Resource Road Rehabilitation Handbook: Planning and Implementation Guidelines (Interim Methods)

by

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Preface

The Watershed Restoration Program (WRP) is an initiative under the provincial Forest Renewal Plan to restore the productive capacity of fisheries, forest and water resources that have been adversely impacted by past forest-harvest practices. The goals of the Water Restoration Program are:

- to restore, protect, and maintain fisheries, aquatic, and forest resources that have been adversely impacted by forest-harvesting practices and that would require several decades to recover naturally
- to provide community-based employment, training, and stewardship opportunities throughout the province
- to provide a mechanism to bridge historical forest harvesting practices and the new standards established by the Forest Practices Code by diversifying jobs in the forest sector.

This manual is one of a series to assist in planning programs to restore watersheds. Watershed restoration attempts to re-establish conditions more similar to those found in unimpacted watersheds by altering the rates of the processes that control the physical and biological structure of watersheds. As such, it encompasses activities ranging from hillslope stabilization and road rehabilitation to riparian revegetation and fish habitat improvement.

This series of manuals provides a common set of techniques to assess opportunities for restoration activities. The first two manuals provide an overview of the planning process and the assessment process for determining the current state of the watershed. The remaining manuals describe procedures for assessing specific watershed components in more detail and specify activities and standards to assist rehabilitation of watersheds. The titles in the series are:

- Planning and Assessment Procedures for Watershed Restoration Projects
- Watershed Assessment Procedure (Interim Methods)
- Resource Road Rehabilitation Handbook (Interim Methods)
- Forest Site Rehabilitation for Coastal British Columbia (Interim Methods)
- Gully Assessment Procedure for British Columbia Forests (Interim Methods)
- Riparian Assessment Procedures (Interim Methods)
- Stream Channel Assessment (Interim Methods)
- Fish Habitat Assessment (Interim Methods)
In planning restoration activities, it is important to recognize the linkages among the various physical and biological subcomponents of watersheds and to integrate activities to ensure their successful implementation. Although the manuals treat particular aspects of watershed restoration separately, you should use them together to develop an integrated program that considers activities for the entire watershed and proceeds successively from the hillslopes to the floodplain to the riparian area to the stream channel.

Many WRP (preliminary) assessment procedures overlap with procedures that will be required as part of the new Forest Practices Code (FPC). When the Forest Practice Code manuals are published, beginning in fall 1994, they will supersede the WRP manuals.
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Introduction

Organization of the Handbook

This handbook is divided into six sections. The Introduction gives an overview of:

- the contents of the handbook
- the problems caused by abandoned resource roads
- the process for rehabilitating resource roads.

The remaining sections give more detailed descriptions of each of the steps in the rehabilitation process.

Contents of the Handbook

Resource road rehabilitation is the upgrading of resource roads\(^1\) to current standards, or the deactivation of resource roads to one of three levels—temporary, semi-permanent, or permanent. This handbook provides technical information and methodologies to help plan and organize resource road rehabilitation projects in areas of past timber harvesting activities, and in areas of other past resource management activities (e.g., mining, mineral claim, and petroleum development). Although the emphasis is on rehabilitating abandoned roads, many of the techniques and processes described apply to abandoned logging trails and to active and permitted, resource roads and logging trails.

This handbook is designed primarily for registered professionals and forestry technologists qualified in resource road engineering, hydrology, and landslide hazard assessment. It focuses on:

- preventing and remedying soil erosion, landslides, and stream sedimentation hazards resulting from resource roads
- restoring hillslope hydrology

\(^1\) Resource roads are forest roads, mining and mineral claim access roads, and petroleum development roads. Forest roads are Forest Service Roads and Operations roads built for use by logging trucks to transport logs and other forest products from a landing to a reloading site or conversion facility. Do not confuse forest roads with logging trails – see Appendix D for definitions of logging trails.
• restoring some road sites to productive forest land.

In addition, this handbook contains the following information to help you identify problems on roads and prescribe treatments to remedy them:

• a process to assign work priorities for corrective action based on the degree of risk to the environment and other values

• a methodology for thoroughly and consistently examining road prisms and drainage structures

• a suggested process to record problems and deficiencies along the road right of way, and existing or potential off-site impacts on the environment and on other resources

• a suggested format for presenting inventory map information, and preliminary time and cost estimates

• a list of site factors to evaluate during the prescription phase of detailed road deactivation planning

• operational strategies for implementing field projects, and planning tips for supervising and monitoring physical remedial works.

Overview of the Watershed Rehabilitation Process

Watershed restoration activities are designed to speed the recovery of environmental values in watersheds that have been degraded by past resource management activities. The rehabilitation of logging-degraded hillslopes and valley flats or floodplains must progress in a logical manner to ensure the success and cost effectiveness of the overall Watershed Restoration Program. Therefore, rehabilitation activities must follow a sequential, top down implementation approach, as illustrated in Figures 1 and 2.

The following questions clearly demonstrate the key links between restoration activities and the importance of carrying out remedial works on roads according to the need for current and future access.
Figure 1
Watershed Restoration Program
Broad Overview of WRP Implementation Sequence

*NOTE: No road deactivation works should be undertaken until access needs for timber development, other forest management, commercial and recreational uses, and other WRP projects, have been determined.
**Figure 2**

Watershed Restoration Program

Detailed Implementation Sequence for Hillslope Restoration

*NOTE: No road deactivation works should be undertaken until access needs for timber development, other forest management, commercial and recreational uses, and other WRP projects, have been determined.*

Refer to boxed area, Figure 1
Hillslope Components

- Are there existing or potential problems with hillslope components such as upper, middle, and lower slope roads (including landings), gullies, landslides, and clear cut areas (including logging trails and fireguards)?

- Do any hillslope components threaten human life?

- Do any hillslope components threaten resource values, such as community water supplies and water quality, fish habitat, landscape aesthetics, timber growing site productivity, and recreational values?

- Are hillslope components connected to riparian zones or stream channels? If so, treat hillslope components before restoring stream channels and fish habitat; if not, you can schedule treatments of hillslope components independently of valley flat or floodplain restoration activities.

- Is access required now or in the future for logging, forest, or other resource management, commercial and recreational activities?

- Have stakeholder groups reviewed and approved access requirements before approval of road rehabilitation projects and other proposed WRP projects:

Valley Flat and Flood Plain Areas

- Are there any existing or potential problems with valley flat or floodplain areas?

- Are there problems with roads on the valley flat or floodplain? Is access required now or in the future for logging, forest, or other resource management, commercial and recreational activities?

- Have stakeholder groups reviewed and approved access requirements before approval of road rehabilitation projects and other proposed WRP projects? If so, rehabilitate the roads.

- Has the riparian zone recovered? Is the floodplain stable? Are stream channels stable? If not, repair the riparian zone and stabilize floodplains and stream channels next. Finally, restore and mitigate lost habitat in stream channels, or if stable, conduct necessary off channel habitat improvement activities.
Problems Caused by Abandoned Resource Roads

While many resource roads are needed on a long-term basis to manage forest resources, a significant number are not required when resource management activities end. Today, it is recognized that roads and their associated developments, such as landings, logging trails, fireguards, and civil structures, must be deactivated when they are no longer maintained or used. However, in the past, many roads were simply abandoned after use and were not deactivated; these untreated and industrially inactive roads belong to a category of resource roads called abandoned resource roads.

Abandoned resource roads are not under active permit, such as a Road Permit, Road Use Permit, Cutting Permit, or Special Use Permit and are not maintained by the forest licensees, the Ministry of Forests, mining and mineral claim companies, or by petroleum development companies. On such roads, there is usually no organization allocating resources to maintain the integrity of road cuts, fills, and drainage works, or to close the roads for access management and safety purposes. Consequently, many abandoned resource roads have been left unattended and have deteriorated over time.

In their current deteriorated condition, many abandoned resource roads have the potential to trigger landslides, produce sediment, and cause sedimentation of streams, particularly where they traverse steep and sensitive terrain. Appendix A, Typical Mechanisms of Road-Associated Erosion and Sediment Production, describes the most common problems encountered on roads. Impacts recorded in the past have included damage to water quality, water supply systems, fish habitat, landscape aesthetics, site productivity, private property and utilities, and threat to human life. Natural erosion and deterioration processes have also weakened bridges, major culverts and retaining walls, and other related civil structures.

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2 The purpose of deactivating roads is to minimize the risk of road-related failures, such as landslides, surface soil erosion, and stream sedimentation. Road deactivation measures give a road system a number of basic failsafe water control elements and road prism construction modifications. These are designed to maintain the integrity of the environment, control access for safety and natural resource conservation, and protect the road investment itself when future vehicle access is planned, during the times that use or maintenance of the road is suspended.
A large inventory of abandoned road networks in the provincial forests need to be either upgraded to current standards or deactivated to an appropriate level to prevent potential road-related environmental damage. If you are unfamiliar with road deactivation measures, refer to Appendix B, *Explanation of Some Road Deactivation Measures*. Appendix C, *Effects of Roads on Freshwater Fish Habitats and Fish Production* provides a comprehensive discussion of impacts of hydrological effects and increased levels of sedimentation on fish habitat, and points out the importance of road deactivation.

**Overview of the Road Rehabilitation Process**

Recognized, qualified personnel must assess each road rehabilitation project individually and plan and organize it according to the following steps (see Figure 3):

- Step 1: Planning project objectives
- Step 2: Conducting field assessments
- Step 3: Preparing reports and maps
- Step 4: Implementing the project
- Step 5: Monitoring and evaluating results
Figure 3
Flowchart of Road Rehabilitation
Project Planning and Implementation Steps
Step 1: Planning Project Objectives

This first step involves five tasks:

1. Identifying project planning priorities by zone.
2. Preparing road inventory base maps.
3. Identifying access needs.
4. Identifying access management strategies.
5. Defining project scope and objectives for each zone.

Identifying Project Planning Priorities by Zone

Rehabilitating forest roads in areas of past harvesting is a large scale initiative that can be quite complex in scope. To make planning and implementing such projects manageable, divide large land management areas into manageable “zones,” by watershed, well-defined geographical boundaries, specific road networks, or other logical means.

Within a particular zone of interest, you should not begin detailed field examination of roads unless you have prepared road inventory base maps and clearly identified the project scope and objectives. The maps should show the locations of existing active and abandoned roads, the current and future access needs, and other pertinent information (see Preparing Road Inventory Base Maps below).

You determine the highest priority zones for planning inventory mapping and field assessments based on the potential risk that abandoned road networks pose to the environment and social and economic values. Local knowledge of problem sites and recognition of special concerns should also play major role in prioritizing zones. It is often efficient to carry out fly-overs using fixed wing aircraft or helicopters to establish or confirm zone priorities (see Level I Field Assessment in Step 2: Conducting Field Assessments).

The rating system in Table 1 may help you prioritize zones for planning purposes.
Table 1: Suggested Criteria to Establish Overview Priorities of Zones

<table>
<thead>
<tr>
<th>Priorities</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Zones that have abandoned road systems that may have an impact on:</td>
</tr>
<tr>
<td>(highest)</td>
<td>• rural development</td>
</tr>
<tr>
<td></td>
<td>• domestic dwellings or industrial development</td>
</tr>
<tr>
<td></td>
<td>• highways and railways, or</td>
</tr>
<tr>
<td></td>
<td>• public utilities.</td>
</tr>
<tr>
<td>2</td>
<td>Zones that have abandoned road systems that may have an impact on:</td>
</tr>
<tr>
<td></td>
<td>• community watersheds</td>
</tr>
<tr>
<td></td>
<td>• moderately to heavily licensed, domestic use watersheds</td>
</tr>
<tr>
<td></td>
<td>• high fishery values</td>
</tr>
<tr>
<td></td>
<td>• visually sensitive areas.</td>
</tr>
<tr>
<td></td>
<td>or</td>
</tr>
<tr>
<td></td>
<td>Zones that have abandoned road systems and that are areas of high</td>
</tr>
<tr>
<td></td>
<td>public involvement and concern.</td>
</tr>
<tr>
<td>3</td>
<td>All other zones that have abandoned road systems that may have an impact</td>
</tr>
<tr>
<td>(lowest)</td>
<td>on other resource values.</td>
</tr>
</tbody>
</table>

Preparing Road Inventory Base Maps

Procedure

Road rehabilitation projects must be documented on, or referenced to, appropriate maps. Road inventory maps should communicate information clearly; they will likely be used as base maps to conduct field assessments of roads, prepare final reports, and prepare maps illustrating rehabilitation prescriptions for the purpose of implementing the project.

1. **Plot the locations of existing abandoned and active roads within the zone of interest to a scale that reflects the requirements of the project.**

In some areas of the province, you may need to use satellite imaging techniques and helicopter reconnaissance to plot road locations on the maps.

In areas of past harvesting, a map scale of 1:20,000 has proved useful for overview planning. Such a small map scale can facilitate the decision making process regarding current and future access requirements for the area. It is appropriate for the overview level of field work associated with a Level I Field Assessment. In contrast, for smaller areas, such as within active cutting permit boundaries, or for detailed field work associated with
a Level II Field Assessment, we suggest a map scale of 1:5,000. (See Step 2: Conducting Field Assessments for descriptions of Level I and Level II Field Assessments.)

2. **Name or number all roads plotted on maps sheets for identification purposes.**

3. **Plot the locations of road-related landslides.** Also identify and highlight stream systems, gullies and community water supplies, and outline the perimeter boundaries of any developed areas that are accessed by the road system (e.g., cutblocks, recreation areas, mines, etc.)

4. **Document the recommended access management strategy for each road.** (See Identifying Access Management Strategy).

5. **Gather information on both timber and non-timber values adjacent to and downslope of the road networks.** It is useful to overlay this information, and other existing resource management information (stream classes and terrain classes) directly on the map sheets.

**Sources of Information**

Sources of information to prepare road inventory base map sheets may include:

- forest cover maps
- TRIM (Terrain Resource Information Management) topographic maps
- other topographic maps
- current aerial photographs
- Forest Development Plans
- Access Management Plans
- community watershed maps
- water rights maps
- terrain stability maps and reports
- soils maps
- current Coordinated Access Management Plan (CAMP) Maps
- Forest District tenure maps
- specialist reports and studies
- plans that show access needs for future timber harvesting and silviculture activities
- other reports, maps and information.
Note: If 1:20,000 scale reference maps are not available use 1:50,000 scale maps. The 1:50,000 scale maps may be enlarged to a 1:20,000 scale for preparing road inventory base maps.

Identifying Access Needs

Once the road inventory base maps are prepared, you can begin to establish current and future access needs for the zone. This process called “access management planning” is explained in British Columbia Institute of Technology (BCIT) course manual, “Forest Road Deactivation RRET 410.” It requires you to answer several questions:

- What types of vehicles currently use the road? Example: heavy trucks, light trucks, no apparent vehicle use. Why is the road currently used and who uses it?

- Which roads are currently required? Which roads are required in the future? Who requires them?

- Which organizations are interested in maintaining and inspecting the road other than the Ministry of Forests?

- How can all the various interest groups best be accommodated?

- What are the short and long-term budget requirements for road inspections and maintenance? Can the roads required for access be physically kept open over the period of planned use, given the anticipated funding limitations?

To answer these questions, you need to assess and evaluate the following factors as outlined in the BCIT course manual:

1. Present condition of roads and terrain sensitivity.
   - hillslope processes
     - are landslides and debris torrents likely to occur?
     - are unstable roads and debris accumulations located upslope?
     - are streams actively transporting sediment and debris across the road?
     - does the road have large cut and fill slopes that appear unstable?

   - terrain and slope stability
     - are landslides and surface soil erosion evident in the area?

   - potential erosion effects of water
     - are segments of the road subject to flooding or erosion due to potential stream channel changes?
• condition and past construction/maintenance history of the road
  - what is the age of the road and how was it built?
  - does the road contain unstable subgrade materials such as rotting wood?
  - has the road been maintained adequately?
  - are drainage structures in good condition or are they worn out?

• climate factors
  - do floods, avalanches, or snowmelt conditions affect the road annually?
  - is the area subject to rain-on-snow events or very high seasonal rainfall?

2. Current and future use requirements for the road.

• Are future users expected to be industrial?
  - log hauling?
  - special forest products?
  - silvicultural?
  - other industrial users?

• Are future users expected to be recreational?
  - vehicular?
  - ATV?
  - other?

3. Availability of funding for inspections and maintenance.

As a general rule, industrial users are required to fund road inspections and maintenance on active roads. Users, other than industrial users, may be provided with subsidies to carry out required road inspections and maintenance; these come from either industrial users, or from general public funding (either recreation, fire protection, silviculture, or some other budget).

Roads, which are to be dedicated to non-industrial uses for long periods, should be deactivated to appropriate levels (see Identifying Access Management Strategy) if users cannot secure funds for road inspections and maintenance.

**Identifying Access Management Strategy**

Identify a suitable strategy for managing road access. There are three possible strategies (see Figure 4):
• **Strategy 1:** Leave the road open for regular use, upgrade it to current standards if necessary, then inspect and maintain it. The road is called a “maintained road.” You must name the agency or organization responsible for inspections and maintenance.

• **Strategy 2:** Deactivate the road to a temporary, semi-permanent, or permanent level, based on the term and type of access desired and on silviculture objectives.

• **Strategy 3:** For sites that have very difficult access or that are partly recovering (i.e., revegetated), leave the road alone if site works could do more harm than good.

Document the recommended strategy for each road directly on the road inventory base maps, map overlays, or tabulated lists, whichever is most appropriate for field use.

You will probably need to reassess recommended strategies for managing access as field assessments proceed—strategies can change based on field evaluations of the severity of road problems and the sensitivity of the terrain. For example, you originally target a road for “semi-permanent deactivation” and four wheel drive access. Later you find that this road cannot be maintained because of stability considerations or because no agency or organization will commit to maintaining it. In this case, you should revise the access management strategy to “permanent deactivation” and prescribe treatments consistent with the new strategy.

Here are detailed descriptions of the requirements for each strategy.

**Strategy 1: Inspect and Maintain Roads and Bridges**

• If you decide to reinstate regular inspection and maintenance operations on abandoned road systems, clearly name the agency or organization that is responsible for the inspection and maintenance.

• The named agency or organization should carry out corrective action on these road systems as soon as possible to address any identified erosion and slope stability hazards.

• Abandoned roads could be maintained under the requirements of Road Use Permits, Road Permits, Cutting Permits, Special Use Permits, or other tenure obligations. Appendix D, *Types of Resource Roads, Logging Trails, and Permits*, explains the various types of road permits.
Strategy 2: Deactivate Roads and Bridges

- Where roads are no longer maintained or used regularly, you must deactivate them so that the roadway prism and cleared width are stabilized and the natural drainage is restored or maintained.

- In the case of temporary (seasonal) deactivation, you must name the agencies and organizations responsible for periodic inspections to assess:
  - the adequacy of drainage
  - the requirements for improved drainage works.

Levels of Deactivation

You can deactivate roads to one of the following three levels:

Table 2: Levels of Deactivation

<table>
<thead>
<tr>
<th>Level of Deactivation</th>
<th>Applies to Roads…</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporary (seasonal)</td>
<td>Where regular use will be suspended for up to three years.</td>
</tr>
<tr>
<td>Semi-permanent</td>
<td>Where regular use will be suspended for up to three years on:</td>
</tr>
<tr>
<td></td>
<td>• winter roads</td>
</tr>
<tr>
<td></td>
<td>• roads with a potential for debris torrents</td>
</tr>
<tr>
<td></td>
<td>• roads in particularly isolated areas</td>
</tr>
<tr>
<td></td>
<td>• roads in areas where harvesting is suspended until the next pass.</td>
</tr>
<tr>
<td>Permanent</td>
<td>That will be closed permanently.</td>
</tr>
</tbody>
</table>

The choice of deactivation level depends on factors such as current and long term access needs, type of access, for example, two wheel drive, four wheel drive, ATV, off-road motorcycle, mountain bike, trail, etc., the present condition of the road, and availability of funding for periodic inspections.

Strategy 3: Leave the Road Alone

In some cases, abandoned roads have recolonized with natural vegetation, making it difficult to reach problem locations with heavy equipment. In these situations, deactivation efforts involving large machinery could have a net detrimental effect on the environment. For example, using an excavator to build a few cross-ditches could cause considerable unwanted soil disturbance.
and destruction of vegetation. However, in some cases where heavy tree growth exists within the road prism, using excavators or explosives may be warranted to retrieve or remove any unstable sidecast fills. Therefore, a complete field assessment of site conditions must compare the level of site disturbance that carrying out remedial works using heavy equipment (or other means) might cause with the possible consequences of leaving the site alone.

In some situations, although culverts still remain in the road fills, the natural drainage system may have re-established itself. Therefore, the culverts may pose no threat of landslides or continued surface erosion; the drainage structures can remain in place. However, where existing drainage structures do pose a definite risk of slope failure, remove them. For sites that are inaccessible, controlled blasting or hand labour may be appropriate methods to remove culverts, install cross ditches and waterbars, or relieve oversteepened fill slopes.

Often, light deactivation work on difficult sites can be done by hand labour. It is quite easy to build small cross-ditches and ditch blocks, breach old grader windrows, and remove small culverts using a hand held or hand operated tool. In addition, carrying out small scale deactivation works by manual labour can be cheaper than using heavy equipment. For example, 20 man-days of manual labour might build as many cross-ditches for the same cost as bringing in an excavator to an inaccessible location.

Defining Project Scope and Objectives for the Zone

You should clearly define the project scope and formulate a clear statement of project objectives for the zone of interest before you ask technicians and specialists to conduct a Level II Field Assessment (see Figure 3). This is important information to the personnel who conduct such detailed assessments because it guides their selection of appropriate road rehabilitation prescriptions. Before proceeding to a Level II Field Assessment, consult with the Ministry of Forests to obtain its comments or suggestions concerning the project scope and statement of objectives.

Scope of the Rehabilitation Project

In many situations, abandoned road networks provide access to landslide tracks and gullies, and cutblocks (including logging trails and fireguards) that need remedial works. Often, these hillslope components can only be treated cost effectively when the road network remain open. It is important to decide how and when to schedule Level II Field Assessments and rehabilitation site works for these other hillslope components.
Plan to make effective use of specialists, technicians, and equipment, while they are on site within the zone of interest. Typically, Level II Field Assessments for road deactivation projects also include examinations of, and prescriptions for, gullies and landslide tracks located along the road corridor. It may be appropriate to schedule Level II Field Assessments for clearcuts (including logging trails and fireguards) separately if they require the involvement and input of specialists with backgrounds other than resource road engineering, such as silviculturalists and soil scientists. Also, ask yourself the following question: Could the proposed road deactivation isolate untreated sites outside the zone, such as roads (including landings), gullies, landslide tracks, pits and quarries, and clearcuts (including logging trails and fireguards)? If so, expand the zone of interest to include these other sites.

You should specify what is and what is not part of the Level II Field Assessment. Examples: “silviculture site treatments are not part of the field work,” or “prescriptions for gullies and landslide tracks are included in the scope of field work,” or “clearcuts (including logging trails and fireguards) are not included in the scope of the field work,” etc. Make reference to the road names or numbers on the inventory base maps to accurately delineate the scope of the work.

**Objectives of the Road Rehabilitation Project**

To define complete project objectives for the zone, you should consider the risk to timber and non-timber values, the strategies for managing access, the road conditions, and other important factors. For example, consider the following factors in setting the rehabilitation project objectives for the Level II Field Assessment:

- the overall condition of the road network, including the integrity and capability of its drainage structures, and the likelihood of potential slope stability and surface erosion problems

- the need to protect human life, and property, if threatened

- the need to protect water quality, water supply, fish habitat, visual aesthetics, and site productivity and timber resources, if threatened

- the requirements for current and future road access, including access needs for timber development, other forest management, commercial and recreational uses, and other WRP Projects. You should review the requirements of existing Access Management Plans, Management Plans and Forest Development Plans for an area.
• the requirements for silviculture enhancement (new growing sites)
• the requirements for long-term road inspections and maintenance
• the rainfall regime, climate, snowmelt, and runoff intensities
• other factors

A statement of objectives should include:

• a general description of the zone
• the intent of the road rehabilitation project. For example: “reduce the risk of slope failure and surface soil erosion that could have an impact on high value fisheries and community water supply”
• the primary concerns that have initiated the project. For example: potential road related slope stability problems, potential erosion of exposed mineral soils across landslide tracks, potential for torrenting of gullies, need for erosion control and water management, etc.
• the recommended access strategy for each road, clearly referenced to the inventory base maps.
Figure 4
Flow Chart for Identifying a Suitable Strategy for Managing Road Access

- Strategy No. 1
  - Keep the road open.
  - Upgrade it as required.
  - Inspect and maintain it.

- Strategy No. 2
  - Deactivate the road

- Strategy No. 3
  - Leave the road alone

- Temporary
  - Used for roads whose regular use is to be suspended for up to three years.
  - Generally, vehicle access is provided.

- Semi-Permanent
  - Used where regular use is suspended for up to 3 years or: winter roads, roads with a potential for debris torrents and those roads in particularly isolated areas, as well as roads in areas where harvesting is suspended until the next pass.
  - Roads may or may not be driveable after deactivation.

- Permanent
  - Used for roads to be closed permanently.
  - Some roads in gentle terrain may be driveable, however, it is not the primary objective of deactivation.

- Will the road be used regularly and be maintained?
  - YES
  - NO

- Are there problems with access to the site?
  - YES
  - NO

- For sites that have difficult access or that are recovering (i.e. revegetated), would deactivation efforts do more harm than good?
  - YES
  - NO
Step 2: Conducting Field Assessments

There are two levels of field assessments (see Figure 3):

- During a **Level I Field Assessment**, you conduct an overview examination of the road network and related structures. This level of field assessment is required only if more information is needed to complete Step 1 tasks.

- During a **Level II Field Assessment**, you conduct a more detailed examination and prescribe treatments. This level of field assessment is conducted after completing Step 1 tasks; it is mandatory for all road rehabilitation projects.

This section describes the two levels of field assessments as well as the recommended qualifications for field inspection staff.

