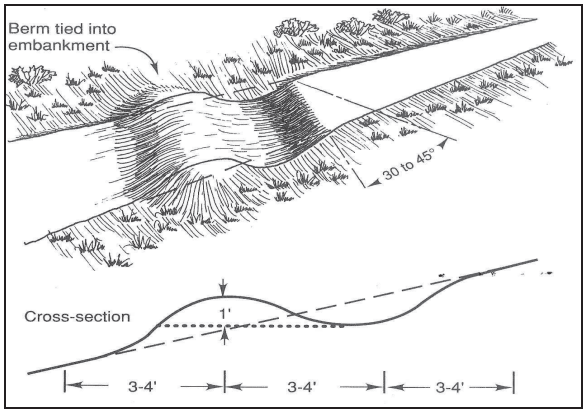

Figure 6. Earth Berm Water Bar Construction.

(Re-printed courtesy of the Wisconsin Department of Natural Resources)

Table 3. Water Bar & Cross Drain Spacing Intervals.

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

Conveyor Belt Water Bars

On active roads or trails, conveyor belts, old snowmobile treads, and similar material (see Figure 7) can be used instead of soil to build water bars. The material is buried on edge in the traffic surface. It bends over to let wheeled vehicles easily pass, but diverts water off of the road. These structures work best on forest roads used by automobile traffic or trails designated for use by off-road vehicles, such as motorcycles and quadrunners.

They are not a good option on active skid trails where the butt of a log or log is skidded on the ground and passes over the conveyer belt portion of the water bar. Moving tracked equipment over these devices is also harmful to the integrity of the belt portion of the water bar. In both cases,

these actions break down the belt material and destroy the ability of this type of water bar to divert water off the road or trail.

When Building Conveyor Belt Water Bars Follow These Instructions:

- Dig a trench at a 30 to 45-degree down slope angle to the road or skid trail. The face of the cut should be on the uphill side.
- Place the conveyor belt against the face of the cut. Leave at least 6 inches of belt above the surface of the road. Refill the trench and compact the soil. For best results, nail boards (e.g. 2-inch by 8-inch) to both sides of the base of the belt to keep it straight and to hold it in the ground.
- Remove berms or other obstructions from the lower end of the water bar to allow water to move off the road. Water should flow into a stable vegetated area, away from open water.
- Space conveyor belt water bars as you would earth-berm water bars (see Table 3).
- Old snowmobile treads and other similar material can be used in place of conveyor belts.

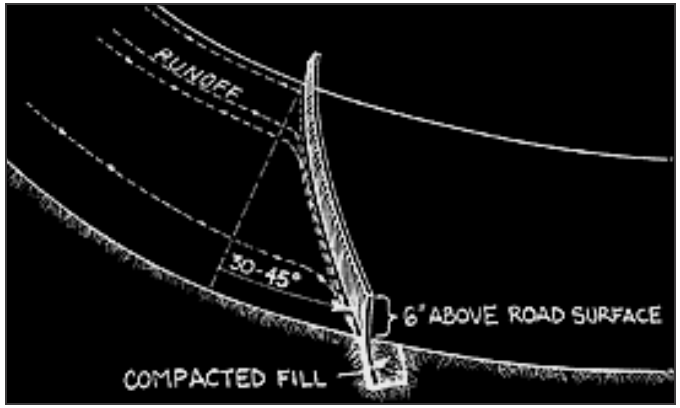

Figure 7. A Conveyor Belt Water Bar.

(Reprinted courtesy of the University of Minnesota Extension Service)

Temporary Water Bars Made from Slash or Logs

Logs or logging debris (slash) consisting of branches, broken tops, and brush can be used to create temporary water bars (See Figure 8). Operators build logging debris water bars across traffic surfaces to divert water into vegetated areas. This reduces erosion and helps maintain the road. Water bars made from logging debris are not as effective as those previously discussed, since water can filter through. Still, they can be used in many applications. They work best in low traffic areas with low slopes (e.g., slopes are less than 5%).

Log and slash water bars are best placed where use of more substantial water diversion options is limited; for example, on roads and trails with limited traffic or little slope, or when forest operations are shut down for a short time. They also can be used when the soil is frozen or when shallow, rocky soils -- such as those found in parts of the Western Upper Peninsula -- make it difficult to install earth-berm or conveyor belt water bars.

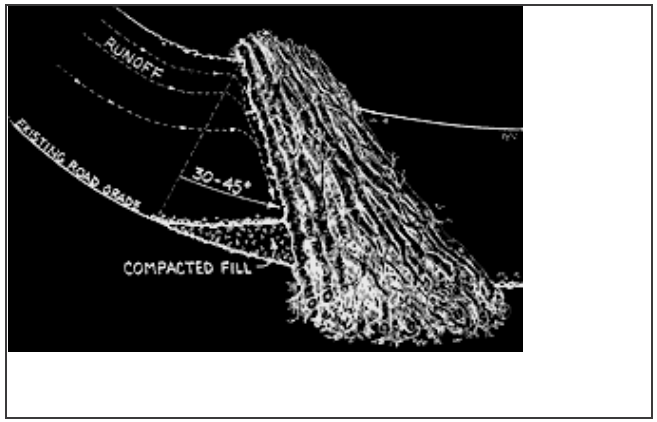

Figure 8. Illustration of a Water Bar Made of Slash.
(Reprinted courtesy of the University of Minnesota Extension Service)

The Following are Instructions for Installing a Slash Water Bar:

- Place the log or slash at a 30 to 45-degree down slope angle to the road or skid trail. For slash, build a mat at least 3 feet wide.
- Make sure water bars are high enough to prevent water from running over them.

- Pack slash down using a truck, dozer, or other heavy vehicle. Keep slash in continuous contact with the soil across the road. Fill gaps with soil or more slash. Water should not be able to run through the slash.
- Bind logs together or stake them down to help hold them in place when traffic passes over them.
- Remove berms or other obstructions from the lower end of the water bar to allow water to move off the road. Water should flow into a stable vegetated area, away from open water.
- Space log and slash water bars at least as close as you would earth-berm water bars.

Broad-Based Dips

A broad-based dip is a surface drainage structure specifically designed to drain water from a permanent use road, while allowing vehicles to maintain normal travel speeds (see Figure 9). It provides cross drainage on haul roads to prevent buildup of excessive surface runoff and subsequent erosion. Broad-based dips can be used on roads and heavily used skid trails having a gradient of 12% or less.
Broad-based dips may be substituted for other surface water cross drain practices such as pipe or box culverts. This practice is not to be used for cross draining spring seeps or intermittent or permanent streams. A key factor to remember when installing a dip is that the roadbed now consists of two planes rather than one unbroken plane. One plane is the 15 foot to 20 foot reverse grade toward the uphill grade and outlet. The second plane is the long grade from the top of a hump or start of a down grade and ends at the outlet of the dip. Neither the dip nor the hump should have a sharp angular break, but should be rounded, allowing a smooth flow of traffic. Only the dip itself should be out sloped since the dip provides sufficient break in grade to turn the water.

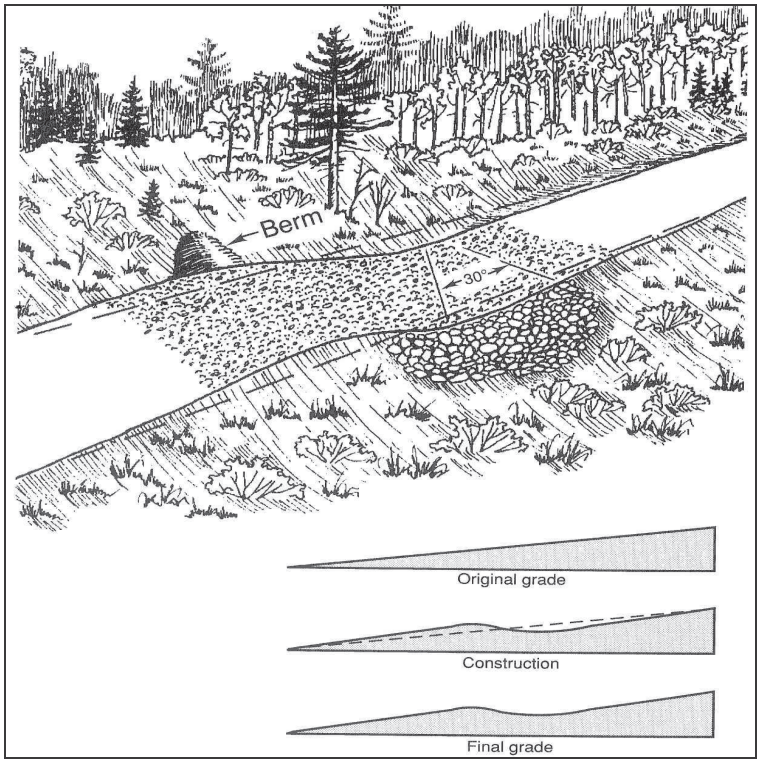

Figure 9. Broad-based Dip.

(Figure courtesy of the Wisconsin Department of Natural Resources)

Specifications for Broad-Based Dip Installation:

- Installation takes place following basic roadbed construction.
- A 20 foot long, 3% reverse grade is constructed into the existing roadbed by cutting from upgrade of the dip location and using cut material to build up the mound for the reverse grade.
- Space broad-based dips as shown in Table 4.
- The most effective locations for these are at the beginning of curves in roads.

Depending on the soils and amount of and type of traffic, the dip and reverse grade section may require applying a layer, 3-6 inches in depth, of 3-inch crushed stone to avoid rutting and/or the breaking down of the dips and the reverse grade section (Figure 9). Another option is to apply geotextile fabric along the length of the dip and reverse grade sections, and apply coarse aggregate or gravel at a minimum depth of 3 inches (6 inches depth is optimal).

Table 4. Spacing for Broad-Based Dips & Diversion Ditches.

Road Grade (%)	Spacing
2	300
3	235
4	200
5	180
6	165
7	155
8	150
9	145
10	140
12	100

Diversion Ditches

A diversion ditch (see Figure 10), sometimes called a "water turnout", serves to divert water away from the roadway and the side ditches. Its key use is to install prior to a forest road intersecting a stream. Install the diversion ditches according to table 4. This will ensure that water flowing off the road surface will be diverted into vegetation. Consequently, sediment deposition into the stream at the stream crossing is minimized.

When a road must be placed where there is little or no slope, a diversion ditch into a collecting basin may be the only way to move water away from the base of the road bed.

Specifications for Diversion Ditches:

- The diversion ditch must intersect the side ditch line at the same depth and be sloped 1 to 3 degrees.
- Diversion ditches should not be located in a wetland without a DEQ permit.
- On sloping roads, the diversion ditch should be placed on the down slope of the road.
- Runoff water is to be spread, retained, or filtered at the outlet of the ditch.
- A diversion ditch should be cleaned periodically to prevent sediment buildup that may clog the ditch and thereby direct sediment into the stream.
- Space diversion ditches according to the table used for Broad-Based Dips (Table 4).
- As shown in Figure 10, construct an earth-berm that follows the entire length of the diversion ditch to ensure runoff stays away from the stream. Also apply seed and mulch to the berm so that it does not become a source of sediment.
- Clean after grading to remove graded material from the beginning of diversions and level out the sides of roads (or, in other words, eliminate “country curbs”).

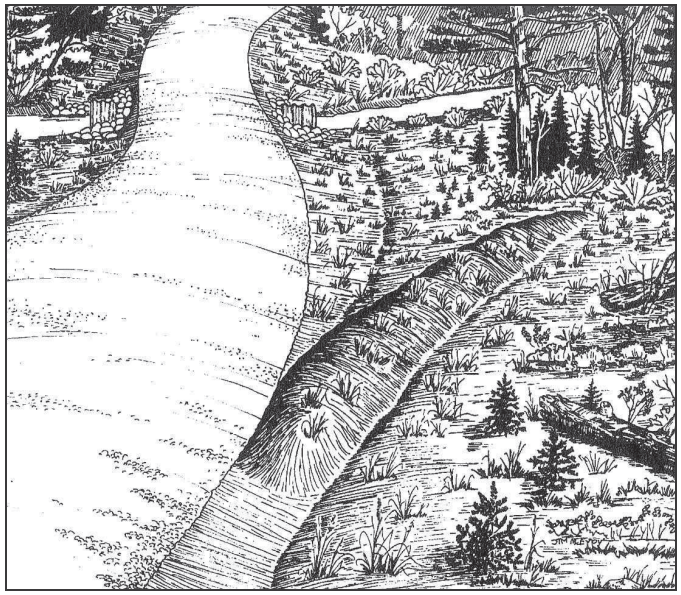

Figure 10. Diversion Ditch.

(Re-printed courtesy of the Wisconsin Department of Natural Resources)

Cross Drainage Culverts for Upland Landscapes

The primary purpose of cross drainage culverts in upland environments is to drain water from a ditch on one side of a road to the other side of the road and into grassy vegetation or energy dissipaters (e.g. 3 to 12 inches rock underlain by geotextile).

BMP Specifications for Installing an Upland Cross Drainage Culvert (see Figure 11):

- Culvert length should be long enough so both ends extend 1 foot beyond side slope (this is in contrast to culverts used for stream crossings which require that the culvert ends extend a minimum of 2 feet beyond the side slope).
- If multiple cross drainage culverts are needed, alternate their downslope direction (e.g., if one has the top, inflow end on the left side of the road, the next one should have its top, inflow end on the right side of the road)."

