BC Ministry of Forests

ENGINEERING MANUAL

BRITISH COLUMBIA
Ministry of Forests

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Table of Contents

Preface

The Ministry of Forests Engineering Manual is intended for internal use by Ministry staff however it is accessible to the public.

The manual is a primary Ministry reference for operational and administrative engineering practices and is useful as a training and succession tool. It provides policy and guidance related to forest road and bridge administration, design, construction, maintenance, and deactivation activities overseen or undertaken by the Ministry.

Some of the information in the manual includes:

- Policy direction on implementation of legislation and regulations
- Mandatory procedures
- Project checklists
- Business best practices
- Technical and professional best practices
- Professional reliance considerations

The manual promotes safety. For more comprehensive guidance on safety or Ministry protocols (such as contracts and procurement) staff must refer to specific applicable guidance outside of this manual.

In exceptional situations where implementation of a policy will not achieve a satisfactory result, a local decision-maker can implement a variation for that specific application. In such cases, the rationale for variation should be clearly documented and placed on the project file.

The Engineering Manual is a “living document” which will be regularly reviewed and improved. The responsibility for overseeing the maintenance and updating of the manual rests with the Engineering Branch Manager, Policy and Legislation.

1 Road Administration

This chapter deals with all aspects of establishing and administering forest roads by Timber Sales Managers (TSMs) and District Managers, including Forest Service Roads (FSRs), permit roads, and roads established by Special Use Permit (SUP). The chapter also provides information on forest road management, transfer, closure, and signage. The responsibilities and practices for administering a forest road will be clear and transparent for those activities carried out on the road right-of-way, from establishment to discontinuation and closure.

1.1 Mandatory Procedures & Best Practices

For the majority of road administration issues, this chapter provides guidance and direction to BC Timber Sales, Timber Operations and Pricing to ensure that an industrial user is able to obtain the necessary permits for their road use or is able to be relieved of the obligations of a permit upon the completion of their use.

Much of the due diligence on the part of BC Timber Sales, Timber Operations and Pricing staff relates to providing timely actions to issue or cancel permits and ensuring that necessary information is contained in the permits being issued.

Following is a table that summarizes in chronological order of the mandatory procedures and best practices with respect to the administration of forest roads. Links are provided to direct the reader to the location in the manual text where the item is discussed.

Table 1-1 Road Administration

Results to be achieved: issuing authorities for industrial road use (Forest Act s. 115-121) for non-industrial use of an FSR, protecting against damage, sediment delivery or endangerment to property, health or safety (FRPA s. 22.1, 22.2; Forest Service Road Use Regulation s. 6, 9, 10, 11; Land Title Act Regulation section 15) consent to connect to an FSR (FRPA s. 23)	
B1	Limit activities on non-status roads to minimize any site-specific risks (to users or the environment) that come to the attention of the TSM/District Manager. [see Types of Roads]
B2	When acquiring legal access, ensure that FOR Forest Land Acquisitions is consulted early in the process and are involved in negotiating appropriate compensation for the land and improvements, which is based on fair market value [see Legal Access]. Compensation value estimates are to be documented and defensible.
M1	The status or clearance width for both FSRs and road permit roads must be 75 m (37.5 m each side of the proposed centreline of the road) [see Road Status]
B3	When including dumps, drop sites, and service landings in a Road Permit, ensure that the permittee provides, for each one: its location and size,

	how long it will be needed for use, and a reclamation prescription for the site. [see Issuing Road Use Permits]
B4	Ensure that a Road Use Permit: limits the weights and sizes of vehicles, when necessary; controls seasonal use; provides indemnification to the Crown for the permittee's actions; provides deposits for works near utilities such as private railway crossings, or in other situations to indemnify the Crown against any damages or losses the Crown might suffer; and identifies maintenance responsibility for the road or road section. [see Issuing Road Use Permits]
B5	Before the Road Use Permit of the designated road being maintained is cancelled, ensure that the road has been maintained to the level required for non-industrial use, to the extent necessary to ensure there is no material adverse effect on a forest resource use, as evidenced by: structural integrity of the road prism and clearing width are protected; and drainage systems of the road are functional. [see Cancelling Road Use Permits]
M2	Except where an industrial user has been delegated responsibility for maintenance under a Road Use Permit, BCTS must be responsible for ensuring that maintenance is carried out on those FSRs that: BCTS (or its predecessor, the Small Business Forest Enterprise Program [SBFEP]) has constructed or established since the inception of the program; or BCTS has not constructed or established, but will be using exclusively for industrial purposes there has been no agreement with Timber Pricing and Operations Division to shift the responsibility back to the District Manager [see Administration of Existing FSRs]
B6	Ensure that any surface maintenance of an FSR undertaken by a commercial or public user is authorized by a Forest Service Road Maintenance Agreement (FS 1205). [see Entering into FSR Maintenance Agreements]
M3	Any non-transportation-related works (facilities) constructed within an FSR right-of-way must be authorized by a Works Permit (NRS 103)(DOC). [see Issuing Works Permits]
M4	All traffic control signs used on Forest Service rights-of-way must conform to Ministry of Transportation and Infrastructure standards, if those standards include a sign to deal with the traffic control issue. [see Signs on Forest Service Roads]
B7	Ensure that a TSM/District Manager authorizes any connection to an FSR. [see Road Junctions]
B8	When reviewing a request for subdivision access from an FSR, ensure that the road is built to a sufficient standard to safely handle the type and volume of traffic. [see Subdivisions Off Forest Service Roads]

M5	FSRs that are surplus to the requirements of BC Timber Sales, Timber Operations and Pricing, as determined through some local access planning process carried out by the District Manager, must be permanently closed as an FSR by the District Manager following deactivation by Timber Pricing and Operations Division/BCTS or preceding transfer by the District Manager through either deactivation or transfer to another user or agency. [see Discontinuing and Closing FSRs]
B9	Ensure that a licensee deactivates a road permit road when: there is no apparent future industrial use for the road; no other party is able or willing to assume responsibility for the road after the Road Permit is cancelled; and the District Manager determines that the road will not be required for ongoing public access. [see Cancelling Road Permits]
M6	When a TSM/District Manager agrees with a licensee that the latter no longer needs a road permit road, confirms that there are no other industrial users that currently require the road, and decides that the road should not be deactivated, the TSM/District Manager must: cancel the Road Permit; and declare the road to be an FSR. [see Declaring FSRs]

In the above table of chronological events:

- **M** = Mandatory procedures
- **B** = Best practices

1.2 Types of Roads & Applicable Permits or Authorizations

Several categories of resource roads can be built or established under the Forest Act or the Forest and Range Practices Act. Note that non-status roads (roads without tenure from the ministry or other agencies) are not within the jurisdiction or responsibility of the Ministry of Forests except where the ministry is required to take action as an agent of the province. In these cases, limit activities on non-status roads to minimizing any site-specific risks (to users or the environment) that come to the attention of the TSM/District Manager. Restoring access is not an acceptable objective of any such work.

1.2.1 Forest Service Roads

A Forest Service Road (FSR) is one that is defined under the *Forest Act* (Sec. 1). TSMs/District Managers administer FSRs and ensure that maintenance is carried out on them until the roads are either transferred to another jurisdiction or deactivated and discontinued and closed.