Recommended Qualifications of Field Inspection Staff

Recognized, qualified professionals and technicians who possess a demonstrated ability and understanding in applying of sound resource road engineering practices should conduct field inspections of roads. Ideally, these individuals should have the following knowledge and skills:

- a thorough understanding of terrain and landslide processes and forest hydrology
- a thorough understanding of road reconstruction, maintenance, and deactivation practices.
- an ability to recognize field indicators of active or potential road-related problems.
- an ability to make rational recommendations for remedial action
- the common sense to know when to seek the assistance of specialists.

Specialists

Field staff must consult specialists when solutions to complex road problems require expert advice, and when these problems are perceived or identified to be a threat to human life, private property, highways, railways, or public utilities. Specialists include B.C. registered Professional Engineers, Geoscientists, and others with relevant training and experience. If the
problem site has prevailed for some time, you will probably also require the extensive help of specialists in road and slope stability, hydrology and revegetation during the field assessment stage and when laying out the work in the field.

In some cases, the specialist must also prepare a prescription for deactivation work. The May 1994 version of the British Columbia Forest Practices Code (Draft) Standards, Section 9.9(5) states the following:

Prescriptions for deactivation work must be submitted and approved before work begins. A professional engineer or professional geoscientist must prepare a prescription for deactivation work in areas that may be prone to mass wasting and, where so specified in the prescription, must certify that the deactivation work was carried out in conformance to the prescription.

Level I Field Assessment

Conduct a Level I Field Assessment if you need more field information to complete the tasks in Step 1 (see Figure 3). The field work carried out under a Level I program can be designed to obtain an overview level of information for a variety of purposes:

- Level I Field information helps confirm the priorities of zones for road inventory mapping and Level II Field Assessments identified in Step 1.

- In some areas of the province, information on the condition of abandoned forest roads is limited. For example, often no local knowledge about the condition of roads exists, despite aerial photograph coverage. A Level I Field Assessment can provide additional information to help you identify new high priority zones for planning road inventory mapping and Level II Field Assessments.

- Level I field information can help establish the best strategy for managing access in a particular zone.

- Level I field information can be useful in preparing preliminary budgets and schedules, and to better define the rehabilitation project scope and objectives for future Level II Field Assessments and site works.

**Important:** Level I Field Assessments are not suitable for prescribing treatments. Only Level II Field Assessments are suitable for such purposes.
The types of activities carried out for a Level I Field Assessment will depend on what information you need to complete Step 1 tasks. A Level I Field Assessment may include some or all the following activities:

- conducting overview field inspections of existing road conditions
- conducting overview risk assessments
- verifying road inventory base map information
- preparing overview cost and time estimates.

These are explained in more detail below:

**Conducting Overview Field Inspections of Existing Road Conditions**

You can drive, walk, or ride mountain bikes or ATV’s over the road, or visually assess it from the air. The method you choose depends on existing access and the level of information desired. Where time and resources are limited, or where information is scarce, a helicopter reconnaissance may often yield a cost-effective overview of site conditions. Certain downslope impacts and drainage patterns may be best detected by aerial reconnaissance. However, there are certain details you cannot examine from a helicopter, such as blocked drainage structures, tension cracks in road subgrade, or old stumps supporting sidecast fill. Helicopter reviews may only be valuable in identifying high hazard road segments and erosion sites that need closer examination on the ground.

Record the following information in your field notes or on field record forms:

1. **General Information:**
   
   - geographic area
   - terrain hazard class
   - zone/watershed/map reference
   - road name/number
   - road type (main, branch, spur, block logging trail, other)
   - date of field inspection
   - assessor
   - weather details
   - licensee (if applicable)
   - file name
   - apparent use status (heavy or light vehicle use or no apparent use)
   - planned road management strategy
   - method of inspection (helicopter, drive, walk, ATV, other)
2. Existing and potential problems identified along the road corridor, including problems with gullies and landslide tracks that must be corrected. You should record your general observations for each road examined. The following problems are often typical of abandoned forest roads.

- plugged ditches/no ditches
- no ditchblocks
- ditchwater flowing directly into streams
- plugged/damaged culverts
- insufficient cross-drain culverts
- undersized cross-drain culverts
- natural drainage blocked/diverted
- ditchline/road surface erosion
- unstable or eroding cut/fill slopes
- washout of road/bridge
- damaged/unsafe bridge
- landslide tracks
- tension cracks on road
- fill/debris in channels
- beaver dams
- cattle usage
- organic material & stumps supporting sidecast fill

Take photographs or videos and regular field notes for documentation purposes. Photographs or videos taken from a helicopter are invaluable for showing an overview of the actual site conditions for later review and analysis.

Appendix F provides examples of road inspection forms that may be useful for recording field data obtained during a Level 1 Field Assessment. You should develop your own field record forms to meet your specific needs. Be sure to use a data format that can be readily entered into a computer data base.

Important: Alert all appropriate agencies immediately if there is a perceived or identified threat to onsite, upslope, or downslope areas along road corridors that contain rural development, domestic dwellings or industrial development, highways, railways, public utilities, water supplies or fisheries habitat.
Conducting Overview Risk Assessments

Record inventories of existing and potential hazards, such as surface soil erosion, landslides, and stream sedimentation. Assess the level of risk to the environment and to social and economic values by considering the factors listed in Table 3. Use the following rating system:

- Very High (VH)
- High (H)
- Moderate (M)
- Low (L)

For additional information on assessing risk, refer to Appendix E, *Risk Assessment Procedure*. Also make a preliminary judgment about how quickly the problems must be corrected. Based on the guidelines in Table 4, prioritize the work sequence for the zone as:

- High (H)
- Medium (M)
- Low (L)
- No Work necessary (N)

Verifying Road Inventory Base Map Information

At the time of overview field inspections, verify and augment road inventory map information, as required.

Preparing Overview Cost and Time Estimates

Prepare preliminary estimates of cost, time and equipment requirements based on an overview assessment of the likely treatments required to correct problems.
Table 3: Factors to Classify Priorities for Work Sequence

When examining roads, evaluate the potential risk that abandoned roads pose to the environment and to social and economic values. Consider the following factors:

- the potential for adversely affecting another resource or third party interest, such as a highway or dwelling, and the potential threat to human life

- rate of site deterioration. Is the site tending towards increased stability with time, or is instability or erosion becoming worse?

- the inherent erodibility and extent of exposed mineral soils and the level of hazard with regard to continued erosion

- whether old slide tracks are continuing to erode

- whether the sites are stabilizing naturally

- whether the sites are or may contribute to sedimentation of a fisheries stream or domestic water supply or debris loading in an area of environmental or public concern.

- the likelihood that the road will deliver eroded materials to an established channel, and the extent of the delivery; proximity is a major consideration

- the age of road networks, the method of construction, the likelihood that road fills and cut banks will fail, and the potential for events to trigger other more extreme erosion events

- the likelihood that the road will deliver sediment to nearby streams and the extent of delivery

- access to sites that require remedial works; for example, poor access may limit treatment options to less effective methods or defer treatment altogether

- the extent of potential damage to water supply, fisheries, visual aesthetics, etc.

- stages of erosion - emergent, active, benign

- significance or cost/benefit of remedial works

- the level of disturbance and damage re-entering an area to carry out remedial measures is likely to cause. For example, remedial works conducted on road segments that have established erosion pavements or re-established vegetation may have a net detrimental effect

- technological ability to remedy the situation

- other factors.
### Table 4: Suggested Guidelines for Assigning Work Sequence Priorities

<table>
<thead>
<tr>
<th>Work Sequence Priority Classes</th>
<th>Criteria Based on Level of Risk to Human life, the Environment and Other Values</th>
<th>Risk</th>
</tr>
</thead>
</table>
| **H** High Priority: physical corrective action along the road segment is required immediately. | Assign to road segments that:  
- have started landslides or have the potential to start landslides (mainly by failure of road fill materials or road drainage interruption), or  
- exhibit evidence of actively producing sediment by surface erosion within the road prism, and that are causing or have high potential to cause any of the following impacts:  
  - a threat to human life  
  - adverse impact on private property, downslope travel corridors, or public utilities  
  - a threat to the stability of the road, therefore to user safety  
  - direct delivery* of sediment into Class A fisheries waters or domestic water supply. Class A fisheries waters are streams and lakes that are frequented by anadromous or resident sports fish. | Very high or high |
| **M** Medium Priority: there is a serious concern, but physical corrective action is not required immediately. | Assign to road segments that:  
- have initiated landslides or have the potential to initiate landslides (predominantly by failure of road fill materials or road drainage interruptions), or  
- exhibit evidence of actively producing sediment by surface erosion within the road prism, but are not likely to threaten human life or to have a direct impact on Class A fisheries waters or domestic water supply.  
- have initiated mass wasting or surface erosion that is causing, or may have high potential to cause, any of the following impacts:  
  - significant, indirect delivery of sediment into Class A fisheries waters, or domestic water source  
  - significant losses of site productivity (>0.1 hectare per occurrence)  
  - significant impact within areas of high quality visual resources. | Very high, high or moderate |
| **L** Low Priority: there is no serious concern, and physical corrective action is not needed immediately. | Assign to sites where actual or potential impacts to the environment are low. Deactivation measures may involve:  
- installing cross-ditches and waterbars, primarily to protect the road investment (i.e. prevent washouts on the road and deterioration of the running surface)  
- controlling access to conserve natural resources. | Low |
| **N** No Work Necessary | Assign to road segments where physical corrective efforts would have a net detrimental effect. Examples include roads that have recolonized with natural vegetation or that have developed well-established erosion pavements and are no longer eroding. | Assessed on individual basis |

*Examples of direct delivery of sediment include:  
- debris from a landslide that enters a water body directly  
- sediment transported through a stream channel or ditchline, where the channel or ditchline is linked to the waterbody directly  
- sediment that is produced by surface erosion of exposed soils, such as cut slopes, fill slopes, and landslide scars, and that is transported directly to a waterbody by surface runoff water.
Level II Field Assessment (Mandatory)

You must conduct a Level II Field Assessment to prepare road rehabilitation prescriptions (see Figure 3).

General Guidelines

Within a zone of interest, detailed field work is normally carried out on all road networks (including specified related developments) using a 1:5,000 scale inventory map for field referencing purposes.

- Carry out field work for Level II Field Assessments using methods that will permit close examination of the road prism, drainage controls, bridges, structures, landings, pits and quarries, gullies, landslides, and clearcut areas (including logging trails and fireguards). Typically, in areas prone to mass wasting, you walk the roads. We do not recommend conducting inspections from a moving vehicle or from the air to prescribe remedial measures on roads.

- You must carry out ground inspections when there is no snow cover.

- Inspections carried out during rainy periods can provide invaluable information regarding the capability of culverts and general water management along the road.

Procedure

1. Review the projects scope and objectives defined for the zone, and ask yourself the following questions:

   - Will prescriptions be limited to the roads, including landings, drainage controls, bridges, retaining walls, other civil structures, and gullies and landslide tracks?

   - Will prescriptions also cover pits and quarries, and clearcuts, including logging trails and fireguards? If not, when will inspections for these components be carried out?

   The next four procedural steps assume that the inspections are limited to the roads (including landings) and gullies and landslides located along the road corridor.

2. Verify and augment road inventory map information, as required.

3. Accurately identify active erosion and potential problems within the road right-of-way, and upslope and downslope, where applicable, through examinations on the ground. Assess and visually locate the
source of problems, such as water diverted down a road, and note sediment and delivery routes. Record this information in field notes. You can also plot it (in the field) on 1:5,000 inventory maps, if appropriate. Assess the level of risk to the environment and to social and economic values by considering the factors listed in Table 3.

4. **Prioritize the work sequence for sites based on the factors in Table 3 and the guidelines in Table 4.**

Use the following rating system:

- High (H)
- Medium (M)
- Low (L)
- No Work necessary (N)

You will use this information later to establish project schedules (see *Step 3: Preparing Reports and Maps*).

To help assign priorities, assess the stage of the erosion process. For example, controlling or preventing early stage erosion on sites is considered more cost effective and more urgent than carrying out corrective measures on sites that are in an advanced stage of erosion. Sites in an advanced stage have begun natural recovery through vegetation re-colonization or have very limited potential for continued sediment production and delivery. When assigning priorities to actively eroding sites, consider the magnitude of the erosion and sediment problem and the immediacy of the impact or potential for initiating greater problems.

5. **Make prescriptions.** The prescription phase takes place in the field. In this phase, you identify and evaluate particular problems, then determine a course of action to address them. Recommended prescriptions must be consistent with the objectives of the rehabilitation project and the approved strategy for managing access in the area. Write clear and detailed prescriptions; they will be used as specifications in site works contracts and must be complete to accurately describe what is required. Refer to *Level II Field Assessment Report* in *Step 3: Preparing Reports and Maps* and Appendix I for formats to present prescriptions.

This task also includes laying out the work on site by flagging using colored ribbons, staking, painting marks, or by other suitable means. Make sure that the marking system used clearly indicates what is required to work crews and equipment operators. Forestry paint works best for marking prescriptions in the field. However, be aware that paint markings made in the field during wet weather will soon disappear. During poor weather conditions, use stakes or other methods that provide durable field identification. Weathering and animals will remove colored ribbons over
time; these markings may also have to be re-established or renewed before
the works are carried out.

If you mark prescriptions well before you expect site works to begin (4 to
6 months or longer), you must establish permanent reference stakes or
aluminum plaques along the road corridor at every 250m slope distance
and at critical control points; where appropriate, use existing kilometer
markers as reference points. This will allow you to re-establish field
markings at some future date by referring to your field notes and
re-chaining slope distances.

Typically, you walk the road with a pedometer, hip chain or pace counter
when you field mark prescriptions. You measure all slope distances in
meters, working from the uppermost end point of each road and walking
along its outside edge. Take photographs or videos and regular field notes
for documentation purposes.

Record the following information in your field notes or on field record
forms:

1. **General Information:**

   - geographic area
   - terrain hazard class
   - zone/watershed/map reference
   - road name/number
   - road type (main, branch, spur, block logging trail, other)
   - date of field inspection
   - assessor
   - weather details
   - licensee (if applicable)
   - file name
   - apparent use status (heavy or light vehicle use or no apparent use)
   - planned road management strategy
   - site characteristics. Example: steepness of side slopes, number
     and location of gully crossings, gradient of the road.
   - strategy for managing road access [for strategy 2, indicate the level
     of deactivation—temporary (seasonal), semi-permanent,
     permanent]. Indicate reasons for changes to planned road
     management strategy.
   - type of access required (2 WD, 4 WD, ATV, other)
   - method of inspection (walk, drive, motorcycle, bicycle, ATV,
     other)
2. Site Works Prescriptions:

- measured distances along the road (slope distances) in meters from station to station, rounded to the nearest meter
- prescription symbol; use standardized symbols for the more common road deactivation prescriptions (see Generalized Definitions for Road Deactivation Prescriptions at the end of this section)
- a written description of the prescription for deactivating or reconstructing the road:
  - clearly specify the stations at which the prescription starts and ends.
  - give a brief note on the problem and other notes providing a rationale for the prescription; the level of detail you record depends on factors such as the immediacy of the problem and the magnitude of potential impacts.
  - specify special requirements for site supervision at the time site works are implemented and any safety concerns.
  - indicate requirements for manual labour.
  - specify extra items - quantity of material to be moved, unusual work required, etc., as required
  - other comments or special concerns
- likelihood of fill or cut failures, consequence of failure, potential risk, and work sequence priority for site

3. Estimates of Machine Time:

- the estimated scale of difficulty for equipment to implement the prescription (easy, average, difficult) and the corresponding estimated machine time
- other site constraints that may impact costs and schedules

4. Silviculture and revegetation prescriptions:

Standards

**Examples of Prescription Activities for Access Management Strategy 1**

Prescription activities for reconstructing road segments may involve improvement to the road prism, drainage structures, and bridges. There are some examples of prescriptions activities:

- Clean ditches
- Install/repair ditchblocks
- Clean/repair damaged culverts
- Install additional cross-drain culverts
- Install larger diameter cross-drain culverts
- Install larger diameter stream culverts
- Restore natural surface water flow
- Remove/breach windrows, as appropriate
- Repair/stabilize road embankment or running surface
- Repair/stabilize cut or fill slopes
- Repair bridge
- Revegetate exposed cut or fill slopes
- Inslope, outslope or crown the road surface
- Install open top culverts
- Take other measures as appropriate

**Examples of Prescription Activities for Access Management Strategy 2**

Road deactivation measures are designed and constructed to stabilize the roadway prism and cleared width and to restore and maintain natural drainage. The primary objective of road deactivation is to minimize environmental impact and control access to suit the level of anticipated use during periods when regular, on-going maintenance is suspended.

Prescriptions prepared for road deactivation projects may include a variety of activities:

**Water Management:**

- Restore natural surface water flow and address seepage
- Clean ditches and culverts (applies mostly to temporary deactivation)
- Remove cross-drain culverts
- Backup cross-drain culverts
- Remove stream culverts
- Backup stream culverts
- Excavate cross-ditches
- Construct water bars
- Install ditch plugs
- Remove all windrows or berms on road
- Outslope, inslope or crown the road surface
- Restore drainage channels
- Remove slash and other debris from drainage channels
- Backfill ditches
- Armour channels
- Install subdrains and other special measures
- Construct fords
- Take other measures as appropriate

**Road Prism:**

- Excavate unstable sidecast and endhaul spoil or place it against the cut slope, as appropriate
- Stabilize cut slopes
- Establish wind firm boundaries along the top of the cut if necessary
- Take other measures as appropriate

**Bridges:**

- Repair or remove bridge structures
- Take other measures as appropriate

**Erosion:**

- Treat cuts, such as slumps, overhanging scarps, etc.
- Treat gullies
- Treat landslides
- Take other site specific measures to stabilize slides

**Revegetation:**

- If appropriate, scarify the road surface and revegetate the former road surface
- Revegetate exposed cut or fill slope or landslide tracks; replant with appropriate species.

Refer to Appendix H for more information on deactivation measures.

**Important:** Alert all appropriate agencies immediately if there is perceived or identified threat to onsite, upslope, or downslope areas along road corridors that contain rural development, domestic dwellings or industrial development, highways, railways, public utilities, water supplies or fisheries habitat.
Generalized Definitions for Road Deactivation Prescriptions

The following table gives generalized descriptions for road deactivation prescriptions. **Caution:** The descriptions are not complete. Modify and expand them to address your site specific conditions and treatments. Clearly state any exceptions to generalized definitions in your field notes and in your Level II Field Assessment report.

To denote specific actions, use the following symbols in field notes and reports, on the 1:5,000 scale works maps, and for field markings.

**Table 5: Generalized Definitions for Road Deactivation Prescriptions**

<table>
<thead>
<tr>
<th>Field Note Report, and Map Symbol</th>
<th>Field Mark</th>
<th>Generalized Definition of Prescription Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>Red bar</td>
<td><strong>Construct cross ditch and ditch block.</strong> Excavate a ditch across the road at a minimum skew angle of 30 degrees (or as marked in the field) and at a sufficient depth, with armoring as appropriate, to divert both road surface water and ditch water off or across the road. The cross ditch also includes construction of a substantial ditch block to ensure no water flows on down the road ditch. Have the material excavated from the cross ditch placed on the downgrade side and compacted sufficiently to form a berm. The berm and cross ditch must allow passage of vehicle traffic, as necessary. Specify the width and depth of the cross ditch, and the vehicle type expected to traverse it (e.g., 4 wheel drive). In erodible materials, the cross ditch channel and outlet must be protected with rock of sufficient size and shape to prevent surface soil erosion. Provide a sketch of a typical cross ditch.</td>
</tr>
<tr>
<td>W</td>
<td>Blue Bar</td>
<td><strong>Construct waterbar.</strong> Excavate a shallow ditch across a road or logging trail at an angle to collect and direct roadway surface water off the road to the fill side or across the road to the ditch side (reverse waterbar). Specify the depth and skew of the waterbar ditch. Have a berm constructed on the downgrade side of the waterbar ditch; it must be constructed to accommodate the types of vehicles anticipated to travel the road. In erodible materials, the waterbar ditch channel and outlet must be protected with rock of sufficient size to prevent erosion. Provide a sketch of a typical waterbar.</td>
</tr>
<tr>
<td>Field Note Report, and Map Symbol</td>
<td>Field Mark</td>
<td>Generalized Definition of Prescription Activity</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-----------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>F</td>
<td>F</td>
<td><strong>Construct ford.</strong> Construct a dip in the roadbed at a stream crossing, instead of a culvert or bridge. The streambed must be erosion-resistant material, or such material must be placed in contact with the streambed. Specify construction details, including erosion protection, and types of vehicles expected to travel over it.</td>
</tr>
<tr>
<td>CC</td>
<td>CC</td>
<td><strong>Clean or repair culvert</strong> (for maintenance purposes or temporary deactivation).</td>
</tr>
<tr>
<td>RWC</td>
<td>RWC</td>
<td><strong>Remove wood culvert and build cross ditch and ditch block.</strong> It is critical to provide erosion protection at the outlet.</td>
</tr>
<tr>
<td>RMC</td>
<td>RMC</td>
<td><strong>Remove metal culvert and build cross ditch and ditch block.</strong> It is critical to provide erosion protection at the outlet.</td>
</tr>
<tr>
<td>BWC</td>
<td>BWC</td>
<td><strong>Backup wood culvert and build cross ditch on the upgrade side.</strong> It is critical to provide erosion protection at the outlet.</td>
</tr>
<tr>
<td>BMC</td>
<td>BMC</td>
<td><strong>Backup metal culvert and build cross ditch on the upgrade side.</strong> It is critical to provide erosion protection at the outlet.</td>
</tr>
<tr>
<td>RW</td>
<td>RW</td>
<td><strong>Remove windrow.</strong> Remove accumulated pile of road fill or surfacing material left on the road shoulder by graders.</td>
</tr>
<tr>
<td>RB</td>
<td>RB</td>
<td><strong>Remove bridge.</strong> Specify components to remove, disposal of materials, window for work, and construction detail for ford.</td>
</tr>
</tbody>
</table>
| PFH                              | Pink Stripe | **Pull back sidecast fill** (**heavy**). For stability reasons, retrieve sidecast fill materials. All material reached by full extension of the excavator bucket should be removed.  

The fill retrieved should be placed tightly against the inside of the roadway and contoured to recreate natural cross slope topography. The roadway ditch must be filled and made inoperable. Old road surface should slope slightly outward. There should be no areas left that will allow water to accumulate along the former road surface.  

The old ditch should not trap or direct ground water. Make sure you leave no windrow or spoil. Specify the width of the pullback and approximate depth of excavation at the road shoulder. |
<p>| PFM                              | 2 Orange Stripes | <strong>Pullback sidecast fill</strong> (<strong>moderate</strong>). For stability reasons, retrieve sidecast fill materials. Description is between light and heavy. Specify the width of the pullback and approximate depth of excavation at the road shoulder. |
| PFL                              | 1 Yellow Stripe | <strong>Pullback sidecast fill</strong> (<strong>light</strong>). For stability reasons, retrieve sidecast fill materials. Specify the width of the pullback and approximate depth of excavation at the road shoulder. |</p>
<table>
<thead>
<tr>
<th>Field Note Report, and Map Symbol</th>
<th>Field Mark</th>
<th>Generalized Definition of Prescription Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>H</td>
<td><strong>Leave heli-pad site.</strong> Site must be flat with clear approaches. Knock down any projections. Specify dimensions based on Transport Canada’s recommendations.</td>
</tr>
<tr>
<td>PL</td>
<td>PL</td>
<td><strong>Pullback landing.</strong> Specify requirements in design notes.</td>
</tr>
<tr>
<td>PWD</td>
<td>PWD</td>
<td><strong>Pullback woody debris.</strong> Pull woody debris off slope and pile on adjacent road or nearby flat area. Typically required to prevent water course damage or plugging if this material moves into channel.</td>
</tr>
<tr>
<td>PO</td>
<td>PO</td>
<td><strong>Pull down overhang cut.</strong></td>
</tr>
<tr>
<td>PS</td>
<td>PS</td>
<td><strong>Pullback for silviculture purposes.</strong></td>
</tr>
<tr>
<td>SR</td>
<td>SR</td>
<td><strong>Scarify the road surface.</strong></td>
</tr>
<tr>
<td>OS</td>
<td>OS</td>
<td><strong>Outslope the road surface.</strong> For water management reasons. Specify cross slope.</td>
</tr>
<tr>
<td>IS</td>
<td>IS</td>
<td><strong>Inslope the road surface.</strong> For water management reasons. Specify cross slope.</td>
</tr>
<tr>
<td>EH</td>
<td>EH</td>
<td><strong>End haul excavation waste materials.</strong> Specify end haul spoil site.</td>
</tr>
<tr>
<td>Use a symbol other than ones used above.</td>
<td>Use a symbol other than ones used above.</td>
<td>Take other measures as required (define the prescription activity).</td>
</tr>
</tbody>
</table>
Step 3: Preparing Reports and Maps

Level I Field Assessment Report

Use the following outline as a guide to the minimum content required for a Level I Field Assessment Report.

Text:

- Description of the area examined
- Method of field assessment – helicopter reconnaissance, vehicle or walking the roads
- Time spent doing the field inspections and the length of roads and number of bridges examined
- Condition of access roads into the area
- Results of road inspection, including:
  - a list in table form of the deficiencies and problems identified on roads
  - an overview assessment of
    (1) the potential risk to on site/upslope/downslope values and
    (2) the work sequence priority assigned to the zone
- Results of preliminary time and cost estimates
- Conclusions and recommendations
- Limitations of the investigation program

Graphic Presentations:

- Key Plan showing the site area
- Maps showing the road systems
- Photographs of specific site problems

Appendices:

- All completed Field Record Forms or field notes
Level II Field Assessment Report

Appendix I gives examples of road deactivation reports and maps. A road rehabilitation report should include the following information:

1. **Introduction.** Describe:
   - the area and general geology, terrain, and hydrological environment
   - general condition of the roads and sites assessed
   - overall severity of problems encountered, and condition of access roads into area
   - field observations and special concerns

2. **Objectives of the rehabilitation project.** Describe the purpose of the Level II Field Assessment and the specific concerns to be addressed in the site assessment.