- Culverts should be installed with a 2% slope to reduce the possibility of clogging with leaf litter or other debris.
- Align the culvert by placing it on a downgrade angle in which the diameter of the culvert is equal to cross sectional area of the side ditch.
- Erosion control materials for both the inflows and outflows of culverts minimize undercutting at the culvert inlet or erosion occurring down slope of the outlet. This protection can be in the form of geotextile fabric overlain by rock large enough not to wash away or move during a significant rain event (ranging from 3-12 inches in diameter). This is particularly important for the inflow side.
- Select the size of culvert according to the size of the road and the general amount of surface area that is being drained by the ditch. Currently, 12 inches is the minimum recommended size for cross-drainage culverts on forest access roads in most Midwestern states. However, there is a trend towards using 18 inches as the minimum diameter. The reasons for this include: 1) a decreased need for maintenance and clean out, 2) a decreased frequency of culvert blockage from debris and sediment deposition, and 3) the decreased possibility of road washouts. In sum, for permanently or frequently used forest access roads, using an 18-inch culvert or larger will often prove to be the most cost-effective choice.

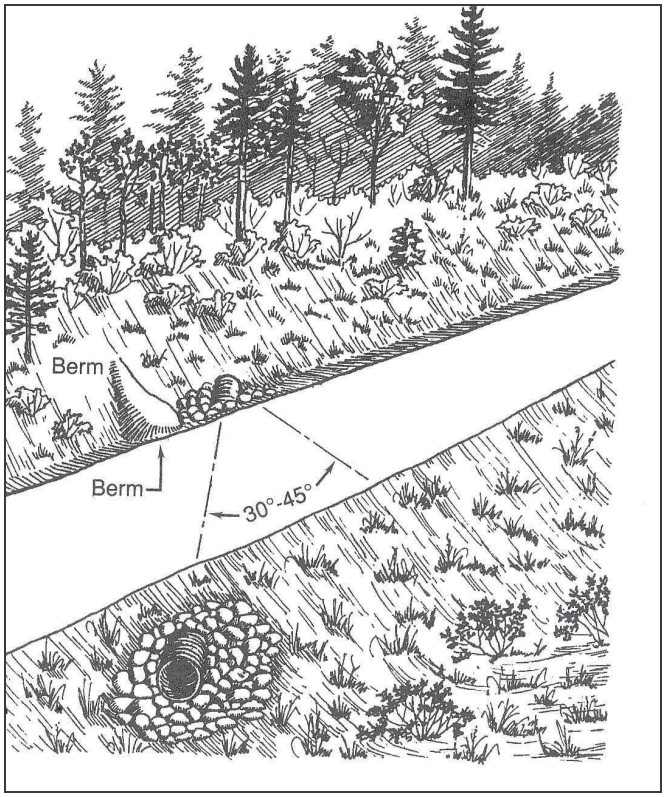

Figure 11. Upland Cross-Drainage Culvert.
(Re-printed courtesy of Wisconsin DNR)

8. STREAM CROSSINGS

As described in section “2. Laws and Permits”, installing a new or upgrading an existing stream crossing requires a permit from DEQ prior to installation. This is through the DEQ/US Army Corps of Engineers (USACE) joint permit application process.

It is best to work with local DEQ staff when developing plans for stream crossings from the outset. This will result in less time and effort for the landowner or their designated agent during the permit application and review process. Information regarding this application is available at

www.michigan.gov/jointpermit. Permit requirements apply to intermittent streams (flows only occur during certain times of the year, particularly spring during snowmelt), as well as permanently flowing streams. Streams have an area with a defined streambed and bank and visible evidence of a continued flow or continued occurrence of water. While dry for much of the year, intermittent streams are important during frequent rains in the spring. Because of these frequent rain events, intermittent streams provide essential habitat for trout and other fish during spawning runs. Therefore, protect them as carefully as you would a permanent flowing stream.

It is against DEQ regulations to transport felled logs or heavy machinery through even the smallest, shallowest dry streambed. Instead, there are two placement techniques for stream crossings that work best, depending on the circumstances -- a pipe culvert installation, or a portable bridge.

Portable Bridges

Portable bridges, often referred to as temporary bridges, are the preferred method when a stream crossing is required to skid or transport timber products and the stream crossing will be temporary in nature (defined by DEQ as a permitted crossing in place less than 2 years). These bridges can be constructed out of laminated, pressure treated wood (see Figure 12) or can be prefabricated folding metal structures (see Figure 13).

These bridges are generally designed to support skidders and forwarders, but may also be constructed sturdy enough to support tandem axle haul trucks, as they transport wood products from the landing to the mill.

Studies conducted by the U.S. Forest Service and University of Auburn on the Talledega National Forest showed that installing a portable bridge resulted in 98% less sediment entering the stream, compared to installing a culvert.

The key advantages over culverts are:

- Minimize stream siltation
- Meet or exceed most BMP standards
- Keep wood and other debris out of waterways
- Reusable
- Minimize erosion

- Keep streams clear of debris after installation
- Provide unimpeded fish passage
- No impacts on the stream bottom

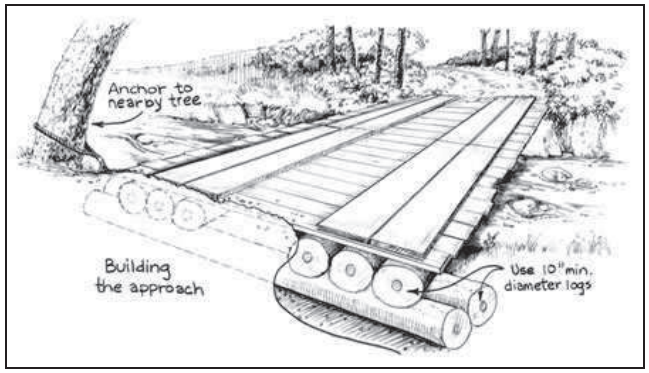

Figure 12. Example of a Wooden Portable Bridge.

(Re-printed courtesy of the University of Minnesota Extension Service.)

Figure 13. Example of a Portable Folding Metal Bridge.

Crossing Streams Using Culverts

Culverts are another option for crossing streams. However, use of culverts instead of portable bridges increases the amount of sediment deposition during installation and removal, as well as increasing the likelihood of impeding fish passage. They are made from corrugated metal pipe or other suitable material (e.g. hard plastic) and placed under a haul road or major skid road to transmit flows from permanent streams and small intermittent streams. Culvert installation and placement requires that the persons responsible for installation and removal take extra care and attention to reduce sediment deposition to the stream as much as possible. It is important to work with local DEQ staff on how to meet permit requirements.

Culvert Installation and Placement

When installation of a portable bridge is not an option, the culvert can be installed using the following BMP specifications:

- Install culverts so that there is no change in the stream bottom elevation. This will allow for unimpeded fish migration (see Figure 14).
- Place barriers or rock from the upstream culvert end to the stream banks to direct flow into the culvert.
- Place barriers or rock at the downstream culvert end to the stream banks.
- Firmly compact fill materials around culverts, particularly around the bottom half. Fill material should be a minimum of 1 foot over the pipe, at a depth specified by the culvert manufacturer, or one-half the diameter of the culvert (see Figure 15).
- Use riprap around the inlet and outlet of the culvert, as well as geotextile underneath the riprap to prevent stream flows from eroding and undercutting the culvert (see Figure 16).
- Pipe length should be long enough so both ends extend 2 feet beyond side slope (cross drainage culverts require only 1 foot beyond side slope).
- The pipe diameter is matched to expected high water flows.

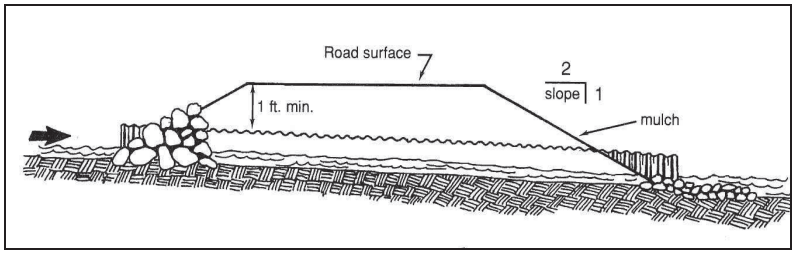

Figure 14. Culvert Installation Without Change in Stream Bottom Elevation.

(Reprinted courtesy of the Wisconsin Department of Natural Resources)

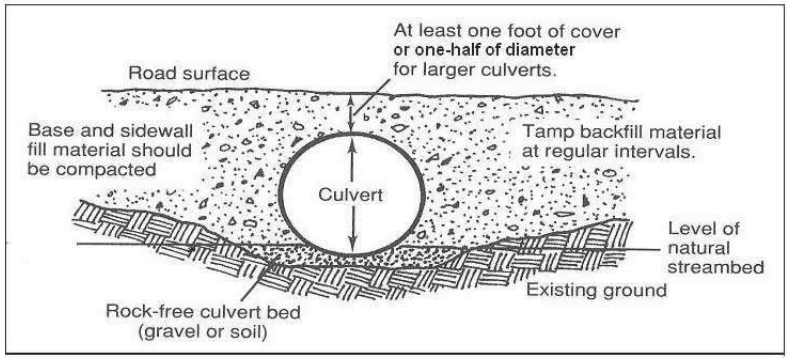

Figure 15. Illustrations and Instructions for Installation of a Stream Crossing Culvert.

(Reprinted courtesy of the Wisconsin Department of Natural Resources)

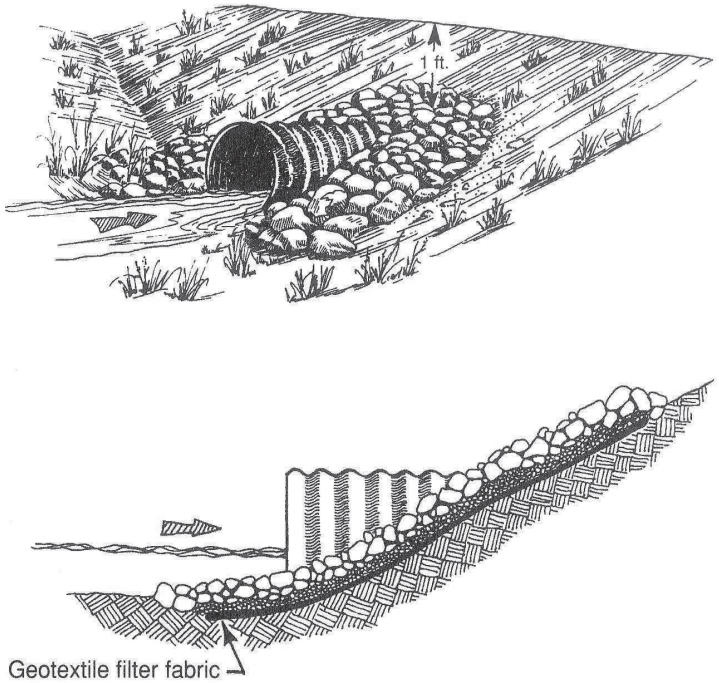

Figure 16. Illustration of Proper Use of Riprap & Geotextile Around Inlet of Stream Crossing Culverts.

(Edited and re-printed courtesy of the Wisconsin Department of Natural Resources)

Methods for Estimating the Diameter of a Stream Crossing Culvert

Two alternative methods may be employed for estimating the appropriate size of a stream crossing culvert: the traditional "Hasty Method" or the newer "MESBOA" method. Both are described below. The basic principle is that matching the culvert diameter to the width of the stream will maximize the longevity of the culvert, prevent erosion, scouring, pooling, and impaired fish passage.

Using the Hasty Method for Estimating the Diameter of a Stream Crossing Culvert

The "Hasty Method" is a method most frequently employed as it is a field expedient method of estimating the appropriate diameter of a culvert for a particular stream crossing. This method of calculating culvert size includes a safety factor of 100%. Figure 17 is an illustration of how to calculate the pipe diameter from measurements taken in the field. Table 5. shows the conversion of the calculated end area in square feet to the equivalent diameter.

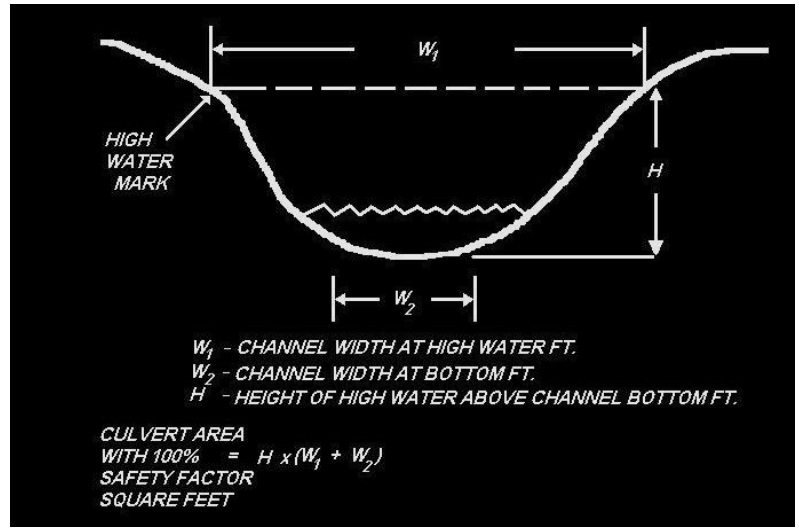

Figure 17. Hasty Method for Calculating Culvert Size

Table 5. Culvert End Area & Diameter

End Area (Square Ft.)	Diameter (Inches)
1.80	18
3.10	24
4.90	30
7.10	36
9.60	42
12.60	48
15.90	54
19.60	60
23.80	66
28.30	72
33.20	78
38.50	84
44.20	90

The MESBOA Method for Installing Stream Crossing Culverts

The MESBOA method, first developed in Minnesota, was a joint effort between the U.S. Forest Service and Minnesota Department of Natural Resources to develop a method that properly sizes, orients and installs culverts based primarily on the stream's physical characteristics. The "MESBOA" is an acronym comprised of the first letter of each of the six steps. The DEQ considers this method as the best method to use when sizing and installing stream crossing culverts. It was developed to ensure unimpeded fish passage and minimizing the risk of a culvert being washed out during a significant storm event.

