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# Overview of Best Management Practices related to Forest Roads: The Southern States

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***Abstract.*** Forest roads are vital in the implementation of most all forest management activities. However, the potential of forest roads to have accelerated erosion losses and degrade water quality through stream sedimentation has long been recognized throughout the U.S. Forest roads have the potential to cause serious environmental impacts (possibly consequences) without effective scientifically based best management practices (BMPs). BMP programs for 13 Southern States were reviewed to determine the nature and extent of BMPs related to forest roads. State BMPs ranged from aggressive regulatory performance-based standards to passive voluntary prescription-based standards. Most states in the review have voluntary BMP guidelines promoting sound land stewardship. Kentucky's BMP program, regulatory in nature, is the most aggressive BMP program supported by a Forest Conservation Act enacted in 1998. Aside from differences in legislation supporting BMPs, forest road BMPs were consistent throughout the South.

**Keywords.** Forest Operations, Best Management Practices, Review, Water Quality, Erosion

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## Introduction

The Federal Water Pollution Control Act (FWPCA) originally enacted in 1972 had the principle objective to restore and maintain the physical, chemical, and biological integrity of one of the nation's most valuable resources, water. The act, amended in 1977, is now commonly referred to by as the Clean Water Act. Two fundamental goals are elemental in the achievement of objectives set forth in the CWA; eliminate discharge of pollutants into the nation's waters and achieve water quality levels in the nation's waters that are fishable and swimmable. At the enactment of the CWA only one-thirds of the nation's waters met the water quality levels safe for fishing and swimming. Today, two-thirds of the nation's waters meet water quality levels desired by the CWA.

The EPA was given the authority to set industry effluent standards and set water quality standards for contaminants in surface waters. The CWA provided for the delegation by the EPA of permitting, enforcement and administrative components of the law to state governments. Section 208 of the amendments identified silviculture as a nonpoint source (NPS) pollution source, requiring states to set guidelines (best management practices) to reduce NPS pollution. States were delegated the responsibility to define and develop either regulatory or voluntary best management practices (BMPs) for forestry practices.

BMPs for forestry practices are recommended for all aspects of forest operations such as streamside management zones (SMZ), stream crossings, forest roads, timber harvesting, forested wetland management, and reforestation. BMPs relating to forest roads are perhaps the most critical practices to influence environmental impacts of forest operations. Forest roads are necessary components in forest management because they provide access to perform management activities. Forest roads are a component of most all Forestry BMPs; thereby, implementing effective forestry BMPs requires addressing this common component. However, little work has been undertaken to investigate the effect of forest road BMPs on erosion and water quality.

Forest road have clearly been defined as one of the major sources of sediment that reaches stream channels on forestlands (Packer 1967; Trimble and Sartz 1957; Haupt 1959). Research has shown adverse impacts on the nation's water quality from soil erosion and stream sedimentation (Authur et al. 1998; Binkley and Brown 1993; Megahan et al. 1991). Controlling and mitigating sediments transported from the forest road prism has become a major emphasis on forest land holdings both industry and federal forestland holdings. Forest roads have been cited as contributing as much as 90 percent of all sediment from forestlands (Anderson et. al 1976; Patric 1976). Designs have been proposed to reduce the environmental impact of road systems (Grace 1998; Alabama Forestry Commission 1993; Swift 1985; Gardner 1978; Hewlett and Douglass 1968; Murphy 1985; Nagygyor 1984). The forest floor, due to its trapping characteristics, has been presented as a means to reduce sediment delivery to streams (Brinker 1993; Swift 1986; Haupt 1959; Megahan and Ketcheson 1996). However, the filtering capacity of the forest floor is not boundless and diminishes with time.

In recent years, application of forest road BMPs to protect water quality has become a common practice in forest activities in the US in response to the CWA. Since the early 1930's, BMPs, such as revegetating areas devoid of vegetation, have been reported to reduce impact of forest operations on soil erosion and water quality (Hursh 1939, 1942; Megahan and Kidd 1972; Swift 1984; Swift and Baker 1973; Grace 2002). The key to reducing water quality impacts of NPS pollution is effective state management and implementation of BMPs (Neat-y et al. 1989). However, States originally developed BMPs based on the little research, applied in conditions beyond their intent, or do not represent state-of-the art technology. This paper reviews the nature and extent of Forestry BMPs for the 13 Southern States related to forest operations, specifically focusing on forest roads.