Table 1-2 Administrative responsibility/authority matrix for administering FSRs

FSR Task	DM	TSM	Authority *

Declare a road to be an FSR	Yes	Yes	FA sec 120.1
Carry-out construction and maintenance	Yes	Yes	FA sec 121 (1) (a) delegation including Dir Eng Br FPPR Authorized person as defined
Enter onto private land to; • take road construction materials • construct and use temporary roads • conduct drainage to take water from the road	Yes	No	FA sect 121, (1) (c), (d) & (e) delegation
Carry-out maintenance	Yes	Yes	FPPR sec 79 (3) Government must maintain
Require payment from users for purpose of timber harvesting, silviculture or natural resource development or prescribed users of prescribed FSRs for maintaining the roads	Yes	No	FRPA section 22.3 (.01) (d) & (1) delegation
Address structural defects of a bridge	Yes	Yes	FPPR section 75 by an Authorized person as defined
Deactivate a road	Yes	Yes	FPPR Authorized person as defined
Authorize a person to carry out significant road work in relation to a FSR	Yes	Yes*	FRPA sec 23.1 (2) delegation * TSM limited to authorizing a person to join a road to a FSR
Exempt a person for use of a FSR for a timber harvesting purpose, silviculture purpose or natural resource development purpose	Yes	No	FRPA section 22.1 (2) delegation
Issuance of RUP	Yes	No	FA sec. 117 (2) delegation Authority granted to the Oil and Gas Commission under

			the OGAA as “specified provision” as defined
Issue FSR Maintenance Order to a RUP holder	Yes	No	FPPR section 79 (4)
Impose requirements on the holder of a RUP for building a bridge, installing a major or fish stream culvert	Yes	No	FPPR sec. 79 (8) (bridges and major culverts administered as significant road work)
Obtain structure records from RUP holder upon cancellation of RUP	Yes	No	FPPR sec. 77 (3)
Obtain structure records from a RP holder upon cancellation of RP	Yes	Yes	FPPR sec. 77 (3)
Issuance of Works Permit	Yes	No	FSRUR sec 11 (administered as significant road work)
Entering into Maintenance Agreement with a non-industrial user	Yes	No	Letter Agreement FS1205
Discontinuation and closure	Yes	No	FA sec 121 (9) (a) delegation
Transfer to MOTI	No	No	FA sec 121 (9) (a1)(c) delegation to Dir, Eng Br & Dir, Forest Ten Br
Close or restrict use	Yes	No	FRPA sec 22.2 (3)
Erect traffic control devices	Yes	No	FSRUR sec 12

* *Forest Act* (FA), *Forest and Range Practices Act* (FRPA), Forest Planning and Practices Regulation (FPPR), Forest Service Road Use Regulation (FSRUR) *Oil and Gas Activities Act* (OGAA)

1.2.2 Declaring a Road Permit Road an FSR

When a licensee no longer needs a road permit road, and the TSM/District Manager confirms that there are no other industrial users to issue a road permit and decides that the road should not be deactivated, the TSM/District Manager **must**:

- cancel the Road Permit; and
- declare the road to be an FSR.

The purpose of this "declaration" is to ensure that the road will be properly inspected and maintained until such time that a new industrial user is issued a Road Use Permit. Prior to declaration, inspect the road or road section that will become the FSR to:

- determine the present condition of the road and any structures;
- identify potential risks; and
- obtain the necessary data for the appropriate bridge register and road management system.

Note: The declaration process applies only to converting road permit roads. Once the above steps have been taken, complete the Declaration of Forest Service Road (FS 302) form and attach an electronic version of the map/plan.

Signing the electronic form finalizes the decision to declare the road as an FSR, and the local office can proceed with any operational activities as though the road was an FSR, even if the new map notations have not yet been completed.

1.2.3 Administration of Existing FSRs

The District Manager or the Timber Sales Manager is responsible for the maintenance of existing FSRs, except where an industrial user has been delegated responsibility for maintenance under a Road Use Permit. Unless the two managers have agreed otherwise for individual roads or BCTS no longer needs the road for future harvesting, BC Timber Sales (BCTS) **must** be responsible for ensuring that maintenance is carried out on those FSRs that:

- BCTS [or its predecessor, the Small Business Forest Enterprise Program (SBFEP)] has constructed or established since the inception of the program; or
- BCTS has not constructed or established, but will be using exclusively for industrial purposes;

and, for any FSRs that do not meet these criteria, Timber Operations and Pricing Division is responsible for ensuring that maintenance is carried out.

Negotiate the administrative responsibilities at the local level between the District Manager and TSM on an annual basis in situations where:

- multiple industrial users (both major and timber sale licensees) are operating on an FSR;

- the primary user designated to carry out the road maintenance (under Road Use Permit) changes;
- the industrial use is seasonal in nature and it is not obvious who should be designated responsible for the ongoing FSR maintenance; or
- the road use includes a mix of commercial operators, rural residents, and recreational access.

Consider the following when negotiating the administrative responsibility for FSRs:

- whether the road in question provides access to communities (in this case, the long-term responsibility would be that of Timber Operations and Pricing Division);
- the future use of the area by BCTS or others;
- the current level and type of industrial use (including other non-forest related industrial users); and
- whether the access is currently required to reach residences, cabins, commercial operations, parks or recreation sites (in this case, the long-term responsibility would be that of Timber Operations and Pricing Division).

Once the TSM has determined that BCTS will no longer need an FSR for future harvesting, report this to the District Manager, for determining whether:

- the road should be deactivated by BCTS; or
- the responsibility for its administration should be shifted to Timber Operations and Pricing Division.

Also, small-scale salvage operations are not considered to be representative of operations that alone would generate future maintenance responsibilities for BCTS. These salvage operations are not tied to one program, but “piggy-back” on any regular harvesting operations.

1.2.4 Administration of Existing FSRs

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- the primary user designated to carry out the road maintenance (under Road Use Permit) changes.
- the industrial use is seasonal in nature, and it is not obvious who should be designated responsible for the ongoing FSR maintenance; or
- Road use includes a mix of commercial operators, rural residents, and recreational access.

Consider the following when negotiating the administrative responsibility for FSRs:

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Also, small-scale salvage operations are not considered to be representative of operations that alone would generate future maintenance responsibilities for BCTS. These salvage operations are not tied to one program, but "piggy-back" on any regular harvesting operations.

1.2.4.1 Road Use Permits and Maintenance Responsibility

All industrial users on an FSR are required to obtain a Road Use Permit (FS 102.pdf) ,unless an exemption is granted in accordance with section 22.1 (4) of *FRPA*. Road Use Permits, including those Road Use Permits required by BCTS licensees, are issued by the District Manager. Ensure that the proposed use will not adversely affect other authorized users of the road, and that the permit:

- limits the and sizes of vehicles, when necessary;
- controls seasonal use;
- provides indemnification to the Crown for the permittee's actions;

Designate only one Road Use Permit holder to be responsible for carrying out maintenance operations on a road or road section. [Forest Planning and Practices Regulation (Sec. 79(4))].Other Road Use Permit holders are expected to contribute a reasonable amount to the expense of maintaining the road FRPA section 22.3 Notice of requirement for payment by user of the road

Record and track the administration of Road Use Permits and maintenance responsibility in a system (such as LRMOPS) including:

- identification of RUP holder;
- identification of the RUP holder responsible for maintenance;
- the issuance and termination dates for RUP and maintenance order /or the conclusion of any maintenance responsibilities.

Ensure that the process for shared maintenance of an FSR described in the Shared Road Maintenance/Cost Sharing Process TSL holders and Major Licensees.PDF is applied where the process in place on a given road is not suitable for one or more of the parties expected to share the maintenance costs.

The current statutory framework *Commercial Arbitration Act.* provides a framework as the fallback when two parties cannot reach agreement on shared road use and reasonable contributions to road maintenance costs. The District Manager is not responsible for resolving disputes, but may assist in appointing a mutually agreed upon third party to find a workable solution to the dispute.

FRPA Division 2-Roads and FPPR Sec 79 Road Maintenance and FPPR Sec.81 Wilderness Roads provides the statutory framework for road maintenance until the road is deactivated in accordance with FPPR Sec. 82 Road Deactivation. . Refer to Chapter 6 of this manual for details of road and structure inspection and maintenance.

1.2.4.2 Issuing Works Permits

Any non-transportation-related works (facilities) constructed within an FSR right- of-way **must** be authorized by a Works Permit (NRS 103)(DOC). Examples include water, gas, hydro, or telephone line works. The Works Permit does not authorize road works or the harvesting of timber, nor does it convey tenure to any part of the right-of-way other than to permit the facilities to remain in place.