The Six Steps in the Sizing and Placement of Culverts

The following are general instructions to apply when using the MESBOA method to determine the appropriate size, length, width and number of culverts needed for a given stream crossing:

1. **M**atch culvert width to bankfull stream width (see Figure 18).
2. **E**xtend culvert length through the side slope toe of the road.

3. **S**et culvert slope the same as stream slope (failure to set culverts on the same slope as the stream is the primary reason that many culverts impede fish passage).
4. **B**ury the culvert 4 to 12 inches into the stream bottom. For culverts 2 to 6 feet in diameter, dig 10 to 18 inches below the stream bottom.
5. **O**ffset multiple culverts.
6. **A**lign the culvert with the stream channel.

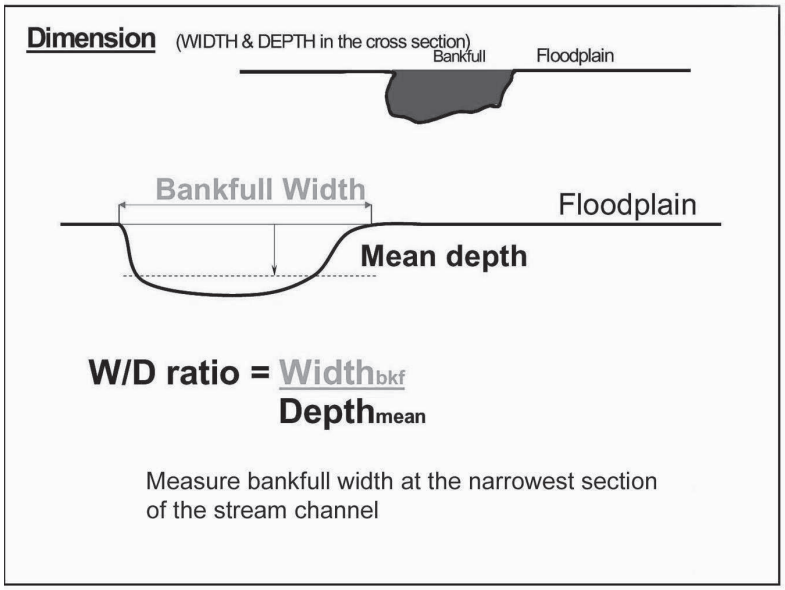

Figure 18. Measuring Bankfull Width.

Guidance Regarding the Application of the MESBOA Method Based on Stream Channel Width and Culvert Diameter

The following is guidance to aid forest managers or loggers as what measurements are needed based on bankfull width of the channel being crossed, stream depth, and the slope of the stream bottom. As the size of both the culvert and channel width increase, so too does the likelihood of having to obtain the services of a professional surveyor and civil engineer, to ensure the culvert is properly sized and installed.

The following guides the efforts or resources that may be required based on culvert diameter and channel width using the MESBOA approach:

- Culverts are 2 to 3 feet in diameter and channel is 2 to 6 feet wide.
  - Need only bankfull width and reasonable estimate of stream bottom slope and burying depth.
- Culverts are 3 to 6 feet in diameter and channel is up to 12 feet wide.
  - Need bankfull width, and accurate longitudinal profile of the stream to have exact slope of the stream and culvert elevation at both the inlet and outlet. Will require the use of level survey equipment.
- Culverts are greater than 6 feet in diameter or wide arch design and channel is greater than 12 feet wide.
  - Need bankfull width, longitudinal profile, and 1-3 cross sections. Use computerized culvert design programs to confirm that all measurements accurately dictate culvert design and installation parameters. Generally applied when stream crossing design requires the involvement of a registered professional civil engineer.

9. RUTTING AND RELATED ISSUES

Rutting occurs when soil strength is not sufficient to support the applied load from vehicle traffic (see Figure 19; Table 2 on page 24 has more on soil susceptibility to erosion). Rutting affects aesthetics, biology, hydrology, site productivity and vehicle safety. In general, rutting can cause soil compaction and loss of forest productivity. Where channelized flow to an open water body occurs, rutting can result in contributing sediment into an open water body. While not always a water quality issue, excessive rutting is certainly a sign that ongoing forest operations need to be modified to prevent further damage to soil and forest resources.

Figure 19. Forest Road Rutting Damage

Table 6 (below) provides guidance on excessive rutting in different areas of a harvest operation, immediate actions to be taken and restoration requirements. The rutting guidance should be applied in relation to the specific area being harvested. Consideration should be given to soils, hydrology, forest type, slope, and other site factors. For example, on certain sites, it may be necessary to change or halt operations before the standards stated are exceeded. Conversely, deep ruts may not be a problem in a landing which will be smoothed and revegetated after a harvest. In addition, excessive rutting in wetlands may require a DEQ permit. To avoid the need for a permit, methods should be employed to avoid and minimize rutting in wetland areas.

Anytime rutting causes sedimentation in a stream, lake or open water wetland, the activity causing the rutting must stop and immediate actions taken to prevent further sediment deposition. Rutting in roads or landings that does not cause sedimentation should be monitored. <u>If ruts begin to exceed the specifications, measures should be taken to prevent further rutting.</u> If further rutting cannot be prevented, the operations should cease until conditions change or until the rutting can be repaired. Off road rutting in the woods may occur on skid trails. Heavily used trails, also called main skid trails, may have more rutting than “one time only’” trails or secondary trails. Consideration should be given to the overall impact of the skid trails across the landscape.

It would be difficult to define guidance related to the total length and depth of skid trails across a forested stand, but in general the amount of skid trails should be minimized. Major skid trails will have more rutting than secondary skid trails. If secondary skid trails begin to resemble major skid trails, then rutting may be too severe, even though the rutting guidance has been followed. Excessive rutting may occur even though

any individual length of skid trail is within the standards. Professional judgment should be used to identify excessive rutting across a forested stand.

Surface water runoff from rain events can also lead to ruts in a logging road. The ruts collect runoff and increase the potential for ruts to deepen and further road erosion. Roads having slopes greater than 5% are especially vulnerable to the creation and deepening of ruts from rain events. Installing the proper water diversion devices, such as diversion ditches or broad-based dips at the appropriate intervals will periodically interrupt and divert stormwater runoff and decrease the volume and velocity of storm water runoff as it moves down slope. This reduces the potential for rutting. Proper grading, crowning of roads and shaping of roads per soil and slope conditions (see Figure 4) can also reduce the potential for rutting. Heavily sloped roads (those with slopes greater than 10%) can become rutted very easily, so the driver/operator must use extra care when driving these roads with heavy loads or under wet conditions.

Finally, the land manager must make sure that all man-made/inorganic materials (e.g. silt fence, tire mats, geotextile fabric) that were used for either rutting, erosion or sedimentation control, are removed from the site shortly after these materials are no longer needed (e.g. grassy vegetation has established). In particular, a silt fence left in place long after its use has past can serve as a barrier to the travel of herptofauna (e.g. turtles, snakes, lizards, salamanders and frogs) and small mammals.

Table 6. Soil Protection Precautions (for rutting)

Immediate Action		
• If a possible problem arises or threatens to worsen, **stop operations**. **Assess the situation**. Can operations be moved to another area to minimize problems without creating additional problems or should operations be stopped until conditions improve? • Can precautionary measures eliminate the problem? For example: ○ Use slash or logs to prevent movement of sediment offsite. ○ Install rock check dams (using rock 3-12 inches in diameter) or water bars at appropriate intervals (water bars can be made from old conveyor belts or other rubberized material) . ○ Use slash, tire mats, or PVC pipe linked together with chain or cable and lay over areas susceptible to rutting or use other suitable methods to prevent further rutting. ○ Install silt fence at edges of landing or other active areas to prevent movement of sediment off site. ○ In RMZ's, fill in rutted areas, apply geotextile fabric over rutted and susceptible areas, then apply gravel or crushed rock over the fabric at a depth no less than 3 inches (6 inches is optimal).		
Location	**Precautions may be needed if:**	**Maintenance/Restoration Options**
Everywhere	A gully or rut of any depth is channelizing flow to an open water body, (i.e. stream, lake or wetland). Note: the discharge of sediment into a surface water body is in a violation of Part 31, Water Quality Protection, NREPA, PA 451, 1994. Enforcement action and daily fines by DEQ may result if the discharge is not stopped	Review site conditions and determine if site remediation would cause more damage to soil resources and site productivity than leaving ruts as they are. Repair gullies and ruts. Disc, plow, smooth, where necessary. Seed and mulch per recommended procedures (see Appendix E). Check dams and water bars should be left in place until grassy vegetation is firmly established. No restoration is recommended if such action causes more damage to site (e.g. disking and plowing may result in unacceptable damage to the root systems of the trees affected by the rutting). Areas prone to rutting may require frequent inspections.

Location	Precautions may be needed if:	Maintenance/Restoration Options
Roads	In a riparian management zone (RMZ) or wetland where a gully or rut is 6 inches deep and 25 feet long. In an upland area (outside of RMZ) where a gully or rut is 12 inches deep and 50 feet long.	Review site conditions and determine if site remediation would cause more damage to soil resources and site productivity than leaving ruts as they are. Where water quality will not be affected, remediation may not be necessary. The type of road and use (temporary, intermittent, continuous or heavy use), may determine the level of restoration effort. If a rutted road must be used (e.g. for access, to move forest products), options for repair include 1) fill in ruts as conditions allow, 2) lay a barrier such as geotextile fabric over the length of the rutted portions and apply gravel or crushed rock at a depth no less than 3 inches (6 inches is optimal). Smooth, seed and mulch as appropriate, for example after timber harvest is completed (Refer to Appendix E for instructions). Be aware of vehicle safety concerns on forest roads. Rutting may require frequent grading during rainy seasons.
Landings (Should not be located in an RMZ)	Soil moves from the landing area.	When landing is no longer needed, smooth, seed and mulch as appropriate (Refer to Appendix E for instructions). Silt fence or barriers should be left in place until grassy vegetation is firmly established. Remove silt fence or barriers after its purpose is no longer required.
Skid trails & harvest areas	When a gully or rut is 12 inches deep & 50 feet long.	No restoration is recommended if such action causes more damage to site (e.g. disking and plowing may result in unacceptable damage to the root systems of the trees affected by the rutting).

10. LANDINGS

The following BMPs apply to the site location and water management with respect to log landings:

- Locate landings outside the RMZ.
- Use previously developed landings, unless they are located in RMZs.
- Avoid locating or using old landings that are located where gullies, seeps, vernal pools and other permanently wet areas exist.
- Locate sites for log landings in advance of road construction. These sites should be located in areas that will help minimize skid trail and haul road distances.
- Where possible, log landings should be constructed on well-drained, gently sloping sites of no more than 5%. On areas greater than 5%, additional erosion control measures may be necessary.
- Locate residue piles (particularly aspen, whose runoff is a suspected toxin to fish) away from drainages where runoff may wash residue into streams, lakes or other open water body.
- Haul roads that terminate at the landing area should be properly drained prior to intersecting the log landing.
- A diversion ditch around the uphill side of landings can intercept the flow of water and direct it away from the landing.

11. SKIDDING

A skid trail is a single lane trail used for the skidding or transporting of timber products from the stump to a landing. After the location of log landings are established and road layout is complete, the skid trail network is then laid out. The major considerations for skid trail placement are to minimize: damage to residual trees, erosion, sedimentation, and rutting.

For some forest conditions such as very steep slopes (over 40%), unstable soil conditions and critical riparian areas (e.g. areas with vernal pools, unique natural communities, such as dune and swale complexes), use timber harvesting techniques and equipment that minimize skidding throughout the stand (e.g. cable skidding, harvesters with knuckle boom cranes and bogey tracks - see Figure 20).

Figure 20. Wheeled Harvester/Processor with Bogey Tracks.

The Following are Considerations for the Location and Use of Skid Trails:

- Gradients of skid trails should not be steeper than 40% (EPA 2005). The goal is to have the average skid trail slopes be no more than 15%.
- Minimize skidding in the RMZ (this helps minimize soil exposure).
- When skidding in areas with steep topography, within safe operating conditions, follow the contour of the slope. This reduces soil erosion and encourages revegetation. If skidding has to be done parallel to the slope, skid uphill, taking care to break the grade periodically. Where the grade is broken, install water diversions.
- Avoid skid trail layouts that concentrate runoff into ephemeral draws (see Figure 21), and avoid skidding up or down ephemeral draws. Skidding through these areas will result in accelerated soil erosion and sediment movement, as ephemeral draws act to channelize water flows.
- If using a wheeled skidder without high floatation tires, winch logs out of the RMZ or directionally fell trees so tops extend out of the RMZ and trees can be skidded without operating the skidder in the RMZ.
- Suspend skidding during wet periods such as spring breakup.
- Any skid trail that crosses a stream will require permits from DEQ and a bridge or a culvert designed to standards acceptable by DEQ prior to DEQ issuing permits for such an activity. Logs cannot be skidded through an identifiable stream channel.
- Approaches to a water crossing should be as near to right angles (90 degrees) to the stream direction as possible.
- Climb up slope on a slant or zigzag pattern, breaking the grade and avoiding long steep grades on the trail. This will reduce the potential for making gullies.

- One primary skid trail may concentrate and minimize soil disturbance and compaction and damage to the residual stand. However, often using several different skid trails instead of only one primary trail disperses the impacts and results in less soil disturbance. This may vary by site, time of year, equipment, and other conditions such as existing vegetation.

- Skidding operations should avoid gullies, seeps, vernal pools and other permanently wet areas.

- Upon completion of skidding operations, install water bars, particularly on skid trails on sloping and variable topography. If natural vegetation does not quickly establish on these trails, apply grass seed and cover with mulch (see Appendix E).

