LOW-VOLUME ROADS, BEST MANAGEMENT PRACTICES:
A Field Guide for US Agency for International Development

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ABSTRACT - Low-Volume Road Engineering, A BEST MANAGEMENT PRACTICES Field Guide for USDA, Forest Service, International Programs and the U.S. Agency for International Development (USAID), by Gordon Keller and James Sherar was an original development funded by USAID/Honduras in support of their Forestry Development Program (FDP) and their National Forestry School (ESNACIFOR). It has since been revised and expanded to be consistent with and complement the training manual titled “Minimum Impact Low-Volume Roads”. This Best Management Practices Field Guide is intended to provide an overview of the key planning, location, design, construction, and maintenance aspects of roads that can cause adverse environmental impacts and list key ways to prevent those impacts. It is intended to present key “DO’s and DON’Ts” in roads activities. These fundamental practices apply to roads worldwide and for a wide range of road uses and standards.

Introduction

Rural low-volume roads, farm-to-market access roads, forest haul roads and skid trails, etc. are necessary parts of any transportation system to serve the general public in rural areas, as well as help forest management and resource extraction. At the same time, roads and disturbed areas can produce significant amounts of sediment and can be one of the greatest adverse impacts on local water quality. They can produce significant erosion, can cause gullies, can impact groundwater, wildlife, and vegetation and can degrade scenic values. Roads are necessary but they must be constructed and maintained in such a way that environmental impacts are minimized. A well planned, located, designed and constructed road will have minimum adverse impacts and will be cost effective in the long term with minimum maintenance and repair costs.

Controlling erosion and protecting or improving water quality are essential to the quality of life, the health of the forest ecosystem, and to the long-term sustainability of forest resources. Forests play a vital role in producing, purifying and maintaining clean water.

The "Best Management Practices’ (BMPs)” presented herein are a compilation of ideas and techniques which can be used in road construction to minimize or eliminate most of the potential impacts from these operations. The objectives of these Best Management Practices (BMPs) are to:

* Protect water quality
* Maintain natural channels and stream flow
* Minimize ground and drainage channel disturbance
* Control road surface water
* Control erosion
* Implement needed slope stabilization measures
* Stabilize the roadway driving surface, and
* Produce a safe, cost effective and practical road design

The scope of this manual is to develop recommended BMPs for low standard roads. The information is also applicable to most rural roads with other uses, such as logging, and is partially applicable to higher standard roads, although this was not the emphasis of this
manual. Soil and water quality issues related to temperature, nutrients, chemical pollution, debris, quantity of flow, etc. are also beyond the scope of this manual, although there are many varied benefits from the application of these practices.

Each topic in this manual contains a problem statement that presents concerns, advantages and potential impacts for that issue. Information on the proper or most desirable way to plan, locate, design, construct and maintain roads, skid roads and landings are presented, along with figures and tables where helpful. Finally, PRACTICES TO AVOID are listed to discourage poor and undesirable practices.

This manual offers the Best Management Practices associated with the various aspects of roads and logging operations. The information presented in this manual should become an integral part of transportation planning and rural road design by applicable roads agencies.

These BMPs are applicable to road construction practices in most field situations. However, BMPS may be modified for site-specific conditions with guidance from experienced engineers, foresters, or other resource professionals. Modifications should be researched, designed and documented and must provide for equal or greater water quality protection before used.

Some important aspects of low-volume road design that are addressed in this manual include:

- Having a stable, structurally sound road surface and using subsurface drainage where needed.
- Reducing erosion by providing good ground cover on cuts, fills, and any exposed or disturbed areas.
- Using stable cut and fill slope angles.
- Using slope stabilization measures, structures, and drainage as needed.
- Applying special techniques when crossing meadows, riparian areas, and when controlling gullies.
- Providing thorough periodic road maintenance.
- Closing or obliterating roads when not in use or no longer needed.

The following is a Table of Contents of the Field Guide:

1. Introduction
2. Environmental Analysis
3. Roads Issues and Special Applications
4. Low-Volume Roads
5. Hydrology for Drainage Crossings Design
6. Tools for Hydraulic and Road Design
7. Drainage of Low-Volume Roads
8. Culvert Use, Installation, and Sizing
9. Fords and Low-Water Crossings
10. Bridges
11. Slope Stability and Stabilization of Cuts and Fills
12. Roadway Materials and Material Sources
13. Erosion Control
14. Stabilization of Gullies

Chapter 3: Roads Issues and Special Applications

Excerpts from Chapter 3, Roads Issues and Special Applications are included as examples of content and format. Chapter 3 includes various aspects of road planning and special applications. Streamside Management Zones (SMZs) are emphasized to help insure water quality protection.

Streamside Management Zones

Streamside Management Zones (SMZs) are those areas adjacent to natural drainages and watercourses that require special consideration during forestry operations. These SMZs are important zones for protecting water quality by
filtering sedimentation that may occur from road construction and logging activities. Harvesting activities must be planned and designed to minimize ground-disturbing activities.