3. **Field work procedures.** Describe:
   - field work done
   - methods used to identify prescriptions in the field
   - dates of the site visits
   - weather details
   - personnel who carried out the prescriptions and those who may have helped.

4. **Definitions of symbols used for marking prescriptions in the field and denoting specific actions on maps.**

5. **A summary, in spread sheet form, of the details of the work on a station by station or site specific basis.** It must be concise, and directed toward a machine operator. Include the following information:
Site Works Prescriptions:

<table>
<thead>
<tr>
<th>Road Name or Number</th>
<th>Chainage or Distance</th>
<th>Symbol</th>
<th>Prescription</th>
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<td>• written description of prescription</td>
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<td>• specify stations at which the prescription starts and ends</td>
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<td>• give a brief note on the problem</td>
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<td>• as appropriate, specify special requirements for site supervision at the time site works are implemented and any safety concerns</td>
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<td>• as appropriate, indicate requirements for manual labour</td>
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<td>• as appropriate specify extra items – quantity of material to be moved, unusual work required, etc.</td>
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<td>• other comments or special concerns</td>
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6. **Annotated site work maps (1:5,000 scale).** Prepare site works maps showing the extent of the site works required and prescriptions on all roads and related developments, as applicable.

7. **The potential risk to the environment and to social and economic values (very high, high, moderate, low) and work sequence priority for site (high, medium, low, no work necessary).** Note that you will use these priorities to schedule the site works (see **Step 4: Implementing the Project**). Display this information in table form or on the 1:5,000 map sheets, as appropriate.

8. **Estimates of costs and equipment time required to carry out the site works.** Costs for road restoration and deactivation activities are highly variable and site-specific. Some basic cost items (there are others) for preparing cost estimates include:
   - the estimated scale of difficulty for equipment to implement the prescription (easy, average, difficult) and the corresponding estimated machine time
   - mobilizing construction equipment, such as backhoes, dump trucks, cranes, bulldozers
   - equipment types and hours (use equipment rental rate guide)
   - equipment supervision
   - inspection of works
   - supplies
   - hand labour, for example, for light deactivation works
   - special techniques, such as blasting
   - other site constraints that may impact costs and schedules
Make recommendations for timing of the site works.

9. **Revegetation recommendations.** Clearly state the objectives of revegetation work for each site, such as erosion and siltation control, visual cover, or maintaining productive tree growth. The choice of technique is critical to ensure successful, cost effective results. Seek the advice of an erosion control specialist, forester or silviculturist, as appropriate.

In your recommendations, specify the following:

- objectives
- type of revegetation (seeding, planting)
- method of application (dry seeding, hydoseeding)
- equipment (hand seeders, truck based, helicopter)
- timing (season, dates, sequence of multi-stage operations)
- seeding materials and rates (seed mix, fertilizer types if suitable for the site, mulch, tackifier)
- planting materials and density (species, seedling stock type, cuttings)
- bioengineering techniques, if applicable
- cost estimate
- site preparation and access requirements to facilitate revegetation).

10. **Site supervision requirements.** State recommendations for site supervision (full time, periodic); also specify the operations or work areas that will require mandatory full time supervision during implementation of the site works.

11. **Safety concerns.** State any concern for safety during implementation of site works (e.g., unstable cut or fill slopes that equipment operators should be aware of).

12. **Recommendations for future work.**

13. **Appendices.** Provide a copy of all completed field notes or Field Record Forms.
Step 4: Implementing the Project

Scheduling Implementation of Site Works

The schedule for carrying out site works depends on:

- work sequence priorities for sites established during the field work (refer to Step 2: Conducting Field Assessments)
- availability of funds
- seasonal or other operational constraints
- future access requirements
- logistics, such as work sequences progressing from the farthest end of the road system and access requirements and constraints
- stability concerns, such as a high potential for a slide to occur at the road, cutting off future access.

Schedules can have multi-staged plans for certain activities, such as seeding and replanting, or stabilizing major slides. In preparing a schedule, take note of any special materials or equipment that will require special planning or procurement in advance.

Site Works Supervision

Ideally, the individual that has made the prescriptions should work closely with the equipment operator to review the work and to ensure that the operator understands why and how certain activities are carried out. This will help the equipment operator make final adjustments in the recommended work based on actual site conditions encountered. For example, the operator can decide exactly how much fill is pulled back in a specific place to ensure that neither too much or too little work is done.

The site supervisor should check off work done against the work map and specifications. Site supervisors may have to collect the following data:

- equipment types used, rates, dates, and hours
- equipment time and motion studies
- labour hours and costs
- deficiencies or revisions from original work map and specifications
- photographs of the site before and after implementation of site works (these can be used as a valuable learning tool for training of equipment operators in the techniques of road rehabilitation)
- over or under expenditures from original cost estimates and budgets
- any unforeseen occurrences.

The site works supervisor should prepare a final inspection report on completion of the work.
Step 5: Monitoring and Evaluating Results

After site works have been implemented, monitor and evaluate the success of the treatment techniques employed.

- Determine whether the techniques employed have achieved the desired objectives.
- Check for renewed erosion or instability.
- Inspect the progress of revegetation.
- Determine the cost-effectiveness of prescriptions, and if their use is justified for future projects.

Experience is invaluable for determining what does and does not work. A successful watershed restoration program builds on past successes; we also learn from failures.

Maintain a data base of successes and failures for future reporting requirements.

Appendix J, pages 102 to 114 of Cost-effectiveness of Erosion Control for Forest Land Rehabilitation, Redwood National Park, provides some ideas on how to predict and evaluate the cost effectiveness of erosion control.
Additional Sources of Information


Bibliography


Bibliography


The author would appreciate your feedback on the usefulness and clarity of the material contained in this handbook. Please take a moment to fill out this questionnaire and send it to the address provided. Your comments will enable the author to improve future editions. Thank you.

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**Additional Comments:**

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Your Occupation: _____________________________________

The following information is optional; however, we would like to have the option to contact you and discuss your suggestions.

Your Name: __________________________________________

Phone #: _____________________________________________

Fax #: _______________________________________________

Please mail this form to:

Glenn Moore
Engineering Section
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B.C. Ministry of Forests
3rd Floor, 1450 Government St.
Victoria, B.C.
V8W 3E7
APPENDIX A

Typical Mechanisms of Road-Associated Erosion and Sediment Production
**Forest Roads and Slope Stability**

**Erosion and Sedimentation Problems**

The general term ‘erosion’ refers to the detachment and transport of soil materials from place to place. There are two types of erosion processes: surface soil erosion and mass wasting. Surface soil erosion is the transport of individual soil particles primarily by the action of water, wind and frost, whereas mass wasting is the movement of large volumes of soil or rock primarily under the influence of gravity. Sedimentation is the deposition of eroded soil material in water.

In the natural forest environment, a thin mantle of vegetation and forest litter protects the soil surface. This organic layer is highly porous, and because of its high rainfall infiltration capacity, surface runoff does not usually occur. Soil erosion is a natural process in a forested watershed but it happens at almost imperceptible rates if the forest floor remains undisturbed.

Forest road construction typically involves clearing the timber to the required width limits, grubbing and stripping at least within the running width, constructing cut and fill slopes, constructing ditches and installing culverts, and preparing a strong subgrade to carry vehicle design wheel loads (see Figure A-1). These activities result in destruction or burial of the protective forest floor cover, and in exposure of unprotected mineral soils, and cause the rates of natural surface soil erosion and mass wasting to accelerate. Mass wasting, landslides, slope movements, slope failures and failures are used interchangeably throughout this appendix.

In the context of forest roads:

**Surface Soil Erosion** includes shallow erosion and gullyng by running water across the road surface or cut and fill surfaces.

**Mass Wasting** includes several dominant groups of landslide processes: debris falls, debris slides, debris avalanches, debris flows, debris torrents, rockfalls, rockslides, slumps and earthflows, and small scale slumping, collapse, and raveling of road cuts and fills.
FIGURE A-1 Typical Forest Road Cross-Section
**Road Construction Practices**

Most forest roads are built by excavating a road surface. The technique of cut and fill construction is commonly used to provide a horizontal running surface across gentle to moderate terrain (Figure A-1). The earthmoving equipment may start at the top of the cut slope, excavating and sidecasting material until the desired road grade and width is obtained. In this case, the sidecast fill material usually forms part of the road running surface.

Generally, steep slopes are those considered to have slope angles greater than 31 degrees (60 per cent). On such slopes, three-quarters to full bench roads are usually built. In full bench construction, the entire road surface is excavated into the hill. For three-quarter bench construction, three-quarters of the road surface is excavated into the hill and the remaining portion of the road width is formed by excavated fill material sidecast onto the natural slope. Many older forest roads were constructed by pushing significant volumes of excess excavated material over the slope, rather than trucking this material to a safe waste disposal site.

Many road-related landslides can begin in unstable road fill or sidecast materials on steep slopes. Once a road fill fails, the failure may continue on as a destructive debris slide or debris avalanche. The most common forms of instability are oversteepened/overloaded fill slopes, oversteepened cut slopes, loss of road fill support, poor road drainage control causing road water to be re-directed onto slopes, removal of material from the toe of the slope.

**Oversteepening of Steep Slopes**

Forest road development requires excavation of material to provide a horizontal running surface. On a slope, this means cuts and fills which oversteepen the slope angle. On slopes that are steep and near their angle of repose, this oversteepening (change in the natural slope geometry) may cause the cut and fill slopes to become unstable, particularly during periods of intense rainfall [Figure A-2(a)]. Failure along some sliding plane within the fill or cut slope materials will occur when the gravity forces tending to cause motion exceed the frictional forces of the soil materials that resist sliding.

Fill slope failures are the most common type of road-related landslide. Slumping of oversteepened road cut slopes may also cause landslides by altering drainage by filling in roadside ditches and culverts with debris.
FIGURE A-2(a) Oversteepening already steep slopes may cause landslides

Steep slopes oversteepened with sidecast fill materials

Sidecast fill fails as a debris avalanche that removes all surficial materials along the slide path

BEFORE

AFTER

FIGURE A-2(b) Overloading already steep slopes may cause landslides

Steep slopes overloaded with sidecast fill materials

Sidecast fill fails as a debris avalanche that removes all material above bedrock along the slide path

FILL

SHALLOW SOIL

BEDROCK

BEFORE

AFTER

FIGURE A-2(c) The practice of using stumps and logs to support fill material provides only short-term stability

Fill material on steep slope retained by stumps and logs

Loss of lateral support of fill material due to decay of stumps and logs - fill material fails and removes all surficial materials along the slide path

Stumps and logs supporting fill

BEFORE

AFTER
Overloading of Steep Slopes

The practice of sidecasting excavated material onto steep, sensitive natural slopes can result in overloading these slopes [Figure A-2(b)]. Most forest roads built before the mid-1970’s were constructed using bulldozers or line shovels. In building roads on steep slopes, bulldozers and line shovels had limited ability to control sidecast or to use excavated soil and rock to finish the roads. Such roads built on steep slopes typically involved three-quarter to full bench cuts, usually in rock. The excavated material was commonly piled loosely on the outer edge of the road subgrade, without end-hauling of the waste materials.

The sidecast material was commonly placed in contact with the surface of the natural ground. As more material was sidecast, more weight was added to the slope. Since there is very little bonding of the sidecast material to the underlying shallow topsoil and competent material, the entire slope is said to be overloaded.

Over time, and particularly during periods of heavy rainfall, the subsurface topsoil or humus layer may weaken and reduce the overall stability of the fill slope. Under these circumstances, the road fill, together with the underlying shallow topsoil layer, may fail and form a destructive landslide.

Loss of Fill Support

As described earlier, many older forest roads were built using bulldozers and line shovels. Such machinery had difficulty in carrying out stripping operations and subgrade preparation in a controlled manner. By comparison, present day hydraulic excavators are better able to strip away stumps and vegetation and separate soil materials to produce clean, well-formed subgrades.

The limited maneuverability of machinery, and poor construction practices, resulted in many cases of older forest roads built on steep slopes by sidecasting excavated material against large stumps, fallen logs, and ground vegetation [Figure A-2(c)]. The stability of the sidecast relied primarily on the holding power of the root system and vegetation. In other cases, older forest roads were built on steep slopes using a retaining wall system to support the sidecast fill. This was achieved by stacking logs to form a wall on the downslope side of the road, and tying the logs from stump to stump to resist the lateral earth pressures. Decay of the stumps, root system, and logs over the years can result in an unstable road prism.

Lateral movements of the sidecast fill material often result in tension cracks forming along the edge of the road bed (Photo A-1). This is an indicator of an unstable road fill and that the fill may be moving downslope. Infiltration of water into tension cracks during heavy winter rains can trigger the road fill to fail completely. Where roads on steep slopes exhibit such tension cracks, the potential exists for large landslides to occur.
PHOTO A-1  Tension cracks in road fill. This is an indicator of an unstable road fill.
Road Drainage Onto Fill Slopes

Road-associated landslides may also occur at sites where breakdowns in the road drainage system directed a concentrated flow of water onto a road fill slope. Often this factor may be the trigger that sets in motion an already unstable road fill, or that destabilizes an otherwise competent fill. The concentrated flow may also cause gully erosion of the fill and natural slope, which could initiate a larger landslide. The road drainage system will be discussed in more detail in the section that follows.

Forest Roads and Water Management

Many road-related landslides can be traced to problems in the road drainage system. The road drainage system consists of two main components – ditches and culverts. If the road drainage system fails by failure of one or more water control elements, landslides and extreme surface erosion and sedimentation can result. For example, if a ditch or culvert becomes blocked by sediment or debris, large quantities of drainage water can move along the road surface (Photo A-3). The water channeled down the road can erode the road surface itself, and if redirected onto a steep sensitive slope, can cause a landslide. In addition, an improperly constructed or failed drainage system can alter natural slope drainage patterns, and poor road construction practices can result in unstable road cut banks and fills, which may also initiate large landslides. The landslide debris, or eroded surface materials, can be quickly transported downstream or downslope, which can cause damage to environmental, economic and social values.

Ditches

Ditches are important in road construction. Ditches are installed to keep the road surface and subgrade well drained. They collect water from the crowned road surface and intercept surface water and seepage from the cut slope above the road. A well-drained road promotes a stronger subgrade surface to support heavy wheel loads (Figure A-3). Well-constructed and regularly maintained ditches are a real key to long-term stability of a road.

Culverts

Water collected in roadside ditches must be relieved at frequent intervals by cross-drain culverts (Figure A-4). Cross-drain culverts need to be installed at frequent intervals to prevent concentration of water and excessive flow in the ditches. To prevent downslope movement of sediment, sediment catch basins are often installed at culvert inlets. Ditch blocks are commonly installed immediately downstream of cross-drain culverts to control the volume of ditch water and to prevent excessive erosion of soil materials. Unstable or erodible fill at culvert outlets should be protected with flumes, rip rap or other erosion-resistant material.
FIGURE A-3 Ditches are important in road construction. They collect water from the crowned road surface, and seepage and surface runoff from the cut slope above the road. A road well drained is stronger.

FIGURE A-4 Water collected in roadside ditches should be a relieved by cross-drain culverts. The number of cross-drain culverts required increases as gradient increases. The fill slope at the culvert outlet should be protected with erosion-resistant material.
In addition to cross-drain culverts, which provide ditch water relief, stream culverts or fords should be installed at all crossings of established permanent or seasonal watercourses.

Culverts that are improperly installed and designed, and not maintained regularly, are directly or indirectly responsible for a large number of road-associated landslides.

**Construction Factors**

Both construction and maintenance factors can contribute to road-associated landslides as a result of problems in the road drainage network. Ditches cause problems when they are constructed too shallow or when they do not have sufficient gradient. A deep ditch allows rapid drainage of the road subgrade or the sidecast material, which reduces the build-up of high water pressures and helps maintain high soil strength and improved slope stability. Water that may pond in shallow ditch lines can saturate the subgrade rather than drain it.

The gradient of ditches is largely determined by the gradient of the road. The gradient should be sufficient to prevent ponding of ditch water; where grades are low, the best way to prevent ponding is by installing more frequent cross drains.

Cross drain culverts should be spaced at appropriate intervals to minimize the transport of sediment. Cross drain culvert spacing is a function of the road grade, soil type, and rainfall intensity. In general, cross-drain culverts that are spaced too far apart can allow ditches to collect too much water. On steep road gradients this can result in severe erosion of the ditchline and plugging of culvert inlets with sediment and debris. Wide culvert spacing can contribute to off-road failures by collecting drainage from large areas and concentrating it onto small slope areas.

If ditches are ineffective, or if cross-drain culverts and stream culverts are sized too small to accommodate peak ditch and stream flows, drainage water may breach the road and flow across the road. This situation can quickly erode the fill slope, causing oversteepening and possibly slope failure.

A cascading outfall from the exit end of a cross-drain culvert can erode and undermine the fill slope. An apron of coarse rock or rip-rap installed over the fill slope at the outlet end of a culvert can prevent erosion and undercutting of the slope. An unprotected fill slope at a culvert outlet can result in significant erosion (Photo A-2). If the undercut slope is not repaired, a larger landslide can result.
PHOTO A-3 Failure of the road drainage system has resulted in redirection of surface water and seepage along the road bed. This causes significant surface erosion of the running surface. Re-direction of surface water onto unstable slopes often triggers landslides.

PHOTO A2 Shows improper culvert installation. Unprotected fill slope at culvert outlet has resulted in significant erosion and undercutting of fill slope.
**Maintenance Factors**

Although construction factors are commonly involved, most road fill slope failures can be attributed to problems with road drainage, which occurs because of inadequate maintenance of the road-side ditches and culverts. Regular maintenance operations of the road drainage system include:

- cleaning and grading of ditches
- cleaning and repairing culverts
- inspections of drainage system structures after major storms, during spring breakup and prior to fall rains to assess their adequacy

The quality of road construction governs the risk of slope failure in the short term, but maintenance of the ditches and culverts determines the road’s stability in the long term. Hence, even if new roads are better built, and existing active roads are fully maintained and properly deactivated before maintenance funding terminates, the extensive network of old Abandoned roads that remain will continue to be a source of landslides, surface soil erosion and sedimentation.

Sediment production from roads can be caused by erosion of road surfaces, sidecast fills, cut bank slopes, and ditch line. Removal of sediment from eroding road surfaces may also adversely affect road stability. As the road erodes, the drainage capacity of ditches and culverts can be reduced, road banks undercut, and the road surface undermined. Such surface erosion can then lead to mass erosion.

A large portion of this eroded material comes to rest in the road drainage system. While in the road drainage system, the soil will reduce the effective water-carrying capacities of the drainage structures, jeopardizing road stability and also overall slope stability. Hence, although surface erosion is not as spectacular as mass-wasting, it is a serious but less visible problem.

If the road drainage system is not regularly maintained, ditches fill in with sediment and culverts become plugged with sediment and debris. Ineffective ditches and blocked culverts can cause ponding of water, saturation of the fill slope and breaching of the road. Blocked culverts are more often a problem than are undersize culverts. Relatively minor blockages can lead to spectacular erosion and landslides.
Road Drainage and Off-Road Landslides

Poorly constructed road drainage systems, and/or lack or absence of drainage maintenance, can alter natural slope drainage patterns. Plugged culverts or filled in ditches can permit road drainage to be channeled down the road (Photo A-3) and redirected across the road onto either unstable fill slopes, or sensitive natural slopes downhill. The channeling of road drainage down the road will also cause major surface soil erosion.

In addition, inadequate relief of ditch water can create major slope stability problems. In this situation, runoff that would usually drain into natural drainage basins may be conveyed away (in the ditchline) from the natural drainages into a drainage area that previously received less water. Pirating of water in this manner increases the size of the affected drainage area and may initiate large landslides downhill of the road location.
APPENDIX B

Explanation of Some Common Road Deactivation Measures
Cross-Ditches and Waterbars

Water management is the most important task in road deactivation. In lieu of maintenance, water control elements that require maintenance can frequently be “failsafed” by adding self-maintained water control elements to accomplish the same objectives. The water control element in this case is backup, i.e., an addition to the drainage system that ensures control if another element fails because of unreliable or complete absence of maintenance. The backup element is typically less prone to failure, if properly installed, and hence is self-maintained. Restoring natural drainage patterns can be achieved by adding many self-maintained water control elements such as cross-ditches, waterbars, and outsloping or insloping the road grade.

The purpose of a cross-ditch (Figure B-1 and Photo B-1) is to capture and divert both road surface water and ditch water off and/or across the road, to prevent surface soil erosion, ditchline erosion, and concentration of drainage water (surface and subsurface). A cross-ditch directs and disperses surface water flow off a road to stable sites on the downhill side of the road. Cross-ditches perform the same function as culverts, but unlike culverts, very little or no maintenance is required to ensure water flow when they are properly constructed, placed in correct locations, and spaced closely.

An overflow cross-ditch provides an overflow channel across the road that will convey water across without excessive erosion if/when an existing culvert plugs or its capacity is exceeded. An example of an overflow cross ditch is illustrated in Photo B-2.

The purpose of a waterbar (Figure B-1) is to prevent excessive flow down the road surface and erosion of road surface materials. The waterbar may be installed to capture and divert road surface water off the road and into the ditchline, or across the road. The waterbar is unlike the cross-ditch because ditch water is not a concern.

The locations or cross-ditches and waterbars are determined by grade, slope length, nature of the road surface materials, and surface and subsurface flows.
Cross-Ditch

Purpose: To capture and divert both road surface water and ditch water off and/or across the road.

Features:
- excavate a cross ditch to a depth that will allow a direct hydraulic connection to roadside ditch
- construct cross-ditch with minimum skew angle of 30 degrees to the perpendicular of the road ditchline
- install a berm on downgrade side of cross-ditch
- provide erosion protection as necessary at the outflow
- flatten berm and widen ditch to accommodate vehicle traffic, as necessary

Waterbar

Purpose: To capture and divert road surface water off the road, and into the ditchline or across the road as appropriate. Note that the waterbar is unlike the cross-ditch where ditch water is also a concern.

Features:
- depth of waterbar ditch below road surface is typically shallow
- skew as required
- install a berm on downgrade side of waterbar ditch
- provide erosion protection as necessary at the outflow
- flatten berm and widen ditch to accommodate vehicle traffic, as necessary

FIGURE B-1  Typical road deactivation measures – Cross Ditch and Waterbar
PHOTO B-1  Cross-ditch, diverts both road surface water and ditch water off and/or across the road

PHOTO B-2  Overflow cross-ditch, provides an overflow channel across the road that will convey water across without excessive erosion if/when an existing culvert plugs or its capacity is exceeded.
Outsloped and Insloped Roads

Outsloped Roads

Water flow may be controlled by sloping road grades. Grading the road surface so it slopes from the cutbank to the road shoulder creates an outsloped surface (Figure B-2). To be effective, the outslope must be sufficient to drain water off the surface. Outsloping is most effective where cutbank slumping will eventually plug the ditch line. Outsloping reduces the number of cross-drains required except where low grades can pond water.

Insloped Roads

Insloping is used along short sections of road to keep road ditch water from flowing onto unstable fill slopes (Figure B-2). The road is sloped inward from the shoulder to the ditch.

Sidecast Pull-Back

In addition to water control, stable road cut and fill slopes are mandatory to prevent road-related landslides. Without regular maintenance, the stability of road cuts and fills can deteriorate (particularly on steep slopes). In lieu of maintenance, and where there is potential for unstable road cut and fill slopes to develop during periods of inattention, the road prism can be re-contoured to ensure stability of the associated hillside and protection of downslope/downstream values.

The purpose of sidecast pull-back is to remove marginally stable fill and sidecast that has a high risk of failure (sliding) during major rainstorms. This technique is employed where fill/sidecast has questionable stability, often as indicated by tension cracks along the outer half of the road. This is common, especially for bulldozer built roads, where stumps and wood (chunks, logs) are buried in the subgrade fill or sidecast. As the woody material rots, the strength of the fill is reduced markedly. (Tension cracks with gently to moderately sloping terrain below may not be a concern).

Typically, an excavator (backhoe) with a cleanup bucket is used to reach as far down the fillslope as possible to retrieve unstable fill/sidecast materials (Photos B-3 and B-4). The excavated material is placed on the inside edge of the road, resting against the lower part of the cutslope. Ditches are ignored (if any remain) since drainage will be handled by cross-ditches. The spoil pile is not placed continuously, but has frequent breaks to allow water to drain through.
Outsloped Roads

NOTES:
• Outsloping is effective on contour roads having gradients of less than 5 percent and overall hillslope gradient less than 20 percent, and for roads having shallow ditches, or ditches subject to plugging by cut bank slumping.
• Cross-ditches are still required.
• Remove any berms along the roadside, or frequently breach berms to allow water to flow off the road.
• Convey road surface runoff onto stable slopes only. Enhance slope stability by suitable revegetation and erosion protection where required.

Insloped Roads

NOTES:
• Inslope roads, along short sections of road only, to keep road ditch water from flowing onto unstable fill slopes. Slope the road inward from the shoulder to the ditch.
• Use insloping where cut slope and ditch are stable.

FIGURE B-2 Controlling Surface Water Flow on Roads by Sloping Road Grades
PHOTO B-3  Conditions on East 520 abandoned road before sidecast pull-back, Chapman Creek watershed. Sidecast pull-back is performed using an excavator.

PHOTO B-4  Conditions on East 520 road after sidecast pull-back was completed, Chapman Creek watershed.
Revegetation

Revegetation measures, including seeding of erosion control mixes, and planting of shrubs and trees are best applied after physical stability has been attained. Revegetation of exposed mineral soils associated with the road system and slide tracks and mass wasting areas is necessary to minimize erosion and sedimentation of streams and to add significant root strength to total soil strength.

If limited road access is maintained, then fillslopes should be grass seeded. Where road deactivation practices involve sidecast pull-back and the planned loss of road access, all exposed mineral soils (cuts, road surface, pull-back material piled on road, and fillslopes) would require revegetation (Figure B-3 and Photo B-5).