1.2.4.3 Entering into FSR Maintenance Agreements

For situations where the wilderness level of maintenance is not sufficient for a commercial or public user, that user may elect to undertake some or all of the surface maintenance of the FSR as authorized by the Forest Service Road Maintenance Agreement (FS 1205) The agreement authorizes the end user to carry out incremental maintenance on FSRs at no cost to the ministry. The works envisioned under this agreement are routine in nature. FSR Maintenance Agreements are issued by District Managers, including any proposed non-industrial maintenance proposed for FSRs that are administered by BCTS.

1.2.4.4 Deactivating, Discontinuing and Closing FSRs

FSRs that are determined to be surplus to the requirements of the ministry, according to current budgetary requirements and as determined through some local access planning process carried out by the District Manager, **must** be discontinued and closed as an FSR by the District Manager following deactivation or preceding transfer by the District Manager (delegated to Director of Forest Tenures) to another user or agency, in keeping with the *Forest Act* [Sec. 121 (9)] and as delegated from the minister.

To declare an FSR discontinued and closed once it has been deactivated, or once it has been determined that another tenure will be established over the road, the District Manager **must** complete and sign an FSR Discontinue and Close Form (FS 301)(PDF), and attach the Exhibit A. Forward a copy of the completed FSR Discontinue and Close Form (FS 301) with attachments to the FOR Forest Land Acquisitions Group, Forest Tenures Branch in Victoria to ensure FSR project history remains current.

In accordance with the *Forest Act* [Sec. 121 (9)], notification of FSR discontinuance and closures **must** occur and shall be at the discretion of the District Manager (as delegated from the minister), depending upon scale and location of the FSR as per the 2012 FOR policy called Discontinue and Close Forest Service Roads Notification (PDF). In accordance with that policy, the methods and dates of notification must be recorded on the FSR Discontinue and Close Form (FS 301)(PDF).

Notification should be done a minimum of three (3) months prior to the FSR closure unless ecological, environmental, or public safety circumstances dictate otherwise.
Once the District Manager signs the FSR Discontinue and Close Form (FS 301), proceed with any administrative activities, such as transfer to the Ministry of Transportation and Infrastructure MOTI or to a tenure holder, as though the road is not an FSR any longer, even if new map notations have not yet been completed.

1.2.4.5 Transferring FSRs from FOR to MOTI

For those instances where MOTI wishes to take over administrative responsibility of an FSR as per the *Forest Act* [Sec. 121 (9) (c)], the next step, after reaching agreement in principle with the local MOTI manager, is to involve the FOR Forest Land Acquisitions Group, Forest Tenures Branch to arrange for the delegated authority of each ministry to execute the assignment. Prior to the final execution of the assignment, the District Manager **must** declare the FSR discontinued and closed by completing and signing an FSR Discontinue and Close Form (FS 301)(PDF).

1.2.4.6 Transferring public highways to FOR

For those instances where FOR wishes to take over administrative responsibility of a public highway there are currently two methods available, after reaching agreement in principle with the local MOTI manager **and** FOR Resource District Manager:

- **Method 1** – transfer the public road as per the *Land Act* [Sec. 106] in consultation with Forest Land Acquisitions Group, Forest Tenures Branch.

- **Method 2** – obtain the survey of the public road, or survey the public road, and contact FOR Forest Land Acquisitions Group, Forest Tenures Branch in Victoria to submit the necessary land transfer in the provincial Land Title System. Authority has been delegated to the respective directors at FOR Forest Tenures Branch and BCMoT Properties and Land Management Branch. This may involve the payment of property transfer taxes.

District staff would then proceed with the FSR establishment process.

1.2.5 Road Permit Roads

Road permit roads are roads built, used, and maintained by timber licensees under a BCTS Road Permit (FS 582)(DOC) or a Road Permit Major Licensee fs582.docxBoth of these permits are issued to a harvesting license holder [see *Forest Act* (Sec. 115 and Sec. 121)]. Such roads usually connect cutblocks and tie harvesting areas to FSRs, public highways or log dumps, but may also include on-block roads that are built before a Cutting Permit is issued. Other industrial users are expected to contribute a reasonable amount to the expense of maintaining the road [*Forest and Range Practices Act* [Sec. 22.3 (1) and (2)].

Optionally, grant an exemption for the use of the road in accordance with the Act (Forest Planning and Practices Regulation section 79.1).

A road is defined in the Forest Planning and Practices Regulation (Sec.1) as including landings. Therefore, in addition to the usual temporary landings authorized for harvesting the right-of-way timber, it is acceptable for a road permit to also authorize the upland portion of log dumps, helicopter drop sites, and helicopter service landings. However, when including such dumps, drop sites, and service landings in a Road Permit, ensure that the permittee provides, for each one:

- its location and size;
- how long it will be needed for use; and
- a reclamation prescription for the site.

BCTS Road Permits

The BCTS Road Permit includes Schedule R which provides for:

- roads constructed, maintained, and deactivated by the Timber Sale Licence holder; and
- roads constructed and maintained by the Timber Sale Licence holder, but not deactivated by the holder.

Schedule Rconstruction and maintenance specifications form contractual requirements. Construction specifications are either:

- General Construction Specifications – form fields on the schedule are filled in for such details as design vehicle load, road width, and road alignment; or
- Detailed Construction Specifications – road design drawings, such as plan profiles, are included as part of the package.

Schedule R Maintenance specifications are divided into two sets of requirements:

- those concerning the maintenance of roads during operations – this maintenance is intended to protect the road from damage (such as from erosion and from debris at culvert inlets); and
- those concerning works and repairs once operations are complete – these works are intended to put the roads in shape when the Timber Sale Licence expires.

1.2.6 Cutting Permit Roads

A cutting permit road is one authorized by a Cutting Permit (or by a license that does not have Cutting Permits). Such permits are only used on roads that are wholly contained within a cutblock. The one exception to this requirement is for roads constructed under a Woodlot Licence: all roads in that case can be authorized by a Cutting Permit, including those outside a specific cutblock. Other industrial users are expected to contribute a reasonable amount to the expense of maintaining the road [*Forest and Range Practices Act*, Sec. 22.3 (1) and (2)].

1.2.7 Special Use Permit Roads

Under the Provincial Forest Use Regulation, a Special Use Permit fs998a Special Use Permit (FS 998A)) is issued by a District Manager for the construction and maintenance of a road for non-forest use, including construction and maintenance of bridges and other drainage structures for non-forest use. Currently, these roads are normally restricted to mining operations outside a claim area, but other resource uses can be contemplated where another agency is not in a position to issue tenure over the road.

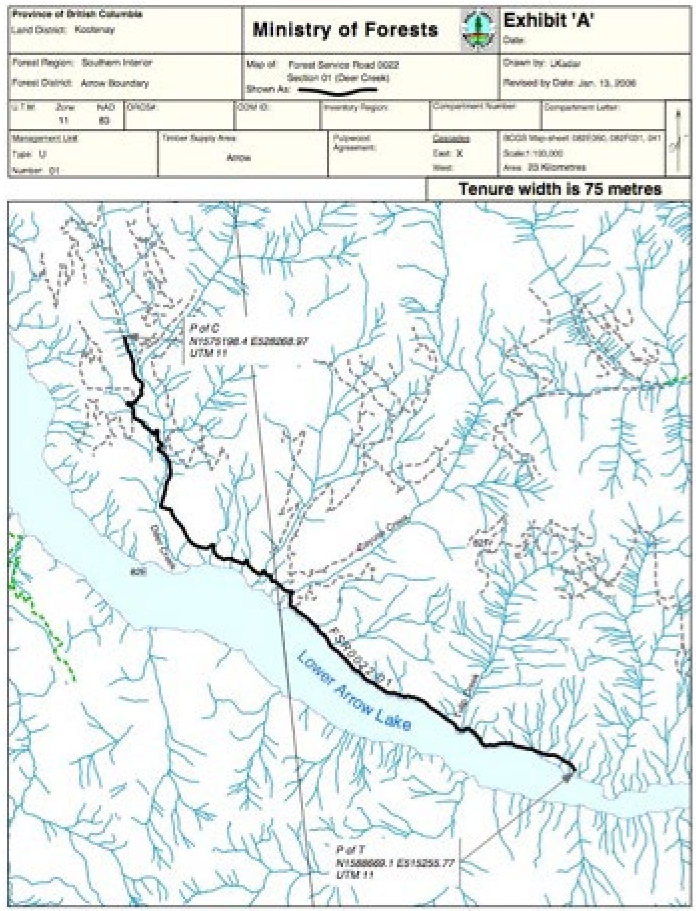
1.3 FSR Establishment and Junctions with Ministry of Transportation & Infrastructure Roads