Logging activities should not be eliminated in SMZs, but should be minimized and modified to insure that stream channels and stream banks are protected from disturbance. The width of the SMZ will vary with the natural ground slope on each side of the stream and with the erodible aspects of the soils. Steeper ground slopes will increase the possibility of sediment reaching the stream. TABLE 2.1 gives a recommended minimum width of the SMZ.

**TABLE 2.1:**

<table>
<thead>
<tr>
<th>Slope Distance</th>
<th>Width of SMZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 m</td>
<td>0 - 20 %</td>
</tr>
<tr>
<td>20 m</td>
<td>21 - 40 %</td>
</tr>
<tr>
<td>30 m</td>
<td>41 - 60 %</td>
</tr>
<tr>
<td>40 m</td>
<td>60% +</td>
</tr>
</tbody>
</table>

Each chapter of the manual contains a list of practices to avoid as an easy reference.

**X - PRACTICES TO AVOID**

* Keep logging debris out of lakes and streams
* Avoid using logging equipment within the SMZ
* Avoid road and landing construction within the SMZ
* Avoid contamination from fuels and oils on forest soils

Chapter 3 also includes general guidelines for timber harvesting, log landings, and skid roads and skid trails. Examples of the bullet statements for skid roads and skid trails and the “Practices to Avoid” sections are included.

**Skid Roads and Skid Trails**

Skidding should be conducted in such a way that soil disturbance is minimized.

* Locate main skid trails before felling operations begin
* Locate skid roads to follow the contour of the natural terrain with natural breaks in grade
* Winch logs from areas of steep slopes or from SMZs
* Locate skid roads and trails in such a way that water is not concentrated onto the log landing
* Cover skid roads and trails with logging slash after operations cease to minimize erosion from exposed soils
* Construct skid roads on grades of 15% or less except for short distances (20 meters) where 30% pitches are acceptable

Chapter 4: Low-Volume Roads

Chapter 4 contains material on the location and design and maintenance aspects of low-volume forest roads. Access roads create more potential for soil erosion than any other activity that occurs during timber harvesting. A well planned, located, constructed and maintained road system is essential for forest management activities. Proper planning and design of the road system will minimize the impacts to water quality that are normally associated with forest roads. Poorly planned road systems have high maintenance and repair costs and contribute to excessive erosion.

**Maintenance**

Much of the work and interest has been in road repair and maintenance of low-volume forest roads. These roads must be maintained during active operations and after operations have been completed to insure that the drainage structures are functioning properly. Natural occurrences of rains cause cut slope failures that block ditches, cause water flow on the road surface, and can erode the surface and fill slope. Debris moves down natural channels during heavy rains and blocks drainage structures, causing water to overtop the road and erode the fill. Routine maintenance during logging operations (Active) will keep the road serviceable, keep drainages clean and will reduce log haul costs.
Road Planning

* Use topographic maps, photos, soils information, etc.
* Consider both short term and long-term access needs
* Limit the total area disturbed by minimizing the number, width, and length of roads
* Use existing roads only if they serve the long-term needs of the area and can be reconstructed to provide adequate drainage and safety
* Minimize the number of stream crossings needed

Road Location

* Use topographic control points and physical features (saddles, rock outcrops, stream crossings, slides, spring areas) to locate the road
* Locate roads outside of wet areas and SMZs except at stream crossings
* Locate roads high on the topography to avoid steep drainages
* Locate roads to follow the natural terrain by rolling the grade
* Locate roads, switchbacks and landings on bench areas and on flatter terrain.

Road Design and Construction

* Use minimum road standards needed for safety and traffic use
* Remove merchantable timber from the road Right-of-way before excavation.
* Windrow slash, tops, unmerchantable trees and stumps removed from the right-of-way at the toe of the fill slope before excavation
* Outslope road surface 2-5% for road grades less than 10% on stable soils, using rolling dips for drainage structures
* Inslope or crown road surface for road grades in excess of 10%. Use ditches and provide cross drainage with pipes or rolling dips.
* Construct roads with grades of 12% of less, using short pitches to 15% where necessary
* Locate Roads with a minimum curve radius of 13 meters
* Construct roads with breaks in grade

* Stream crossings increase the cost of the road
  - Steep grades increase long-term maintenance costs of the road

X - PRACTICES TO AVOID

- Avoid road construction on steep side slopes
- Avoid construction during periods of wet weather
- Avoid steep road grades
- Avoid vertical cut slopes on ditched roads
- Avoid very flat areas
- Avoid locating roads within the SMZ, except at crossings
- Avoid wet and spring areas, slide areas

Chapters 5-14:

Chapters 5-10 include recommended practices for design and installation of drainage structures for low-volume roads. In many parts of the world, drainage design principles are severely lacking and this became an emphasis of this manual and much of the training that has been provided.

Chapters 11-14 include recommended practices for slope and gully stabilization, erosion control and roadway materials. Many field practices are illustrated which give the user good general guidelines for stabilizing soils in most low-volume road applications.

Summary

This manual was originally written in Spanish in cooperation with US AID/Honduras and is being translated into English for use in English speaking parts of the world. The authors wish to thank and acknowledge all who have contributed to this work.