If the objective is to return the site to productive forest, the road surface is decompacted (as appropriate) and planted with suitable conifers.
FIGURE B-3  Cross-section of resloped road

PHOTO B-5  Resloped and revegetated road
APPENDIX C

Effects of Roads on Freshwater Fish Habitats and Fish Production

Introduction

Forest harvest causes a number of physical changes within watersheds which affect a spectrum of physical, chemical, and biological processes. However, forest harvest involves a complex spectrum of activities including road construction and maintenance, falling, yarding, and post-harvest silviculture treatments including prescribed burning, scarification, tree planting, and herbicide use. Each of these activities has specific effects and biological consequences; however, the effects of many of these activities are overlapping and occur at the same time that fish populations are managed for both commercial and sport fisheries.

Interactions between complex aquatic ecosystems, which are variable both spatially and temporally, with the multiple and concurrent effects of both forest-harvest and fish-harvest management makes separation of cause-and-effect relationships for watersheds and their fish species difficult. Therefore, quantifying the specific effects of one component such as forest roads on fish habitats and production requires long-term, time-series studies of ecosystem processes in order to accurately quantify and partition the effects of many interacting variables. Despite this complexity, several long-term investigations conducted in British Columbia, Washington State, and Oregon have demonstrated some clear effects of road construction, operation, and maintenance on watershed processes and the abundance and survival of resident fish populations.

Forestry-related activities are not always harmful to freshwater fish populations. For example, a long-term, intensive study of logging on fish populations in Carnation Creek, Vancouver Island revealed that the annual growth of juvenile coho salmon (*Oncorhynchus kisutch*) actually increased in years immediately after logging due to increases in air and water temperatures in the drainage basin after forest canopy removal. Larger size permitted these fry and yearlings to survive the winter in refuge habitats at higher rates than were observed prior to logging (Hartman and Scrivener 1990; Holtby 1988; Tschaplinski and Hartman 1983). However, no such positive effects on fish growth and survival have ever been associated with the construction, use, or maintenance of forest roads.
Discussion

Road-related changes that are harmful to fish habitats and fish populations are brought about principally by alterations to the input, character, and transport of water, sediment, and organic matter through the stream system. These changes, despite linkages, can be divided broadly into alterations in hydrologic regime and sedimentation.

Hydrological Effects

Many hydrological changes associated with forestry are directly attributable to roads. At Carnation Creek, road construction interrupted sub-surface water flow, increased surface erosion, and re-routed water in the drainage basin through culverts and ditches to the fish-bearing part of the stream such that: (1) time between peak rainfall and peak stream discharge was reduced, and consequently, (2) peak seasonal flows increased in magnitude and erosive energy (Cheng 1988; Hetherington 1982, 1988).

Increased erosive energy is especially harmful to fish habitats and fish survival in winter when heavy rainfall occurs frequently. Seasonal increases in the frequency and severity of landslides, and subsequent reductions in chinook (O. tshawytscha) and coho populations were associated with roads in the Clearwater River drainage in the western slopes of the Olympic Mountains, Washington (Cederholm et al. 1978, Cederholm and Lestelle 1974, Cederholm and Reid 1987, Cederholm and Salo 1979).

Increased peak flows due to road-related hydrologic changes resulted in debris torrents entering winter refuge habitats used by juvenile salmonids, and morphological alterations to main fish-bearing streams by scouring spawning gravels and causing large movements of stream substrates (Cederholm et al. 1981). Stream channel erosion thus resulted in less habitat suitable for salmonid spawning and egg incubation during autumn and winter. Additionally, less rearing habitat was available for juveniles in summer because bedload movements filled in pools which also became less abundant due to the removal large woody debris necessary for their stability. During one winter following road construction, 40 – 50 % of previously-constructed redds were destroyed by streambed scour and bedload movements (Cederholm et al. 1981, Cederholm and Salo 1979). These observations clearly illustrated the sensitivity of salmon eggs and alevins to hydrologic conditions and were consistent with the discovery of a significant inverse relationship between chinook fry abundance in summer and maximum peak discharge of
the previous winter in these northwestern Washington streams (Cederholm et al. 1981, 1987). Clearly, even small increases in the magnitude and frequency of peak discharges can reduce the survival of salmon eggs and alevins in streams.

Sedimentation

It is widely accepted that high levels of sedimentation lower salmonid production from freshwater environments (Gibbons and Salo 1973, Iwamoto et al. 1978, Everest et al. 1978). All salmon life stages are adversely affected by sedimentation. Mortality in eggs and alevins has been shown to be due to increases in fine sediments through reductions of stream gravel porosity, intragravel flows, and dissolved oxygen concentrations (Everest et al. 1987; Hall 1984; Koski 1966, 1975; Wickett 1954, 1958). Eggs and emerging fish may be buried and can suffocate when excessive fine sediments infiltrate spawning/incubation gravels (Koski 1975).

Eggs, alevins, and older juvenile salmonids may also be stranded in secondary channels due to coarse sediment influx in combination with road-related hydrological changes. Sedimentation may cause some of these channels to become dry in summer. For example, one tributary in the Clearwater River drainage became seasonally dry after a road-related debris torrent caused heavy sediment deposition. Annual smolt production from that tributary consequently fell from 350 – 1 000 fish to 50 – 400 fish (Cederholm and Reid 1987).

Direct habitat reductions for stream-dwelling juvenile salmonids can occur through reductions in pool depth and alterations in channel morphology in both summer rearing areas in streams and in winter refuge habitats in small floodplain channels (Cederholm and Reid 1987).

Fry, smolts and adult salmonids can be physiologically stressed by turbidity due to the input of fine sediments alone into streams. High levels of suspended sediments can kill fish by abrading and clogging their gills. Campbell (1954) reported that caged rainbow trout (O. mykiss) were killed within 20 days in the Powder River, Oregon when suspended sediment concentrations were 1 000 – 2 500 ppm.

Finally, increases in sedimentation on aquatic substrates and within them have been shown to reduce (1) the macroinvertebrate food resources which juvenile salmonids use for food (Culp and Davies 1983, Ziebell 1960), and (2) primary producers which support some of these invertebrate populations. Hynes (1960) reported that high turbidity due to heavy sediment loads can prevent photosynthesis. Culp and
Davies (1983) showed that macroinvertebrate densities in summer were reduced by 23 – 50 % during logging in Carnation Creek. Culp et al. (1986) experimentally introduced fine sediments (0.5 – 2.0 mm in diameter) into Carnation Creek riffles and observed 50 % reductions in macroinvertebrate biomass and abundance within 24 hours.

All species of salmonids in freshwater habitats are adversely affected by excess sedimentation. For example, sediment-related changes in channel morphology and diversity of rearing and overwintering habitats will affect all stream fishes, especially coho salmon, some chinook, and rainbow and cutthroat trout (O. clarki) because these species may spend one or more years in streams and lakes. However, even species such as pink salmon (O. gorbuscha) and chum (O. keta), whose fry leave streams for the ocean shortly after they emerge from the stream gravel, are sensitive to sedimentation. Everest et al. (1987) thought that fine-particle sedimentation from road surfaces probably presented a greater hazard to the eggs and alevins of pink and chum because (1) these species spawn in the lowermost reaches of streams where fine-sediment deposition is frequently prevalent, and (2) roads produce a chronic supply of fine-grained sediments.

Conclusions drawn by Everest et al. (1987) are supported by observations made elsewhere. Hartman and Scrivener (1990) summarized that egg-to-fry survivals in Carnation Creek were reduced by one-half for both chum and coho salmon between pre-logging and post-logging periods. Prior to logging, survivals were 20.3 and 28.8 % for chum and coho salmon respectively. These respective percentages fell to 10.9 and 15.6 % in post-logging years. Annual chum escapements to Carnation Creek fell drastically from pre-logging and during-logging levels of 275 – 4 168 to only 28 adults in 1991. Although logging-related effects such as sedimentation were clearly only one factor, this reduction in stock size was dramatic and parallels other southern BC stocks of chum salmon which face the dual impacts of freshwater habitat deterioration and reductions in marine survival.

Numerous studies have shown that forest roads are principal sources of logging-related sediment in streams (Brown and Krygier 1971, Cederholm et al. 1981, Cederholm and Reid 1987, Megahan and Kidd 1972, Reid et al. 1981, Rice et al. 1979). For example, Beschta (1978) reported that annual yields of fine sediments (<0.85 mm diameter) increased from 27 – 97 tons/km² to 90 – 300 tons/km² after road construction and forest harvesting in the Alsea watershed, Oregon.

An intensive (eight-year) study involving 45 salmon producing sub-basins within the Clearwater River system in western Washington revealed that anadromous fish populations
(chinook and coho salmon, rainbow trout, and cutthroat trout) declined radically over pre-logging levels, and that massive landsliding and surface erosion due to logging roads was thought to be directly responsible for the sedimentation of spawning and rearing habitats and the subsequent decline of these populations (Cederholm et al. 1978, 1981, 1982; Cederholm and Reid 1987; Reid 1981; Reid and Dunne 1984). This synoptic study consisting of field observations supplemented by several controlled experiments determined the following:

1. Significant amounts of fine sediments (< 0.85 mm diameter accumulated in the spawning grounds of some heavily-roaded tributary basins.

2. Accumulations were greatest in basins where the road area exceeded 2.5 % of the basin area.

3. Accumulations were greatest in low-gradient basins where freshet-induced flushing of fine materials was less extensive than in steeper basins.

4. Survival of salmonid eggs and alevins declined significantly as the percentage of fine sediments increased in the spawning/rearing gravels above the natural levels of 10 %. A rapid decrease in egg survival was observed for every 1 % increase in fine sediments over natural levels.

5. In drainage basins where gravel roads made up > 2.5 % of basin area, average road use was found to be responsible for producing sediment at 2.6 - 4.3 times the natural rate.

6. Road-related sources of sediment included landslides, erosion of back-cuts along hillsides, side-cast erosion, gully formation, and road-surface erosion.

7. About 60 % of road-related sediment production was caused by landslides while erosion from road surfaces accounted for another 18 - 26 %. Although road-surface erosion contributed smaller proportions of total sediment input, road-surface materials produced 41 - 49 % of all fine sediments introduced into the aquatic environment (an equal amount was contributed by landslides).

8. Sediment rating curves (mg/s sediment discharge vs. mL/s water discharge via culverts) showed that sediment production was much less from light-use or abandoned roads compared with heavily-used roads. However, fine-sediment contributions from light-use and abandoned roads were still substantial and chronic, especially for older roads which were constructed by using side-cast techniques in steep terrain. Older roads were often associated with landslides; additionally, cross drains
on these roads were often poorly protected from gully erosion and frequently resulted in undercutting of fills and eventual slumping. Newer road-building methods incorporating erosion-prevention measures vastly reduced these problems.

The overall conclusions from studies in the Clearwater River drainage were that production of sediments from logging roads resulted in significant decreases in salmonid (especially coho salmon) egg survival to emergence, and thus lowered the success of salmonid spawning and recruitment from this major drainage basin. These reductions were potentially serious for some small and sensitive stocks of coho salmon which at the same time were being heavily fished in coastal marine waters (Cederholm et al. 1981, Cederholm and Reid 1987).

From the results of Clearwater River study, the investigators recommended several alternative methods of road construction, erosion prevention, and forest harvest techniques to reduce the effect of roads on salmonid populations. **One recommendation was to put old roads “to bed”; that is, to close them off to traffic and to water-bar them to prevent surface erosion.**

The intrusion of fine-grained sediments in the Clearwater system was the most significant forestry-related adverse effect on its fish populations. The effects of road-related sedimentation on fish will certainly vary geographically according to local conditions of hydrology, geology, stream gradient and geometry, and dominant erosion-transport processes (Everest et al. 1987). However, persistent sediment sources such as roads are potentially more detrimental than other, more temporary, sources. Road surfaces are subject to repeated heavy rains and freshets, and can cause fine sediments to accumulate in streams and related aquatic habitats for years whenever their introduction rates outstrip their rates of removal by scour. Salmonid fisheries resources are clearly economically and socially important in western North America. One relatively inexpensive method to protect these resources from excess sedimentation in freshwater environments after local forestry-related activities are concluded, is to deactivate road systems in watersheds.
REFERENCES CITED


APPENDIX D

Types of Resource Roads, Logging Trails, and Permits
Types of Resource Roads

A forest road is defined as a transportation corridor built for use by logging trucks to transport logs and other forest products from a landing to a reloading site or conversion facility. A landing is a leveled area where trees or logs are assembled for transport to the reloading site or conversion facility.

Forest Roads are typically planned and constructed for either permanent or short-term use. Examples of permanent and short-term use roads are:

- **Permanent Use Road**: A main, system or branch road that provides access to a number of cut blocks. These roads are generally required for continuous or intermittent long-term use.

- **Short-Term Use Road**: A spur road or short branch road located on or adjacent to a cut block. These roads are generally required for the harvesting and post-harvesting period only.

Several categories of forest roads can be built under the *Forest Act* or former act. These include Forest Service roads and Operations roads (Figure D-1). In addition, mining roads can be built under this legislation. Other resource roads, such as petroleum and natural gas development roads and low standard mineral claim roads, can be built under other statutes. Here are definitions of the resource roads in Provincial Forests.

**Forest Service Roads**

These are forest roads built for the ministry, but are maintained by the Ministry of Forests or by the forest companies that use them.

**Operations Roads Under Permit**

These are forest roads built and maintained by forest companies. The majority of these roads are built for short-term use only. In total, Forest Service and Operations roads far exceed in length the entire provincial highway systems. The Ministry of Forests issues a Road Permit or a Cutting Permit to forest companies to construct Operations roads. Regular maintenance requirements are part of the permit conditions.
FIGURE D-1 Types of Forest Road
Mining and Mineral Claim Roads Under Permit:

For uses of Crown land other than for logging, the Ministry of Forests issues a Special Use Permit; for example, the ministry issues this permit to mining and mineral claim companies to authorize the construction of their access roads.

Types of Logging Trails

When roads are inspected, the entire right-of-way—including the road prism, drainage controls, bridges, major culverts, and retaining walls—is examined. **Landings, logging trails, and other related developments should also be inspected if these contribute to a problem at the road.** For example, inadequate drainage measures on a logging trail may result in a significant increase in the amount of water being delivered to a sensitive segment of road; this changed hydrologic condition may cause a landslide at the road.

A logging trail can be defined as any of the following types of site disturbance required to harvest timber within a cut block:

**Skid Trail:** A random pathway traveled by ground skidding equipment while moving trees or logs to a load out area. A skid trail differs from a skid road in that stumps are cut very low and the ground surface is mainly untouched by the blades of earthmoving machines.

**Skid Road:** A bladed or backhoe constructed pathway where stumps are removed within the running surface as necessary. Skid roads are suitable only for tracked or rubber-tired skidders bringing trees or logs from the felling site to a landing.

**Designated Skid Road/Skid Trail:** A pre-planned network of skid roads or skid trails that is designed to reduce soil disturbance and planned for use in subsequent forestry operations in the same area. Multiple passes by tracked or rubber-tired skidders or other equipment is anticipated.

**Backspar Trail:** A bladed or non-bladed pathway over which mobile backspar equipment travels.
Types of Permits

On Crown land, works cannot be carried out, and resource roads cannot be built or modified, without the appropriate authorization. The following permits are issued and administered by the Ministry of Forests:

1. **F.S. 582 Road Permit (Build, Modify and Use):** Part 8 of the *Forest Act* deals with Roads and Right-of-Way and provides the authority to access timber. Road construction for harvesting purposes must be authorized by either a Road Permit (FS 582) or a cutting authority. All roads other than those spurs situated on a cut block, must be authorized by a Road Permit (FS 582).

   The Road Permit is issued to forest companies to construct Operations roads when they have a right to harvest timber. Maintenance, and now deactivation requirements, are part of the Road Permit condition. The Road Permit also authorizes the use or modifications of existing abandoned roads for timber harvesting. Since logging activities frequently move from place to place and new permits are issued and old ones expire, the number of kilometres of Operations roads and abandoned roads are always in a constant state of influx.

2. **F.S. 102 Road Use Permit (Use of a Forest Service Road):** The Road Use Permit is issued to all industrial users of Forest Service roads unless exempted by a District Manager. Among other purposes, the Road Use Permit controls maintenance operations on Forest Service roads, especially where there are several industrial users sharing a common road.

3. **F.S. Special Use Permit:** The Special Use Permit is used to authorize the use of Crown land in Provincial Forests. Typical use of Crown land by mining companies is the construction of an access road to mine or a mineral claim.

4. **Cutting Permit:** The Cutting Permit document or, in the case of the Small Business Forest Enterprise Program (SBFEP), the Timber Sale Licence (and associated amendments), constitutes the legal cutting authority.

   The authority for requiring a Cutting Permit before harvesting can begin is found in the *Forest Act* and pertains to major tenures as follows:

   1. Forest Licence *Forest Act*, Section 12(f)
   2. Tree Farm Licence *Forest Act*, Section 28(f)
   3. Timber Sale Licence *Forest Act*, Section 17(d)
   4. Timber Licence *Forest Act*, Section 25(f)
APPENDIX E

8.3 Risk Assessment Procedure

Currently, the ministry’s Engineering Program requires that risk assessment be used as a decision-making tool for:

1. preparing the engineering component of Forest Development Plans (see Chapter 9);
2. providing a rationale for “triggering” a road survey and design submission (see Chapter 9); and
3. allocating staff and funding for effective and efficient monitoring of licensees’ forest road practices.

This chapter deals with risk management, and risk assessment, for purposes of allocating staff and funding to monitoring activities.

Purpose of Risk Management and Risk Assessment:

Risk Management is a rational decision-making process. It involves planning, organizing, directing and controlling resources to minimize detrimental impacts at the least possible costs.

Risk assessment is the basis for allocating staff and funding. Roads that impose higher risks to on-site/downslope/downstream values require more frequent, and intense, monitoring than roads that impose lower risks. The ministry selects the degree of risk it can afford to accept and then allocates suitable resources to carry out the corresponding level of monitoring.

The ministry uses two approaches to monitor road development activities:

- a process-oriented monitoring program
- a results-oriented monitoring program

All roads require a results-oriented monitoring program to assess the impact of the final road construction works on user safety, and to determine that work conformed with the ministry’s Forest Road and Logging Trail Engineering Practices (Interim) document.
As the level of risk increases, risk management becomes more process-oriented. For example, when there is a high risk, the objective of monitoring a road during its life cycle is to detect and stop deviations from the engineering standards and approved specifications, or to recommend changes to these if necessary, to suit particular site conditions. This objective is achieved by:

- devoting more time to reviewing licensee’s forest road submissions (pre-construction stage)
- by being on site often enough during the various field stages of road activities (i.e. construction, maintenance and deactivation).

**Elements of Risk**

Risk is an assessment of potential damage to both timber and non-timber values which may result from proposed or existing road development. The risks being assessed are the likelihood of loss or damage to water quality and water supply, fish habitat, forest site productivity, landscape aesthetics, recreation, private property, utilities and threat to human life. Based on the level of risk to values, priorities for monitoring roads during their life cycles can be established.

Risk assessment is a procedure which requires knowledge of two factors: the likelihood of a hazard occurring, and the consequence, or severity of impact, should the hazard occur. In quantitative terms,

\[
\text{Risk} = \text{Hazard} \times \text{Consequence}
\]

There are four levels of risk rating, which correspond to the combinations of ratings for hazards and consequences as shown in Table 2.
Table 2 - RISK RATING CHART

<table>
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<th>HAZARD RATING</th>
<th>CONSEQUENCE RATING</th>
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</table>

Hazard

Hazard refers to the probability of increased erosion and stream sedimentation events during or after road construction. Erosion includes mass movement (mass wasting) events originating in upland areas, and surface soil erosion processes. Sedimentation is the deposition of eroded soil materials in water.

In the context of logging roads:

- mass wasting includes several dominant groups of landslide processes: debris falls, debris slides, debris avalanches, debris flows, debris torrents, rockfalls, rockslides, slumps and earthflows, and small scale slumping, collapse, and ravelling of road cuts and fills;
- surface soil erosion includes shallow erosion and gullyng by running water across the road surface or cuts and fills.

Although many events that contribute to risk are naturally occurring, it is widely recognized that logging activities, and logging roads in particular, increase the probability of landslides and debris flows in potentially hazardous terrain. Mass wasting erosion is the predominant mode of sediment transport from forest roads. Compared to the hazard of road-related surface soil erosion, landslides initiated or accelerated by road construction can cause the greatest damage to values. The construction or roads across some slopes can initiate or accelerate slope failure from several to hundreds of times, depending on such variables as soil type, slope steepness, presence of subsurface water and road location.
However, it should be recognized that shallow erosion and gullying caused by water running across the road surface or cuts and fills can be an important sediment generating process at some sites. Sediment production from exposed mineral soils can be a great concern with regard to water supply and fish habitat.

There are well established methods to estimate the likelihood of slope failures occurring after conventional road building. These methods are discussed later in this chapter. However, methods to estimate the probability of surface soil erosion by road building are not so commonplace. To simplify matters, let us make the assumption that the more terrain is unstable, the more it is susceptible to surface soil erosion processes. Then, hazard can be simplified to mean the probability of mass movements originating in upland areas, such as road-induced landslides or debris flows.

**Consequence**

Consequence refers to the probability that if erosion and sedimentation events occur, they will have an impact on on-site/downslope/downstream resource, social and economic values.

**Determining Hazard Potential Ratings**

The likelihood of landslides can be forecast by identifying terrain that is naturally unstable or can be rendered unstable through forest management activities. Road construction and logging activities can strongly influence the stability of natural forested slopes by:

- removing the toe support of marginally stable slopes
- overloading slopes by improperly placing fill for embankments
- impeding or altering natural surface and subsurface drainage regimes
- reducing short-term anchoring and reinforcing effects of tree roots

These factors can upset the delicate balance between external gravitational forces tending to pull soil materials downslope, and internal soil strength forces tending to oppose downward movement. If the gravitational forces exceed the resisting forces, landslides will result.

Areas with fragile or potentially unstable soils have a moderate to high likelihood of an increase in landslide frequency following logging or conventional road building. Conventional road building practices involve constructing the road subgrade with bulldozers or backhoes, and placing excavated soil materials on the downslope side of the road to form a portion of the running surface.
Tables 3A and 3B show four methods of assessing the likelihood of road-related landslide activity. These are:

### METHOD

**METHOD**

**TABLE NO.** | **METHOD DESCRIPTION**
--- | ---
Table 3A: | 1 Coastal Terrain Stability Classification
2 Interior Terrain Stability Classification (Peculiar to Nelson Cariboo Forest Regions only)
3 E.S.A. Classification

Table 3B: | 4 Landscape Approach

**Table 3A: GUIDELINES TO ASSESS HAZARD RATINGS METHODS 1 TO 3**

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</tr>
<tr>
<td>2 Interior Terrain Stability Classification</td>
<td>Class: Low</td>
</tr>
<tr>
<td>3 E.S.A. Classification</td>
<td>Areas not designated as Es, Es1 or Es2</td>
</tr>
</tbody>
</table>

**NOTE:** (a) If the risk assessment approach is used to facilitate operational decisions, use only Methods 1 and 2 to determine the hazard rating or, consult with a professional engineer or geoscientist. Method 3 is not considered reliable enough to be used for operational decisions. Examples of operational decisions include: selection of one route corridor over another; choice of full bench cut and end haul versus conventional road building techniques; and choice between temporary and semi-permanent road deactivation measures.

(b) The Ministry of Forests is presently developing provincial terrain stability mapping standards.
### Table 3B - GUIDELINES TO ASSESS HAZARD RATINGS

#### METHODS 4

<table>
<thead>
<tr>
<th>METHOD</th>
<th>HAZARD POTENTIAL RATINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LOW</td>
</tr>
<tr>
<td><strong>PART A</strong></td>
<td>EVIDENCE OF LANDSLIDES</td>
</tr>
<tr>
<td>4</td>
<td>Landscape Approach</td>
</tr>
<tr>
<td><strong>PART B</strong></td>
<td>NO OBSERVED LANDSLIDE ACTIVITY</td>
</tr>
<tr>
<td></td>
<td>Slope Categories</td>
</tr>
<tr>
<td></td>
<td>Dry Belt:</td>
</tr>
<tr>
<td></td>
<td>Wet Belt:</td>
</tr>
<tr>
<td></td>
<td>Wet Belt:</td>
</tr>
</tbody>
</table>

**NOTE:**

1. Sources of information for this method are: aerial photographs; topographic maps; local knowledge; visual observations; and survey data.

2. Part A of Method 4, Table 3B may be used to determine the hazard rating for operational decision making.

3. Do not use Part B of Method 4, Table 3B if Terrain Stability Mapping or reliable/detailed E.S.A. mapping information is available. Part B of Table 3B is not considered reliable enough to be used for operational decisions.
Rate the likelihood of road-related landslide activity using the following scale:

- Low Hazard Potential: Low
- Moderate Hazard Potential: Mod.
- High Hazard Potential: High

To evaluate risk to values from landslide and sedimentation hazards, a third factor needs to be considered in addition to the consequence rating and the likelihood of landslide hazard. This third factor is sediment deliverability, or the likelihood of sediment from a landslide reaching on-site/downslope/downstream values (see 5th step of risk assessment procedures).

The length of the runout zone of potential road-related landslides is an important consideration. If the likelihood is high that sediment from potential road-related landslide occurrences will reach values such as water supply, fish habitat, life/property/transportation or utilities, do not adjust the risk rating determined in the 4th step of the risk rating procedure. If the likelihood of sediment deliverability is low for these four values mentioned, decrease the risk determined in the 4th step by at least one rating.

The likelihood of sediment deliverability may be determined often from terrain stability maps. When included, these maps have landslide runout distance symbols on each terrain polygon.

Where terrain stability maps are not available, or if runout distance symbols are not included on polygons, adopt the following rationale for establishing risk for purposes of prioritizing monitoring activities:

- Where streams, highways and other roads, railways, residential or commercial developments, or utilities are separated from the toe of steep slopes by a flat bench or terrace (e.g. at least 200 m from a slope less than 20 degrees), decrease the risk by at least one rating.

- If no such separation exists, do not adjust the risk rating.

Where there is some question about the length of the runout zone of potential road-related landslides, consult with a specialist.
IMPORTANT POINT: When assessing the likelihood of landslides, also consider situations where roads lie above a steeper, more landslide-prone slope. Many slides have been caused by water diversions on very innocuous-looking roads, which have dumped water onto the steeper slope below.