Figure 21. Example of Ephemeral Draw

12. WETLAND BMPS AND FOREST ROADS

A wetland is characterized by the presence of water at a frequency and duration sufficient to support, and that under normal circumstances does support, wetland vegetation, or aquatic life. These features are commonly referred to as bogs, swamps, or marshes. As mentioned above in the section on applicable regulations, the following activities are prohibited in wetlands, to protect water quality, unless a Part 303 permit has been obtained from the DEQ:

- Deposit or permit the placing of fill material in a wetland.
- Dredge, remove, or permit the removal of soil or minerals from a wetland.
- Construct, operate, or maintain any use or development from a wetland.
- Drain surface water from a wetland.

Regulated wetlands are defined in Part 303 and associated administrative rules.

Forest Road Construction in Forested Wetlands

Per Part 303, Wetlands Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), the activity of constructing forest roads or temporary roads for moving forestry equipment in a wetland environment is exempt from obtaining a Part 303 permit, as long as adverse effects on the wetland are minimized and best management practices as listed below are implemented. This guidance is for forestry purposes only. If roads are constructed in or through a forested wetland environment for non-forestry purposes or if fill material is deposited in a wetland, then a wetlands permit is required.

The following are general road construction BMPs, that, if applied, will minimize adverse effects on the wetland and allow the landowner, forester or logger to be exempt from obtaining a wetlands permit:

- Equipment access to wetlands should be minimized by utilizing knuckllebooms or cranes or methods such as logging by cables from the adjacent upland where and when possible.

- If the crossing can be accomplished at a time when the wetland is relatively dry, construction mats or other temporary crossing methods should be employed. Following the operation, the wetland should be returned to its original condition.

- Conduct timbering operations during winter when the wetland is often frozen and passable and will not require the use of fill or other methods that may permanently damage the wetland.

- If there is an existing roadway through a wetland, that roadway should be utilized, unless upgrading to minimal standards will cause more wetland damage than selecting an alternative route.

- Wetland crossings should be held to the minimum feasible number, width, and total length consistent with the needs only of the forestry operations.

- Wetland crossings should be designed, constructed and maintained in a manner that keeps vegetative disturbance in the wetland to a minimum and prevents the disruption of migration or other movement of fish or wildlife within the wetland or contiguous water.

- Where fill is necessary, it should be taken from uplands and should consist of clean material. Upon placement, it should be stabilized and maintained to prevent erosion into waters or wetlands during and following construction. Depositing fill into a wetland requires a permit.

- Wetland crossings should include placement of culverts and other structures necessary to ensure adequate passage of flow under and through the road without causing excess drainage to upstream or downstream wetland areas. Drainage should be designed to maintain pre-existing hydrology on either side of the road.

- Wetland crossings may not be located in proximity to public water supply intakes or otherwise constructed at a location or in a manner where they would pose a threat to health, safety or welfare, or otherwise be in violation of federal, state or local laws.

- Always monitor operating conditions closely, but especially after the occurrence of a warm rain or above freezing temperatures at night. Cease operations in wetlands if ruts reach 6 inches in depth and are 25 feet long.

BMP Specifications for Forest Road Construction on Organic Wetland Soils

The federal publication, “Forested Wetlands: Functions, Use and Best Management Practices”, (Forest Service publication number NA-PR-01-95), recommends different road construction techniques and BMPs, depending on the nature of the wetland soils in which forest management activity is scheduled to occur. One key component is that roads built on organic wetlands should provide for cross drainage of water on the surface and in the top 12 inches of the soil.

Construction techniques vary, depending on the type of soil involved (mineral versus organic). Where organic soils are involved, the depth of the organic layer also influences these techniques. The following practices, which differ based on soil type and thickness, are recommended for wetland road construction:

- For road construction on soils with **organic layers close to 16 inches** in thickness, these are the recommended practices:
  - Place 24 inch diameter culverts with their bottom half in the upper 12 inches of the soil to handle subsurface flows and the top 12 inches to handle above ground flows every 300 feet or so (see Figure 22).

- For road construction on soils with organic **layers in excess of 4 feet** in thickness, these are the recommended practices:
  - The road should be constructed across the top of the soil surface by placing fill material on top of geotextile fabric, while allowing for cross drainage via the use of a 12 inch think layer of porous material such as large stone into the roadbed (see Figure 23). This material should be separated from the adjacent fill layers by geotextile fabric, and be incorporated into the road fill design so as to lie in the top 12 inches of the soil to provide continuous cross drainage. Corduroy or pvc bundles could be alternatives.
  - Where such porous layers are not used, place culverts at points where they will receive the greatest support from the soil below.

- Construct ditches parallel to the roadbed on both sides to collect surface and subsurface water, so as to carry said water through a given culvert. Note that these ditches should be located 3 times the depth of the organic layers from the edge of the road fill.

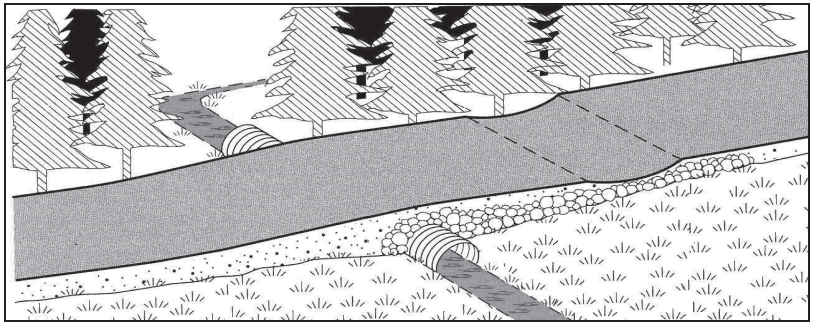

Figure 22. Proper Culvert Installation and Use on a Wetland Road.

(Re-printed courtesy of the United States Forest Service)

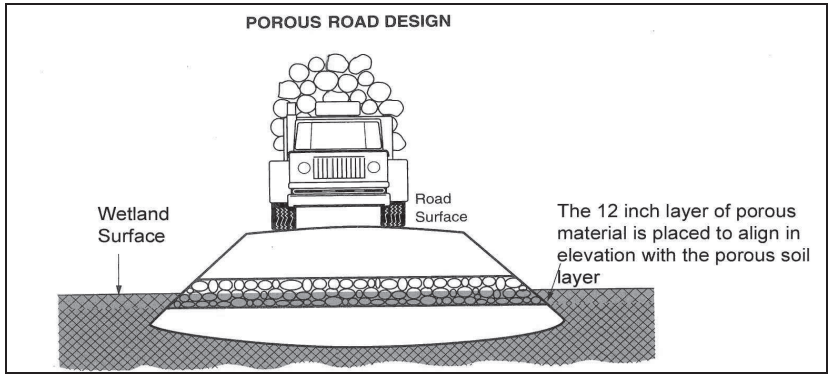

Figure 23. Porous Road Design Using Large Stone.

(Re-printed courtesy of the United States Forest Service)

- For road construction on soils with **organic layers between 16 inches and 4 feet** in thickness, these are the recommended practices:
  - Place fill directly on the peat surface and allow the fill to compress or displace the peat until equilibrium is reached. In this technique, culverts are used instead of porous layers to move flows through road fill material.
  - Place all culverts at the lowest elevation on the road centerline with additional culverts installed as needed to provide adequate cross drainage.
  - Construct all ditches parallel to the road centerline and along the toe of the fill to collect surface and subsurface water flows, carrying said flows through the culvert(s), redistributing the flows to the other side of the road.

Specifications for Roads Constructed on Mineral Soils or a Thin Organic Layer

When roads are being constructed on mineral soils or on soils with surface organic layers less than 16 inches in thickness, the following are the recommended practices:

- Roads through mineral soil wetlands can be constructed using normal road construction techniques.

- Apply geotextile fabric first before adding fill to increase bearing strength of the road and to preserve the bearing strength of fill material so as to prevent mixture with fine soil particles.

- In mineral soil wetlands, a culvert should be placed at the lowest elevation on the road centerline with additional culverts as needed to provide adequate cross drainage (see Figure 22 and 24).

- Shallow ditches parallel to the road centerline should be constructed along the toe of the fill to collect surface and subsurface water flows, carrying flows through the culvert(s) to the other side of the road and into a vegetated area (see Figure 24). Any ditches must be of depth and width only to allow cross drainage and support the stability of the road. **Deeper or excessive ditching will require a permit from the DEQ.**

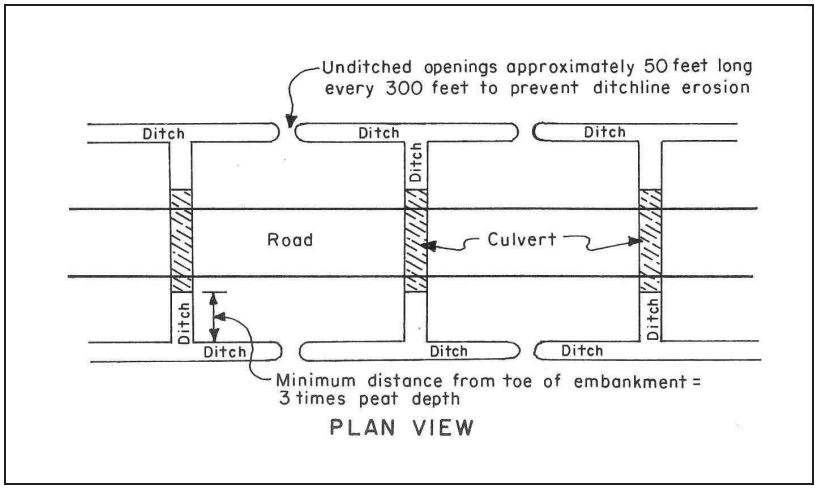

Figure 24. Illustration of Use and Placement of Culverts and Ditches for Wetland Roads.

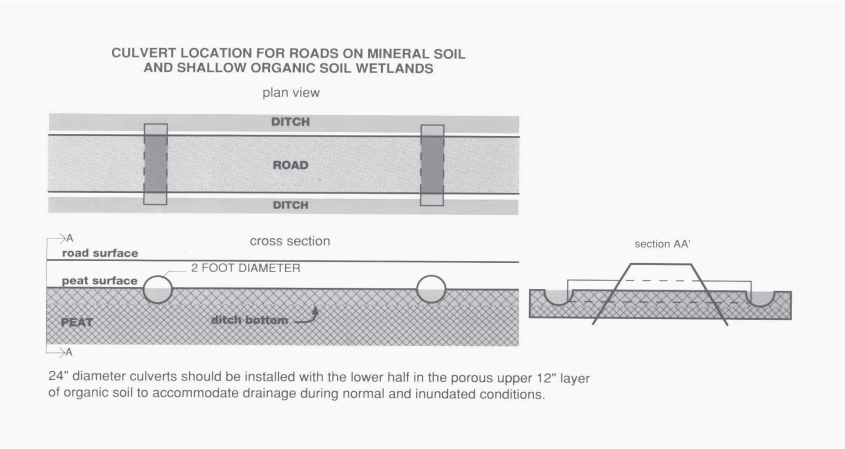

Figure 25. Cross-section of Culvert Location for Wetland Road.

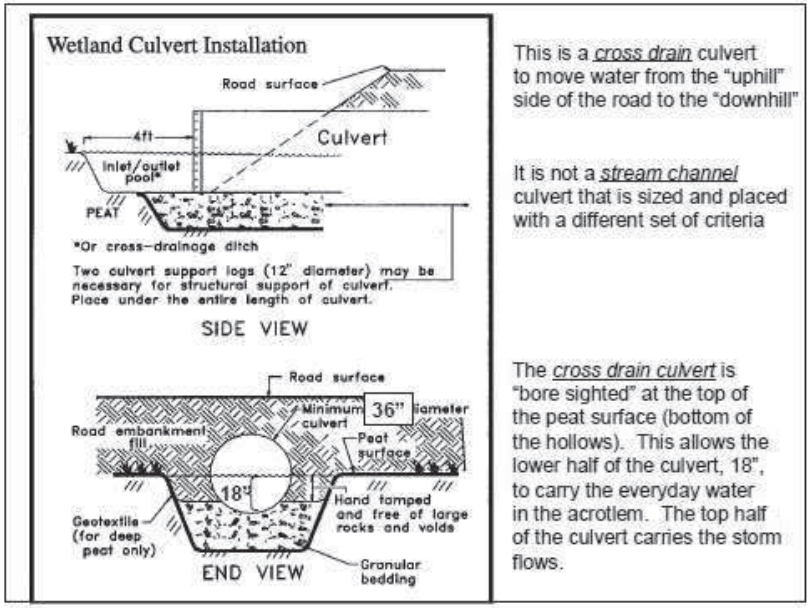

Figure 26. An Example of a 36-inch Diameter Cross Drain Culvert Used for a Road Constructed in a Wetland Area.

13. FOREST ROADS - CONTROLLING SEDIMENT MOVEMENT AND TRANSPORT DURING RAIN EVENTS

During rain events, excessive water flows can erode a forest road, causing sediment to be eventually transported into a stream or other water body. Described below are various devices that can help mitigate erosion and sediment movement. These devices work by interrupting the flow of water and sediment, causing the sediment to be deposited, trapped or filtered out before reaching an open water body. Following a routine maintenance schedule which takes into account rain events is key to the proper functioning of these devices. Generally, this is the responsibility of the logger during an active timber sale and the landowner's responsibility before and after such sales.

Described below are examples of such control devices:

- **Erosion Barriers** – Pre-seeded erosion control products at the toe slope of a road and at the outlets of culverts, diversion ditches, water bars, or broad-based dips, or the use of rock or large stone (an average diameter of 6 inches) placed on the toe of road and outlet of the diversion structures should be the first choices. Although it's cheap and handy, laying down slash is not very good in reducing the velocity and erosive impacts of concentrated flows during significant rainfall events.