## BMP Guidelines

BMPs programs for 13 southern states were reviewed to determine the nature of guidelines and/or regulations regarding forest operations. BMP program reviews were conducted by reviewing individual state BMP manuals for forestry and contacting designated state forestry agencies for additional information. BMP programs for the southern states ranged from non-regulatory (voluntary) to regulatory (mandatory) (Table 1). Standards or guidelines under BMP programs can be prescription-based or performance-based or a combination of each standard.

**Table 1. Summary of BMP Requirements for 13 Southern States*.**

| State | Compliance Requirements | Year of Manual |
|---|---|---|
| Alabama | Voluntary | 1993 |
| Arkansas | Voluntary | |
| Florida | Voluntary | 1993 |
| Georgia | Quasi-Regulatory | 1999 |
| Kentucky | Regulatory | 1996 |
| Louisiana | Voluntary | 1998 |
| Mississippi | Voluntary | 2000 |
| North Carolina | Quasi-Regulatory | 1994 |
| Oklahoma | Voluntary | 1994 |
| South Carolina | Voluntary | 1994 |
| Tennessee | Voluntary | 1996 |
| Texas | Voluntary | 2001 |
| Virginia | Voluntary | 1994 |

* information current when table was generated and omissions are due to incomplete data. BMP manuals and guidelines can be obtained from your State Forestry Agency.

Of the 13 states reviewed, Kentucky was the only state with comprehensive laws regarding forestry BMPs. Kentucky's Forest Conservation Act (KRS 194.330 to 149.355) enacted during the 1998 regular session of the Kentucky General Assembly requires (beginning July 15, 2000) loggers and operators to;

- have a master logger on site and in charge of commercial timber harvests;
- use appropriate BMPs during timber harvest; and
- correct damage to land and water.

The legislation also provides for civil penalties for loggers and operators failing to comply with the act. The Forest Conservation Act does not affect several categories of tree removal such as cutting of firewood, Christmas trees, timber in a utility or highway corridor (unless timber is sold), or timber by non-industrial private landowner conducting his/her own harvest operation.

North Carolina and Georgia guidelines had components that were both regulatory and voluntary. These programs were defined by State Forestry Agency contacts as quasi-regulatory programs. North Carolina, for instance, requires site-disturbing forestry activities be in accordance with forest practices guidelines (BMPs) to maintain exemption under the states Sedimentation Pollution Control Act. County and local laws and ordinances relating to road protection, watershed protection, land use plans, and zoning, however, may affect Forest operations in Georgia. The remaining states in the southern region all have voluntary guidelines, which are recommended to promote sound stewardship of forest resources.

### *Federally Mandated BMPs*

Section 404 of the CWA requires permitting from the US Army Corps of Engineers before discharging dredged or fill materials in the waters of the US. Section 404 affords an exemption from permitting requirements for forestry operations in wetlands provided the operation;

- qualifies as "normal silviculture" under an "established" silvicultural operation,
- is free of toxic pollutants listed under Section 307 of the CWA,
- adheres to the 15 federally mandated BMPs for road construction in wetlands (Appendix 1),
- adheres to the six BMPs for site preparation in wetlands (Appendix 2).

## Forest Road BMPs

Roads on the forest landscape can range from access roads to temporary roads to skid trails. Clearly, roads are the veins that make most all forest operations feasible and efficient. Most state BMPs manuals recognize forest roads as a major concern in forest management. This recognition is likely influenced by over 70 years of research documenting the potential and observed impacts of forest roads on soil erosion and water quality. BMPs for roads are designated the greatest amount of text in all the manuals reviewed in this work.

### *Location / Planning /Design*

Planning is the most important consideration in designing environmentally acceptable forest road systems. Southern state BMPs programs agree that planning for water quality should be the first consideration to minimize potential NPS pollution. Roads should be planned with long-term forest management objectives as a major consideration. Roads planned and designed considering long-term objectives reduces the need for additional road miles to service a given area. Planning should rely on valuable resources such as topographic maps, aerial photography, soil surveys, and hydrologic maps to identify points of interest for the area. Water related points of interest such as perennial and intermittent streams, ephemeral areas, ponds, lakes, and wetlands should be identified and avoided if at all possible. Verification of points of interest with a field reconnaissance is recommended because no maps are 100 percent accurate.