Coastal Terrain Stability Classification Method

Terrain stability maps are interpretive maps derived from terrain maps. The terrain stability maps, prepared by terrain specialists, are developed from data on surficial materials, landforms, geomorphic processes, slope angle, soil texture, moisture regime, landscape position, vegetation and bedrock types. The following reference describes the five classes of the Coastal Terrain Stability Classification system:

- Ministry of Forests
  Vancouver Forest Region
  Coastal Terrain Stability Classification
  (See Appendix 2 of this chapter)

A definition for Classes I to V follows:

Terrain Stability Classes:
Class I:
- No stability problems exist

Class II:
- No significant stability problems exist
- Normal road construction and logging practices will not significantly decrease terrain stability, except along road cuts
- Periodic maintenance involving ditch clearing is expected due to sloughing along road cuts.

Class III:
- Minor stability problems can develop.
- Harvesting should not significantly reduce terrain stability; there is a low likelihood of post-logging failure.
- Slumping is expected along road cuts on roads crossing areas with slopes greater than 30 degrees, especially for one or two years following construction.
Class IV:
- Expected to contain areas where there is a moderate to high likelihood of slope failures following conventional road construction. Wet period construction will significantly increase the potential for slope failure.
- There is a moderate likelihood of failure in logged areas.
- A specialist should inspect these areas prior to any development in order to assess in detail the stability of the affected area.

Class V:
- Contain areas of natural instability.
- There is a high likelihood that slope failure will follow logging or conventional road building.
- A specialist should inspect these areas prior to development in order to assess in detail the stability of the affected area.

The five class terrain stability system only flags the likelihood for any landslide to occur. It does not provide the expected size or frequency of landslide failures. For example, a Class V polygon on the east side of Vancouver Island may experience 1 slide/100 hectares/10 years, while a Class V on the west coast of the Queen Charlottes will experience about 10 slides/100 hectares/10 years. To address this, the risk to values within areas of very high frequency of intense rainfall (e.g. west and north coast of Vancouver Island, west coast Charlottes, mid-coast, Mission-Hope area, etc.) should be increased by at least one rating (see 6th step of risk rating procedure).

**Interior Terrain Stability Classification Method**

Nelson and Cariboo Forest Regions have in the past used a different terrain stability classification system than the Coast. The Nelson and Cariboo Forest Regions use a low, moderate, high and very high (or extreme) system. It is expected that provincial terrain stability mapping standards, which are currently being developed, will adopt only the Five Class Terrain Stability Classification System for the whole province.

The very high and high classes used in the Nelson and Cariboo Regions are comparable to the V and IV classes used on the Coast. The following references provide some additional information on the Interior Terrain Stability classes:

E.S.A. Classification Method:

Environmentally sensitive areas (E.S.A.) are identified and delineated during a forest inventory through photo interpretation, ground investigation, low-level helicopter flights, and data provided by other resource agencies and public interest groups. The E.S.A. classification system recognizes these E.S.A. categories: soil (Es), forest regeneration (Ep), snow avalanche (Ea), recreation (Er), wildlife (Ew), water (Eh), and fisheries (fisheries symbols).

Except for Tree Farm Licence (TFL) areas and private land, forest inventory map information exists for all areas of the province. Inventory Branch is responsible for collecting and updating the information.

The following references provide details on each E.S.A. Category:

- Ministry of Forests
  Vancouver Forest Region
  Memo April 7, 1992
  File: 870-3 (See Appendix 1 of this chapter)

- Ministry of Forests
  Inventory Manual
  Volume 1, Chapter 2

For the soil (Es) category, and most other categories, two E.S.A. classes are recognized: high and moderate. These are denoted by the subscripts 1 and 2, respectively (Es1 and Es2).

Definitions for Es1 and Es2 classes are:

Soil Sensitivity (Stability) Class Definitions:

Es1:
- It is highly likely that landslides will follow logging or conventional road construction.

Es2
- Expected to contain areas where there is moderate likelihood of landslides following logging and a moderate to high likelihood of landslides following conventional road construction.

For consistency, the Es1 and Es2 categories are roughly equivalent, but more crudely mapped, to the Class V and IV categories, respectively, of the Five Class Terrain Stability Classification System. This five class system is in widespread use on the B.C. coast.
IMPORTANT NOTE: Es1 and Es2 units are suitable for establishing the hazard potential rating and risk rating for purposes of prioritizing and scheduling road monitoring activities. However, these units are not considered reliable enough to be used for operational decisions.

Landscape Approach

Use the Landscape Approach for unmapped areas.

Use Part A of Method 4 (Table 3B) for areas where there is evidence of past landslides. In areas of steep gullied terrain or terrain which exhibits natural landslide activity (either recent or revegetated landslide scars, present or suspected), rate the likelihood of slope failures following conventional road building as High. Draw large polygon boundaries around these areas, in order to capture all potential unstable or gullied areas that are not visible on air photos.

Use Part B. Method 4 (Table 3B) for areas that do not exhibit natural landslide activity. The slope class boundaries are suitable for establishing the hazard potential rating and risk rating for purposes of prioritizing and scheduling road monitoring activities. Do not use the slope class boundaries if Terrain Stability Mapping or reliable/detailed E.S.A. mapping information is available. The slope class boundaries are not considered reliable enough to be used for operational decisions.

Other Approach

For those who want a “do it yourself” landslide hazard evaluation for specific sections of road, refer to the following publications:

- Ministry of Forests

- Ministry of Forests
Determining Consequence Ratings

Hazards such as landslides, surface soil erosion and sedimentation can impose high economic, environmental and social consequences. The values that may be affected by erosion and sedimentation include:

On-Site/Downslope/Downstream Resource Values

- water quality and supply
- fish habitat
- wildlife habitat and migration
- forest site productivity

On-Site/Downslope Social and Economic Values

- human life; private property or equipment; downslope railways, highways and other roads
- utilities
- landscape values
- recreation values

Identify the types and sensitivity of social, economic, and forest resource values in areas located along a proposed or existing road. There are a number of ways to assess the types and sensitivity of values that may be affected by erosion and sedimentation:

Map Overview

- reviewing the on-site and downslope/downstream areas on the district atlas, forest cover maps and other maps. These maps are typically plotted at 1:20,000 scale

Contracting Other Users

- contacting other resource agencies, utility companies and local land owners

Local Knowledge

- local knowledge and observation through aerial photography overview, ground traverse, or viewing adjacent development

NOTE: Document local knowledge and observations
Forest Development Plan (Five-Year Development Plan) Submission

- reviewing the information received during the review of the Forest Development Plan

Pre-Harvest Silviculture Prescriptions

- reviewing contents of the pre-harvest silviculture prescriptions, or

Combination

- Some combination of the above.

Assess if landslides or sediment from landslides or other sources could reach the value below. For each particular value identified, use Table 4 to forecast the severity of the damage should erosion and sedimentation occur. Rate the consequence using the following scale:

- Low Consequence - Low
- Moderate Consequence - Mod.
- High Consequence - High

NOTE: The highest consequence rating determines the overall rating for the road system or individual road under study.
<table>
<thead>
<tr>
<th>ON-SITE DOWNSLOPE/ DOWNSTREAM VALUES ADJACENT TO ROAD ALIGNMENT</th>
<th>CONSEQUENCE (OR SEVERITY) RATINGS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>WATER SUPPLY</td>
<td>Forecast the consequence or severity of the damage or loss to a specific value, should erosion and sedimentation occur</td>
<td></td>
</tr>
<tr>
<td>LOW</td>
<td>Areas not rated as Moderate or High</td>
<td>Areas having very high water values, but less sensitive than those with High ratings (e.g., Eh2 class areas; individual licensed domestic use watershed, licensed irrigation/industrial users)</td>
</tr>
<tr>
<td>FISH HABITAT</td>
<td>Areas having low fishery values (e.g., Class IV stream and not tributary to Class I, II or III streams)</td>
<td>Areas having moderate fishery values (e.g., Class III stream and not tributary to Class I and II streams)</td>
</tr>
<tr>
<td>WILDLIFE HABITAT AND MIGRATION</td>
<td>Areas not rated as Moderate or High</td>
<td>Areas having high wildlife values, but less sensitive than those with High ratings (e.g., Ew2 class areas)</td>
</tr>
<tr>
<td>FORESTRY SITE PRODUCTIVITY</td>
<td>Areas not rated as Moderate or High</td>
<td>Areas having moderate potential to grow merchantable timber</td>
</tr>
<tr>
<td>SOCIAL LIFE, PRIVATE PROPERTY, ROADS AND RAILWAYS</td>
<td>Areas that are uninhabited and undeveloped, or occasionally inhabited territory and cultivated farmland</td>
<td>N/A</td>
</tr>
<tr>
<td>UTILITIES</td>
<td>Areas with no utilities</td>
<td>N/A</td>
</tr>
<tr>
<td>LANDSCAPE (VISUAL) FEATURES</td>
<td>Areas having non-visible development or Low Landscape Sensitivity</td>
<td>Areas having high value for viewing, but less sensitive than those with High ratings (e.g., Er2 class areas of Medium Landscape Sensitivity)</td>
</tr>
<tr>
<td>RECREATIONAL FEATURES (PHYSICAL, BIOLOGICAL, CULTURAL OR HISTORIC)</td>
<td>Areas absent of, or having low, physical, biological, cultural or historic features</td>
<td>Areas having high value for recreation, but less sensitive than those with High rating (e.g., Er2 class areas)</td>
</tr>
</tbody>
</table>
APPENDIX F

Miscellaneous Road Inspection Forms
ROAD INSPECTION REPORT
(ON REVERSE, SEE CHECKLIST OF CODES AND PROBLEMS NOTED)

<table>
<thead>
<tr>
<th>DATE</th>
<th>Y</th>
<th>M</th>
<th>D</th>
<th>FILE NO.</th>
<th>CUTTING PERMIT NO.</th>
<th>ROAD PERMIT NO.</th>
<th>AMENDMENT NO.</th>
<th>SECTION NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LICENSEE

FOREST REGION  | FOREST DISTRICT  | LOCAL ROAD NAME  | ROAD NO. |
|               |                  |                   |          |

INSPECTION TYPE:  
☐ CONSTRUCTION  ☐ MAINTENANCE  ☐ DEACTIVATION

<table>
<thead>
<tr>
<th>km</th>
<th>NON-COMPLIANCE ITEMS (BY CODE OR DESCRIPTION)</th>
<th>PROBLEMS NOTED</th>
<th>RECOMMENDED REMEDIAL ACTION (BY CODE OR DESCRIPTION)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

INSPECTOR  
Y M D  LICENSEE REPRESENTATIVE  Y M D

FIELD OPERATIONS SUPERVISOR  
Y M D  RESOURCE OFFICER, ENGINEERING  Y M D

SIGNATURES

DISTRIBUTION: WHITE - DISTRICT OR LICENSEE; CANARY - CUTTING PERMIT FILE; PINK - ROAD PERMIT FILE; GREEN - RESOURCE OFFICER, ENGINEERING OR INSPECTOR
### ROAD CONSTRUCTION CHECKLIST

<table>
<thead>
<tr>
<th>CODE</th>
<th>CONSTRUCTION ITEMS</th>
<th>PROBLEMS NOTED</th>
<th>CODE</th>
<th>ACTION REQUIRED</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>Clearing</td>
<td>Clearing width, merchantable timber, danger trees; disposal of non-merchantable timber</td>
<td>C(a)</td>
<td>Correct to specification</td>
</tr>
<tr>
<td>C2</td>
<td>Grubbing and stripping / slash and debris disposal</td>
<td>Slash / debris disposal method; soil cover, natural water courses and existing ground profiles; 3-metre setback requirements</td>
<td>C(b)</td>
<td>Certify structures</td>
</tr>
<tr>
<td>C3</td>
<td>Subgrade construction</td>
<td>Cut / fill slopes; road width; turnouts; design criteria; hazards; tension cracks; controlled blasting methods</td>
<td>C(c)</td>
<td>Stabilize slopes</td>
</tr>
<tr>
<td>C4</td>
<td>Ditches and culverts</td>
<td>Ditch depth; ditch blocks; slope protection; culvert diameter; length; skew; inlet and outlet protection; natural drainage patterns; minimum cover; markers</td>
<td>C(d)</td>
<td>Rectify hazards</td>
</tr>
<tr>
<td>C5</td>
<td>Road surfacing</td>
<td>Material type; depth; final shaping; windows</td>
<td>C(e)</td>
<td>Carry out extra work</td>
</tr>
<tr>
<td>C6</td>
<td>Bridges and major culverts</td>
<td>Structure design sealed by P. Eng. of B.C.; Table 3, Forest Road Specification Checklist</td>
<td></td>
<td>Other (specify on front)</td>
</tr>
</tbody>
</table>

### ROAD MAINTENANCE CHECKLIST

<table>
<thead>
<tr>
<th>CODE</th>
<th>MAINTENANCE ITEMS</th>
<th>PROBLEMS NOTED</th>
<th>CODE</th>
<th>ACTION REQUIRED</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>Compliance with Maintenance Plan Submission; inspection records; visual evidence</td>
<td>No documented maintenance program or inspection records</td>
<td>M(a)</td>
<td>Licensee inspections required as per Plan</td>
</tr>
<tr>
<td>M2</td>
<td>Sight distances (brush)</td>
<td>Brushing-in of right-of-way</td>
<td>M(b)</td>
<td>Carry out brushing</td>
</tr>
<tr>
<td>M3</td>
<td>Snags and danger trees</td>
<td>Danger trees exist</td>
<td>M(c)</td>
<td>Remove snags and danger trees</td>
</tr>
<tr>
<td>M4</td>
<td>Ditches</td>
<td>Ditchline sloughing, erosion, debris plugging ditches</td>
<td>M(d)</td>
<td>Clean ditches</td>
</tr>
<tr>
<td>M5</td>
<td>Culverts</td>
<td>Plugged culverts, scour, damaged ends, markers</td>
<td>M(e)</td>
<td>Clean culvert inlets and outlets</td>
</tr>
<tr>
<td>M6</td>
<td>Surface condition</td>
<td>Potholing; washboard; windrowing material, dust</td>
<td>M(f)</td>
<td>Grade surface</td>
</tr>
<tr>
<td>M7</td>
<td>Subgrade condition</td>
<td>Shoulder slumps, erosion, slides, tension cracks</td>
<td>M(g)</td>
<td>Stabilize subgrade</td>
</tr>
<tr>
<td>M8</td>
<td>Bridges / major structures</td>
<td>Running planks, decking delineators, guard rails</td>
<td>M(h)</td>
<td>Replace planks, delineators, etc.</td>
</tr>
<tr>
<td>M9</td>
<td>Cattle guards</td>
<td>Broken cross-members; fence posts; clean-out required</td>
<td>M(i)</td>
<td>Replace or repair cattle guard</td>
</tr>
<tr>
<td>M10</td>
<td>Signs</td>
<td>Traffic; radio frequency; kms</td>
<td>M(j)</td>
<td>Replace signs</td>
</tr>
<tr>
<td></td>
<td>Other (specify on front)</td>
<td>Other (specify on front)</td>
<td></td>
<td>Other (specify on front)</td>
</tr>
</tbody>
</table>

### ROAD DEACTIVATION CHECKLIST

<table>
<thead>
<tr>
<th>CODE</th>
<th>PROBLEMS NOTED</th>
<th>DEACTIVATION LEVELS</th>
<th>CODE</th>
<th>ACTION REQUIRED</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>Road surface erosion</td>
<td>Temporary .......... (T)</td>
<td>D(a)</td>
<td>Install or repair cross-ditches</td>
</tr>
<tr>
<td>D2</td>
<td>Ditchline erosion</td>
<td>Semi-Permanent .... (S)</td>
<td>D(b)</td>
<td>Install or repair</td>
</tr>
<tr>
<td>D3</td>
<td>Plugged ditches</td>
<td>Permanent ........... (P)</td>
<td>D(c)</td>
<td>Remove or breach windows</td>
</tr>
<tr>
<td>D4</td>
<td>Plugged culverts</td>
<td></td>
<td>D(d)</td>
<td>Remove cross-drains / stream culverts</td>
</tr>
<tr>
<td>D5</td>
<td>Damaged culverts</td>
<td></td>
<td>D(e)</td>
<td>Clean or repair cross-drain / stream culverts</td>
</tr>
<tr>
<td>D6</td>
<td>Insufficient number of cross-drain culverts</td>
<td></td>
<td>D(f)</td>
<td>Back up cross-drain / stream culverts</td>
</tr>
<tr>
<td>D7</td>
<td>Undersized cross-drain or stream culverts</td>
<td></td>
<td>D(g)</td>
<td>Clean ditches</td>
</tr>
<tr>
<td>D8</td>
<td>Tension cracks on road</td>
<td></td>
<td>D(h)</td>
<td>Repair / replace bridges</td>
</tr>
<tr>
<td>D9</td>
<td>Washout on road</td>
<td></td>
<td>D(i)</td>
<td>Remove bridges</td>
</tr>
<tr>
<td>D10</td>
<td>Washout of culvert</td>
<td></td>
<td>D(j)</td>
<td>Outslope road</td>
</tr>
<tr>
<td>D11</td>
<td>No hazard signs posted</td>
<td></td>
<td>D(k)</td>
<td>Inslope road</td>
</tr>
<tr>
<td>D12</td>
<td>Spacing interval of waterbar or cross-ditches too wide</td>
<td></td>
<td>D(l)</td>
<td>Install / repair erosion protection</td>
</tr>
<tr>
<td>D13</td>
<td>Waterbars or cross-ditches plugged or improperly constructed</td>
<td></td>
<td>D(m)</td>
<td>Install / repair sediment basins</td>
</tr>
<tr>
<td></td>
<td>Other (specify on front)</td>
<td></td>
<td>D(n)</td>
<td>Revegetate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>D(o)</td>
<td>Pull back sidecast</td>
</tr>
</tbody>
</table>

### EXAMPLES

<table>
<thead>
<tr>
<th>km</th>
<th>Non-compliance Items</th>
<th>Problems Noted</th>
<th>Recommended Remedial Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>C3</td>
<td>Tension cracks</td>
<td>C(a)</td>
</tr>
<tr>
<td>2</td>
<td>D4 (P)</td>
<td>Plugged with gravel</td>
<td>D(d)</td>
</tr>
<tr>
<td>1</td>
<td>Pavement</td>
<td>Pavement cracked and buckled</td>
<td>Resurface</td>
</tr>
</tbody>
</table>
# ROAD MAINTENANCE CHECKLIST

<table>
<thead>
<tr>
<th>REF. NO.</th>
<th>LOCATION</th>
<th>MAINTENANCE ITEMS</th>
<th>PROBLEMS NOTED</th>
<th>ACTION REQUIRED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1. Compliance with Maintenance</td>
<td>No documented maintenance program or inspection records</td>
<td>A. Licensee inspections required as per Plan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plan Submission; Inspection records; visual evidence</td>
<td></td>
<td>B. Carry out brushing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Sight distances (brush)</td>
<td>Brushing in of RW</td>
<td>C. Remove snags and danger trees</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Snags &amp; Danger Trees</td>
<td>Danger trees exist</td>
<td>D. Clean ditches</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Ditches</td>
<td>Ditchline sloughing, erosion, debris, plugging ditches</td>
<td>E. Clean culvert inlets and outlets</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. Culverts</td>
<td>Plugged culverts, scour, damaged ends, markers</td>
<td>F. Grade surface</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. Surface Condition</td>
<td>Potholing; washboard; windrowing material; dust</td>
<td>G. Stabilize subgrade</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7. Subgrade Condition</td>
<td>Shoulder slumps, erosion, slides, tension cracks</td>
<td>H. Replace planks, delineators, etc</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8. Bridges/Major Structures</td>
<td>Running planks, decking delineators, guard rails</td>
<td>I. Replace or repair catteguard</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9. Catteguards</td>
<td>Broken cross-members; fence posts, cleanout required</td>
<td>J. Replace signs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10. Signs</td>
<td>Traffic, radio frequency, kms</td>
<td>K. Other (specify)</td>
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<td></td>
<td></td>
<td>11. Other (Specify)</td>
<td>Other (specify)</td>
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**RECORD NON-COMPLIANCE ITEMS AND RECOMMEND REMEDIAL ACTION**
ROAD MAINTENANCE CHECKLIST (continued)

RECORD NON-COMPLIANCE ITEMS AND RECOMMEND REMEDIAL ACTION

<table>
<thead>
<tr>
<th>REF NO.</th>
<th>LOCATION</th>
<th>MAINTENANCE ITEMS</th>
<th>PROBLEMS NOTED</th>
<th>ACTION REQUIRED</th>
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# ROAD DEACTIVATION CHECKLIST

<table>
<thead>
<tr>
<th>REF. NO.</th>
<th>LOCATION</th>
<th>DEACTIVATION LEVELS</th>
<th>PROBLEMS NOTED</th>
<th>ACTION REQUIRED</th>
</tr>
</thead>
<tbody>
<tr>
<td>km/station</td>
<td>Temporary</td>
<td>1. Road surface erosion</td>
<td>A. Install or repair cross ditches</td>
<td></td>
</tr>
<tr>
<td>stream name</td>
<td>Semi-Permanent</td>
<td>2. Ditchline erosion</td>
<td>B. Install or repair waterbars</td>
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</tr>
<tr>
<td>photo number/video counter</td>
<td>Permanent</td>
<td>3. Plugged ditches</td>
<td>C. Remove or breach windows</td>
<td></td>
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<td>4. Plugged culverts</td>
<td>D. Remove cross-drains/</td>
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<td>5. Damaged culverts</td>
<td>stream culverts</td>
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<td></td>
<td></td>
<td>6. Insufficient number of cross-drain culverts</td>
<td>E. Clean or repair cross-drain/</td>
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<td>7. Undersized cross-drain or stream culverts</td>
<td>stream culverts</td>
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<td></td>
<td></td>
<td>8. Tension cracks on road</td>
<td>F. Back up cross-drain/</td>
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<td></td>
<td></td>
<td>9. Washout on road</td>
<td>stream culverts</td>
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<td></td>
<td>10. Washout of culvert</td>
<td>G. Clean ditches</td>
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<td>11. No hazard signs posted</td>
<td>H. Repair/replace bridges</td>
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<td></td>
<td>12. Spacing interval of waterbar or cross-ditch too wide</td>
<td>I. Remove bridges</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>13. Waterbars or cross-ditches plugged or improperly constructed</td>
<td>J. Outslope road</td>
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<td></td>
<td></td>
<td>14. Other (Specify)</td>
<td>K. Inslope road</td>
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<td></td>
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<td></td>
<td>L. Install/repair erosion protection</td>
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<td></td>
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<td></td>
<td>M. Install/repair sediment basins</td>
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<td>N. Revegetate</td>
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<td></td>
<td>O. Pull back sidecast</td>
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<td>P. Other (Specify)</td>
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</table>

**RECORD NON-COMPLIANCE ITEMS AND RECOMMEND REMEDIAL ACTION**

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# ROAD DEACTIVATION CHECKLIST

*Record non-compliance items and recommend remedial action*

<table>
<thead>
<tr>
<th>REF NO.</th>
<th>LOCATION</th>
<th>DEACTIVATION LEVELS</th>
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APPENDIX G

9 Forest road engineering

Guiding principles

- The establishment, maintenance, and deactivation of forest roads should maximize public benefits by optimizing the integration of identified resource values.

- Planning for road establishment, maintenance, and deactivation should be carried out within the framework of forest development planning to facilitate coordination with harvesting activities and to simplify public participation and agency referral. Forest development planning should ensure that roads are planned at least five years into the future over a logical geographic unit.

- Forest road networks should be planned to optimize industrial efficiency and minimize environmental impact while providing for user safety. Consistent with these objectives, such networks should avoid unstable or otherwise hazardous terrain, incorporate well-designed and properly placed drainage structures, and minimize the total length of road for a given unit.

- Where alternatives exist, stream crossings should be minimized and sensitive areas such as critical wildlife habitat, steep slopes, areas with high-value aesthetic values, and riparian areas should be avoided. Where stream crossings cannot be minimized or sensitive resource areas avoided, mitigating measures or different harvesting methods should be used.

- Roads should be either fully maintained or appropriately deactivated in order to provide for user safety, to protect the road investment, and to minimize any negative effects on resource values. The main concern to be addressed by maintenance or deactivation activities, after safety of structures, should be the prevention of soil erosion and mass wasting.
9.1 Road planning

9.1.1 Access development planning

1. Access development planning must be carried out for all road construction or reconstruction, as part of a Forest Development Plan or an Access Management Plan, and must identify:
   - objectives for access development and short- and long-term forest management goals;
   - resource values and the effects of the road on those values;
   - the extent of known hazards and their consequences;
   - primary route corridors (projections) from the logging areas to the existing road system;
   - proposed roads from the logging areas to the existing road system;
   - duration and periods of use (seasonal or all-weather) and anticipated traffic types and volumes;
   - other known users;
   - existing roads (including the road network tie-in to the public road system, processing plant, or log dump) and bridges and major culverts (2000 mm diameter or greater);
   - proposed and existing log dumps and other log handling and storage areas;
   - private properties; and,
   - public utilities.

2. Roads must be planned to avoid known hazards. Where it is necessary to traverse areas with known hazards, those areas must be identified so that mitigating measures can be prescribed. The district manager, in consultation with other appropriate agencies, must approve the areas to be traversed.

3. Duplication of access must be avoided, existing access must be used, and roads must be matched to harvesting methods and resource uses, all to the fullest extent possible.

Field Guides:
Under preparation: how to carry out access planning; how to prepare access development information as part of Forest Development Plans or Access Management Plans
9.1.2 Road maintenance planning

1. Road maintenance planning must be carried out annually as part of a Forest Development Plan or an Access Management Plan, for all roads that are in use and have not been deactivated.

2. Road maintenance planning must identify the forest roads to be used each year for forest management, industrial, and other purposes, and maintained to:
   • protect the structural integrity of the road, the structures on the road, and the cleared area;
   • minimize the environmental impact; and,
   • meet user safety requirements.

Field Guides:
P1
Under preparation: how to prepare maintenance planning information as part of Forest Development Plans or Access Management Plans.