1.3.1 Road Status – Preparing Road Status Requests

When a new FSR or road permit road is required, or when an existing non-status road is to be established as an FSR or road permit road, some basic information is needed to move the decision forward to implementation. To identify what interests or rights that may exist and to establish a registered interest over the land, carry out a road status (adjudication report). The status or clearance width for both FSRs and road permit roads **must** be 75 m (37.5 m each side of the proposed centreline of the road), which is also the width of the FSR right-of-way and the width of the Road Permit. When preparing a status request, ensure that:

- the proposed or actual road has been plotted on the area reference map and an Exhibit "A" sketch produced;
- a status of the route shown on the Exhibit "A" sketch has been performed and all file or other reference numbers recorded;
- each file or other reference number has been investigated to determine if any tenures have been issued;
- copies of all tenure documents have been obtained and examined to determine if a conflict between the tenure rights and the proposed road location exists; and
- negotiations with tenure holders have been conducted and the agreement of the tenure holder obtained before road use or construction begins.

Figure 1-1 Exhibit "A" sketch



Road Status & Resolving Road Status Conflicts

Road establishment involves identifying appropriate road location, “clearing” such road routes, and issuing appropriate authorization to physically construct the road. Appropriate status and clearance procedures are key to avoiding conflicts, including possible legal action with other authorized tenure holders.

Status Procedure

The status process involves plotting the selected road route and file reference number on a digitized reference map. This updates the reference map so that other potential tenure holders are aware of the prior rights of the applicant. It also provides a report of existing tenures on or within 37.5 m each side of the centreline of the road.

Clearance Procedure

The adjudication report is actually a report of file numbers and legal descriptions related to tenure and other land use activities assigned by various resource agencies. In order to complete the clearance process, research all file numbers and legal descriptions in the land information systems [e.g., Tantalis (Gator)] to determine whether any conflicts exist and, if so, their nature. Determine whether a tenure has been issued or is pending, and whether the tenure area and tenure rights conflict with those about to be granted to the road applicant. Where conflicts do exist, resolve them before the road is constructed and used. Conflicts may arise with SUPs, mineral claims, Indian Reserves, leaseholds and private property.

Resolving Conflicts with Mineral Claims

Where pits and quarries are identified for the purposes of Forest Service Road (FSR) building and maintenance, establish a *Forest Act* map notation or *Land Act* reserve (plus a mineral staking reserve in the case of rock quarries, or placer staking reserve in the case of gravel pits located in placer mining areas) to prevent future tenures being issued under the *Mineral Tenures Act* (Sec. 22). The first step is to consult the office of the Chief Gold Commissioner Miner Acts Title to check for recently issued mineral tenures or to request a mineral staking reserve.

If proposed operations are to take place adjacent to a mineral, placer, or other tenure – and so possibly interfere with the tenure holder's rights – consult the tenure holder before operations take place.

- If the proposed operating area is in conflict with a mineral, placer, or other tenure and operations will still proceed, seek consent from the tenure holder to surrender rights to the proposed operating area. Document such consent (for amending a mineral or placer claim, confirmed with a quit claim from the mineral claim holder). Ensure that the tenure area is amended before operations begin. Protect operations in such amended areas by a staking reserve, as above.
- If consent cannot be obtained, relocate the gravel pit or quarry. If it is not possible to do this and the consent of the tenure holder cannot be obtained, consult with FOR Forest Land Acquisitions for advice on arbitration procedures, as provided for in the *Mineral Tenure Act* or other relevant Acts.

1.3.2 Legal Access for FSRs

Through the planning process, decide whether the access requirements related to the establishment of an FSR are of a temporary or permanent nature (long term).

When acquiring legal access, ensure that FOR Forest Land Acquisitions negotiates appropriate compensation for the land and improvements, which is based on fair market value.

To initiate the acquisition, complete a Right-of-Way Acquisition Request (FS 959A) form, and submit it using the Shana forms (or by pdf) located on the ministry's forms directory. Time is of the essence when requesting a right-of-way, as negotiating compensation and providing the legal survey can be time consuming.

Where access is required for a limited period of time, consider the use of a temporary statutory right-of-way agreement (Guidelines for Legal Forest Access). Secure permanent or long-term access with a dedicated right-of-way involving a legal survey and purchase of right-of-way from the landowner.

Obtain a junction permit from the Ministry of Transportation and Infrastructure where an FSR joins a public highway. Exercise care in choosing the best junction site possible – ideally, a T junction with ample sight distance – since relocating highway junctions can be difficult and expensive, particularly where private property is involved.

1.3.3 Right-of-Way Acquisition Compensation

The framework of the Ministry's compensation policy is based on the existing legislation. The *Forest Act* and the *Ministry of Forests and Range Act* (Section 5) provide the legislative authority to the Minister of Forests, Lands and Natural Resource Operations to acquire land for forestry purposes. The *Expropriation Act* and the *Financial Administration Act* both refer to the requirement of government to deal in terms of fair market value when acquiring land and other assets.

Ultimately, the fair market value for land, combined with a value determined for depreciated road improvements, and certain damages represents the compensation due to a property owner. This value may be capitalized to represent an annual fee for a short-term agreement or paid in full for long-term or permanent acquisitions. Road use fees or charges based solely on the volume of timber or the amount of use are not reflective of fair market compensation and do not serve the equitable interests of the property owner and the Province. However, volume and use charges may be applied to maintenance costs, provided they reflect the actual costs to maintain the road used.

Estimating the Value of Depreciated Road Improvements (DRIV)

Direct all matters regarding the acquisition of land and the application of the compensation policy to the Senior Land Acquisition Officer, FOR Forest Land Acquisitions, Forest Tenures Branch (FTB). Acting on the advice and recommendations of Ministry Forest land acquisitions staff, the Director, FTB, who is the only delegated signing authority for the Minister, reviews all land agreements to determine that the principles of fair market value have been applied, and signs off on the agreement.

It is recommended to involve and consult with ministry Forest Lands Acquisitions staff early in the process when considering entering into an agreement for the purchase [dedication] or rental [statutory right-of-way agreement] of land to become a forest service road. Forest Lands Acquisitions staff will assist in the determination of appropriate compensation.

Ministry engineering staff will be required to inspect or have inspected by individuals knowledgeable in road construction and costing, the current road condition and provide an estimate for the value of the road and associated improvements in its present condition. This value is referred to as the depreciated road improvement value [DRIV]. Forest Land Acquisition staff are not specialists in road cost estimating. A DRIV will need to be provided by ministry engineering staff to the Forest Land Acquisition Project Manager working on each forest service road project. The DRIV will be used in the compensation negotiations and if necessary, where a mutually satisfactory agreement cannot be reached, in expropriation. Any DRIV calculation should be documented and supported by background preparation guidelines/policy/direction for provincial consistency. In the case of expropriation, the compensation estimate (DRIV) and methodology is required to be shared with the land owner per section 20 (1) (e) of the *Expropriation Compensation Act*.

There are a number of ways that can be used to estimate the DRIV. One method is to estimate what the road would have cost to construct in the first place and subtracting the cost of repairs to bring it back to its original condition.

1. Inspect the road

2. Determine how much it would cost to construct the road today. Possible approaches to estimating value of the road and improvements include:

    - Detailed engineering cost estimate, Information from the appropriate appraisal manual
    - Use of comparable, recent road construction contract results
    - Application of local knowledge
    - Current value per unit rate

3. Determine the costs of any road failures, required upgrades and repairs to bring the existing improvements up to a new road standard [culverts, structures, ditching, surfacing, grading, brushing, etc. (some wooden bridges might have a negative value (require works to remove or other measures to make safe)].