Properly planned, located, and designed roads can have minimal impact on soil erosion and water quality. However, poorly planned, located, or designed roads have increased potential to adversely impact the forest landscape and water quality. Careful location should be the first consideration in designing roads that satisfy access objectives and minimize impacts on soil erosion and water quality. Poor road location can negate any possible benefits from BMPs to minimize environmental impacts.

### *Construction*

The road planning process should have already determined the extent, standard, and location of the road. Roads construction activities, as with most other forest operations, should be conducted during dry periods. The road should be constructed to the minimum design standard capable to accommodate the anticipated traffic loads safely. Cut and fills should be balanced to minimize soil disturbance and minimize the need for borrow material. These slopes should be kept equal or less than the natural repose of the soil to minimize mass failures / slumping.

### *Stabilization / Revegetation*

Research has documented the effect of stabilization of the road prism on minimizing soil erosion and water quality impacts. Stabilized road sideslopes have been cited to reduce erosion losses by greater than 80 percent (Swift 1984, 1985; Grace 1999; 2000). State BMP programs recognize the erosion control benefits of vegetative stabilization of newly constructed and existing forest roads. Seed should be applied to disturbed areas following road construction to promote vegetative establishment. Vegetative stabilization should consider a seeding mixture adapted for the particular region, application season, soil type, and site fertility. Viability of vegetation depends on matching the appropriate mixture with site conditions which many times requires soil tests to determine appropriate fertilizer and lime application rates. The seeding mixture should also provide for quick establishing vegetation as well as long-term establishment.

### *Drainage Structures*

Removal of water from the road prism without increased sediment export should be the major focus of environmentally acceptable road designs. Accomplishing this goal requires designs that minimizes grade and reduces volume requirements for drainage structures. Grade directly influences the energy associated with surface runoff by reducing infiltration and increasing head (elevation and velocity) of runoff. Increased elevation and velocity head of runoff translates to increased energy to detach and transport sediment. Most Southern states recommend road grades between 3 and 10 percent to reduce the erosive energy associated with surface runoff (Table 2). Many states provide exceptions for steep slopes over short distances, typically less than 500 feet. Several states also recommend reduced grades on highly erosive soils due to increased sensitivity to surface runoff. Alabama and Florida are the only states in the South that currently have no specific guidelines for forest road grade. However, Alabama's BMP guidelines recommend minimizing grade where soils are highly erodible and/or topography is steep (Alabama Forestry Commission 1993).

Table 2. Road Grade BMP Recommendations for Southern States.

| | Grade | Exceptions |
|---|---|---|
| Alabama | Minimize for highly erodible soils and/or steep topography | |
| Arkansas | < 10% preferred<br><8% for highly erodible soils | >8% for highly erodible soils for <150 feet |
| Florida | No grade recommendation | |
| Georgia | Up to 10% for access roads<br>Up to 25% for temporary access roads | Up to 12% for short distances on access roads<br>Reduce grade and install water control structures on highly erosive soils |
| Kentucky | Not to exceed 15 % | Not to exceed 18% for distances < 200 feet |
| Louisiana | Between 2% and 10%<br><8% for highly erodible soils (>12% acceptable for 150 feet on highly erodible soils | >10% should not exceed 500 feet in length<br>> 15% should not exceed 200 feet in length |
| Mississippi | Between 2% and 10% | >10% for short distances |
| North Carolina | Setween 1% anti 1 0% | > 10% for distances <200 feet |
| Oklahoma | < 10% for sustained grades | Up to 18% for distances < 500 feet |
| South Carolina | < 10% | Except where terrain requires short, steep grades |
| Tennessee | Between 3% and 10% | Up to 12% for short distances |
| Texas | Between 2% and 10%<br>8% or less for highly erodible soils (>12% for 150 feet acceptable) | > 10% not to exceed 500 feet<br>> 15% not to exceed 200 feet |
| Virginia | Between 2% and 10% | > 15% not to exceed 200 feet |

* Information current when table was generated and omissions are due to incomplete data. BMP manuals and guidelines can be obtained from your State Forestry Agency.