9.1.3 Road deactivation planning

1. Three-year road deactivation planning must be carried out annually, as part of a Forest Development Plan or Access Management Plan, for all roads, including the structures on them, that will no longer be regularly maintained.

2. Road deactivation planning must detail the following:
   • mapping of roads that are currently deactivated to a temporary or semi-permanent level;
   • roads that have been permanently deactivated, by year and level of deactivation; and,
   • a list that identifies the roads, level of deactivation by year, and types of vehicles expected to use each road after deactivation.

Field Guides:
P1, P2
Under preparation: how to prepare deactivation information as part of Forest Development Plans or Access Management Plans
9.2  Reconnaissance

1  The optimum road location must be selected on the basis of the access development planning information.

2  The optimum road location must be marked in the field.

3  Areas that may be prone to mass wasting must be identified so that mitigating measures can be prescribed where roads are anticipated to traverse these areas.

4  Areas that may be prone to surface soil erosion must be identified so that mitigating measures can be prescribed where roads are anticipated to traverse these areas.

5  Roads must be located to protect and maintain identified resource values as specified in landscape level management objectives or higher-level plans. Road locations that conflict with identified resources must be approved by the district manager in consultation with other appropriate resource agencies.

6  Watercourse crossings must be selected such that channel and bank disturbances can be prevented or mitigated and structure security provided.

7  Road location lines must be tied to references, other control points, and other identified resource data.

Field Guides:
Under preparation: how to identify areas prone to mass wasting/soil erosion

9.3  Survey

1  A site survey must be carried out for all bridges and for culverts (2000 mm diameter or greater).
Standards:

1. Site surveys must record:
   - stream/lake class;
   - high water mark;
   - streamflow measurements;
   - description of streambed materials;
   - streambed gradient;
   - cross-section and profile of crossing;
   - date of survey; and,
   - existing improvements and other known resource values.

2. A location survey to obtain data for detailed road design must be carried out in areas with slopes greater than 50%, in areas identified as having terrain stability class IV or V slopes, or where they are required in higher level plans.

Field Guides:
P1, P3
Under preparation: how to select an appropriate level of survey

9.4 Roadway design

1. Road widths must be designed to accommodate the intended vehicle sizes and traffic volume.

2. Clearing widths must be the minimum required to accommodate the road prism, user safety, subgrade drainage, subgrade stability, spoil areas, equipment operability, snow removal, and fencing and other structures.

3. Road alignment must be designed to provide for user safety by including, for example:
   - turnouts;
   - traffic controls;
   - appropriate travel speeds and stopping distance; and
   - suitable stopping and sight distances at road junctions.

4. Road designs must incorporate measures to mitigate surface soil erosion.
A geometric road design must be carried out, based on the location survey data in areas with slopes greater than 50% and in areas identified as having terrain stability class IV or V slopes.

Fill slope angles must be designed such that they do not exceed the angle of repose of the soil or rock materials.

Cut slope angles must be designed so as to remain stable over the expected life of the road, unless ravelling or sloughing of the cut bank would not be expected to contribute to slope failures.

Field Guides:
P1
Under preparation: how to mitigate surface soil erosion

9.5 Drainage design criteria

1 Bridges, culverts, and fords must be designed to maintain natural surface drainage patterns.

2 Bridges and culverts must be designed to prevent or mitigate channel and bank disturbance and to provide structure security.

3 Cross-drain culverts must be spaced and ditches designed to prevent ditch water accumulation and accelerated ditch erosion.

Standards:

1 Unless soil and runoff conditions require increased sizes, minimum pipe culvert diameter sizes must be 400 mm east of the Cascade Mountains and 600 mm west of the Cascade Mountains, and minimum opening size for log culverts must be 0.5 m in depth and 1.5 m in width.

4 Culvert inlet and outlet protection measures must be designed to provide protection against erosion and mass wasting.

5 Crossings in fish-bearing waters must be designed to provide safe fish passage.
Culverts on all seasonal and continuous watercourses must be designed so as not to destabilize the stream channel.

Protective measures must be designed to protect the structural integrity of culverts where debris cannot safely pass.

New bridges, their approaches, and stream culvert structures must be designed to meet the peak flow criteria as shown in the following table:

<table>
<thead>
<tr>
<th>Minimum design peak flow</th>
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<tr>
<td>All stream culverts</td>
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<tr>
<td>Permanent bridges</td>
</tr>
<tr>
<td>Semi-permanent bridges</td>
</tr>
<tr>
<td>Temporary bridges</td>
</tr>
</tbody>
</table>

However, bridges whose vulnerable components are removed at times of risk must be designed to pass expected flows for the seasons of use.

Design drawings and technical specifications must be prepared for bridges and major culverts.

Full-width decking between curbs must be designed for new and replacement decks.

**Field Guides:**

P1

Under preparation: design of fords and log culverts; culvert sizing and spacing; preparation of design drawings / specifications; culvert design / material selection

**9.6 Design by professional engineers and professional geoscientists**

Where it is necessary to traverse areas identified on terrain hazard mapping as having a terrain stability class IV or V slopes, suitable mitigating measures must be prescribed by a professional engineer or professional geoscientist.

Cattleguard fabrication, retaining walls, and other special structures must be designed by a professional engineer.
Proposed Forest Practices Standards

3 All bridges and log culverts must be designed by a professional engineer, except where both of the following conditions apply:
   • the structures are composed of single-span, temporary log superstructures on timber cribs or sills, with the superstructure sized from tables or design aids prepared by a professional engineer; and,
   • the designer can show from past experience with similar structures that the structure is adequate for the given site condition.

4 The size and installation of all permanent material culverts having a pipe diameter of 2000 mm or greater, or having a maximum design discharge of more than 6 m³/second, must be designed by a professional engineer.

5 Professional engineers must design permanent and semi-permanent bridges according to the latest code requirements of the Canadian Standards Association for Design of Highway Bridges, CAN/CSA-S6 and the latest version of the Canadian Foundation Engineering Manual. The peculiarities of logging truck unbalanced loads and eccentricities must be considered in all bridge design.

Field Guides:
P1, P4

9.7 Construction

9.7.1 Clearing

1 All standing trees within the clearing width must be felled. Natural surface drainage patterns must be maintained.

2 Trees must be directionally felled away from watercourses, to the fullest extent possible. Felling and yarding techniques must be selected to prevent streambanks from destabilizing.

3 Danger trees (as defined by the Workers’ Compensation Board) with the potential to reach the proposed road surface must be felled concurrently with clearing operations.

4 All stumps, roots, embedded logs, organics, and other unsuitable soils within the roadway prism width must be removed, except
those organics outside the road subgrade width portion of the road on the downhill side, in areas having slopes other than terrain stability class IV or V slopes, and where downslope consequences are rated low.

Note: This Rule does not apply to overlanding or snow roads. Also, potentially unstable slopes must be pulled back when the road is deactivated.

5 Full bench cuts and end haul must be used on short-term roads built on areas identified as having terrain stability class IV or V slopes, unless other measures are designed by a professional engineer or professional geoscientist.

Note: If stumps and logs are left under or against the fill, the fill slopes must be pulled when the road is semi-permanently or permanently deactivated.

Field Guides:
P1

9.7.2 Slash and debris

1 Slash and debris must be disposed of in an environmentally safe manner, reflecting the visual quality objectives described in landscape level management objectives or higher level plans.

Standards:

1 Disposal of slash and debris must be carried out by one or more of the following methods, unless otherwise exempted by the district manager in consultation with appropriate agencies:

- **Scattering:** Excess slash and debris must be piled downslope of the road shoulder and, except for buffer zones in visually sensitive sites, away from standing timber. The material must be spread to make snow removal easier and piles must be breached to permit controlled drainage and wildlife passage.
• **Pile and burning:** Slash and debris must be piled away from standing timber and burned no later than the first burning season after construction.

• **Burying:** Slash and debris must be buried between the lower clearing width boundary and the toe of the road, where it conforms with existing ground profiles and does not interfere with runoff and natural watercourses. Buried slash must be covered with at least 0.3 m of soil.

• **End-hauling:** Unsuitable materials must be end-hauled to a designated waste site.

2 Slash and debris must not be deposited in a watercourse or deposited in a location where such material could reasonably be approved by the district manager with agreement from appropriate resource agencies.

**Field Guides:**
P1

### 9.7.3 Subgrade construction

1 Temporary or permanent drainage systems must be built concurrently with subgrade construction and must be fully functional.

2 Excavated material must not be sidecast on slopes identified as being terrain stability class IV or V, unless the sidecasting has been prescribed by a professional engineer or professional geoscientist.

3 If there is an approved prescription prepared by a professional engineer or professional geoscientist, the road must be constructed according to that prescription and, where so specified in the approved prescription, the resulting construction work must be certified by a professional engineer or professional geoscientist as being in general conformance with the approved prescription.

4 Roads that have been designed to incorporate measures to mitigate surface soil erosion must be constructed according to those design measures.
5 In rock work, only rock drilling and blasting techniques that minimize flyrock and reduce the potential for landslides or slope instability must be used. The scheduling and procedures for blasting must accommodate other identified resources and existing improvements.

6 Borrow pits, quarries, waste areas, and end-haul disposal sites must be located on sites where eroded soil materials or other deleterious materials can be prevented from entering watercourses. These sites must be left in a stable condition and a visually acceptable state.

7 The construction site must be kept clean of deleterious substances.

8 Construction surveys must be used to control construction operations in areas identified as having terrain stability class IV or V slopes.

**Standards:**

1 Construction surveys must ensure that design specifications are met. These surveys must include:
   - marking of the clearing width boundaries;
   - re-establishment of the road centreline;
   - grade staking; and,
   - centreline relocations and redesigns, as needed to accommodate unforeseen site conditions.

9 Ground disturbance must be minimized during snow road construction through the use of clean compacted snow and ice as fill material.

10 Roads must be constructed in general conformance to the approved layout and design. To deal with previously unforeseen ground conditions, modifications that may adversely impact other resources must be approved by the district manager before continuing with construction.

11 Roads must be constructed so that the road surface is above the water table during the operating period.
12 Unprotected erodible fill material must not be placed below the high water level of adjacent watercourses, whether these watercourses are continuous or seasonal.

13 Construction equipment must not be serviced adjacent to, or washed in, watercourses.

14 Equipment crossings must be limited to one location on a stream, for each road crossing of the stream. Otherwise the district manager, in consultation with other agencies, must approve any additional equipment crossing locations.

Field Guides:
P1, P5
Under preparation: road construction specifications; controlled rock blasting/blasting specifications

9.7.4 Drainage

1 Bridges, culverts, fords, and ditches must be constructed to maintain natural drainage patterns.

2 Bridges, culverts, or fords must be installed at all crossings of permanent or seasonal watercourses.

3 Drainage systems must be provided to intercept sidehill drainage, drain ditches, control ditch erosion, prevent ponding of water where instability may occur, prevent water from being directed onto sensitive soils, or prevent deleterious materials from being deposited directly into watercourses.

4 Stream and cross-drain culverts must be constructed to ensure they are structurally sound, functional, and stable.

Standards:

1 All culverts must have a depth of fill cover as required by manufacturers’ specifications, but at least 300 mm.

5 Road embankment and waste materials must be prevented from encroaching on culvert inlets and outlets.

Required depth of fill cover for culverts
6 Unstable or erodible fill at culvert outlets must be protected with erosion-resistant materials or drainage structures.

7 Bridges and culverts must be constructed to prevent or mitigate streambank disturbance and to protect downstream water quality.

8 Crossings in fish-bearing streams must be constructed at a time and in a way that provide safe fish passage and protect fish and fish habitat.

Standards:

1 A fish salvage plan, approved by a designated B.C. Environment official, must be in place where any in-stream work has the potential to temporarily strand fish, and required fish salvage must be implemented according to the approved plan.

2 Ice/snow bridges must be removed before snowmelt freshet and, on fish-bearing streams, must provide for fish passage. The district manager, in consultation with appropriate resource agencies, may permit such bridges to be left in place during the snowmelt freshet.

9 Once construction of those bridges and major culverts requiring professional design is completed, a professional engineer must certify that the entire structure is in general conformance with the design drawings and specifications and is at least as durable and as strong as the original design intended.

10 Ditch blocks must be installed immediately downstream of all cross-drain culvert inlets, except where ditch water converges at the culvert inlet.

Standards:

1 Ditch blocks, made up of material resistant to erosion or displacement by ditch flows, must be installed such that their crests are between the top of the culvert and 150 mm below the adjacent road surface.
Proposed Forest Practices Standards

11 Geotextile filter fabrics must be used to prevent migration of fines on gravel surface log stringer bridges and log culverts.

12 Catch basin or other sediment control devices must be constructed adjacent to the inlet of cross-drain culverts where sedimentation may adversely affect downslope resources.

13 Fords and approaches must be composed or constructed of erosion-resistant materials capable of withstanding the intended traffic.

14 All permanent bridge and culvert materials must be fabricated according to standards of the Canadian Standards Association.

15 Pile driving records and, for new materials, mill test certificates, in-plant steel fabrication drawings, concrete test results, compaction results, and other pertinent field and construction data must be obtained and kept. As-built drawings must be prepared and kept.

**Standards:**

1 An as-built set of drawings must be prepared, reflecting all changes made during construction. For structures designed by a professional engineer, the as-built drawings must be sealed by an inspecting professional engineer. In addition, the certification of construction must be kept on file.

**Field Guides:**

P1, P6

Under preparation: construction of fords and log culverts; processes related to ditch drainage

### 9.7.5 Road surfacing

1 Road surfacing materials must be applied where, except at breakup, the subgrade material cannot carry the design wheel loads or where erosion of the subgrade material may adversely affect adjacent watercourses.
Field Guides:
Under preparation: guidelines for capping road surfaces to minimize surface erosion in sensitive areas

9.7.6 Revegetation

1 Seed must be applied to all exposed soil that will support vegetation in the first growing season after construction, and the soil must be revegetated within two years of road construction. The areas to be treated this way are:
- inactive borrow pits;
- waste areas;
- road cuts;
- fill slopes; and,
- other disturbed areas within the cleared width.

The district manager, in consultation with appropriate resource agencies, may vary the time requirement.

Field Guides:
Under preparation: revegetation prescriptions for exposed road soils

9.8 Maintenance

9.8.1 Bridge and major culvert inspection, evaluation, and maintenance

1 All temporary and semi-permanent bridges and major culverts must be inspected by qualified inspectors at least once every two years and permanent bridges at least once every three years, or after unusually heavy floods or other unexpected events that are likely to damage the structures. More frequent inspections must be carried out where structural defects are evident. Records of inspection, noting the general condition of all components, must be kept.

Standards:

1 Bridge and major culvert inspections must record:
- condition of components;
- recommendation for repairs;
- date of inspection;
- next inspection date; and,
- schedule for repairs.
2 If, as a result of inspection by a qualified inspector, a bridge is suspected of having structural deficiencies, a professional engineer must evaluate the bridge according to the latest code requirements of the Canadian Standards Association for Design of Highway Bridges, CAN/CSA-S6.

3 Any deficiencies that put road users or the environment at risk must be corrected. Otherwise, the structure must be closed, restricted to traffic, or removed.

4 Where a professional engineer has determined that a bridge is unable to carry its original design load, a sign must be placed on each bridge approach stating the actual capacity of the bridge.

9.8.2 Road inspection and maintenance

1 Roads must be inspected and maintained to:
   • protect the structural integrity of the road prism and cleared area;
   • keep the drainage systems functional;
   • minimize sediment production and the effects on other resources; and,
   • meet user safety requirements.

2 Road maintenance inspections must be carried out at frequencies commensurate with the risk to the road, its users, and adjacent resources, and must assess the adequacy of ditches and culverts, the requirements for improved drainage works or road surfacing or revegetation, and other elements of road integrity and safety.

3 Maintenance work must be carried out according to the approved Forest Development Plan or Access Management Plan.

Standards:

1 Maintenance must be carried out as described in the approved Forest Development Plan or Access Management Plan, including:
   • providing vegetation control to provide safe travel, sight distance, and unobstructed ditches;
   • cleaning and grading ditches;
Proposed Forest Practices Standards

- cleaning and repairing culverts and ancillary drainage works; and
- maintaining and repairing road surfaces and subgrades and bridge and other structure components.

4 Remedial works identified by inspections must be carried out within a period of time that is commensurate with the risk to the road, its users, and the environment.

5 Roads must be maintained until the road is deactivated according to the approved Forest Development Plan or Access Management Plan.

Field Guides:
P1, P6, P7
Under preparation: road inspection frequencies, reports/checklists; suitable levels of maintenance

9.9 Deactivation

1 Roads must be deactivated, according to the approved Forest Development Plan or Access Management Plan, when they are no longer in regular use and are not being maintained, such that the roadway prism and cleared width are stabilized and the natural drainage is restored or maintained.

2 Integrated resource management objectives and ongoing and future vehicle access requirements must be incorporated into deactivation planning.

3 The extent of deactivation must be commensurate with the period of time that regular use of the road is to be suspended, and with the risk to other resources.

4 Information must be posted to advise road users of hazards that may be expected due to deactivation.
5 Prescriptions for deactivation work must be submitted and approved before work begins. A professional engineer or professional geoscientist must prepare a prescription for deactivation work in areas that may be prone to mass wasting and, where so specified in the prescription, must certify that the deactivation work was carried out in conformance to the prescription.

6 Site-specific measures must be applied to reduce erosion and must be consistent with the processes described below:

**Temporary (seasonal) deactivation:** Temporary deactivation must be used for roads whose regular use is to be suspended for up to three years.

- Windrows on the outer edge of the road surface must be removed or breached.
- Inspections must be carried out at frequencies commensurate with the risk to the road, its users, and adjacent resources, to assess the adequacy of ditches and culverts and the requirements for improved drainage works, road surfacing, or revegetation.
- Remedial works identified by inspections must be carried out within a period of time that is commensurate with the risk to the road, its users, and the environment.
- Bridges must be repaired or removed, as necessary.
- Waterbars or cross-ditches must be constructed along the road or the road must be insloped or outsloped, as appropriate, where there is a risk of adversely impacting the road and other resources through erosion, to prevent excessive flow accumulating and channeling down the road surface.

**Semi-permanent deactivation:** Semi-permanent deactivation must be used where regular use is suspended for up to three years on: winter roads, roads with a potential for debris torrents, and those roads in particularly isolated areas, as well as on roads in areas where harvesting is suspended until the next pass.

- For areas with slopes greater than 50% and areas identified as having terrain stability class IV or V slopes, the natural flow patterns must be restored through the removal of all existing stream culverts, the restoration of channel stability, and the installation of fords, where possible, if access is required during the period of deactivation. Alternatively, stream culverts must be backed up with similarly sized cross-ditches on the downhill side.
For areas with slopes greater than 50% and areas identified as having terrain stability class IV or V slopes, all cross-drain culverts must be removed and replaced with cross-ditches, and ditch blocks must be intact. Alternatively, cross-drain culverts must be backed up with similarly sized cross-ditches on the downhill side.

Additional cross-ditches must be constructed where there are steep grades, heavy ground water seepage, or switchbacks and road junctions, and where ditches are prone to plugging.

Where overflow of the stream channel is expected, stream culvert excavations must be backed up with a cross-ditch on the downhill side.

Temporary and semi-permanent bridges must be removed or, if the bridges are to be left in service, must be repaired or replaced, as necessary, to protect users during the period of deactivation.

Windrows on the road surface must be removed or breached.

The road surface must be outsloped or insloped, as appropriate.

Sidecast fill must be pulled back onto the outsloped road grade to ensure drainage where there is a high risk of slope failure or where stability of the fill is questionable. Fill material placed against the cut slope must not exceed its angle of repose.

Cross-ditches must be installed where the ditchline ends.

Exposed soil surfaces must be revegetated.

**Permanent deactivation:** Permanent deactivation must be used for roads to be closed permanently.

The natural flow patterns must be restored through the removal of all existing stream culverts and the restoration of channel stability.

Where overflow of the stream channel is expected, stream culvert excavations must be backed up with a cross-ditch on the downhill side.

All cross-drain culverts must be removed and replaced with cross-ditches, and ditch blocks must be intact.

Additional cross-ditches must be constructed where there are steep grades, where there is heavy ground water seepage, where switchbacks and road junctions are located, and where ditches are prone to plugging.

All bridge superstructures must be removed. Substructures must be removed where failure will affect downstream values.

Windrows on the road surface must be removed.

The road surface must be outsloped or insloped, as appropriate.
 Proposed Forest Practices Standards

- Sidecast fill must be pulled back onto the outsloped road grade to ensure drainage where there is a high risk of slope failure or where stability of the fill is questionable. Fill material placed against the cut slope must not exceed its angle or repose.
- Cross-ditches must be installed where the ditchline ends.
- Deactivation measures must be carried out to increase site productivity on reception sites and must include, but not be limited to, compaction of the soils within the road prism, revegetation of exposed soil surfaces, and reforestation.

Field Guides:
Under preparation: guidelines for monitoring/tracking of deactivated roads

9.10 Classified areas

Note: For a complete list of Standards, see Section 3.4, Classified areas.

Riparian management areas

<table>
<thead>
<tr>
<th>Standards:</th>
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<tbody>
<tr>
<td>1</td>
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<td>3</td>
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<tr>
<td>4</td>
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</table>
5 Gravel or fill material must not be removed within riparian management areas, unless approved in advance by the district manager in consultation with appropriate agencies.

6 Bridge or culvert material storage and equipment turnaround sites must be provided outside riparian management areas, where the normal cleared width cannot accommodate such sites.

9.11 Community watersheds

Note: For a complete list of Standards, see Section 3.5, Community watersheds.

Standards:

1 Where road construction work will proceed after snowfall, all stream courses must be marked before snowfall so as to be visible at the time of construction.

2 At least 48 hours before the start of road construction, the road operator or proponent must notify water purveyors and appropriate resource agencies of the start date of construction.

3 All road construction materials placed below the high water mark of adjacent watercourses must be non-toxic.

4 An impermeable absorbent mat must be placed under equipment during servicing, to catch spills of fluids and waste materials.

5 Fill heights above culverts measured at the road centre-line must not exceed 4 m unless protective measures are designed by a professional engineer.

6 Culverts must be designed to pass the 100 year return period instantaneous peak discharge with zero head above the top of the culvert inlet, unless a professional engineer has designed inlet and outlet protection measures.
<table>
<thead>
<tr>
<th></th>
<th>Proposed Forest Practices Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Stripped topsoil or slash and other organic debris must not be placed within a 100 m radius of a water intake, measured above the intake.</td>
</tr>
<tr>
<td>8</td>
<td>Culverts must be installed in such a way as to enable maintenance equipment to remove obstacles at the culvert ends.</td>
</tr>
<tr>
<td>9</td>
<td>Those portions of stream channels upstream of culverts located outside the cleared width must not be altered unless a designated B.C. Environment official gives approval to do so.</td>
</tr>
<tr>
<td>10</td>
<td>Within community watersheds, roads that are constructed of erodible parent material must be surfaced with erosion-resistant, compactible gravel or rock to a minimum depth of 150 mm. Otherwise, suitable mitigative measures must be designed, approved, and carried out to accomplish the objectives of surfacing.</td>
</tr>
<tr>
<td>11</td>
<td>Road building is not permitted on sites with terrain stability class III slopes and a high risk of sediment delivery, or on terrain stability class IV or V slopes, unless a detailed assessment and road design by a professional engineer or professional geoscientist demonstrate that slope stability and water quality impacts can be mitigated.</td>
</tr>
<tr>
<td>12</td>
<td>Rock from known acid-generating rock formations must not be used for road construction.</td>
</tr>
<tr>
<td>13</td>
<td>Roads and landings must be located so as to maintain the infiltration capacity and subsurface flow paths of a spring recharge area.</td>
</tr>
</tbody>
</table>

**Field Guides:**

P1
K1

Under preparation: community watershed guidelines; biodiversity guidelines
APPENDIX H


ROAD
Construction, Maintenance & Deactivation
Province of British Columbia
Ministry of Forests
Vancouver Forest Region
1. Some of the material contained in this binder is still under development. Check with your local Forest Service Office (Resource Officer Engineering) for the most up-to-date version.

2. Comments regarding the material are welcomed for improvement purposes. Contact the Ministry of Forests, Ron Jordens, at 4595 Canada Way, Burnaby, B.C. V5G 4L9, Phone 660-7640, Fax 660-7778 or your local Forest Service Office - Resource Officer Engineering

3. This material is the property of the Ministry of Forests. Contact Dennis Smith, Regional Engineering Officer, 660-7633 if you wish to use any of the material.

January 4, 1993
This is NOT a road building course. Rather it is a collection of information that the Ministry wishes to show to and discuss with road builders, and those associated with roads including Ministry of Forests and other agency staff for the purposes of minimizing the negative impact of roads.

Logging roads can cause damage to forest resources and impair water quality.

The Ministry of Forests and the forest industry have a responsibility to minimize the negative impacts of road and logging related activities.

Poor road construction/maintenance and deactivation practices can cause unnecessary erosion, siltation and landslides.

The Coast Fish/Forestry Guidelines and the new Ministry Roads Standards set the principles and guidelines for road and logging activities.

Everybody associated with roads within our forests must be completely familiar with these two important documents.

The material that follows focuses on the practical aspects of road construction, maintenance and deactivation activities covered in these documents.

December 31, 1992
COURSE OBJECTIVES

To encourage discussion and solutions of road related issues between road builders and government agencies.

To understand the impact of road construction on other resources and resource users.

To enable the identification and resolution of road-related problems before they happen.

To promote the understanding of the types and steps of road deactivation.

To provide knowledge about environmentally safe practices for road construction, maintenance and deactivation.
FOREST ROADS

- All roads built in the forests are reviewed and approved by the Forest Service. Road Permits and Cutting Permits containing specifications authorize the construction of roads.

- Roads can be either permanent or temporary.

- Temporary or Permanent roads constructed on side slopes greater than 60% require a higher degree of planning and engineering and must have site specific constraints about sidecasting and drainage control. The following sketches give some conditions under which forest roads can be built.
The following series of drawings show the desired results for temporary and permanent roads in different soils [rock or OM (other material)], and on different side slopes.

The drawings are generic and are meant to generate ideas, concepts and options and will not necessarily solve site specific situations.