- **Silt Fence** – A geotextile fabric, when installed properly, has the capability of retaining most suspended materials, (e.g. sediment) and releasing the filtered runoff through the fabric. Do not use in permanent flowing streams or in any location with concentrated flows. See Figure 5 for an illustration of how to properly install a silt fence. It is most commonly installed at or beyond the toe of a slope to trap sediment coming from overland sheet flows during a storm event. Silt fence must be installed along the same elevation contours across the slope to prevent runoff from flowing around the fence. For long slopes or large areas, silt fence should be installed parallel to each other in a series with an average spacing of 200 feet and drain no more than one-half acre per 100 feet of fence.

- **Armoring/Energy Dissipation** – This term refers to rock installed at the outlet of diversion devices and drainage culverts to prevent erosion from occurring at the outlet. The rock must be large enough (ranging from 3 to 12 inches in diameter) to stay in place at the outlet during times of strong concentrated flows. The length of the riprap should be at least 5 feet long and 3 feet wide, to ensure concentrated flows have an adequate space to slow down and filter into the soil or vegetation.

- **Check Dams -** Check dams (see Figure 27), generally constructed of rock, may be necessary to reduce the velocity of flow in roadside ditches or other concentrated flow areas. Check dams can reduce the potential for erosion and protect vegetation in the early stages of growth by reducing water flow to non-erosive velocities. See Figure 28 for proper spacing of check dams. For rock based check dams, construct the check dam using rock having a range of sizes from 3-12 inches in diameter (average 6 inches). The key is that the rock stays in place to withstand strong concentrated runoff flows.

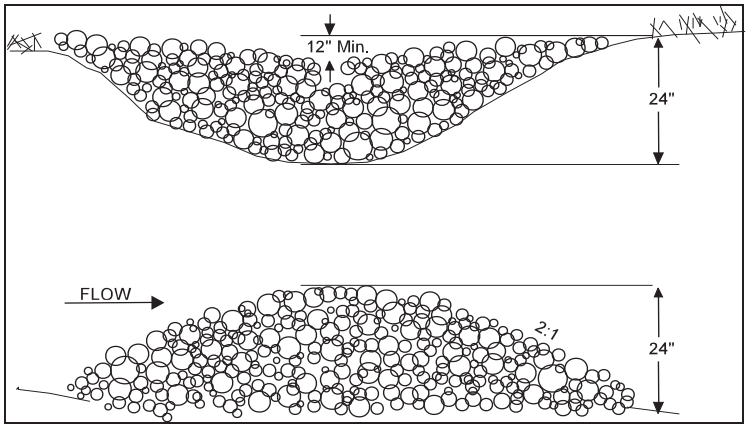

Figure 27. Cross Sectional Views of a Check Dam.

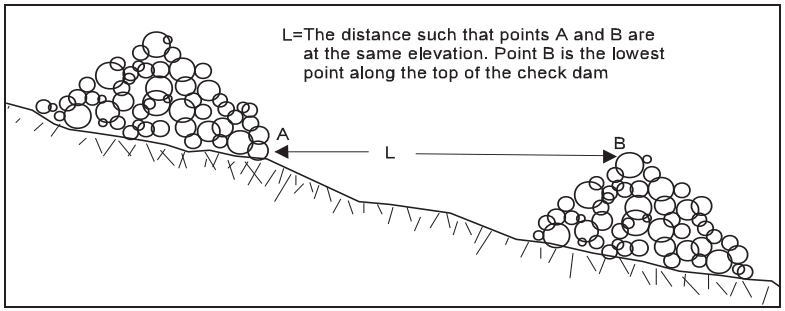

Figure 28. Check Dam Spacing.

14. SITE PREPARATION, REFORESTATION AND FOREST PROTECTION

The long-term management of forest land includes a commitment to a sustainable forested landscape. It is necessary for management plans that include timber harvesting to also include consideration of site preparation work and regeneration efforts. Site preparation can include mechanical means, prescribed burning, and chemical treatments. Reforestation can occur naturally or be established using mechanical seeding and planting techniques.

For all forested land where timber products are harvested, the landowner should consider regenerating stands by either natural or mechanical means. Site preparation refers to methods that establish desired tree species, control undesirable competing vegetation, reduce organic debris and logging residue and reduce wildfire risks.

Pay special attention to avoid any unnecessary surface disturbances, especially in areas of steep slopes or in areas subject to periodic flooding, such as spring break up flooding.

Mechanical Preparations

The following are recommended specifications for various mechanical means:

- General Considerations:
  - Use mechanical site preparation techniques which cause the least disturbance to the site and still achieve the owner's objective.
  - Recognize adequate RMZs.
  - To minimize erosive impacts, mechanical treatment should be oriented along the contours of the site.
  - Evaluate site for saturated soil conditions. Avoid operations during periods of saturated soil conditions that may cause rutting or accelerated soil erosion.

- Shearing and Raking:
  - Avoid dumping or concentrating residues from shearing and raking operations in flood plains or wetland areas. These residues should be deposited in stable areas so they do not interfere with drainage or cause erosion.

  - Locate windrows and piles to minimize interference with natural drainage patterns.
  - Locate windrows outside the RMZs.
  - Give preference to locating windrows along contours to mitigate the effects of overland flow.
  - Minimize incorporation of soil material into windrows and piles. Two examples of preferred practices are: a) shearing and raking under frozen soil conditions, and b) light raking which would only remove slash.
  - Avoid shearing and raking operations on organic soils, except under frozen soil conditions.

- Disking (and other scarification treatments, such as chain drags and land breakers):
  - Limit to slopes of less than 10%, for all highly erodible soils.
  - Follow the land contours with proper consideration given to equipment operator safety.
  - Advantageous because it reduces soil compaction and incorporates organic matter.

- 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 to maintain operator safety.

- Drum Chopping:
  - Limits soil exposure as residual trees and debris are knocked down.
  - Maximum benefit comes from drum chopping up and down the slope so that blade depressions are on the contour, reducing the occurrence of channeled surface flow.

Prescribed Burning

Using fire under controlled conditions can have benefits including: reduction of slash, reduction or elimination of undesired and competing vegetation encroachment, and creation of a seed bed or surface condition for natural or artificial regeneration of desired tree species. To achieve desired conditions and protect water quality, prescribed use of fire must be carefully planned and executed under strict weather and fuel conditions.

- After the prescribed burn is complete and a significant rain event has occurred, inspect the fire lines on hilly or steep terrain where a stream or small body of water is close by to determine if these fire lines are eroding away and sediment is being transported down to a stream or water body. If this is occurring, install earth-berm water bars (probably only requiring a shovel) and during inspection, determine if any other areas of bare mineral soil (a result of the burn) are eroding into a water body. Inspect the site and determine if the bare areas will re-vegetate quickly from the surrounding area or if the soil will require the application of grass seed that establishes quickly and require the application of mulch (see Appendix E).

- If the prescribed burn is adjacent to an intermittent or perennial water body, the staff in charge should establish an RMZ, if it has not been done so already. The use of fire retardant foam at the boundary of the RMZ is permitted. Note that fire retardant foam is not toxic to aquatic life.

Chemical Treatment

Use of chemicals to control vegetation (herbicide), insects (insecticide), small animals (rodenticide), and molds and fungus (fungicide) can be an efficient and effective means of site preparation. Herbicides have advantages over mechanical means because there is no soil disturbance and can be used where steep slopes prevent use of machinery. Herbicides can also be used in an existing stand for pre-harvest treatment. Rodenticides and fungicides can be applied to seeds or seedlings before or during planting to increase planting survival. However, water quality impacts must be a consideration in all use of chemicals to prevent their reaching ground water and surface water bodies.

Potential water quality impact varies widely from one chemical to another

and depends primarily on the: a) chemical's mobility, b) chemical's persistence, c) accuracy of the chemical's placement, and d) orientation of site to streams. Water quality can be protected by knowledge of the chemical being used and adherence to the manufacturer's specification and directions. The label contains information regarding the safety of the applicator, species for which the chemical is registered, the pesticide rate or concentration, appropriate weather conditions for application, environmental impact and proper container disposal. Material Safety Data Sheets providing toxicological data are available from a chemical's manufacturer.

Reforestation

All of the above-described means of site preparations are designed to meet the objective of maintaining a healthy and vigorous forest which aids in maintaining water quality of adjacent water bodies. Regeneration of desired tree species and associated plant communities occurs through natural process and by seeding and tree planting.

Use of Pesticides

Use of chemicals to control forest pests and to eliminate vegetative competition with desired tree species may be the most effective and efficient means of accomplishing those management functions. If you have any questions about pesticide application, please contact the Michigan Department of Agriculture, Pesticide and Plant Pest Management Division at 517-373-1087, or online at www.michigan.gov/mda.

The forest manager must be aware of the risk of water contamination and apply the following considerations:

- The basic federal law regulating pesticides and their use is the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). The Michigan Pesticide Control Act further regulates use, handling and application of pesticides. Additional laws pertaining to pesticide uses, transport and application exist.

- All pesticides are classified for either "general" or "restricted" use. Restricted pesticides may be used only under supervision of certified applicators. Pesticide users need to be familiar with the laws and regulations pertaining to certification and proper use of pesticides.

- Follow directions and heed all precautions on the label. Store pesticides in original containers in secured areas, out of reach of children and animals, and away from food and feed.

- Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

- Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment, as specified on the container/label.

- Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

- The use of returnable pesticide containers is recommended. Otherwise, dispose of empty pesticide containers promptly, in a landfill licensed to accept toxic materials.

- Special precautions should be taken around RMZs.

Wildfire Damage Control and Reclamation

When wildfire strikes, the primary purpose is to control and suppress the fire, as quickly as possible. However, forest fire suppression measures themselves can add to the problem of water quality protection.

The loss of vegetative cover, destruction of soil holding features such as roots, the creation of a carbon layer in place of the organic top layer of soil, and the exposure of bare mineral soil, are combinations that make the burned area highly erodible. The effects of suppression efforts and equipment operations necessary to control and stop the fire can magnify the erosion problem. The following are specifications for reclamation of burned areas.

- Unless further activity would create problems, bare mineral soil should be actively re-vegetated, particularly if soil could erode into a nearby stream or other water body.

- First priority for re-vegetation is all areas of bare soil adjacent to banks of surface water bodies so that the RMZ function is re-established. Until site stabilization occurs, the use of silt fences or erosion mats or blankets may be necessary.

- Fire lines should be stabilized and re-vegetated, if soil is being transported to a nearby stream or other open water body. Other areas altered by suppression equipment operations should be repaired and re-vegetated as necessary. Where fire lines cause surface water to channelize and flow directly toward or into a water body, water bars should be placed in the fire line, at the spacing indicated in Table 3.

APPENDIX A - GLOSSARY

Access Road: A temporary or permanent access route for vehicles into forest land.

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.

Basal Area: The area of the cross section of a tree trunk near its base, usually 4½ feet above the ground. Basal area is a way to measure how much of a site is occupied by trees. The term basal area is often used to describe the collective basal area of trees per acre.

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): This phrase and acronym are taking on new meanings, and the context of its use must be assessed for its meaning. Traditionally, the term referred to a practice or combination of practices that were deemed the most effective, practicable (including technological, economical and institutional considerations) means of preventing or reducing the amount of water pollution generated by nonpoint sources. Specifically, the term was used with respect to surface water and practices for complying with the Federal Clean Water Act. “Water Quality BMPs” is the phrase often used for this connotation. Increasingly, however, the term “BMPs” is used in a broader sense and encompasses subjects beyond surface water quality, such as soils, visual management, and other timber management practices.

Bog: A nutrient-poor peatland community characterized by acidic,saturated peat and the prevalence of sphagnum mosses and low shrubs, such as leatherleaf, and insectivorous plants. High quality bogs are often occupied by rare plants and animals.

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 a permanent road, while allowing vehicles to maintain normal travel speeds.

Buffer Strip: An area of land adjacent to a water body which acts to trap and filter out suspended sediments, nutrients, and chemicals before reaching surface waters. Harvesting and other forest management activities are permitted in the strip, as long as the functional integrity of the strip is maintained. Shade from the strip may also reduce thermal pollution of an adjacent stream. Referred to in this manual as Riparian Management Zone (RMZ).

Check Dam: A small dam constructed of rocks and placed in roadside ditches, ruts, gullies or other areas of channelized flow. The purpose of check dams is to interrupt the movement of channelized flows, decrease the flow velocities, and promote deposition of sediment at regular intervals.

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

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 wood roads. Dips are considerably lower in cost than culverts, so time spent in careful construction is well-justified.

Disking: A site preparation system whereby a heavy cultivating implement 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.

Drain: The legal definition of a “drain” or “drainageway” is part of **THE DRAIN CODE OF 1956 (EXCERPT) Act 40 of 1956. Section 280.3: Drain; definition. Subsection 3. It reads as follows:** The word “drain”, whenever used in this act, shall include the main stream or trunk and all tributaries or branches of any creek or river, any watercourse or ditch, either open or closed, any covered drain, any sanitary or any combined sanitary and storm sewer or storm sewer or conduit composed of tile, brick, concrete, or other material, any structures or mechanical devices, that will properly purify the flow of such drains, any pumping equipment necessary to assist or relieve the flow of such drains and any levee, dike, barrier, or a combination of any or all of same constructed, or proposed to be constructed, for the purpose of drainage or for the purification of the flow of such drains, but shall not include any dam and flowage rights used in connection therewith which is used for the generation of power by a public utility subject to regulation by the public service commission.

Ephemeral Draw Area: A topographic feature that during rain events or snow melt, acts as a small drainage area and channels overland flows into a stream. These features do not have a defined bed or bank or a defined continuous channel and have an intact forest floor. In areas with terrain, this is a topographic feature that is the lowpoint in which two ridges or mounds of earth come together. They are a natural drainage path for surface water runoff and channel water flow into first order streams. Skidding up or down these features should be avoided.

Ephemeral stream: A stream that flows only during and for short periods following precipitation and flows in low areas that may or may not have a well-defined channel.

Energy Dissipaters: Materials or structures, placed at the discharge end of a culvert or ditch, which interrupt and spread the flow of water, thus reducing the water's power to cause erosion. Rock or heavy slash are examples of energy dissipaters.