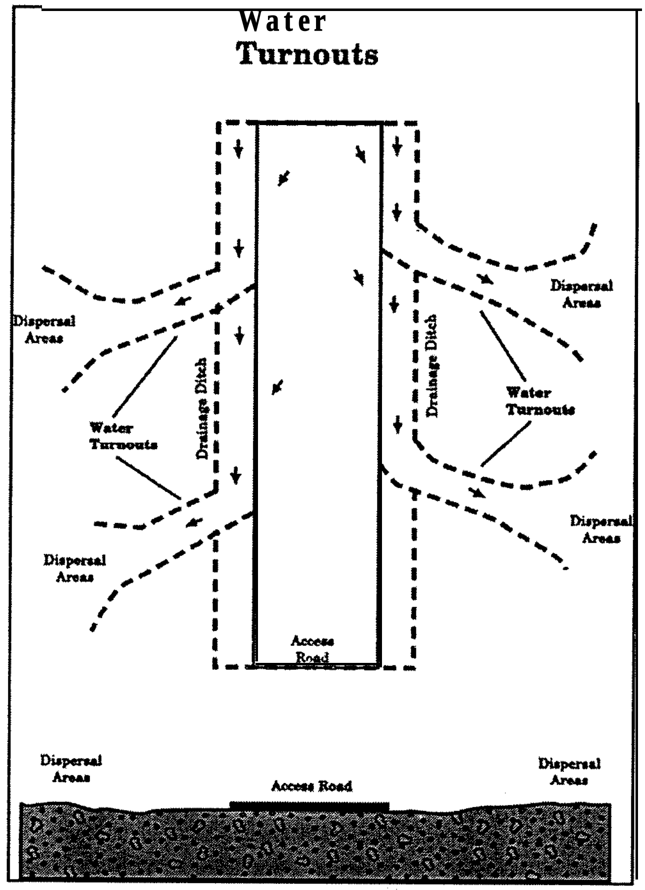
Drainage structures, such as turn-out (wing) ditches, broad-based dips, rolling dips, cross drains, and water bars (for skid trails), are critical components in removing water from the road prism and minimizing the impact of roads. All states reviewed recommend use of some type of drainage structure to accomplish drainage goals. Spacing of drainage structures which minimizes head (elevation and velocity) and volume has the greatest potential to minimize the erosive energy of road runoff. Recommendations regarding spacing of drainage structures based on road grade varied slightly from state to state (Table 3). Most state BMP manuals provided explicit detail and diagrams on design of drainage structures while others simply provided general specifications. For example, Figures l-2 are diagrams found in two state BMP manuals.

**Table 3. Road BMP Drainage Structure Spacing for Southern States.**

| | Spacing (Slope%) | | | | |
|---|---|---|---|---|---|
| | Broad-Based Dips | Turn-out / Wing Ditches | Cross-drain Culvert | Rolling Dips | Water Bars |
| Alabama | 235-125 (3%-15%) | 235-125 (3%-15%) | No recommendation | No recommendation | 200-30 (3%-40%) |
| Arkansas | 300-140 (2%-10%) | 200-75 (2%-10%+) | 500-125 (1%-16%) | 300-120 (2%-15%+) | 250-35 (2%-30%) |
| Florida | 180-110 (3%-22%+) | 200-40 (0%-22%+) | 200-75 (3%-22%+) | No recommendation | 250-30 (0%-22%+) |
| Georgia | 235-135 (3%-12%) | 500-100 (2%-20%) | 500-100 (2%-20%) | 235-135 (3%-12%) | 245-40 (2%-25%) |
| Kentucky | 500-100 (2%-18%) | 500-100 (2%-18%) | 500-100 (2%-18%) | | 400-29 (1%-40%) |
| Louisiana | 300-150 (2%-8%) | 250-60 (2%-11%) | As needed | 300-127 (2%-15%) | 250-60 (2%-11%) |
| Mississippi | 400/Slope%+100 (2%-10%) | 200-75 (2%-10%) | As needed | | 250-30 (2%-40%) |
| North Carolina | 500-135 (1%-12%) | As needed | As needed | 150-120 (5%-16%+) | 135-35 (5%-30%) |
| Oklahoma | 300-140 (2%-10%) | 500-100 (2%-20%) | 500-100 (2%-20%) | 300-140 (2%-10%) | 250-30 (2%-40%) |
| South Carolina | 300-115 (2%-25%) | 245-40 (2%-25%) | 300-115 (2%-25%) | No recommendation | 24540 (2%-25%) |
| Tennessee | 300-140 (2%-10%) | No recommendation | As needed | No recommendation | |
| Texas | 300-130 (2%-12%) | 200-75 (2%-10%) | 400/Slope%+100 (2%-15%) | 180-120 (2%-15%+) | 250-35 (2%-35%) |
| Virginia | 300-135 (2%-12%) | As needed | As needed | 180-120 (2%-15%+) | 250-35 (2%-30%) |