4. Reduce the cost of [1] by the cost of [3] and you have the DRIV.

Assistance in developing road construction cost estimates can be obtained through the Engineering Branch, Engineering Group for the respective region.

Acquiring Right-of-Way for Railway Crossings

Crossing a railway right-of-way is costly and requires ongoing maintenance obligations. The type of crossing and required safety features are dictated by the railway authority. In cases where railway crossings cannot be avoided, obtain tentative approval in principle from local railway authorities and prepare a plan. Key steps in this process are:

- submit a formal application for approval by railway and federal or provincial transport agencies, including the plan and the following information:
    - whether the proposed road right-of-way is junior or senior to trackage;
    - who will pay for construction and crossing;
    - what the projected daily traffic count will be for all vehicles (public and industrial);
    - whether school buses will be using the crossing; and

- allow eight months from the time of application to the time the crossing permit receives final approval.

Legal Access for Utility Right-of-Way Crossings

Obtain interim approvals for the location of the crossing from local utility (power, oil/gas, and communications) field offices. Special considerations are involved if the utility is situated within private property.

Legal Access for Road Permit Roads

Where the status/clearance process has identified conflicts with a proposed road permit route, licensees are expected to resolve such conflicts themselves. If the permittee is unfamiliar with the steps necessary to resolve such conflicts, assistance can be obtained from the private sector. FOR Forest Land Acquisitions can provide a list of firms and individuals providing this service.

Legal Access for Cutting Permit Roads

Since proposed harvest areas are statused and cleared before Cutting Permits are issued, a separate status and clearance procedure is not necessary for roads constructed within these areas. Because the permittee needs the flexibility to locate roads as best suits harvest operations, and as these roads are usually of a temporary low-order nature, their location is normally not specified in the Cutting Permit document itself.

Legal Access for Special Use Permit Roads

Under certain circumstances, roads within a provincial forest or wilderness area may be authorized by SUP, in keeping with the Provincial Forest Use Regulation [Sec. 7 (1)(a)].

These types of roads are normally issued to holders of rights authorized by the *Coal Act*, *Geothermal Resources Act*, or *Mineral Tenure Act* and may also be issued to Clean Energy Projects (CEP) proponents if they choose to apply for a road authorization under a SUP rather than under a *Land Act* Licence of Occupation, but in rare cases may be issued for other purposes.

SUP roads are normally mapped and statused in a process similar to that described for FSRs or road permit roads (described above). Like Road Permits, Special Use Permits authorize road construction and use only on unalienated Crown land. If tenure conflicts are identified during the status process, Special Use Permit holders are expected to resolve such conflicts before road construction and use. If the Special Use Permit holder is unfamiliar with the resolution process, this service is available from the private sector. FOR Forest Land Acquisitions should be consulted for further information on private sector firms or individuals providing this service.

Road Junctions

Ensure that a TSM/District Manager authorizes any connection to an FSR using a Road Junction Requirements Form Letter (FS 1209)(DOC).

Note: A Road Permit, Cutting Permit and Timber Sale Licence incorporate an authorization for a junction of the road permit road to the FSR.

Before approving an application to connect, ensure that the location, sight distances and drainage are acceptable (see Road Design Criteria). Ensure that requests from landowners for variance from the established alignment conditions are accompanied by a Professional Engineer's recommendation.

1.3.4 Authorization to connect a Forest Service Road to a Provincial Public Highway designated as a controlled access highway

The authorization of the Minister responsible for the *Transportation Act* is required, to create or change access to a forest service road, natural resource or industrial road off a provincial highway designated as a controlled access highway in accordance with ***Transportation Act***

Restrictions on access

49 (1) A person must not,

a. without the authorization of the minister, construct or reopen, or allow the construction or reopening of, any means of access to or from a controlled access highway, or
b. obtain access to or from any controlled access highway other than by way of an access point
   i. constructed by the minister, or
   ii. authorized by the minister under paragraph (a).

Refer to the Ministry of Transportation and Infrastructure (MOTI) highway use permit application process for access

1.4 Subdivision Off Forest Service Roads

The subdivision process involves the legal survey and creation of a number of separate smaller parcels of land from a larger parcel of privately owned or Crown land.

When reviewing a request for subdivision access from a Forest Service Road (FSR), ensure that the Engineering Group Leader confirms that the road is built to a sufficient standard to safely handle the type and volume of traffic. The minimum requirements set out in the Land Title Act Regulation (Sec. 15) (BC Reg. 334/79) concern the road width as it relates to the maximum width of vehicle allowed on the road.

Examine the width of the entire length of the FSR from the end of the nearest public road to the location of the proposed subdivision and determine whether or not the road width meets the requirement of the Regulation.

In addition, record all relevant factors (e.g., the general condition of the roads, expected traffic volumes, condition of structures, and safety features such as turnouts, widenings, and signage).

The process of subdivision normally requires the dedication and construction of public access roads administered by the Ministry of Transportation and Infrastructure, or a municipality if the subdivision falls within an organized area. However, the use of other forms of access to subdivided areas is also considered, and Section 15 of the *Land Titles Act Regulation* deals with access by FSRs and prescribes the maximum allowed width of vehicles based on different minimum road widths. Minimum widths mean the width of the entire running surface from the nearest public road to the subdivision, other than for permitted exceptions that are spelled out in the Regulation.

Approving Officers consider a number of factors when deciding whether a particular subdivision application should be approved. However, the Approving Officers cannot approve a subdivision application that relies on an FSR for access until the Engineering Group Leader certifies that the FSR in question meets the width requirements of the Regulation.

1.5 Signs on Forest Service Roads

Signs may not be erected on a Forest Service right-of-way without the approval of the District Manager. In general, commercial signs are not approved.

Standard informational and resource road radio communication signage has been developed for use on Forest Service roads:

- Forest Service Road Sign Standards

Other traffic control signage shall conform to Ministry of Transportation and Infrastructure (MOTI) standards:

- Manual of Standard Traffic Signs & Pavement Markings

The Forest Service road sign **must** be placed at the start of an FSR system where there is potential for public or multiple industrial users. Determine:

- whether name signs are necessary on a particular road;
- the size of the signs; and
- where the signs should be placed.

A primary justification for a traffic control sign is that the risk to users is greater than what a user would normally encounter on an FSR such that the safety of the user may be dependent on the sign being in place.

1.6 Abandoned Vehicles on Forest Service Rights-of-Way

Occasionally, ministry staff is faced with having to deal with abandoned vehicles or logging or road building equipment along Forest Service rights-of-way.

Consider the following when deciding whether or not to remove or dispose of such vehicles:

- The vehicle or equipment may or may not have some residual value.

- The vehicle or equipment owner may or may not be identifiable if the licence plates or serial numbers have been removed.
- The cost of moving and disposing of the vehicle may be greater than the recoverable costs.
- The vehicle may be causing a danger to other road users or it may be a visible disturbance.

1.7 Temporary Closures of Forest Service Roads

Where the District Manager determines that a road will be closed temporarily because of safety, sediment delivery, or property issues, place a "road closed" sign at the beginning of the road and install a physical barrier to keep vehicles off the road. Notify potential users of the closure through some form of local advertising. Closures of roads for environmental protection issues such as pressures on wildlife populations are carried out by Ministry of Environment staff through their legislation, and not through the powers provided to FOR.

1.8 Cancelling Road Permits

Cancel a licensee's Road Permit at the request of the permittee where it is evident that the permittee will not need the road any longer to harvest timber under a harvesting agreement.

Ensure that the permittee deactivates a road permit road when:

- there is no apparent future industrial use for the road;
- no other party is able or willing to assume responsibility for the road after the Road Permit is cancelled; and
- the District Manager determines that the road will not be required for ongoing public access.