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

Felling: The process of severing trees from stumps.

Fen: A type of groundwater-fed wetland. It is a peatland community dominated by sedges, rushes, and grassesthat occurs on moderately alkaline organic soil and marl. Fens occur where cold, calcareous groundwater rich in calcium and magnesium carbonates reaches the surface to form perennial springs and seeps. The flow rate and volume of groundwater passing through a fen strongly influence vegetation patterning.

Filter Strip: See riparian management zone.

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

Forest Floor: Organic matter on top of the mineral soil surface in the forest, including litter and unincorporated humus.

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

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

Gully: A form of soil erosion which is a channel in the soil, caused by storm runoff, usually more than 6 inches deep and 6 inches wide.

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

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 that flows only during wet periods of the year and flows in a continuous well-defined channel with definable beds and banks.

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

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.

Nonpoint Source Pollution: Pollution caused when rain, snowmelt, or wind carry pollutants off the land and into lakes, streams, wetlands, and other water bodies. Hydrologic alterations and atmospheric deposition are also considered nonpoint source pollutants.

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 the lake, marsh or stream bed. 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 predominately aquatic to predominately terrestrial.

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.

Riparian Management Zone (RMZ): An area of land adjacent to a water body which acts to trap and filter out suspended sediments, nutrients, and chemicals before reaching surface waters. Harvesting and other forest management activities are permitted in the strip, as long as the functional integrity of the strip is maintained. Shade from the RMZ may also reduce thermal pollution of an adjacent stream.

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.

Rut: A depression in the soils of the forest floor or depressions in dirt roads or skid trails made from the passage of vehicles or logging equipment.

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: The legal definition of sediment is defined in Part 91, Soil Erosion and Sedimentation Control, Natural Resources and Environmental Protection Act, 1994, Public Act 451, As Amended, in section 324.9101, Definitions; A to W, subsection 9101, subpart (14). It reads as follows: "Sediment" means solid particulate matter, including both mineral and organic matter, that is in suspension in water, in being transported, or has been removed from its site of origin by the actions of wind, water, or gravity and has been deposited elsewhere.

Seep (also called a spring seep or spring): A permanent or intermittent discharge of water that emerges from the ground and flows across the soil surface without defined bed and banks. The limits of the seep are demarked by the extent of surface water, water-stained leaves, or other signs of hydrology (e.g. oxidized root channels).

Severe Erosion Hazard: A rating in the classification of soils indicating the relative risk of soil loss in well-managed forest land. A severe rating indicates the need for intensive management, or special equipment and methods to prevent excessive soil loss.

Silt Fence: A fabric made of geotextile and installed to prevent the off-site movement of sediment transported by overland flows.

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.

Slash: 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. May be useful as material to deposit on skid trails to slow water movement and erosion.

Stream: The legal definition of a stream is defined in Part 301, Inland Lakes and Streams, Natural Resources and Environmental Protection Act, PA 451, 1994, as amended, in Section 324.30101, Definitions. subsection (h) of Part 301. It reads as follows: "a river or stream or creek which may or may not be serving as a drain as defined by the drain code of 1956, PA 40 MCL 280.9 to 280.630 or any other body of water that has definite banks, a bed and visible evidence of a continued flow or continued occurrence of water….."

Trout stream: Any stream or portion of a stream that contains a significant population of any species of trout or salmon, as determined by the DNR. The DNR shall designate not more than 212 miles of trout streams in which only lures or baits as the DNR prescribes may be used in fishing, and the DNR may prescribe the size and number of fish that may be taken from those trout streams. (Per Act 451, MCL Section 324.48701).

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.

Vernal pool: A small (usually less than an acre), shallow, temporary body of water in a depression that lacks a perennial inlet or outlet stream and has no permanent fish population. It will appear after snow melt and gradually dry up as the summer progresses. They may be vegetated or non-vegetated bodies of water during the wettest seasons of the year, while in dry seasons, they may only be recognizable as an isolated depression on the forest floor. They provide critical habitat for breeding amphibians and are also important for certain invertebrates and plants. Bears coming out of hibernation also rely on vernal pools as a food source during the spring.

Water Bar: A ditch and trench 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 water runoff does not gain the volume and velocity which causes soil movement and erosion. Properly installed man-made materials, such as conveyor belts, may also be used as water bars.

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, wetlands, rivers, streams, ditches, springs, and waters from underground aquifers, regardless of their size or location.

Wetlands: Geographic areas characteristically supporting wetlands vegetation or aquatic life and commonly referred to as a bog, swamp, or marsh. Surface water is usually present all or some part of the year; however, wetlands may also be delineated by the type of soils and vegetation contained therein.

Wildfire: Uncontrolled fires occurring in forest land, brushland, and grassland.

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

APPENDIX B - WORKING WITHIN THE LAWS GOVERNING NONPOINT SOURCE POLLUTION

Forestry BMPs are practical and cost effective methods that are specifically designed to help protect the State's aquatic resources by minimizing the effect of nonpoint source (NPS) pollution caused by human activities on the landscape. The NPS pollution is one of the leading causes of water pollution and aquatic ecosystem degradation in the nation.

The NPS pollution comes from a wide variety of diffuse sources including atmospheric deposition, agriculture, urban storm water runoff, mine drainage, land development, road building and numerous other land use activities. In the forested landscape, rainfall or snowmelt runoff moving over and through the ground can carry natural and man-made pollutants toward water sources eventually depositing them into lakes, rivers, wetlands, coastal waters, or underground aquifers. Examples of these pollutants include excess fertilizers and pesticides from silvicultural activities and sediment runoff from harvest sites, skid trails, road building, bridge or culvert installation and other land altering activities.

There are a number of state and federal statutes that relate to Michigan aquatic resource protection including the protection of ponds, inland lakes, the Great Lakes and intermittent and perennial streams. In Michigan, Part 31 of the Natural Resources and Environmental Act, 1994 PA 451, as amended (NREPA), addresses direct or indirect discharges that impact water quality, wildlife, fish, aquatic life and plants. Appendix C highlights Part 31 and other specific laws regulating forestry activities and related infrastructure installation and maintenance (bridges, culverts, roads).

Permits are required in a number of situations such as crossing streams and wetlands or building haul roads. These state and/or local permits help ensure proper engineering design and environmental protection. If you have questions regarding specific permit requirements, please contact the DEQ Environmental Assistance Center at 800-662-9278, or the local district DEQ Service Center (Note that a storm water permit is not required for mobile logging operations).

Failure to secure the necessary permits while engaged in logging, road building, and/or crossing streams activities is against the law. Violations could lead to enforcement actions and the possibility of fines of up to $25,000 per day.

APPENDIX C - LIST OF APPLICABLE LAWS IN MICHIGAN

Part 17, Michigan Environmental Protection Act, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA).
This Act provides for the protection of air, water, and other natural resources, and the public trust associated with those resources. It provides the right to any person to bring an action against another person, agency, corporation, and political subdivision for conduct that may pollute, impair or destroy air, water, or other natural resources.

Part 31, (Section 3108) Water Resource Protection (Floodplain Regulatory Authority), of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA).
A Part 31 permit (Section 3108) is required for any occupation, construction, filling, or grade change within the 100-year floodplain of a river, stream, drain, or lake. Bridges and culverts are considered an occupation of the floodplain, as are activities that involve storage of materials in the floodplain. A 100-year flood has a 1% chance of occurring or being exceeded in any given year. These activities are regulated by a permit system with the purpose of ensuring that the channels and floodways are kept clear and uninhabited and that structures placed outside the floodway are properly protected from flood damage. The floodway includes the stream channel and that portion of the floodplain that is required to convey the flow of floodwater. Structures that are placed outside of the floodway portion of the floodplain must be properly protected from flood damage. This can be accomplished by elevating structures above the 100-year floodplain elevation or by designing the structures to be water tight without human intervention.

Part 31, (Section 3109) Water Resource Protection (Discharge into state waters), of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA).
Section 3109 of Part 31 is the statute used in the State of Michigan to address direct or indirect discharges of a substance that is or may become injurious to any of the following: a) public health, safety, or welfare, b) waters used for domestic, commercial, industrial, recreational or other uses, c) value and utility of riparian lands, d) livestock, wild animals, birds, fish aquatic life, or plants or to their growth and propagation, and the value of fish or game. Pursuant to the Part 31 statute, specific rules have been promulgated to address pollutants or substances such as excess sediment that can become injurious to waters of the State and aquatic life and its productivity.

Part 91, Soil Erosion and Sedimentation Control (SESC), of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA).
The purpose of Part 91 is to prevent soil erosion and to protect the waters of the State from sedimentation. A permit is required for any earth change that disturbs one or more acres of land OR that is within 500 feet of a lake or stream. Plowing and tilling for crop production and integral activities associated with logging and mining do not require permits. Access roads leading to or from a logging area, and ancillary and support activities associated with logging and mining, are subject to permits. A SESC permit is obtained by contacting your local county or municipal enforcing agency, CEA or MEA. For more information on the SESC program, please visit www.mi.gov/deqland and select “Soil Erosion and Sedimentation Control.”

Whether a permit is required or not, the landowner is responsible for preventing off-site sedimentation. Activities that result in sedimentation to the waters of the State are a violation of Part 91 and are subject to enforcement actions by either the County Enforcing Agency or the State of Michigan. The counties are primarily responsible for issuing Part 91 permits. Prior to obtaining a permit, the landowner, or his/her designated agent, must submit an application and comprehensive soil erosion and sedimentation control plan to the appropriate county agency.

Part 301, Inland Lakes and Streams, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA).
The intent of the Inland Lake and Stream Protection Program is to protect the integrity of the land/water interface, the correlative rights of other riparian owners, and public trust in the inland waters of the State. Crossing a permanent or intermittent stream while skidding forest products or transporting them to the mill requires a Part 301 permit.

Road and pedestrian crossings, as well as utility crossings, that disturb land below the ordinary high water mark, are examples of common projects that require a Part 301 permit. A storm water outfall, with or without stream bank or streambed protection (riprap), stream relocations and enclosures are also examples of projects requiring a permit.

Part 303, Wetlands Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA).
Part 303 defines a wetland as "land characterized by the presence of water at a frequency and duration sufficient to support, and that under normal circumstances does support, wetland vegetation, or aquatic life, and is commonly referred to as a bog, swamp, or marsh."

The following construction activities are prohibited in wetlands, unless a Part 303 permit has been obtained from the DEQ:

- Deposit or permit the placing of fill material in a wetland.
- Dredge, remove, or permit the removal of soil or minerals from a wetland.
- Construct, operate, or maintain any use or development from a wetland.
- Drain surface water from a wetland.

Regulated wetlands are defined in Part 303 and associated administrative rules. However, silvicultural and timber harvesting activities, such as the building of roads for wood transport, are exempt from obtaining a Part 303 permit, as long as adverse effects on the wetland are minimized and the roads are built solely for logging or forestry purposes.

Part 305, Natural Rivers Act, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA).
This statute regulates all development and land uses, including timber harvesting and stream crossings, on both public and private lands, that are within 400 feet of a designated stream. Part 305 requires DNR approval of plans for the location and construction of any utility or publicly provided facility, including roads, bridges and culverts, within a designated Natural River Area. Each designated river system is managed according to a long-range management plan. This plan outlines the specific manner in which lands and water are to be managed to protect the unique river values of a designated Natural River system. Both mainstream and tributaries are regulated under Part 305.

Part 323, Shorelands Protection and Management, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA).
This program provides for the designation and proper management of environmental areas, high-risk erosion areas and flood risk areas along the Great Lakes shoreline. These areas include coastal wetlands and the adjacent uplands that provide habitat and nursery for fish and wildlife. A Part 323 permit is required for certain activities in a designated environmental area.

Part 353, Sand Dunes Protection and Management, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA).
The designated critical dune areas along the Great Lakes shoreline are areas where the most unique and fragile sand dunes are found. This program minimizes the impact of development on these critical dune areas. A permit is required for all proposed new uses in designated

critical dune areas mapped in the "Atlas of Critical Dune Areas", prepared by the DEQ.

Part 365, Endangered Species Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA).
This statute protects threatened and endangered species from being taken or harmed during project development activities, unless a permit is issued by the DNR. Where threatened and endangered species are thought to exist, the landowner or responsible party is required to request an environmental review by the DNR to determine whether or not threatened or endangered species may be impacted by planned activities.

Part 515, Forest Protection and Forest Fires Act, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA).
This establishes the machinery to protect the forest from fires. It applies to all forest land; timbered, potential timber producing, cutover or burned timber land or grasslands, not including farmland. It requires a permit for burning on or adjacent to forestland, except for domestic purposes, and when the ground is snow covered.

National Pollutant Discharge Elimination System (NPDES) – Michigan Environmental Protection Act, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA).
A NPDES permit is required for fixed forestry activities such as permanent log storage areas maintained by paper mills or saw mills. Discharge to a storm sewer does not go to a municipal treatment facility, and is considered a direct discharge. Discharge to a municipal treatment facility may require a permit from the municipality under the Industrial Pretreatment Program.

Act 676 of 2002, Right to Forest Act.
An Act to provide for circumstances under which certain forestry operations shall not be found to be a public or private nuisance; to provide for certain forestry management practices; to provide for certain powers and duties for certain state agencies and departments; and to provide remedies.

APPENDIX D - FREQUENTLY ASKED QUESTIONS REGARDING STREAM CROSSING REGULATIONS AND PERMITS

APPLICABLE LAWS: Part 301, Inland Lakes and Streams, Part 91, Soil Erosion and Sedimentation Control, and Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA).

Definition of a stream: Has a defined bed, bank and some occurrence of water flow at sometime during the year.

Who is in charge of enforcing this law? The Michigan Department of Environmental Quality (DEQ).

When do I need to apply for a permit? Any time you plan to engage in an activity that may involve putting material or structures in or over a stream or stream bank.