NOTE THE FOLLOWING ABOUT THE DRAWINGS:

1. Scale is 1:100.

2. The cuts and fills are to scale. Fills contain a 33% swell factor.

3. Distance to the edge of the right-of-way is 3m from top of cut and 3 m from toe of the stump and overburden pile, unless otherwise approved by the Forest Service.

For permanent roads, excavate cut slopes to their stable angle of repose.

It is normally the downhill slope on which sidecasted material is to be placed that requires our attention.

It is critical that everyone (especially the operator) knows in advance exactly what disposal criteria apply for excavated material to each particular section of road; if not - ask!
The following aspects require consideration when recommending or approving the construction method(s) shown on the sketches or any other methods.

- the proximity of important water bodies (Class I or II streams, lakes, ocean, etc.);
- the proximity of gentler slopes on the uphill or downhill side;
- the depth and type of failure plane (i.e. thin mantle of organics over smooth bedrock, type and location of rock faults or discontinuities);
- potential site degradation;
- other upslope or downslope values (i.e. tree plantations, private properties etc.);
- aesthetics;
- the strength (diameter, species, root depth and anchoring) of stumps holding back sidecast and debris - only permitted when sidecast retrieval is required or downslope stability is not a concern;
- soil types;
- moisture conditions;
- season of construction;
- time between construction and deactivation;
- behavior of existing road in the same or similar drainage having similar soils, moisture conditions, aspect and slope.
CLEARING WIDTHS

Total cleared width

Cut danger trees that could reach the road.

Cut leaning trees.

variable

Up to 3m

3m

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<thead>
<tr>
<th></th>
<th>ROCK</th>
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<tbody>
<tr>
<td>CUT SLOPE (CS)</td>
<td>Vertical - $\frac{1}{2} : 1$</td>
<td>$\frac{3}{4} - 1\frac{1}{2} : 1$</td>
</tr>
<tr>
<td>FILL SLOPE (FS)</td>
<td>1 : 1</td>
<td>1$\frac{1}{2} : 1$</td>
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</table>

ClearWid
January 21, 1993

SCALE 1:100
FALLING

Ensure that the clearing width is wide enough to accommodate the necessary cut and fill slopes and also provide room for debris disposal. Minimum clearance on cut side is 3 metres - fill side is variable.

Buck logs into length that maximize market value.

Recover any trees that have been felled into standing timber.

Fall any danger trees that may fall or blow down onto the road.

December 31, 1992
Merchantable wood must be recovered and protected prior to sidecasting and/or blasting.

On steep slopes avoid "stacking" too much timber against standing timber and overloading the slope. In such cases make arrangements to remove the felled and bucked prior to subgrade construction.
ROAD WIDTH

Road widths are to be such that they are safe for use for their intended purpose yet site loss is minimized.

The Ministry standard is 5m of useable running surface.

However:

- road widening is necessary for
  * side tracking for curves and
  * turnouts

- narrower roads are encouraged whenever conditions permit
SIDE CASTING

Slope overloading must be avoided.

This...

...results in this.
PERMANENT ROAD
O.M. or Rock

Moderate Slope
Well drained soils: less than 60%
Poorly drained soils: less than 50%

- Waste pile must be breached as necessary to allow drainage, but must not redirect water that will cause damage to resources further down the hill.

40% slope.

This slope to be less than 70%.

| SCALE | 1:100 |

<table>
<thead>
<tr>
<th>Rock</th>
<th>Blasted Rock</th>
<th>O.M.</th>
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<tbody>
<tr>
<td>Rock</td>
<td>Blasted Rock</td>
<td>O.M.</td>
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<tr>
<td>Organic</td>
<td>Fill</td>
<td>Organic Debris</td>
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<th>CUT SLOPE (CS)</th>
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<td>Vertical - 1 : 2</td>
<td>1/4 - 1 1/2 : 1</td>
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<th>FILL SLOPE (FS)</th>
<th>ROCK</th>
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<td>1 : 1</td>
<td>1 1/2 : 1</td>
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</table>
Full Bench Construction

This wedge of material must be end hauled and placed in a suitable spoil area.

- If the slope is wet then full bench construction and end hauling may be required on slopes as low as 45%.

70% slope.

- Ministry approval may be given to sidecast all or some stumps, organic debris, and O.M. if there is a bench that will support the side cast or if it is a designated spoil area.

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<td>1 1/2 : 1</td>
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PERMANENT ROAD
O.M.
60 - 70% slope

SCALE 1:100

PR-60/70
January 21, 1993
### PERMANENT ROAD

**O.M.**

Very steep

**GREATER THAN 70% SLOPE**

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<thead>
<tr>
<th>CUT SLOPE (CS)</th>
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<td>$\frac{1}{4} - 1\frac{1}{2} : 1$</td>
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<tr>
<td>1 : 1</td>
<td>$1\frac{1}{2} : 1$</td>
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</table>

100% slope.

- Nothing to be sidecast.
- Everything to be end hauled:
  - stumps
  - slash
  - organic debris
  - mineral soil.
  - unless otherwise authorized by BC Forest Service.

- R/W wood removed to a safe place.

**SCALE**

1:100

PR-70

January 21, 1993
TEMPORARY ROAD
Rock or O.M.

Moderate slope • less than 65%

For wet poorly drained soils full bench and end-haul could be required for slopes as low as 45%.

Note:
Ministry will require pull back on the slopes less than 65% if there are signs of instability.

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<tr>
<td>CUT SLOPE (CS)</td>
<td>Vertical -½ : 1</td>
<td>¼ - ½ : 1</td>
</tr>
<tr>
<td>FILL SLOPE (FS)</td>
<td>1 : 1</td>
<td>1½ : 1</td>
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</table>

50% slope.

< 70%.

• Place overburden in a stable manner which can be reached for recovery, if required.

• Waste pile must be breached as necessary to allow drainage, but must not redirect water that will cause damage to resources further down the hill.

SCALE
1:100

TR - RK/OM
January 7, 1993
TEMPORARY ROAD
O.M.

STEEP
greater than
65% SIDE SLOPE

- Ministry approval is required prior to construction of roads on such steep slopes.
- Geotechnical analysis by a registered professional geotechnical engineer or geo-scientist is a pre-requisite.
- There are several other methods to provide structurally sound (yet temporary) retaining structures.

- Pull-back of this side-cast material is MANDATORY within a specified time (check your permit).
- Sidecasting must be done carefully. We are relying on the holding power of green stumps (minimum diameter should be 1 metre).
- Sidecast material is to remain within reach of an excavator to facilitate pullback.

* IT IS VERY CRITICAL TO CLARIFY THAT YOU ARE BUILDING A TEMPORARY ROAD.
DRILLING & BLASTING

Use proper techniques to keep rock on grade. Thrust of the blast should be upwards NOT outwards.

DESIGN DRILLING & BLASTING ACTIVITIES TO:

- minimize fly rock
- provide fragments of usable size for use as ballast, rip rap and surfacing
- prevent overloading the slope with fly rock
- minimize damage to the trees.

DO

DO NOT

SCALE
1:200

DRILL/BL
January 7, 1993
Drilling and blasting techniques must accommodate:

- volume of material to be moved or created
- sensitivity for rock type and structure
- minimal flyrock
- retention of blasted material on site
- required rock fragmentation

The following general practices apply:

1. Drill holes to be in parallel, evenly spaced lines to achieve consistent burden between individual holes, and between holes and outside edge of the rock formation.

2. Stemming of all holes with 12 mm (1/2 in.) to 19 mm (3/4 in.) crushed rock or drilling chips is required. Drill dust or dry dirt is not allowed. Stemming depth to be calculated with a minimum of 1.22 metres. Where required on horizontal holes utilize bags and a loading pole.

3. All holes are to be drilled below subgrade using a rule of thumb 0.3 x burden.
4. The minimum stiffness ratio will be greater than 2 when using a 6.35 (2.5 in.) cm hole and when the hole is greater than 3.05 metres (10 ft.) in length.

5. In order to energize one row ahead before each row fires, timing delays will be utilized on each hole using the recommended m.s./ft delays for individual rock types.

6. Stick powder is preferred where it is anticipated, or found, that normal blasting agents will not achieve the desired results. This does not preclude the use of other agents and suitable multiple delay systems.

7. Utilize the expertise of explosive suppliers and drilling and blasting professionals where required.
DRILLING & BLASTING

Common Definitions:

Burden
• Distance from the drill hole to the free face.

Stemming
• Top portion of the drill hole filled with inert material (crushed rock or drilling chips) to contain explosive impact of the gases.

Stiffness Ratio
• Ratio of rock column length to the burden. Relates to difficulty in breaking.

\[
\text{Distance } B = \text{ Burden} \\
\text{Stiffness Ratio} = \frac{\text{Column Length}}{\text{Burden}}
\]
A) To hold shot, leave sufficient burden on outside holes and/or load lightly using lomex, stick/spacers or small diameter powder.

B) Load inside holes more heavily to produce fines.

C) Horizontal spacing should be the same or greater than the vertical burden at the toes of the hole.

D) Delay pattern should give horizontal slices, sloping down towards inside face. Every hole is delayed.

NOTE
Each rock formation and site condition needs to be considered prior to deciding on length and spacing of holes, the amount and type of explosive and the type and timing sequence of the blast.

December 31, 1992
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**PERMANENT ROAD**

**Rock**

**STEEP**

greater than 60%

- R/W logs may require removal prior to blasting.
- Use controlled blasting techniques.
- Nothing to be sidecast.
- Everything to be endhauled.

- Ministry approval *may be given* to sidecast blasted rock and/or stumps and organic debris *if* there is a bench that will support the side cast.

---

**SCALE**

1:100

PR- >60%

January 7, 1993
**TEMPORARY ROAD**

**Rock**

60 – 70% SIDE SLOPE

- R/W wood may require removal prior to blasting.
- Use controlled blasting techniques.
- Ministry Review is required to decide if pull-back is mandatory.

**NOTES:**
For this type of road it may be acceptable to:
- bury organic debris and stumps
- leave stumps and organic debris in a place on fill side.

* IT IS VERY CRITICAL TO CLARIFY THAT YOU ARE BUILDING A TEMPORARY ROAD – LICENSEE IS TO DEACTIVATE BY A CERTAIN DATE!

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<tr>
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<td>Vertical - $\frac{1}{2} : 1$</td>
<td>$\frac{1}{4} : 1\frac{1}{2} : 1$</td>
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<td><strong>FILL SLOPE (FS)</strong></td>
<td>$1 : 1$</td>
<td>$1\frac{1}{2} : 1$</td>
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</table>

**SCALE**

1:100
TEMPORARY ROAD
Rock

VERY STEEP • GREATER THAN 80%

Site Specific
- R/W logs may need to be removed prior to blasting.
- Use controlled blasting.
- Nothing to be sidecast.
- Everything to be end-hauled.

Ministry approval may be given to sidecast stumps and organic debris if there is a bench that will support the sidecast.

- Ditch may or may not be required. If no ditch crown, inslope or outslope the road surface.

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</tr>
</tbody>
</table>
Consider relocating the road to avoid steepest sections.

END HAUL

* An EXPENSIVE operation!

- Give consideration to alternate logging systems.

- Spoil areas require Ministry approval.
- Use material in order of preference.
  - use for road fills, road widening, surfacing, turnouts or landings.
- Place over stable rock sidecast.
- Place in abandoned rock quarries or gravel pits.
- Place on other stable and non-productive flatter areas.
TO MINIMIZE THE HIGH COSTS OF END-HAUL, INVESTIGATE THE FOLLOWING:

At the Planning Stage:

- Relocation. Is the road in the best location to minimize excavation quantities? Take advantage of gentle terrain. It might be better to introduce a short section of steep grade to get to a bench rather than have a long section of a lesser grade on a steep slope.

- Can the end-haul section of the road be avoided by changing the logging system or landing(s) location?

- Use smaller logging trucks and yarding equipment. Build the road as narrow as possible (reducing the subgrade width from 6m to 5m reduces the volume by ±30% [bank measure]).

- Can other portions of the route be located so they are built as fills to utilize end-haul material, i.e. move the P-Line to a lower elevation on gentle slopes and achieve the desired final grade line by constructing the road as a fill. Compaction equipment will likely be required to construct fills over 3 meters in depth.

- Do an accurate route location survey with special attention to cross-section detail.
At the Design Stage:

- Design the road to minimize quantities by adjusting the horizontal and vertical alignments.
- Make the cut slope as steep as possible yet still stable.
- Calculate the amount of end-haul material required to be moved and calculate the area planned for disposal to insure sufficient area is available. Remember to use a suitable expansion and compaction factors.
- Place grade stakes on the cut side to insure only the amount of material needed to be excavated is excavated. Place fill stakes as required at the disposal site.

At the Construction Stage:

- Can a "tote road" be built through or around the end-haul section in order to utilize end-haul material for fill section(s) up-chainage of the end-haul section? This should also be a consideration at the location and design stage.
- Utilize the end-haul material for fills, ballasting, surfacing, turnouts and landings.

At All Stages:

- Be innovative.
- Explore options.
- Have the road foreman and crew involved at any or all stages of the project to insure the final plan is practical and can be done.
- Communicate the plan to all involved.

January 15, 1993
STEEP GULLIES ARE CRITICALLY IMPORTANT

PLAN VIEW

- Cut material in this section must not be sidecast
- Haul or push it away from the gully and place it where it will not cause problems.
- A "tote" road will be needed to use the waste area on the left hand side of the gulley.

SCALE
1:1000

SteepGul
January 7, 1993
DRAINAGE PRINCIPLES

Maintain the natural drainage pattern.

Every ephemeral, seasonal and perennial stream must have their own drainage structure. Can be metal, wood, plastic, concrete or in some cases a ford.

In addition, install ditch culverts to handle road surface runoff, water seeping through the cut slopes and overland flow.

**DO NOT ALLOW**

1. Silt laden ditch water to directly enter a Class I or II stream.

2. Water to run over unprotected, erodible sidecast
   
   * that is what causes erosion, siltation, road failures and in some cases, landslides.

3. Water to pond in a ditch (except for catchment basins), on the road, or on sidecasted material.

February 11, 1993
Ditch width, depth and cut slopes need to vary based on the following factors:

* the amount of water to be accommodated
* the gradient of the ditch line
* the erodibility of the soil type
* the type of road - permanent or temporary

**GENERALLY**

* ditches are to be constructed into the mineral soil

<table>
<thead>
<tr>
<th>Shape</th>
<th>Slope (S)</th>
<th>Depth (D)</th>
<th>Width (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>loose erodible material</td>
<td>wide</td>
<td>2:1</td>
<td>up to 1m</td>
</tr>
<tr>
<td></td>
<td>bottom</td>
<td></td>
<td>Variable If D=1, W=3</td>
</tr>
<tr>
<td>non-erodible material:</td>
<td>V</td>
<td>1:1</td>
<td>up to 1 m</td>
</tr>
<tr>
<td>rock, cemented soils</td>
<td>Shape</td>
<td></td>
<td>Variable If D=1, W=2</td>
</tr>
</tbody>
</table>

December 18, 1992
Ditches may not always be required.

The construction of ditches requires additional excavation into the slope. This increases the amount of material to be removed by the square of the horizontal width of the full bench, i.e.: full bench no ditch - 5 metres wide
full bench with 1 m ditch - 6

Increase in volume of excavated material is \(6^2 - 5^2 = 36 - 25 = 11\)

\[
\frac{11 \times 100\%}{25} = 44\%
\]

This increased volume results in:

* increase costs for excavation and sidecasting
* more exposed area for potential erosion and source of siltation
* increased volume to be sidecasted and possible slope overloading
* extra growing site disturbed

Ditches may not be required for:

* top of vertical curves
* temporary roads in rock
* outslope or inslope roads
* roads with swales built in
  * full bench rock cuts
    (crown, inslope or outslope)
* overland construction
BUT

* if there is no ditch road and bank seepage water must be controlled by crowning, insloping and/or by constructing a sufficient number of adequate drainage grade breaks and swales at predetermined intervals.

Open top culverts are also a good solution for roads without ditches and/or to intercept road surface water on long, steep gradients.

Grade Breaks and Rolling Dip (Swales) also are an excellent "self maintaining" drainage structure.

Ditch gradients steeper than 8% can give collected water too much momentum and the ability to carry excessive sediment and debris for great distances.

This erosion leads to filling up the ditch where the gradient is shallow, clogging culvert inlets and creating the possibility of carrying sediment into streams.
If grader leaves a berm on either side of the road, the falling rain will be forced to run along the road. In a short period of time, a surprising amount of surface material will wash away. If nothing is done, the road could become impassable within a few years.
WITHOUT OUTLET PROTECTIVE MEASURES...

...THIS will become THIS...

loose erodible fill or side cast

CULVERTS SPILLING DIRECTLY ON TO UNPROTECTED FILL SLOPES ARE A COMMON PROBLEM
SOLUTIONS

PLACE RIP RAP

INSTALL FLUME

• 1/2 ROUND OR FULL CULVERT

INSTALL CULVERT
on natural ground slope
- Skew culvert to road Centre Line by 3° for each 1% that the road grade exceeds 3% (max 45°).

- Ensure that the culvert is long enough
- Slope at least 2%

- Construct the crest of the ditchblocks lower than the road shoulder

- Erosion protection
WOOD CULVERT

- Use cedar for longer life.
- Use lower value species for temporary roads - i.e. those that will be removed following logging.

Brow logs to contain road fill (drift or secure by cable rapping to sill log)

Road surface

Filter fabric

Sill Logs (placed outside wetted perimeter, and below scour level)

- Box notch or drift stringers (punching).
- Ensure adequate length. Extend 1m beyond the toe of the fill.
CMP
(corrugated metal pipe)

Road surface

Fill depth at least 1/2 culvert diameter

Compact in 300mm layers

• Culvert bed free of sharp rocks to avoid culvert puncture.

• Compact haunches up to at least 1/3 of culvert diameter.

Rock
Blasted Rock
O.M.
Organic
Fill
Organic Debris

CMP January 3, 1993
FORDS (Squamish) CULVERTS
NEED D.F.O. & M.O.E. APPROVAL

Maximum high-water level

ROAD PROFILE
Clean shot rock or cobbles

Stream ± 10m
Shot rock/cobbles ~ ±10cm
Out slope 2-3%

Shot rock/cobbles ~ >5cm

Large shot rock or boulders ~ ±1m

STREAM PROFILE

Consider for use:
• for Class 3 or 4 streams
• for streams prone to debris torrents
• for low traffic roads
• for semi-permanent deactivated roads.

Ford
January 7, 1993
DITCHES & CROSS DRAINS

Before road construction

- Impervious layer
- Subsurface flow

After road construction

- Compacted surface reduces infiltration capacity
- No vegetation
- Cut
- Vegetation removed
- Intercepted subsurface flow

DitchXdr
January 7, 1993
Class II stream

- If stream is Class I or II, you must divert ditch flow through a cross drain onto vegetative cover, or filter out the sediment before draining into the streams.
- Open bottom culvert, or bridge may be required by Fisheries.
- Ensure that the culvert is long enough!

- Note: At this particular culvert there is a dip in the road.

- Sediment is dispersed and filtered through the forest floor.
The length and depth must provide the needed drainage, but not be a driving hazard. The cross grade should be at least 1% greater than the original road grade.

- Inslope to keep road surface runoff away from erodible sidecast.
- If sidecast is stable and vegetated then road could be outsloped.
ROAD SURFACE DRAINAGE
With or Without a Ditch

OPEN TOP CULVERT

Running Boards 10 cm x 10 cm

20 cm Diameter Logs

15 cm

Ditch Flow

Down Grade

Water Flow

30°

Ditch Plug

Plan View
Road Surface

* Used when road gradients are steep (> 16%) and rolling dip, swale, or grade break would make the road impassable for truck-haul.
Objective
To minimize surface erosion revegetate all exposed and plantable surfaces with:

* Grasses and legumes - by hand
  - by hydraulic seeder

* Shrubs

  * Specie selection for both can be site specific. Check the local Ministry R.O. Engineering for advice.

- When building road by sidecasting save the top soil and place it on top of mineral soil to provide a better growing medium. Overburden from landings and pits can also be stockpiled for future use.

- Keep the sidecast slope <70% and make it rough to provide plantable sites.

  Areas of priority
  * around streams
  * erodible sidecasts and fills
  * bridge fills
  * ditches
  * plantable cut slopes
  * spoil areas
  * gravel pits

- The time to seed is after construction in the spring after thaw and/or the fall before the freeze.
Often it is not the road construction that causes the damage but the lack of maintenance. Somebody has to be appointed to be responsible for maintenance.

1. Clean out culverts before they wash out. A 5 minute stop by an alert operator or resource assistant could prevent major damage!
2. If ditch erosion is becoming noticeable do something about it. Consider installing another cross-drain culvert.
3. Clean out ditches and culverts during and/or immediately after yarding operations and when necessary.
4. Ensure road surface drains properly. Maintain adequate crown or inslope/outslope the road surface.
5. Look for and repair sloughing cut banks.
6. Drain ponding water.
7. Look for tension cracks. If a failure appears likely, pull back the sidecast. If it is settlement, fill in the tension cracks by excavating and repacking the road bed to prevent water from entering and further saturating the fill and lubricating a potential failure plane. Keep water away from such areas.
8. Minimize disturbance to revegetated areas. Revegetate disturbed areas caused by maintenance activities.
9. **Inspect roads:**
   * during and after logging; clean out ditches and culverts;
   * prior to Fall rains;
   * during and/or after major storms;
     * while you are driving the road; fix what you can while you are there and report potential problems to those who are responsible for that road.
10. Remove or frequently breach grader berms to provide drainage relief. Care required to choose outlet location.
DEACTIVATION

KEY POINTS

• Locate and construct the road to minimize the need for deactivation works.

• There must be a deactivation plan - know what it is and carry it out.

• It must identify the short/long term needs for the road.

• Deactivate as you go - expensive to bring equipment back.

• Deactivation measures can include:
  * bridge and culvert removal
  * construction of fords
  * road crowning, insloping or outsloping
  * construction of cross-ditches and/or water bars
  * cut slope stabilization
  * ditching
  * sidecast pull back
  * slide rehab projects
  * armouring
  * vegetation
DEACTIVATION

- Depending on what the short and long term plan for the road or area is, deactivation of a road can include some or all of the above measures.

- Deactivation work is best done during dry weather.

- The main concept for all levels of deactivation is to insure the "natural drainage pattern" is established in a maintenance free fashion and that water is dispersed in small amounts in intervals that do not cause damage.

- Always be careful where water is to be directed. Many slides or other types of damage has occurred because of the lack of attention to this important consideration.

- Don’t trust ditches

THE MINISTRY HAS 3 LEVELS OF DEACTIVATION:

1. Temporary (Seasonal)
2. Semi-Permanent (Rotation Maintenance)
3. Permanent

February 11, 1993
1. Temporary (Seasonal) Deactivation:

- Use temporary deactivation when regular use of the road is to be suspended for up to three years.
- Do when a road is to be left unmaintained.
- Do for roads or road sections having ditches prone to plugging or washing out.
- Decide what kind of access is required (2wd, 4wd, ATV, Mountain Bike, Trail, etc.).

(a) Remove or breach any windrows on the outer edge of the road surface.
(b) Carry out inspections after major storms, during spring breakup and prior to fall rains, to assess the adequacy of ditches and culverts, and requirements for improved drainage works or road surfacing or revegetation.
(c) Carry out required maintenance.
(d) Repair bridges as necessary to protect the user during the period of deactivation.
(e) In areas of sensitive and steep terrain, or heavy rainfall, construct waterbars or cross-ditches along the road to prevent accumulation and channelizing of excessive flow down the road surface or ditch line.
(f) Do whatever is required to protect the road and the other resource values that may be affected.
(g) Remove drainage structures as required.
(h) Drain the road surface as necessary by crowning, insloping or outsloping.
2. Semi-Permanent Deactivation (Rotation Maintenance):

Use semi-permanent deactivation for winter roads, for roads in particularly isolated areas where regular use is suspended for up to three years, and when harvesting is suspended until further logging or the next rotation.

- Decide what type of access is required (2wd, 4wd, ATV, Mountain Bike, Trail, etc.).

(a) Except for flat areas with minimal downslope consequences, restore the natural flow patterns by removing all existing stream culverts, restoring channel stability, and installing fords where possible if access is required during the period of deactivation. Alternatively, back up stream culverts with similarly sized cross-ditches on the downhill side.

(b) Back up stream culvert excavations with a cross-ditch on the downhill side, where overflow of the stream channel is anticipated.

(c) Except for flat areas with minimal downslope consequences, remove all cross-drain culverts and replace with cross-ditches. Ensure that ditch blocks are intact.

(d) Construct additional cross-ditches on steep grades, at locations of heavy ground water seepage, at switchbacks and at road junctions.

(e) Construct cross-ditches using the criteria given in the sketch on Page 47.

(f) Remove temporary and semi-permanent bridges or, if the bridges are to be left in service, repair and replace them as necessary to protect users during the period of deactivation.

(g) Remove or breach any windrows on the road surface.

(h) Outslope/inslope the road surface, as appropriate.

(i) Pull-back sidecast fill onto the outsloped road grade, to ensure drainage, where there is a high risk of slope failure where stability of the fill is questionable. Place this fill material against the cut slope at the angle of repose or flatter. Ensure that cross-ditches are installed where the ditchline ends. Revegetate exposed soils surfaces.

(j) If erosion or sedimentation is a concern, armour the exposed erodible bottom surfaces of waterbars, x-ditches and fords and their outlets.

February 11, 1993
3. Permanent Deactivation:

Use permanent deactivation when the road is to be closed permanently.