Where a major licensee has deactivated a road according to regulations, it normally provides a declaration to the District Manager that the licensee has met its deactivation obligations. The District Manager has up to 15 months to approve the works after the licensee has provided the declaration. Once the works are approved, or the 15 months passes without inspection, the District Manager will terminate the road permit.

For those road permit roads that a TSL holder deactivates, the TSM ensures that the road deactivation was carried out properly and in accordance with the regulations, and then notifies the District Manager that the work has been completed. The District Manager will normally rely upon the advice of the TSM but may carry out an inspection of the deactivated road to ensure that the work has been carried out satisfactorily.

For those road permit roads operated by a TSL holder where future use of the road by non-BCTS users may preclude deactivating the road, the TSM notifies the District Manager accordingly, preferably well in advance of the completion of the TSL. Should the District Manager determine that the road should be deactivated in any event, he will notify the TSM, again prior to completion of the TSL. If the District Manager determines that the road will not be deactivated, the District Manager may either issue a permit to another user or declare the road to be an FSR under the administration of the District Manager.

Once the road has been deactivated, or the tenure has been shifted to another user, or the road has been declared to be an FSR, subject to the notifications and possible inspections as described in the preceding paragraphs, the TSM will terminate the existing road permit held by the timber sale licensee.

Do not create non-status roads by cancelling Road Permits for non-deactivated roads unless either transferring the responsibility to another party or taking on a clear ministry administrative role by declaring the road an FSR.

1.9 Cancelling Road Use Permits

An industrial user may apply to the District Manager to be relieved of their Road Use Permit on an FSR when that road will not be required for industrial purposes. Before the Road Use Permit of the designated maintainer is cancelled, ensure that the road has been maintained to the level required for non-industrial use, to the extent necessary to ensure there is no material adverse effect on a forest resource, as evidenced by:

- structural integrity of the road prism and clearing width are protected; and
- drainage systems of the road are functional.

Otherwise, the permit will remain in force even while the user is idle for periods of time, and any designated maintenance obligations remain during those same periods.

1.10 Cancelling Works & Special Use Permits

Works Permits and SUPs will either expire on a given date (as shown in the permit) or be cancelled when the permittee advises the District Manager that the permit is no longer required for its intended purpose.

If a Works Permit has been issued for a Forest Service Road (FSR) that is about to be permanently discontinued and closed or transferred, and the permittee intends to continue using the works, refer the permittee to another agency to obtain a replacement tenure for these works.

1.11 Protocol Agreements Related to Roads

- Currently Ministry of Forests Engineering Branch has not established any formal protocol agreements related with other agencies or branches)

1.12 Resource Road Mobile Radio Communications

Mobile radio communications is extensively utilized, to improve upon safe travel, on resource roads in BC. Mobile radios are used to communicate location and direction when travelling on resource roads.

Most resource roads are "radio assist" and the use of mobile radios for communicating location and direction is not mandatory. Always drive safely according to road and weather conditions and if using a mobile radio, do not solely rely on mobile radio communications recognizing that not everyone has or is using a mobile radio.

Government in collaboration with Innovation, Science and Economic Development Canada (ISED), FPInnovations, industrial and other stakeholders, implemented a standard radio communication protocol for use on Forest Service Roads (FSR) and other natural resource roads across the province. FSRs with industrial activity and many other resource roads have adopted and are using the standard protocols which consist of:

1. dedicated, standardized bank of resource road radio channels
2. standard call protocols - call content and order
3. standardized signage

1.13 Standard Bank of Resource Road Radio Channels

The standard bank of resource road radio channels has been distributed across the BC landscape to minimize the likelihood of interference. The standard bank of resource radio channels has been provided by ISED for exclusive and dedicated use for mobile radio communications when travelling on resource roads in BC. ISED is the federal agency with the responsibility for licensing radio spectrum in Canada. By agreement, the Ministry of Forests is responsible for administering the use of the standard bank of resource road radio channels in BC.

The standard bank consists of 40 channels (35 RR (Resource Road) and 5 LD (Loading) channels). The standard bank of RR channels is administered by FOR at the operational level. District engineering staff will monitor and adjudicate RR channel assignments and changes, for use in the field, and update channel assignment maps as required.

The standard bank of resource road mobile radio channels is available, to those with mobile radio licenses, for programming at local commercial mobile radio shops.

All industrially active FSRs shall implement RR channels from the standard bank of resource road radio channels. Although, many industrial users have adopted the use of the RR channels on their roads, it is important to note that not all resource roads are required to adopt the protocols and standard bank of resource road radio channels.

1.14 Standard Call Protocols

The standard default radio call protocol, for drivers using radios to communicate location and direction, is as follows:

- when starting, stopping, entering or leaving a resource road
- at “must call” signs
- every 2 kilometers
- “up” with increase or “down” with decrease in km signs
- in order of: road name, km, up/down, number of vehicles (if convoy calling), vehicle type (optional)
- no call if part of a convoy called by a lead vehicle within 1 km

The default call protocol is used unless otherwise provided for by a sign posted on the road in which case call according to the posted protocol.

Local road user/safety groups may establish alternative call protocols which vary from the standard. The local call protocols would need to be provided on signage posted on the roads of applicability.

1.15 Channel Assignment Maps

The standard bank of resource road radio channels have been carefully distributed across the B.C. landscape. For each resource district, channel assignment maps have been developed assigning channels to polygons and in some cases specific high use roads to minimize potential interference between operating and surrounding areas. The full landscape is mapped with channel assignment polygons with the intent of avoiding interference between polygons and surrounding areas.

Resource district engineering staff is responsible for operational administration of the channel assignments on the landscape within their area and for maintaining the channel assignment maps. Modifications to channel assignment maps require ISED approval.

The channel assignment maps should not be relied upon for appropriate channel selection for use in the field, as in some cases, the channel assignments may have not been implemented on the ground. The radio channel signage in the field will govern over channel assignment maps at all times. The following notation shall be place on all channel assignment maps:

> **Note: These maps are for planning purposes. Resource Road Channels may or may not be implemented as shown. These maps should not be relied upon to determine appropriate channels or frequencies use in the field. Field posted radio channels or frequencies shall always govern over what is on the map.**

Copies of approved modified channel assignment maps are to be forwarded by district engineering staff for posting on the government public website: Resource Road Radio Channel Planning Maps.

1.16 Procedures for modifying channel assignment maps

The standard set of RR mobile radio channels (35 road channels, 5 loading channels), has been assigned by Innovation, Science and Economic Development Canada (ISED), for the purpose of communicating location and direction when travelling on resource roads in British Columbia. Channels are assigned for use in specific areas and on specific roads to avoid conflicts between channels. The assignment of the standard channels must be carefully and judiciously managed to avoid conflicts with existing and future channel assignments as there are no additional RR channels anticipated to be provided for resource road mobile radio communications going forward.

The standard bank of RR channels has been assigned to the Ministry of Forests by ISED, to be managed and administered in conjunction with ISED. The Ministry of Forests will be responsible for administering, tracking and application of channels assignments in the field.

It is recommended that proponents for modifying channels assignments or seeking temporary channel assignments discuss and consult with other stakeholders that may be impacted. In particular engagement and consultation with road user groups (where they exist) should be undertaken. Diligence must be used to avoid mobile radio communication conflicts, ensure safe implementation and use, and promote long term sustainability of the RR channel network.

In order to effectively and efficiently manage the RR channels, the following procedure has been established for modifying RR channel assignments in the field:

1. Proponents should submit a request for a channel assignment or change requests, with rationale for the request, to Ministry of Forests district office, attention Engineering Officer. The rationale should include:

- a map showing the geographic area with proposed change
- anticipated time that change would be required (e.g. short term temporary use versus long term or permanent change)
- proposed channel for implementation
- results from consultation with affected stakeholders
- steps that will be undertaken for implementation and decommissioning in the case of temporary use including:
- further consultation and communications to be undertaken
- signage to be implemented and decommissioned (in the case of temporary use

2. The Engineering Officer will evaluate the request and assess its feasibility. If feasible, the Engineering Officer will:

- Determine whether further consultation with other stakeholders, particularly road user groups, is needed.
- Request further consultation or directly consult with stakeholders as may be appropriate. Consultation should include discussions on implementation roles and responsibilities (e.g., identify who will be responsible for communications and for new or changed signage), potential for the change to create radio interference, and plans for other radio channel changes.