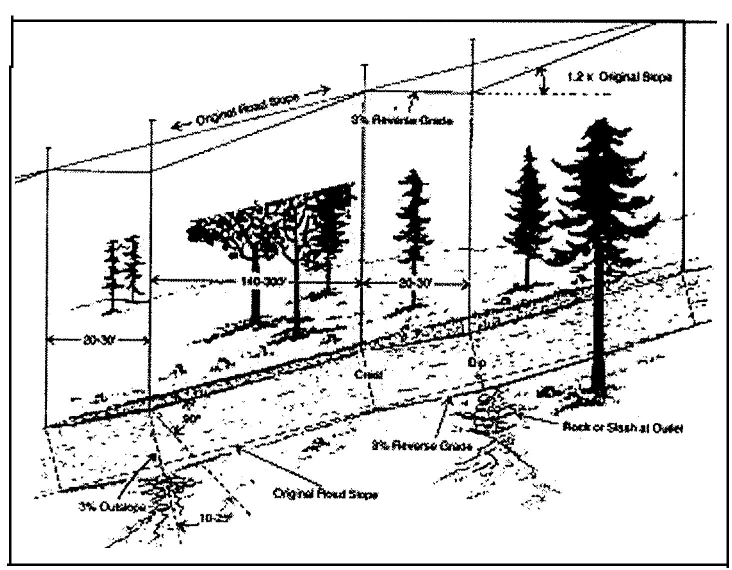
* Information current when table was generated and omissions are due to incomplete data. BMP manuals and guidelines can be obtained from your State Forestry Agency.

**Figure 1. Diagram for the Design and Installation of Turnouts. ***




*Source: Division of Forestry, Florida Department of Agriculture and Consumer Services

**Figure 2. Diagram for the Design and Installation of Broad-Based Dips. ***




'Source: Arkansas Forestry Commission, Arkansas Forestry BMP Guidelines

Most state BMPs recommend diverting road runoff through filter strips below road systems to minimize sediment delivery to stream systems. Historically, filter strips have been recognized an effective technique to reduce the erosive energy of surface runoff due to the increased surface cover and roughness the undisturbed forest floor. However, little information is available about the longevity of reductions realized from using the forest floor as a sediment filter. Sediment transport distances increases as the forest floor retains more and more sediment from upslope areas. As sediment plumes develop, the surface runoff can flow unimpeded over the relatively smooth plume surface and travel increased distances onto the forest floor. Therefore the effective width between a road system and the stream becomes narrower over time with an increased potential to deliver sediment directly to stream systems.

An alternative to simply relying on the forest floor as a filter is to utilize some type of sediment control structures, such as sediment basins, brush barriers, rock mats, vegetation, hay bales, and sediment fences, at outlets of turnouts, culverts, and dips. Sediment control structures have been shown to filter as much as 85 percent of sediment from road runoff (Grace 1999, 2000). Most state BMPs mention or recommend erosion control at drainage structure outlets through the use of brush barriers, rock fills, and rock checks. However, only four states (North Carolina, Texas, Georgia, and Arkansas) recommended and provided general diagrams of sediment control structures to filter sediment-laden runoff.

### *Maintenance*

Only one state failed to address and emphasize the critical nature of road maintenance in protecting water quality. Road maintenance is perhaps second only to planning and design in reducing water quality impacts of roads. Improper maintenance can result in road degradation, which could lead to accelerated soil erosion (Figure ?). The recommendation of inspecting and cleaning drainage structures is a common theme throughout Southern State BMPs. BMP guidelines are also consistent in recommending controlling access of roads to prevent unnecessary damage from traffic.

### *Stream Crossings*

One of the primary objectives of Forestry BMPs is to reduce or negate any impacts of forest activities on water systems. This objective is accomplished primarily by controlling surface runoff or filtering sediment laden runoff before it reaches stream systems. Detention of surface runoff is one technique utilized to reduce suspended sediments by slowing runoff and allowing time for particles to settle out on the forest floor. Dispersion is another technique to reduce suspended sediments and runoff volumes by providing adequate distance from water points of interest for filtering before runoff can reach stream systems. Stream crossings present challenges in protecting water quality through the above-mentioned techniques because the road prism intersects the steam system. Stream crossings have perhaps the greatest potential to adversely impact water quality on the forest landscape.