Typical logging/forestry situations requiring a Part 301, Part 91, and Part 31 permits include:

1. Moving equipment or logs across a stream at any time during a logging or forest management operation.
2. Installation of a culvert or temporary bridge.
3. Modification or improvement of an existing culvert or bridge.
4. Activity that may result in deposition of material in a stream or that may affect natural stream flows.
5. Activity that occurs below the ordinary high water mark of the stream (e.g. the top of the stream bank).
6. Use of “ice bridges” that involve placing fill, snow or slash in the stream bed area.

Where do I go to apply for a permit? Contact your local DEQ office. A map showing the location of local DEQ offices throughout the State is available www.michigan.gov/deq, under “DEQ Locations” at the bottom of the website.

How much does this permit cost? The majority of stream crossings used for logging/forestry will have a permit cost of $50. If the drainage area of the stream is more than two square miles, the permit cost is $100. Installation of a newly created **permanent** stream crossing may have a permit cost of $500.

How much will it cost to install a stream crossing? Costs may vary from several hundred to several thousand dollars, depending on what

infrastructure is required and how much labor is involved in meeting DEQ permit requirements.

What is the preferred method of crossing a stream? The use of portable wooden or steel bridges is the preferred method, as proper installation involves the least amount of impact on the stream, as well as unimpeded fish passage.

What about the use of rocks or logs to cross the stream? The DEQ will not issue a permit for the use of such materials to construct a stream crossing. Rare exceptions may be made, but only after careful review and consideration by DEQ permitting staff.

What can I do to shorten the time it takes to get a permit? Contact your local DEQ office and work with the appropriate person closely throughout the permitting process. Providing clear and accurate photos of the stream crossing site and meeting with permitting staff on site may also help speed up the permitting process.

How can I find out more information regarding stream crossing permits: Please contact your local DEQ office or visit the DEQ/USACE Joint Permit Application website: http://www.michigan.gov/jointpermit, and select “Joint Permit Application” in the middle of the website. This website provides an extensive amount of information regarding the permit requirements for construction activities where the land and the water meet.

APPENDIX E – VEGETATIVE EROSION CONTROL GUIDANCE FOR NATURAL RESOURCE MANAGEMENT

Introduction

The purpose of this document is to provide information to facilitate the successful and timely re-establishment of vegetation following earth change activities. In most situations, vegetation is the best means of controlling wind or water erosion and preventing sediment transport and off-site sedimentation.

This document focuses on methods for the quick establishment of vegetative ground cover and establishing permanent native vegetative ground cover. It also discusses what environmental regulations apply regarding establishing vegetative cover for erosion control.

With respect to erosion control, the key legislation (and its administrative rules) that applies here is Part 91, Soil Erosion and Sedimentation Control (SESC), of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA). As discussed in the manual, *"Sustainable Soil and Water Quality Practices on Forest Land"*, Part 91 applies whenever there is an "earth change" (e.g. removal of the vegetative cover and soil disturbance by a bulldozer) that is one or more acres in size or within 500 feet of a water body. Refer to the manual's section 2, "Laws and Permits" and "Appendix C – List of Applicable Laws in Michigan", for more information regarding Part 91 and its requirements.

Natural revegetation of areas in which the vegetative ground cover has been removed rarely occurs with the rapidity or vigor required to prevent erosion. Consequently, methods that quickly re-establish vegetative ground cover are required. Seeding using grass species is the most commonly used and most effective means of re-establishing vegetation.

For erosion control, many governmental agencies and landowners have relied heavily on using certain non-native and invasive plant grass species. However, increasingly, it is being recognized that these species can cause ecological damage. Alternatives are being sought to control erosion using grass species native to the region and state. An additional consideration is to use native plant species seed of a locally adapted genotype (seed from local populations of native species), as locally adapted genotypes often have better long-term growth.

Definitions That Apply To This Document

Native plants are naturally occurring species that existed in Michigan prior to European settlement.

Native plant genotypes are represented by genetic strains that have evolved in Michigan and are assumed to be adapted to Michigan's conditions.

Non-native species are species that were not naturally occurring in Michigan prior to European settlement. Some of these plants have had little impact on native species, others have had direct negative impacts on native species.

Invasive non-native plants are species that have had direct negative impact on the State's natural resources. These plants are very aggressive and out-compete native plants. Examples include autumn olive and purple loosestrife.

Native and Introduced Species

Within the natural resource management field, as well as the general public, there is increasing concern regarding current and potential future damage to native ecosystems due to the establishment and spread of certain non-native plant species (e.g., garlic mustard, purple loosestrife, crownvetch). These non-native species are referred to as "invasive", as they disrupt native ecosystems that maintain or conserve native plant and animal biodiversity.

Many non-native grasses and other plant species introduced in the past and promoted for erosion control have proved to be less beneficial for their intended purpose than native species. Some of these introduced species have become invasive or noxious. However, many non-native plant species, such as those used for erosion control, are economical and readily available relative to native plant species.

Native species can be expensive and only available from a limited number of suppliers. Despite these factors, forest land managers and others are realizing long-term ecological and economic benefits by re-establishing locally adapted genotypes of native vegetation for erosion control and other restoration efforts.

In Michigan, the DNR and federal land management agencies emphasize or, in some cases, require the use of native species vegetation, and, if available, locally adapted genotypes on the lands they manage. The DNR encourages the use of native seed or native vegetation on private lands as well.

To meet legal requirements and prevent soil from eroding into a water body, certain introduced species may be used, especially if quick establishment of vegetative cover is needed. However, this document only recommends those non-native species that are not considered to be invasive, which are most likely to promote the natural succession of the site to native ground cover or are not likely to interfere with the native seed applied at a later date.

Planning and Site Assessment

Proper planning and site assessment is essential to ensure erosion control and establishment of native ground cover. The selection of plant species to use and establishment procedures should match the plant's adaptations to local site conditions, including:

- available sunlight
- slope
- topography
- local climate
- soil drainage class
- soil texture
- proximity to environmentally-sensitive areas or natural plant communities
- soil fertility
- soil pH

To ensure proper establishment, a soil test may need to be taken at the site and soil amendments (e.g., fertilizer and lime) may need to be applied. In many cases, soil amendments will not be necessary when using suitable native plants. Managers should plan to stockpile the topsoil that was removed from the site during road and landing construction, to later use when topsoil is needed for the re-establishment of vegetative ground cover.

Site Preparation

The purpose of site preparation is to have good contact between soil and seed to achieve acceptable levels of germination. For temporary roads, landings and primary skid trails, site preparation generally occurs after harvest operations have been completed. Where disturbed/bare soil sites are small and soil compaction is minimal, it may be suitable to use a hand rake to prepare the seedbed (e.g., secondary skid trails in a RMZ on dry, upland or non-saturated soils).

Topsoil Use

It is essential for successful and quick revegetation to have a suitable depth of firm, but friable topsoil. Part 91 erosion control guidelines state that disturbed sites have a minimum of 3 to 4 inches of firm, but friable topsoil. However, these same guidelines allow for professional judgment and knowledge as to what depth of native topsoil will work as a suitable seedbed. Stockpiled topsoil that was removed from the site during road or landing construction should be re-applied when the constructed roads and landings are no longer required for operational or other forest management purposes (e.g. access to replant tree seedlings after a clearcut has occurred).

On sloped areas, prior to re-application of topsoil, roughen the subsoil to prevent a shear or smooth surface and slippage of the topsoil. Typically, surface roughening is accomplished by running tracked equipment (e.g. bulldozer) up and down the sloped area. If more topsoil is required to provide suitable seedbed germination, acquire topsoil from a source native to the area. Use topsoil that is not contaminated with non-native, weedy and invasive species.

Part 91 administrative rules state that a person shall complete permanent soil erosion control measures for all disturbed land areas within 5 calendar days after final grading or the final earth change has been completed. However, when seedbed preparation and/or seeding must be delayed due to weather, climate, seasonal conditions or certain resource management issues (pertinent to the site), then *appropriate* temporary erosion control (e.g. mulch) and sedimentation control measures (e.g. silt fence) shall be installed and maintained until seedbed preparation and seeding can commence.

Seeding and Erosion Control– Native and "Safe" Non-Native Species Use

Seed may be applied by hand, mechanical spreader, seed drill, or by hydro-seeding. Some native species must be applied with a drill.

Two objectives should be considered when seeding:

1) What is required to meet Part 91 requirements (quick establishment of vegetative cover and minimal erosion and sedimentation).

2) Long-term establishment of native vegetation.

To meet both of these objectives usually requires, at a minimum, the application of grass seed that is fast growing and provides fairly quick erosion control. As with other BMPs, there are a number of options based on the conditions of the site and when the seed is applied.

Seeding Recommendations

Seed Rates

All seeding rates, such as those stated in Table 8, are in pounds of "pure live seed" (PLS). In the case of certain native species, this can be significantly more than the weight of bulk seed. When accounting for the amount of PLS, one will need to purchase and use more bulk seed than the weight per acre recommendations given for a particular seed species. Use the following formula to derive the required weight of bulk seed from the PLS rate. Germination, hard seed (a characteristic of legume seeds), and purity percentages are found on the information label attached to all commercially purchased seed.

$$\text{Pounds (lbs) of Bulk Seed} = \frac{\text{lbs PLS}}{(\text{purity}^* + \text{hard seed}^*)\,(\text{germination}^*)}$$

*express % purity, hard seed, and germination in hundredths; i.e. 97% = 0.97

For example, a seed label indicates Canada Wild Rye that has a germination rate of 90%, no hard seed content, and a purity of 97%. The "Cool Season" seed mix from Table 2 requires 4 pounds of Canada Wild Rye PLS/acre. Compute the bulk seed rate as follows:

$$\text{lbs of bulk Canada Wild Rye seed} = \frac{4}{(0.97+0)\,(0.90)} = \frac{4}{0.873}$$

lbs of bulk Canada Wild Rye seed = 4.6 (which is the equivalent of 4 lbs of PLS)

Table 1 provides a list of native and non-native ground cover species (grasses and forbs) to consider for erosion control. Table 7 provides, by plant species, the soil texture, soil moisture, and sunlight requirements for successful germination and establishment. The comments portion contains information as to whether a species is native or non-native, perennial or annual, and (for grasses only), if it is considered a warm season or cool season grass.

Key for Information in Tables 7 and 8			
SOIL	**MOISTURE**	**LIGHT**	**REGION**
S - Sand	D - Dry	S - Full Sun	UP-Upper Peninsula
L - Loam	M - Moist	P – Partial Shade	NLP-Northern Lower Peninsula
C - Clay	W - Wet	Sh – Shade	SLP -Southern Lower Peninsula
M - Muck			SW - Statewide

Table 7. Native & Non-Native Plant Species To Use For Erosion Control In Forest Land

SPECIES NAMES Common (*Latin)*	SOIL	MOISTURE	LIGHT	REGION	Comments
Grasses:					
American beach grass (*Ampophila breviligulata*)	S	D	S	SW	Native perennial, dune stabilization – use plugs, not seed
Annual rye (*Lolium multiflorum*)	S-L-C	D-M-W	S, P, Sh	SW	Non-native annual, temporary cover
Big bluestem (*Andropogan gerardii*)	S-L-C	D-M-W	S	SW	Native perennial, warm season grass*
Creeping red fescue (*Festuca rubra*)	S-L-C	D-M-W	S , P	SW	Non-native perennial
Indian grass (*Sorghastrum nutans)*	S-L-C	D-M-W	S-P	NLP, SLP	Native perennial, warm season grass*
June grass (*Koelaria micrantha*)	S-L-C	D-M	S, P	SW	Native perennial, cool season grass**
Little bluestem (*Schizachyrium scoparius*)	S-L	D-M	S, P	SW	Native perennial, warm season grass*, dune stabilization
Oats (*Avena sativa*)	S-L-C	D-M	S, P	SW	Non-native annual, temporary cover

SPECIES NAMES Common (*Latin)*	SOIL	MOISTURE	LIGHT	REGION	Comments
Redtop (*Agrostis gigantea*)	L, C, M	M-W	S	SW	Non-native perennial, cool season grass**
Switchgrass (*Panicum virgatum*)	S-L-C	D-W	S	SW	Native perennial, warm season grass*
Wild-rye, Canada (*Elymus canadensis*)	S-L	D-M-W	S, P, Sh	SW	Native perennial, cool season grass**
Wild-rye, Virginia (*Elymus virginicus*)	L-C	M-W	S, P, Sh	SW	Native perennial, cool season grass**
Forbs (Wildflowers)					
Legumes:					
Alsike Clover (*Trifolium hybridum*)	L-M	D-M-W	S, P	SW	Non-native, perennial, good for forest roads in northern hardwoods
Lupine (*Lupinus perennis*)	S-L	D-M	S - P	SLP + Newaygo Co.	Native perennial, butterfly host, nectar source
Medium Red Clover (*Trifolium pratense*)	S-L-C	D-M-W	S, P	SW	Non-native, perennial legume, good for forest roads in northern hardwoods
Round-headed bush clover (*Lespedeza capitata*)	S-L	D-M	S	SLP + Newaygo Co.	Native perennial legume, wildlife food
White Dutch Clover (*Trifolium repens*)	L-C-M	D-M-W	S, P	SW	Non-native, perennial legume, good for forest roads in northern hardwoods
Other Wildflowers:					
Black-eyed Susan (*Rudbeckia hirta*)	L-C	D-M	S-P	SW	Showy native perennial, yellow

SPECIES NAMES Common (*Latin*)	SOIL	MOISTURE	LIGHT	REGION	Comments
Butterflyweed (*Asclepias tuberosa*)	S-L	D-M	S	SW	Showy native perennial, orange
Common milkweed (*Asclepias syriaca*)	S-L	D-M	S-P	SW	Native perennial, pink, butterfly food
Horsemint (*Monarda punctata*)	S-L	D-M	S	SW	Native perennial, white/pink
Lance-leaved coreopsis (*Coreopsis lanceolata*)	S-L-C	D-M	S.P	SW	Showy native perennial, yellow
Starry false solomon-seal (*Smilacina stellata*)	S	D-M	S-P	SW	Native perennial, dune stabilization, white
Wild Bergamot (*Monarda fistulosa*)	S-L-C	D-M	S	SW	Showy native perennial, pink

* Warm season grasses = most of their growing occurs during the warm summer months, July, Aug, Sept.
** Cool season grasses= most of their growing occurs in cool, spring months, May, June

Table 8. Two Examples of Seed Mixtures Using Native Plants

Mix type	Common Name	Rate. lbs/acre
Cool Season	Canada Wild-rye	4
	Wild Virginia-rye	5
	Annual rye	5
Warm Season	Big Bluestem	4
	Indian grass	3
	Switchgrass	1
Note: For the Upper Peninsula, substitute Little Bluestem for Indian Grass		

Other Items to Consider When Planting Native Species in a Forested Setting:

While Part 91 erosion control guidelines can contain helpful information, they were developed with the primary purpose of establishing grass cover on construction sites after final grading has been completed. The next paragraph provides a few additional considerations specifically designed for natural resource management purposes. For more specific technical information as to the proper timing, soils and general methods to ensure long-term establishment of a native plant seeding, contact the firm from which you purchased the seed.