3. Ministry of Forests Engineering Officer completes consultation and evaluation of the request including proposed or changed channel(s) to be implemented.

4. If Ministry of Forests Engineering Officer agrees with moving forward with the request, they will forward to ISED for their review.

5. ISED would then review potential conflicts & approve and/or make recommendations as may be appropriate.

6. If approved by ISED, the MFLNRO Engineering Officer would ensure coordination of implementation is addressed with proponent(s) including:

- communications of change
- signage changes
- modification of district mobile radio channel maps and website are updated
- Where temporary use has been applied, decommissioning of signage subsequent to use has occurred.

7. If Ministry of Forests Engineering Officer does not agree with moving forward with the request, they will inform the stakeholder that the request has been rejected and why.

1.17 Pre-approval of Temporary Channel Assignments

Channel assignments can be pre-identified for temporary use in a specified geographic area in order to address operational requirements for planned, short duration intensified industrial resource road traffic. The intent would be to pre-approve specified RR channels for temporary use within a specified geographic area. Pre-approved temporary RR channels can be managed at the local level without seeking further approvals.

1.18 Loading (LD) Channels are not to be used for resource road travel communications

Loading (LD) channels have been specifically identified for use on loading, landing, and pad sites in order to provide for communications between local equipment and transient trucks while on those sites. The intent of the LD channels is to avoid having the local onsite communications interfere with road channel communications. LD channels are not intended to be used for communicating location and direction when travelling on a resource road.

Guidance on recommend best practices for mobile 2-way radio communications on B.C.'s radio-assisted resource roads, and to highlight important considerations for radio installation and maintenance can be found at:

- Best Practices, Installation & Maintenance of Mobile 2-way Radios (PDF)

1.19 Standard Signage

Sign materials and formats were standardized to complement the new resource road mobile radio communications protocols. Learn more about standard signage for Forest Service Roads:

- Forest Service Road Sign Standards

1.20 Appendix – Channel Assignment Limitations

Appendix - RR Channel Assignment Limitations

2 Road Layout

Access is a primary consideration in planning forest development. Although the principles for determining road locations apply to both main and secondary Forest Service Roads (FSRs), secondary roads are more site-specific to the harvesting system and the equipment used. Decisions made during access planning (defined as preceding road layout and typically identifying route corridors, selecting life expectancies of various road types, and establishing intended road users and vehicle types) and road layout may have significant effects on road construction and maintenance costs, user safety, and other resources. Select and locate routes to meet the objectives of higher-level plans within the constraints of any approved operational plans or permits. Road layout is a process of route selection and field marking based on pre-field investigation and field reconnaissance to determine a site-specific road location. The level of detail and the type of information required for road layout depends on the required road design standards, the complexity of terrain, the size and complexity of stream crossings, and the need to consider other resource values.

This chapter presents the ministry's mandatory procedures and best practices related to professional responsibility, pre-field and field investigation, and to the associated outputs. It is intended to provide the reader with enough detail to be able to understand the processes and expected mandatory procedures, as well as ensuring that the road meets the regulatory requirements related to safety and protection of other resources.

2.1 Mandatory Procedures & Best Practices

The *Forest and Range Practices Act* (FRPA) and the Forest Planning and Practices Regulation (FPPR) require the ministry to construct a Forest Service road in a manner that achieves certain resource protection objectives or meets specific criteria. In doing so, a key component of a road's development is the layout of the road.

To address safety, resource protection and mitigation measures related to road layout, provide appropriate levels of expertise and resources to pre-construction of a road, and suitable checks and balances to ensure that the work is proceeding according to plan.

For each regulatory requirement, ensure that:

- suitable levels of data collection are applied;
- professional input is obtained as required;
- reconnaissance information is appropriate in terms of quality and quantity; and
- assurance that the necessary steps were taken and issues addressed (see Project Tracking Checklist).

Following is a table that summarizes in approximate chronological order the mandatory procedures and best practices with respect to the layout of Forest Service roads.

Table 2-1 Road Layout
Results to be achieved:

a road layout identifies and addresses land alienations such as private property and First Nations land (FA s.1(1) - definition of forest service road) FSP results/strategies are achieved or carried out for visual quality or cultural heritage resources (FRPA s. 21 (1)) do not cause landslides or gully processes that would have a material adverse effect on the subjects contained in FRPA s. 149 (FPPR s. 37, 38) maintain natural surface drainage patterns (FPPR s. 39) no construction of a road in a riparian management area (FPPR s. 50) no fan destabilization that would have a material adverse effect on forest resources (FPPR s. 54) no road construction within a specified distance from a spring in a community watershed, or within 100 m upslope of a licensed waterworks in a community watershed (FPPR s. 60, 62) comply with any general wildlife measures, or do not damage or render ineffective any resource feature or wildlife habitat feature (FPPR s. 69, 70) road is safe for industrial use (FPPR s. 72) meet the requirements for a road site plan (FRPA s. 10, 11)	
Legislation supported: FA section 1(1)	
M1	The CM must ensure that the land status along the proposed route has been checked, to identify alienated lands and other potential conflicts that may require land acquisition; (see land alienations)
Legislation supported: FRPA section 21 (1), FPPR sections 37, 38, 39, 50, 54, 60, 62, 69, 70, 72	
M2	The CM must ensure that the FSP or other applicable planning process has been completed with respect to the proposed road layout; (see Road Layout Professional Responsibilities & Considerations)
B1	Ensure that consultations were carried out at the time of the FSP preparation, and that further consultations and assessments are carried out concurrent with the road layout; (see Road Layout Professional Responsibilities & Considerations and consultations)
B2	Ensure that the person conducting field reconnaissance has established skill sets. [see Field Reconnaissance Procedures & Records]
B3	Mark the centreline (P-line or L-line) of all proposed routes with intervisible flagging tape, and include cumulative chainages and control points on the flagging tape. [see Field Reconnaissance Procedures & Records]
B4	Ensure that appropriately qualified forest visuals professionals and archaeological professionals carry out office and field reviews as necessary to ensure that the road layout achieves the visual and cultural objectives. [see Use of Appropriate Professionals]
B5	Consider the visual impacts of the road and the road corridor on the surrounding landscape. Where visual quality objectives (VQOs) have been established or visual impact issues can be foreseen, consider alternate route locations to lessen the visual impact of road [see Visual Impact].
Legislation supported: FPPR sections 39: maintaining natural surface drainage patterns	

B6	Ensure that the Reconnaissance Report includes information about all continuous and intermittent drainage flow channels, springs, seeps, and wet areas [see drainage]
Legislation supported: FPPR section 50: no construction in a riparian management area except as provided	
B7	Ensure that the Reconnaissance Report identifies the riparian areas of the streams near the road. [see riparian].
B8	Ensure that the layout places the road beyond the riparian management areas for each stream, except as provided in section 50 (1) of FPPR [see Riparian].
B9	Ensure that the Reconnaissance Report identifies the fish stream crossings, so that suitable crossing structures can be designed and built. [see stream crossings]
Legislation supported: FPPR section 54: no fan destabilization	
B10	Where a proposed road will cross an alluvial or colluvial fan, ensure that an appropriately qualified professional carries out a fan stability assessment to determine the potential impact on forest resources from debris flows, debris floods or water floods. [see fan destabilization]
Legislation supported: FPPR sections 56, 57: protection of fish passage and fish habitat	
B11	Ensure that the Reconnaissance Report identifies stream riparian classes and crossing data, and describes measures to protect fish and fish habitat at stream crossings. [see stream crossings]
Legislation supported: FPPR sections 60, 62: no construction near licensed waterworks or springs in a community watershed	
B12	Ensure that the Reconnaissance Report identify licensed waterworks and springs in community watersheds [see locations], and, unless there is an exception in accordance with FPPR, the layout places the road center-line so as not to damage a waterworks and to achieve at least 100m distance from any such waterworks or springs in community watersheds.
Legislation supported: FPPR sections 69, 70: wildlife measures, resource features and wildlife habitat features	
B13	Ensure that the Reconnaissance Report determines potential impacts on other resources, so as to locate roads in such a manner as to address general wildlife measures, resource features or wildlife habitat measures. [see applications]
Legislation supported: FPPR section 72: roads and structures are safe for industrial users	
M3	A terrain stability assessment must be conducted by a qualified professional to determine whether measures are required to reduce the likelihood of a landslide occurring, or to reduce the likelihood of a landslide affecting forest resources, in the following situations: terrain stability mapping indicates that the road is located on terrain that is unstable or potentially unstable; the mapping referred to in paragraph (a) has not been done, and the road is located on terrain with slopes greater than 60%; or