(a) Restore the natural flow patterns by removing all existing stream culverts and restoring channel stability.
(b) Back up stream culvert excavations with a cross-ditch on the downhill side, where overflow of the stream channel is anticipated.
(c) Remove all cross-drain culverts and replace with open cross-ditches, and ensure that ditch blocks are intact.
(d) Construct additional cross-ditches at locations of steep grades, heavy ground water seepage, at switchbacks and at road junctions, and where ditches are prone to plugging.
(e) Construct cross-ditches using criteria given in the sketch on Page 47.
(f) Remove all bridge superstructures. Remove substructures where failure will affect downstream values.
(g) Remove any windrows on the road surface.
(h) Outslope/inslope the road surface, as appropriate.
(i) Pull-back sidecast fill onto the outsloped road grade, to ensure drainage, where there is a high risk of slope failure during major rainstorms, or where stability of the fill is questionable. Place this fill material against the cut slope at the angle of repose or flatter. Ensures that cross-ditches are installed where the ditchline ends. Revegetate exposed soil surfaces.
(j) Scarify the road surface, if required, and revegetate.
Cross-ditch

**Purpose:**
To capture and divert both road surface water and ditch water off and/or across the road.

**Notes:**
- Excavate the cross-ditch to a depth that will allow a direct hydraulic connection to road-side ditch.
- Provide a ditch block on the downhill side of the cross-ditch.
- Construct cross-ditch with minimum skew angle of 30 degrees to the perpendicular of the road centre-line.
- Construct a berm on downgrade side of cross-ditch.
- Flatten berm and widen ditch to accommodate vehicle traffic, as necessary.
- Do not direct water to an erodible area.
- Protect cross ditch channel and outlet as necessary to prevent excessive erosion.

January 5, 1993
NOTES:
- angle 30 degrees as shown
- ditch block
- berm on downhill side
- vegetative or rip-rap protection at outflow
- driveable with 4WD
- inlet about 1 m wide; outlet about 3 m wide (as measured on the inside of the waterbar)
- can be constructed by grader, bulldozer, backhoe or other equipment with a blade or backhoe
- compact the berm to facilitate vehicle passage.
Waterbar

Purpose:
To capture and divert road surface water off the road to the fill side or across the road to the ditch side (reverse waterbar).

Note that the waterbar is unlike the cross-ditch where the ditch water is also a concern.

Notes:
• Depth of waterbar ditch below the road surface is typically shallow.
• Skew as required.
• Install a berm on downgrade side of waterbar ditch.
• Flatten berm and widen ditch to accommodate vehicle traffic as necessary.
• Provide erosion protection as necessary at the outflow.

January 4, 1993
Normal Waterbar- Directs road surface runoff toward the fill side of the road

Reverse Waterbar- Directs road surface runoff toward the ditch - used when water is to be kept away from erodible side cast
CROSS DITCH AND WATER BAR SPACING GUIDE
FOR ROADS & SKID AND BACK SPAR TRAILS (in metres)

Note: This is only a guide - field conditions will dictate the actual spacing.
Never direct water to an erosion-prone area - adjust spacing to avoid such areas.
The main concern is where water will be directed.

<table>
<thead>
<tr>
<th>Road Gradient</th>
<th>Silts &amp; fine sands</th>
<th>Coarse sands &amp; cohesive clays</th>
<th>Gravels &amp; rock ballast</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 5</td>
<td>100</td>
<td>160</td>
<td>210</td>
</tr>
<tr>
<td>6 - 10</td>
<td>80</td>
<td>110</td>
<td>160</td>
</tr>
<tr>
<td>11 - 15</td>
<td>50</td>
<td>90</td>
<td>130</td>
</tr>
<tr>
<td>16+</td>
<td>Site Specific</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This spacing must be modified for slope position and sideslope steepness as follows:

Correction Factors

<table>
<thead>
<tr>
<th>Slope Position</th>
<th>Side Slope (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-20</td>
</tr>
<tr>
<td>Upper slope</td>
<td>1.0</td>
</tr>
<tr>
<td>Middle Slope</td>
<td>0.8</td>
</tr>
<tr>
<td>Lower Slope</td>
<td>0.7</td>
</tr>
</tbody>
</table>

See notes on Page 51
A. To use the tables:
1. Divide the road into sections of similar grades, soil types and slope.
2. Measure the average road gradient in percent.
3. Visually estimate the soil type in the ditch and on the road surface. Choose the spacing required for the most erodible soil if ditch and road surfacing material differ. **Erodibility generally decreases:**

| SILT—FINE SAND—CLAY—GRAVEL—CEMENTED MATERIAL—COARSE GRAVEL—SHOT ROCK |

4. Choose the slope position.
5. Measure the average sideslope for the road section.
6. Choose the basic spacing from the road gradient and soil type, and multiple it by the appropriate correction factor.
   **EXAMPLE:**
   Silt soil, road gradient = 15%; side slope = 60%, middle slope.
   Water bar spacing should be about 50 x .6 = 30 m. This can be considered the maximum spacing.

B.
Soils are identified by a visual estimate and are classified to the high percentage of the grain size percent. If a soil is estimated to contain 20% silts and sands and 80% rock ballast, then use the spacing for gravels and rock ballast.

**It is stressed that the outlet of the waterbar/cross ditch is the governing factor when choosing the location in the field...and not this table.**
OUTSLOPING

Outslope 2% (10 cm in 5 m)
Remove berm
Good practice
Original road
Filter can be brush, non-merchantable, shrubs, etc.

NOTES:
• outsloped roads provide a means of dispersing water in a low-energy flow from the road surface
• appropriate where fill slopes are stable
• good for contour roads having gentle gradients and gentle ground slope, and for roads having no ditches, or ditches subject to plugging
• waterbars still required
• if the road is left open for use, then outslope should be increased to 4% (i.e. 20 cm in 5 m).
NOTES:
• used to keep water away from unstable fill slopes
• can be used with or without a ditch
• used for short sections of road
• install cross drains as required to avoid build-up of fast running water.
SIDE CAST PULL BACK

RECONTOURING:

Do this when:

- The road is no longer needed for access
- There is a danger of a failure and downslope impacts
  - place pull back material against the cut slope
  - leave a rough surface to provide holding areas for grass and legume seed
  - place stumps and logs on top of pull back. Orient them up and down slope to prevent them from downslope movement, or place parallel to the slope partially buried to trap finer soils to create a growing medium
- seed as you go or for larger jobs where hydro seeding is required use of a helicopter maybe appropriate

Note:

- Normally required on slopes >60% and/or where there are tension cracks
- Only do what needs to be done
- Keep the natural drainage patterns open and free from pull back material
- Pull back slope to be ±65%. The reconoured slope should be ±65%
- Does not need to be a tidy job.

![Diagram of pull back process]

Place logs, stumps and organics on top

Recontoured slope (±65%)

Old road

Pull back to original ground line or (±65%) which ever is less

Outslope the old road surface and/or cross ditch to direct subsurface drainage to desired locations.

PullBack
April 28, 1994

54
Partial sidecast pull back is generally required on slopes <65% and is done where there are tension cracks in the sidecast or road bed and/or there is potential for downslope impact. The pull back is done in a manner that leaves the outside road bed intact and passable by 4wd, ATV’s, dirt or mountain bikes or by foot (i.e. a trail).

* Pull back just what is required.
* Place against cut slope or spread on the road.
* Maintain natural drainage patterns.
* Outslope or inslope.
* Construct water bars as required.
* Hand seed exposed non-travelled surfaces with an appropriate seed mix as you go.
* All slopes to be left at <65%

January 4, 1993
SEMI-PERMANENT DEACTIVATION

Note: Wood culvert has been removed.

- In this case fill slopes need not be pulled back.
- Average side slope is about 50%.
- Road could still be passable by 4wd if cross ditches are constructed properly.
- Direction of water bars may be reversed to direct water towards the ditch.
Road Construction

We have learned that this is to be a Permanent Road; soil is glacial till...

1) What is the slope of the line?
2) Horizontal line is our road surface. Width = ______ m.?
3) Draw cut slope 1/2 : 1
4) Draw fill slope 1 1/2 : 1
5) Draw overburden layer 0.6 m. thick.
6) Show how pile of stumps and overburden will look.
7) Measure required width of right-of-way.
Questions
1. How many culverts would you place in this section of road?
2. What else must you know before you can answer this question?
CULVERT EXCERCISE

Refer to page 'D'

1. Clearly indicate location of ditch blocks.

2. What things would you consider before deciding whether or not to use a "trash rack" at this site?

3. Where might you place the "trash rack"?
DEACTIVATION EXCERCISE

Refer to page 'D'

If you were permanently deactivating this road and you were worried about the large amount of debris upstream, what would you do for this section of road?
DEACTIVATION EXCERCISE

Refer to page 'G'

1. Clearly note on the attached sketch what should be done to permanently deactivate this road.
   - Road grade is 15% (up hill to the right).
   - Soil is sandy.

Use these symbols:

- Pull back fill slopes
- Construct cross-ditch
- Ditch block
DEACTIVATION EXERCISE

1000 mm CSP

DITCH

8 m SPAN LOG BRIDGE

45% SIDE SLOPE

40% SIDE SLOPE

STEEP 70% SIDE SLOPE

* road width is exaggerated

SCALE
1:5000
EXERCISE 'H'

Sketch how you think this temporary road will look after 15 years—assume it was NOT deactivated.

- What damage has been caused?
- How could that damage have been prevented?
Introduction
Most private and public forest lands in the western U.S. are plagued by extensive networks of abandoned, currently unused or unwanted access and service roads built by landowners and resource managers. For example, after timber harvest and restocking, there may be little need or incentive for forest landowners to properly maintain spur roads which no longer access marketable timber resources. The tendency is to abandon these currently unneeded roads until access to the area is again desired.

In steepland areas of northwestern California, many harvested watersheds contain extensive road networks that have been progressively constructed over several decades. For example, in a 30,000 acre area of the Redwood Creek basin that is currently managed for timber resources, over 175 miles of logging road have been constructed since 1947. As of 1985, from 65 percent to over 90 percent of the road systems in four inventoried sub-basins were no longer being maintained. An average of 53 percent of the road network was no longer passable to vehicles. Many sections of these abandoned and unmaintained roads exhibit serious and persistent erosion problems. Other roads remain largely intact but display the potential for substantial erosion during future winter storms.

The degree of erosion and off-site sedimentation effects caused by abandoned roads is dependent upon a number of factors including: 1) the date of road abandonment, in relation to the occurrence of past and future winter storms and flood events, 2) terrain characteristics (slope steepness, the number and size of stream channels crossed, natural slope and soil stability, and soil erodibility), and 3) road characteristics (adequate culvert size, proper culvert location and installation, adequate debris "filters" to prevent culvert plugging, and the grade of the roadbed over the stream crossing).

Erosion and sedimentation effects caused by forest roads can be both local and far removed from the site. For example, an undersized culvert which becomes plugged or whose capacity is exceeded by storm runoff can cause erosion at the site where it is installed as all or part of the fill crossing is washed out. In addition, streamflow can be diverted from the channel and cause considerable erosion in downslope areas where gullies will form, and in far removed fish-bearing streams where the sediment is finally deposited.

In addition to being spatially displaced from its source, the adverse effect may also be delayed in time. The undersized culvert on an abandoned road may not plug or its capacity be exceeded for many years, and the resultant erosion and sedimentation may not occur for decades after the original disturbance. An entire road network, which is not being permanently maintained or whose culverts have been under-designed (because they were installed many years ago), may be...
not reveal significant erosional impacts from road construction until a major storm causes widespread culvert failure, stream crossing erosion and stream diversions. Similarly, mass soil movement of unstable sidecast materials may not occur for years following placement, as organic debris decomposes and subsurface hydrology interacts with newly loaded slopes.

**Fluvial (Gully) Erosion from Abandoned Roads**
Stream diversions at logging road and side trail stream crossings have been found to be the overwhelming, leading cause of sediment production from abandoned, unmaintained roads in the 280 mi² Redwood Creek basin. Diverted waters often created large, complex gully systems which are responsible for documented increases in hillslope drainage density, sediment production and yield, and enlarged stream channels. These hillslope processes, in turn, led to further off-site impacts associated with stream channel aggradation. Although most road-related erosion occurs during relatively short-lived, large magnitude storms, the heavy runoff merely acts to trigger accelerated erosion that had been pre-destined by certain landuse practices.

Triggering mechanisms for stream diversions are almost always traceable to either culvert plugging, undersized culverts whose capacity is exceeded during storms, or the absence of a culvert at the crossing of an intermittent or ephemeral stream. By whatever method the culvert is overtopped, diversion of streamflow can only occur if the stream crossing itself was constructed with a high **diversion potential (DP)**; that is, at locations where the road and ditch system slope away from the crossing in at least one direction. This allows streamflow to be diverted down the road.

To describe this situation, a diversion potential rating system was developed. It is based solely and simply on the gradient of the road as it crosses a stream channel. Each crossing is examined in the field and assigned one of two potentials. For crossings with no diversion potential, the road gradient on both approaches dips into the stream channel at the crossing. Even if the culvert plugs, flow cannot escape the drainage system. For crossings with a high diversion potential, the road surface slopes away (down) from the stream crossing in at least one direction. The steepness of the road as it slopes away from the crossing affected the size of the gully that developed on the road or in the ditch, but any slope more than about 0.5 percent was found to be sufficient to divert the streamflow.

Uncontrolled streamflow at crossings constructed with no diversion potential can, at worst, only erode the volume of material placed in the fill crossing; no extensive gully networks can develop from diverted water. However, stream crossings constructed with a high diversion potential have been inadvertently designed to create extensive gully systems on adjacent hillslopes when stream flow exceeds the capacity of the culvert, for whatever reason, and is diverted out of its natural channel.

There are thousands of stream crossings in the Redwood Creek watershed, and on other lands throughout northern California, which exhibit high diversion potentials but whose culverts have not yet plugged. These crossings are "loaded guns" waiting for a large storm and flood to cause
culvert plugging and stream diversion. Many other culverted crossings have already plugged and experienced stream diversions at least once since they were installed.

For example, 70 percent of the logging road stream crossings surveyed in the lower Redwood Creek basin were constructed with a high diversion potential. Of these, 56 percent have experienced diversions at least once, only to be reconstructed again with a high diversion potential. Based on the sample percentages, we estimate there are over 5,200 stream crossings in the 280 mi² Redwood Creek basin alone which have been constructed with a high stream diversion potential. When major storms occur in the future, or if the stream bed very mobile at these sites, the mechanism still exists to once again plug the culvert, divert the flow and significantly accelerate fluvial sediment yield to stream channels through hillslope gullyng.

**Mass Movement of Sidecast Materials**

The winter of 1981-2 produced several moderate precipitation events (maximum ten-year return interval for 24 hour rainfall) which resulted in numerous hillslope failures in the lower Redwood Creek basin. Each was in some way associated with logging roads or tractor skid trails constructed for previous timber harvesting. Particularly evident were debris flows and debris torrents. Coincidentally, these are the hillslope landslides that are most amenable to cost-effective treatment and prevention.

A detailed study of these failures yielded a data base which has been used to refine watershed rehabilitation and erosion control practices in the basin and could be of considerable utility in improving and directing road construction, road closure and road abandonment practices on steep forest land elsewhere (LaHusen, 1984). Identification of their pre-failure morphology and likely location are essential for effectively closing and erosion-proofing roads which cross steep, stream-side slopes.

All 40 hillslope failures observable from low altitude aerial reconnaissance of a 77 mi² study area were examined. In addition to a dimensional survey, a field inspection of each failure was performed to document slope shape, slope gradient, hillslope aspect, and distances to streams and the nearest major change in slope gradient. Site examination also included soil profile descriptions, vegetative associations and spatial relationships to roads, skid trails, and tractor or cable yarded harvest units. The year of road construction and harvest histories were determined from aerial photographs. Impacts inventoried included: 1) size and quantity of sediment and organic debris delivered to streams, 2) formation of log-jams and 3) damage to old growth forest lands. Local continuous rainfall records were analyzed to define precipitation intensities and to identify possible hydrologic controls on slope stability.

Although the failure volumes (157 yd³ - 12,550 yd³) and sediment delivery volumes 0 yd³ - 8.250 yd³) varied widely, specific site conditions were remarkably similar. All debris flows originated in and consisted predominately of landing, road or skid trail side-cast fill material. Once initiated, these mass movements often induced failure in original ground.
Most features were located in or immediately downslope of large clearcuts. Soils on the 30 to 36 degree slopes were deep (more than 3.5 ft) inceptisols with a fine-loamy texture typically exhibiting gleyed subsurface horizons less than one meter in depth. Limited bedrock exposures revealed saprolitic (deeply weathered) Redwood Creek schist. Most failures occurred in minor swales or headwaters of ephemeral drainages where no surface runoff was evident and no culvert had been installed through the road prism. The inherently wet conditions of these sites were substantiated by unusually dense and vigorous hydrophilic vegetation which showed prominently on color infrared aerial photographs.

**Treatments for Road Abandonment and Closure**

It is easy to overlook or not recognize land use practices which have high probabilities of resulting in far removed effects which, once initiated, will result in persistent downslope and downstream changes. However, the recognition of future causes of erosion and downstream effects can be predicted through knowledge of the relative importance of various erosional processes operating in a watershed or along an abandoned road network. A *large percentage of these persistent effects can be entirely avoided by minor changes in road construction and road abandonment practices.*

The ability to define specific road fills and sidecast sites as areas with high failure potential is essential to optimize cost-effective erosion prevention, and road stabilization or removal practices. Field identification of relevant conditions enables you to predict potential failure locations and prevent most debris flows directly originating from logging road fills. The limited number of road segments thus identified can be assigned a high priority for treatment to substantially reduce this source of sediment production and road failure. Treatment of susceptible sites not only lessens impacts to downstream resources but reduces reconstruction costs when access to the area is again needed.

*Improved road and skid-trail location and design could have prevented most of the significant sidecast and fill failures* studied in Redwood Creek, and reported in research from elsewhere in northwestern California and western Oregon. Where it is necessary for roads to cross steep ephemeral drainages, two road design practices could lessen the incidence or magnitude of failures: 1) minimizing the amount of fill placed in swale areas by reducing the width of the road and following the hillslope contours more closely, and 2) providing adequate drainage through and/or under road prisms. As typical forest roads cross a hillslope, the fill/cut ratio is usually the greatest in swales (topographic depressions). Studies show these relatively deep, wide fill wedges appear to impede subsurface flows. This results in elevated pore-water pressures and leads to hillslope failure where slopes are steep and groundwater is shallow.

On mountainous slopes managed for timber production, *road construction and abandonment practices must also address and anticipate the occurrence of extreme storms* which frequently trigger widespread fluvial erosion. This, too, can be effectively accomplished by employing preventive land management techniques.
For example, measures which prevent stream diversions would largely eliminate fluvial gully erosion and its long term effects, as well as substantially lowering efforts needed to reconstruct roads after prolonged abandonment. Simple land management measures to accomplish this include:

1) constructing and reconstructing road and skid trail stream crossings so they have no diversion potential (i.e., both approaches dip into the crossing);

2) performing regular and storm maintenance of roads and drainage structures throughout the life of the road;

3) putting unused roads "to bed" by removing culverts and excavating fill crossings;

4) installing adequately sized culverts, with debris filters, and

5) excavating skid trail stream crossings following harvest operations.

Recent changes in California’s Forest Practice Rules have begun to address most of these issues, but only with respect to future harvest operations. Thousands of miles of existing, abandoned forest roads still need treatment before future erosional impacts can be expected to decline. Long term maintenance of road systems needs to be made an integral part of all forest operations. If some roads cannot be maintained, because of limited funds or personnel, then they should be "erosion-proofed" (put-to-bed).

**Techniques and Costs for Effective Road Closure**

Steps in successful, cost-effective road closure and abandonment include:

1) determine specific road treatment objectives (controlling current erosion for short term closure; preventing future erosion for longer term closure; or complete road removal (erosion proofing alignment with no intention of reopening)),

2) systematically inventory and map erosion problems along the road alignment to identify sites and features which could impact downstream resources if left untreated (unstable cut banks or fill materials, unstable landings, road surface drainage problems, compacted areas and stream crossings, etc),

3) development road treatment prescriptions (including excavation locations and specifications, cut and fill requirements, fill storage sites, equipment needs (types, times and costs), and projected labor-intensive treatments (mulching, planting etc),

4) contract for and/or supervise heavy equipment operations,
5) apply the most cost-effective hand-labor erosion control and revegetation treatments to sites which were disturbed during heavy equipment operations, and

6) fully document and evaluate the work effort (costs and hours) and results (effectiveness).

1. Determine objectives: The specific objectives set for road treatment affect all future work prescriptions and the level of road closure costs. For this reason, it is imperative to development concise, clearly stated objectives that are within the available budget and accomplish the desired result. Three different types of objectives are listed above. Each implies differing levels of effort and expense.

2. Inventory potential erosion problems: Once objectives are set, sites along the road alignment are inventoried (on erosion inventory forms) and mapped on aerial photos. Collected information includes a site number, the location of the site, nature of the erosion problem (potential landslide, fill failure, stream crossing, etc.), the volume of erosion likely to occur in the future, the amount expected to be delivered to a stream (if any), the likelihood the erosion will actually occur (erosion potential), an evaluation of its treatability, and the heavy equipment and labor-intensive work prescriptions (including expected times and excavation volumes) needed to solve the problem or prevent it from occurring.

The location of all existing and potential erosion problems along the road alignment must be clearly identified, described and quantified. Using a standardized data form, the information from each site can be input to a database program, compared with other sites and prioritized according to the need for the treatment and the projected cost-effectiveness of performing the work.

Erosion problems along the road are differentiated according to whether or not they: 1) threaten the future integrity of the roadbed, 2) threaten to damage downstream resources through increased sedimentation, or 3) both. The volume of potential future erosion at each potential work site must then be quantified to finally determine the cost-effectiveness of treatment areas along the road alignment. Those possible treatments that are not cost-effective, or otherwise required, become lower priority elements of the road closure plan. Erosion problem areas and work sites that would, if left untreated, severely damage the road or cause downstream sedimentation become high priority for treatment.

3. Develop treatment prescriptions: The third step in a cost-effective road closure plan is to develop specific heavy equipment prescriptions and to implement the erosion control and erosion prevention work at the selected work sites. It is very likely that most road segments will require intensive treatment at only a few locations. The remainder of the alignment may require very little work to prevent future erosion and maintain the integrity of the roadbed. Thus most or the road bed may be left largely intact.

There are seven basic heavy equipment techniques used for road closure or road removal (Table 1). Typical road treatments include (from least intensive to most intensive) surface
Table 1. Techniques and costs for erosion proofing forest roads

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Typical use or application</th>
<th>General Costs¹</th>
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<tbody>
<tr>
<td>Ripping or decompaction</td>
<td>improve infiltration; decrease runoff; assist revegetation</td>
<td>$500 - $1600/mile</td>
</tr>
<tr>
<td>Construction of cross-road drains</td>
<td>drain springs; drain insloped roads; drain landings</td>
<td>$1/ft ($25-$50 ea)</td>
</tr>
<tr>
<td>Partial outsloping (local spoil site)</td>
<td>remove minor unstable fills; disperse cutbank seeps and runoff</td>
<td>$1/ft³; $2500 - 9500/mile</td>
</tr>
<tr>
<td>Complete outsloping (local spoil site)</td>
<td>used for removing unstable fills where nearby cutbank is dry and stable</td>
<td>$5000 - $10000+/mile</td>
</tr>
<tr>
<td>Exported outsloping</td>
<td>used for removing unstable road fills where cutbanks have springs and cannot be buried</td>
<td>$2 - $4/ft³, depending on haul distance</td>
</tr>
<tr>
<td>Landing excavations</td>
<td>used to remove unstable material around landing perimeter; spoil stored locally</td>
<td>$1 - $2/ft³, high organics can increase costs</td>
</tr>
<tr>
<td>Stream crossing excavations</td>
<td>complete removal of stream crossing fills</td>
<td>$1.50 - $3.50/ft³, 2x for endhauling</td>
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¹ Heavy equipment treatments performed using D-7 size tractors and hydraulic excavators. Costs will vary with equipment types and operator experience.

decompaction (ripping), ripping and cross road drain construction, partial outsloping and complete outsloping. Low standard roads crossing moderately sloping, stable terrain can be totally obliterated for $5000/mi but costs can vary dramatically with treatment intensity, terrain characteristics and the number and size of stream crossings. Successfully erosion-proofing most roads will cost a fraction of complete road removal. Costs are highly dependent on the frequency and nature of the potential erosion problems along the alignment.

4. Controlling erosion on bare soil areas: The fourth, and next-to-last, step in road closure is to control erosion on the areas disturbed by heavy equipment road closure work, and then to revegetate the alignment. In many coastal areas, natural revegetation will be sufficiently rapid to stabilize most of the roadbed. However, even on the most favorable sites, immediate (short-term) erosion control may be needed at sensitive locations such as 1) in the streambed of excavated stream crossings (to protect against downcutting or channel widening), 2) on the sideslopes of excavated stream crossings (to control surface rilling and gullying where sediment could enter a live stream) and 3) on large expanses of steep, bare soil which have access to a watercourse (to control surface rilling and gullying).
Most of these erosion control practices are performed using hand labor, perhaps with some equipment assistance. The costs and general effectiveness of these techniques have been documented for steeplands in the Redwood Creek basin and elsewhere (Weaver and Sonnevil, 1984). A summary table of costs and cost-effectiveness, and technical specifications is available from the author.

5. Monitoring and documentation: The fifth and final step in the road closure process consists of post-project documentation of work (rates and volumes) and costs (labor and equipment hours for each job element). Quantitative documentation is critical to derive cost estimates for future work, to improve the cost-effectiveness of work prescriptions and to justify future projects based on a comparison with typical costs of road reconstruction where road closure has not been performed. Photographic documentation can also be a valuable tool for training future equipment operators in the techniques for road closure.

Conclusion
It is no longer enough to close roads by simply closing the gate or blocking the road. Specific techniques are available to successfully prevent road- and landing-related debris flows, to prevent or correct stream diversions (the leading cause of serious gullying in many areas), to prevent stream crossing washouts, to prevent fill failures and to dewater gullies and landslides fed by road runoff. Existing Forest Practice Rules already specify employing such preventive practices for stabilizing new temporary roads.

Planned, systematic road closure can be an inexpensive and successful technique for minimizing long term resource damage caused by roads built in steepland areas. It provides land managers with the opportunity to permanently prevent or control the majority of post-construction road-related erosion, and its associated on-site and downstream impacts. Implementing technically sound road closure practices also minimizes structural damage to widespread, expensive forest road networks that cannot be economically maintained for the long time period between harvest rotations.