As with introduced grasses, native grass/wildflower seed germination success requires good seed contact with soil. Depending on the site conditions, prepare the soil as needed and either handsow or use a prairie drill such as the Tye drill, Truax drill, or the John Deere Rangeland drill. If handsowing, it is advisable to mix the seed with a contact mulch such as wetted sand or vermiculite. If handsowed, rake or drag the seed in so that it is lightly covered with soil. Roll the site with a roller or drive over it to firm seed into the soil. Do not roll the site, if the soil is wet so as to avoid soil compaction. Hydro-seeding is generally not recommended for wildflower and prairie grass seeding, as it does not ensure firm seed-to-soil contact.

Mulch Use after Seed Application

In some cases, applying the detritus from the forest floor may be considered, if erosion is not an immediate threat, the site is not near a water body, and conditions are right for seed within the detritus to establish.

In most situations, it will be appropriate to apply a light covering of clean, weed-free straw with some moisture content, as this will increase germination rates. This is particularly helpful on dry sandy soils and heavy clay soils. Straw should just cover the soil surface, but not bury it. Some soil should be visible through the straw. Chopping and blowing the straw onto the area is the best method, as chopped straw is less susceptible to being blown away by the wind. On steep slopes, hold the straw in place by using biodegradable stakes and mesh over the straw. Never use field hay, as it invariably contains innumerable weed seeds.

Conclusion

These guidelines are just that, guidelines as of early 2007. Introduced plant species used for erosion control and site stabilization have been researched and used for a long time. Conversely, the amount of information available regarding the use of native plant species for erosion control and site stabilization is far less, especially with respect to what will work for the various ecological regions of a given state, such as Michigan. Hence, it is essential that users of these guidelines keep abreast of vegetation erosion guideline updates. Use professional judgment and past experience as to what will prevent erosion, meet Part 91 requirements, and result in the establishment of native vegetation genotypes adapted to the local site conditions.

The DNR and DEQ recognize that the use of native species is more expensive than using introduced species and are more difficult to obtain. However, native species with local region genotypes are the species best adapted to the site conditions and survival for the long-term, without harm to the environment or Michigan's biodiversity conservation efforts.

A number of Michigan firms which produce seed native to Michigan have formed an association called the Michigan Native Plant Producers Association. Their website is: http://www.mnppa.org/. Another source for information is the Michigan Wildflower Association. Their website is: http://www.wildflowersmich.org/. Another related site is the Michigan Association Conservation District's website on native plants. This website is: http://www.macd.org/nativeplants/nphome.html. Many county conservation districts sell native plants, as well as provide general and technical information regarding the uses and benefits of various native plant species.

APPENDIX F – NATURAL RIVER BUFFERS

River	Public Lands		Private Lands (1)		Counties
	Mainstream	*Tributary*	*Mainstream*	*Tributary*	
Upper Peninsula					
Fox	200	200	100	100	Alger, Luce, Schoolcraft
Two Hearted	100	100	100	100	Luce
Northern Lower					
Au Sable	150	150	75	50	Crawford, Oscoda, Otsego, Roscommon, Montmorency, Iosco, Alcona
Betsie	100	100	50	50	Benzie, Manistee
Boardman	100	100	75/50	50	Grand Traverse, Kalkaska
Jordan	100	100	100	25	Antrim, Charlevoix
Pere Marquette	150	150	75	50	Lake, Mason, Oceana, Muskegon
Pigeon	200	150	100	75	Otsego, Cheboygan

River	Public Lands		Private Lands (1)		Counties
	Mainstream	*Tributary*	*Mainstream*	*Tributary*	
Pine	175*	100 - 155**	100	50	Wexford, Osceola, Lake, Manistee
Upper Manistee	175*	100 - 155**	75	75	Antrim, Otsego, Crawford, Kalkaska, Missaukee
Southern Lower					
Flat	50	50	25	25	Montcalm, Ionia, Kent
Huron	100	100	50	50	Livingston, Washtenaw
Kalamazoo	150	150	50	50	Allegan
Rifle	150	100	75	50	Ogemaw, Arenac
Rogue	100	100	50	25	Kent
White	100	100	50	50	Newaygo, Oceana, Muskegon

Note: All distances listed above are measured in feet from the ordinary high watermark.
(1) When working on private lands along Natural Rivers, a Natural River permit is required when cutting within the buffer.

* Buffer includes the entire face of a bluff where the toe of the bluff is within 175 feet of the river's edge and lands within 50 feet of the crest of a bluff.

** Buffer width increases depending on steepness of slope.
Contact the Department of Natural Resources, Natural Rivers Program for additional buffer information at 517-373-1280.

APPENDIX G - DESIGNATED NATURAL RIVERS AND TRIBUTARIES

UPPER PENINSULA

FOX RIVER
Mainstream: Alger and Schoolcraft Counties
Tributaries:
Alger County: Casey Creek, West Branch Fox River
Schoolcraft County: Camp Seven Creek, Clear Creek, Cold Creek, East Branch Fox River, Hudson Creek, Little Fox River, Spring Creek, Spring Ponds, West Branch, Fox River
Luce County: Bev Creek, Deer Creek, East Branch Fox River, Spring Creek

TWO HEARTED RIVER
Mainstream: Luce County
Tributaries:
Luce County: Dawson Creek, East Branch Two Hearted River, North Branch Two Hearted River, South Branch Two Hearted River, West Branch Two Hearted River

NORTHERN LOWER PENINSULA

AU SABLE RIVER
Mainstream: Upstream of Loud Dam - Alcona, Crawford, Iosco, and Oscoda Counties
Tributaries:
Alcona County: Blockhouse Creek
Crawford County: Big Creek (including East Branch, Middle Branch and West Branch), Bradford Creek, East Branch Au Sable River, Kolka Creek, North Branch Au Sable River, South Branch Au Sable River
Montmorency County: Middle Branch Big Creek
Oscoda County: Beaver Creek, Big Creek, Big Creek Township (including East Branch and West Branch), Blockhouse Creek, Comins Creek, East Branch Big Creek, Greenwood Township, Glennie Creek, Loud Creek, Middle Branch Big Creek, Greenwood Township, Nine Mile Creek, Perry Creek, Sohn Creek, Wolf Creek
Otsego County: Chub Creek, Kolka Creek, North Branch Au Sable River, Turtle Creek, West Branch Big Creek
Roscommon County: Beaver Creek, Douglas Creek, East Creek, Hudson Creek, Robinson Creek, South Branch Au Sable River, South Creek, Thayer Creek

BETSIE RIVER
Mainstream: Benzie and Manistee Counties
Tributaries:
Benzie County: Little Betsie River, Dair Creek

BOARDMAN RIVER

Mainstream: Grand Traverse County

Tributaries:
Grand Traverse County: Bancroft Creek, Beitner Creek, Carpenter Creek, East Creek, Jackson Creek, Jaxson Creek, North Branch Boardman River, Parker Creek, South Branch Boardman River, Swainston Creek, Twenty Two Creek

Kalkaska County: Crofton Creek, Failing Creek, North Branch Boardman River, South Branch Boardman River, Taylor Creek

JORDAN RIVER

Mainstream: Antrim and Charlevoix Counties

Tributaries: All tributaries entering the mainstream upstream (south) of Rogers Bridge, Charlevoix County, T32N, R7W, Section 26/35

PERE MARQUETTE RIVER

Mainstream: Lake and Mason counties

Tributaries:
Lake County: Baldwin River, Blood Creek, Bray Creek, Cole Creek (including North Branch and South Branch), Danaher Creek, Kinney Creek, Leverentz Creek, Little South Branch Pere Marquette River, Middle Branch Pere Marquette River, Sandborn Creek, Sweetwater Creek

Mason County: Big South Branch Pere Marquette River, Carr Creek, Swan Creek, Weldon Creek,

Newaygo County: Big South Branch Pere Marquette River, Cedar Creek, Little South Branch Pere Marquette River, McDuffee Creek, Pease Creek

Oceana County: Big South Branch Pere Marquette River, Ruby Creek

PIGEON RIVER

Mainstream: Otsego and Cheboygan Counties

Tributaries: All tributaries in both counties upstream (south) of M-68, Cheboygan County

PINE RIVER

Mainstream: Osceola, Lake, Wexford and Manistee Counties

Tributaries:
Wexford County: North Branch of the Pine River, Spalding Creek, Fairchild Creek, Poplar Creek, Dowling Creek, Hoxey Creek, Unnamed stream with sources in sections 27 and 34, South Branch Twp., Yates Creek

Osceola County: North Branch of the Pine River, Sixteen Creek, Fairchild Creek, Unnamed stream with source at dam in section 8 of Burdell Twp., East Branch of the Pine River, Rose Lake outlet, Emery Lake outlet, Edgetts Creek, Diamond Lake outlets, Unnamed stream with source in section 20, Sherman Twp., Sprague Creek, Beaver Creek, Little Beaver Creek, Coe Creek, Dyer Creek

Lake County: Unnamed stream with source in section 14, Ellsworth Twp., Coe Creek, Sellars Creek, Unnamed stream with source in section 20, Dover Twp., Unnamed stream with source in section 19, Dover Twp., Unnamed stream with

source in section 24, Newkirk Twp., Silver Creek including all perennial tributaries, Unnamed stream with source in section 13, Newkirk Twp., Unnamed stream with source in section 11, Newkirk Twp., Unnamed stream with source in section 7, Dover Twp., Unnamed stream with source in section 1, Newkirk Twp., Poplar Creek

RIFLE RIVER

Mainstream: Arenac and Ogemaw Counties

Tributaries:
Arenac County: Fritz Creek, Mansfield Creek

Ogemaw County: Dedrich Creek, Eddy Creek, Gamble Creek, Houghton Creek, Klacking Creek, Little Klacking Creek, Mansfield Creek, Mayhue Creek, Oyster Creek, Prior Creek, Silver Creek, Vaughn Creek, West Branch Rifle River, Wilkins Creek

UPPER MANISTEE RIVER

Mainstream: Antrim, Otsego, Crawford, Kalkaska and Missaukee Counties

Tributaries:
Antrim County: All headwater streams

Otsego County: Frenchman's Creek

Crawford County: Lost Lake Outlet, Unnamed stream, section 30, Frederic Twp. (T28N, R4W), Goose Creek, Portage Creek, including all perennial tributaries

Kalkaska County: Unnamed stream with source in section 13, Blue Lake Twp., Goose Creek, Portage Creek (including all perennial tributaries), Clear Creek, Black Creek (including all perennial tributaries), Dempsey Creek, Big Devil Creek, Big Cannon Creek, North Branch of the Manistee River (including all perennial tributaries), Willow Creek, Pierson Creek, Maple Creek, Little Cannon Creek, Silver Creek, Waterhole Creek (including all tributaries), Babcock Creek, Filer Creek, Nelson Creek, Spring Creek, Bourne Creek, Ham Creek, Haynes Creek, Fisher Creek

Missaukee County: Silver Creek, Filer Creek, Ham Creek, Gravy Creek, Hopkins Creek, Fisher Creek

SOUTHERN LOWER PENINSULA

FLAT RIVER

Mainstream: Ionia, Kent and Montcalm Counties

Tributaries:
Ionia County: Dickerson Creek

Kent County: Clear Creek, Coopers Creek, Wabasis Creek

Montcalm County: Coopers Creek, Dickerson Creek, Wabasis Creek, West Branch Flat River

HURON RIVER

Mainstream: Livingston and Washtenaw Counties

Tributaries:
Livingston County: Davis Creek

Washtenaw County: Arms Creek, Mill Creek

LOWER KALAMAZOO RIVER
Mainstream: Allegan County

Tributaries:
Allegan County: Bear Creek, Mann Creek, Rabbit River, Sand Creek, Swan Creek

ROGUE RIVER
Mainstream: Kent County

Tributaries:
Kent County: Barkley Creek, Cedar Creek, Duke Creek, Rum Creek, Shaw Creek, Spring Creek, Stegman Creek

WHITE RIVER
Mainstream: Muskegon, Newaygo and Oceana Counties

Tributaries:
Muskegon County: Carlton Creek, Carleton (Lanford) Creek, Cleveland Creek, Sand Creek, Silver Creek, Skeels Creek

Newaygo County: East Branch Heald Creek, Five Mile Creek, Flinton Creek, Martin Creek, Mena Creek, Mullen Creek, Wrights Creek

Oceana County: Braton Creek, Carlton Creek, Cobmoosa (Osborn) Creek, Cushman Creek, Knutson Creek, Mud Creek, Newman Creek, North Branch White River, Robinson Creek, Sand Creek

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