Stream crossings require special attention and considerations due to the potential impacts on water quality associated with stream crossings. BMP programs for each state emphasize stream crossings as a critical area in forest management. For example, Georgia's BMPs for Forestry Manual states, ". ..stream crossings are the most critical aspect of the road system". State BMPs are consistent in recommendations to cross steams only if planning and location of road systems deems a crossing unavoidable to accomplish forest activities. Minimizing water quality impacts should be a major consideration in the selection of the type of stream crossing. Bridges, culverts, and fords are recommended crossings for all states in this review. However, there are differences in the acceptability of log crossings (pole fords) across the South. Alabama, Mississippi, North Carolina, and Virginia clearly list log crossings as acceptable stream crossings. While other states are vague in acceptability of such crossings or state that crossing should not constrict or impede flow.

## Conclusions

BMP programs related to forest roads reviewed and reported in this paper exemplify the parity among the Southern states. Some differences are apparent in the legislation (or lack of) supporting BMPs from state to state. BMPs for forestry are primarily voluntary for Southern states with Kentucky having the only true mandatory forestry BMPs. In recent years, BMPs for forestry for many states have become more regulatory in nature with the incorporation of state, county, and local rules and regulations regarding water quality in specific areas. Forest road are emphasized by all states as one of the major areas of potential impacts to water quality from forest activities and where BMPs can have a beneficial effect,

Additional research is required to address critical gaps that exist in the science supporting BMPs recommended by States. In the past few years, many States have begun to re-evaluate existing BMP guidelines, including forest road BMPs, in an attempt to promote science-based practices. This initially resulted in many states conducting BMP implementation and compliance surveys to evaluate the impact of BMP programs. BMP compliance, for states conducting compliance surveys, has steadily increased over the past 5 years. For example, Florida's most recent compliance survey reports 97 percent statewide compliance for all silvicultural activities and 94 percent for forest road BMPs. However, the impact of state BMP programs has greater dependence on the effectiveness of these practices than compliance (Adams et al. 1995). Currently, BMP effectiveness studies have begun across the South in an attempt to determine if BMPs have the desired effect on maintaining or improving water quality. The lack of science to validate selected BMPs effectiveness in maintaining or improving water quality is one shortcoming of many BMPs related to forest roads.

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## Appendix

Appendix 1. Federally Mandated BMPs for road construction and maintenance in wetlands to retain exemption from permit requirements under Section 404.

1. Roads and trails in U.S. waters must be the minimal number, width, and total length consistent with the silvicultural operation and topographic and climatic conditions;

2. Roads must be located far enough from streams to minimize discharge of dredge or fill materials into waters of the U.S.(except portions which must cross these waterways);

3. Road fills must e bridged, culverted, or otherwise designed to prevent restriction of expected flood flows;

4. Fills must be properly stabilized and maintained during and following construction to prevent erosion;

5. Discharges of dredge or fill material into U.S. waters to construct a road fill must be made such to minimize the encroachment of trucks, tractors, bulldozers, or other heavy equipment within waters of the U.S. and wetlands that lie outside the lateral boundaries of the fill;

6. In designing , construction, and maintenance of roads, disturbances in waters of the U.S. must be minimized;

7. The design, construction, and maintenance of roads must not disrupt the migration or movement of aquatic species inhabiting the water body;

8. Borrow material shall be taken from upland sources when feasible;

9. The discharge must not take, jeopardize, or adversely modify the critical habitat of a threatened or endangered species as defined under the Endangered Species Act;

10. Discharges into breeding and nesting areas for water fowl, spawning areas, and wetlands must be avoided when less harmful alternatives exist;

11. The discharge must not be located in the proximity of public water supply intake;

12. The discharge must not occur in areas of concentrated shellfish production;

13. The discharge must not occur in part of the National Wild and Scenic River System;

14. The discharge must be free of toxic pollutants in toxic amounts;

15. All temporary fills must be entirely removed and the area restored to it original elevation.

Appendix 2. Federally mandated BMPs for mechanical site preparation in wetlands.

1. Minimize soil disturbance associated with shearing, raking, and moving trees, stumps, and other undesirable vegetation.

2. Avoid excessive soil compaction and maintain soil tilth.

3. Arrange windrows to limit overland flow, runoff, and erosion.

4. Prevent disposal or storage of logging debris in SMZs.

5. Maintain the natural contour of the site and ensure that activities do not convert the wetland.

6. Conduct activities with appropriate water management techniques to minimize impacts to off-site water quality.