	the road is located on terrain where there are indicators of slope instability. [see terrain stability]
B14	Where no geometric road design will be required, ensure that the Reconnaissance Report provides suitable horizontal and vertical road alignment criteria in a road layout and design schedule. [see maximum]
B15	Ensure that the professional specialists who have been retained to do the work are in fact qualified to do this work. [see Use of Appropriate Professionals]
B16	Ensure that each reconnaissance report addresses terrain conditions and road sections that are in unstable or potentially unstable terrain. [see Reconnaissance Report]
Legislation supported: FRPA sections 21 (1), FPPR sections 37, 38, 39, 50, 54, 60, 62, 69, 70, 72	
M4	The Reconnaissance Report must be reviewed and accepted by the Coordinating Member. [see Reconnaissance Report]
M5	The Coordinating Member must sign (and seal as appropriate) the Road Project Assurance Statement [see Chapter 8: Professional Responsibilities & Considerations]
B17	Ensure that the necessary steps in the road layout process were undertaken and issues addressed [see Project Tracking Checklist]
Legislation supported: FRPA section 10, 11	
B18	For BCTS projects, as the holders of a FSP, ensure that a Reconnaissance Report provides sufficient details to address the requirements of a road site plan. [see site plan]

2.2 Road Layout Professional Responsibilities & Considerations

Road layout includes pre-field and field reconnaissance works that address safety and resource issues directly or lead to suitable applications at the survey, design and construction stages. Practices include:

- review and confirmation of any FSP or other planning outcomes;
- field determination of any signs of landslide prone terrain;
- professional terrain and fan stability assessments;
- riparian classification of streams near the road;
- applying qualified personnel to the project;
- selecting the optimum route;
- preparing a Reconnaissance Report that addresses:
    - road survey instructions;
    - seepage;
    - locations of springs and licensed waterworks in community watersheds;
    - resource features;
    - wildlife habitat features; and

    - road alignment controls where no geometric road design will take place;
- flagging and traversing the proposed road center-line; and
- field checks of the proposed road location by professionals and FOR staff, as necessary due to project complexity or specific issues.

The CM is responsible for considering the composition and interaction of all the road layout components, as well as their relationships and impact on not only the users, but also on the road components and other resources. A key concept is continuity of professional oversight and output reviews. The CM is charged with retaining a close familiarity with the progress of the project, and with coordinating the various specialist inputs into the road layout and, as such, carries overall professional responsibility for the delivery of the layout.

The CM may need to update a road layout based on:

- the results of consultations that have taken place after the road layout commenced; and
- the field reconnaissance and recommendations made by other members, specialists or road personnel.

A Road Project Assurance Statement fs1366 is to be completed by Coordinating Member after completion of a project. For more information, see Chapter 8: Professional Responsibilities & Considerations.

2.3 Pre-Field Investigation

2.3.1 Road Layout

Allocate adequate time and resources to road layout. The road layout stage begins with the collecting and analyzing of all available information for the development area, focusing on the route corridor resulting from any approved access plan.

The first step in determining a road location is the pre-field investigation, which includes:

- carrying out a thorough map and air photo review; and
- preparing a working map of the area that shows study area boundaries, existing access, major drainages, land alienations, and other key planning elements.

2.3.2 Maps & Air Photos

Maps and air photos are a major source of information for examining terrain features and collecting information about the study area. Use the following types of maps at 1:5,000 or 1:10,000 scale for pre-field preparation, particularly for difficult or broken terrain:

- contour maps;
- Terrain Resource Information Management (TRIM) maps;
- forest cover maps; and
- soil and landform maps, terrain and stability maps, and ortho imagery.

Use the most recent series of air photos in conjunction with the available maps, to interpret physical features, drainage, and forest cover. Photo scales at 1:15,000 and 1:20,000 enable detail to be examined, although 1:60,000 photos are helpful for general landform orientation.

Complete an in-depth review of the maps and air photos to identify features and control points along potential route ("recce") locations, including:

- stream crossings where location is critical;
- rock bluffs, benches, passes, saddles, and other dominant terrain features;
- potential switchback locations;
- harvesting systems and potential location of landings;
- potential disposal sites for excavation spoil or debris;
- alienated lands, including powerline, gas pipeline, or railway crossings;
- current access to and junction with existing roads;
- log dumps, mill yards, or other destinations;
- avalanche chutes;
- talus slides;
- swamps and wet areas;
- forest cover and stand condition; and
- potential environmentally sensitive areas.

2.3.3 Visual Impact

Consider the visual impacts of the road and the road corridor on the surrounding landscape. Where visual quality objectives (VQOs) have been established or visual impact issues can be foreseen, consider alternate route locations to lessen the visual impact of road. However, consider the impact of any increased costs to do so in evaluating the route alternatives. The Visual Impact Assessment Guidebook provides details for consideration in the layout of forest roads.

2.3.4 The Working Map

The working map provides a visual summary of all information gathered during the pre-field investigation. Once assembled, it provides a picture of:

- an outline of the study boundaries;
- the location, volume, and species of timber to be accessed;
- alienations that may apply to the access development, such as Indian Reserves or private property and utilities;
- location of administrative, environmental, special interest, and land status concerns, including Visual Quality Objectives (VQOs); and
- specifications that may affect the access itself, such as grade, alignment, haul requirements, or the needs of other users.

In developing working maps, carry out the following steps:

- Establish control points (including those to be used as photo ties) that may affect physical access or define where the road recce needs to be.
- Establish a minimum of one photo tie per kilometer.
- Use the maps and air photos to locate the recce routes that most effectively and economically connect the control points and meet the general specifications for road grade and travel speed.
- Mark the control points and proposed route locations on the air photos for verification during field reconnaissance.
- If 1:5,000 or 1:10,000 topographic mapping is available, check the grades along the proposed route options. Position roads away from water bodies and wetlands. Avoid areas of potential open-slope instability, potential surface soil erosion, and gully instability. Locate roads on benches, ridge tops, and flatter slopes to minimize erosion. Avoid erosion hazards such as:
    - heavy groundwater seepage;
    - soft clay or sensitive silt soil strata;
    - concave slopes;
    - steeply dipping rock layers; and
    - areas where there is a hazard of high mass wasting or erosion, including downslope sensitive areas.
- Select stream crossings at locations where channel and bank disturbance will be minimized. Keep the number of stream crossings to a minimum.

2.3.5 Land Alienations

The CM ***must*** ensure that a proposed road is free of any potential land alienations. Check the land status of an area as a prerequisite for road layout, to identify alienated lands and other potential conflicts that may require right-of-way (R/W) acquisition.

Alienations and interests or conflicts that may require R/W acquisition generally fall into one of the following categories:

- fee simple land;
- provincial government leasehold/tenure/interest;
- reserve by Ministerial Order/OIC; or
- federal reserve.

Where applicable, notify land owners of the intent to enter. However, avoid any discussion concerning possible land acquisition (and, in particular, expropriation). Limit discussions to the topic of access being required for reconnaissance purposes only. Also, advise a landowner that, should the ministry require legal access across the property, then a Forest Land Acquisitions Project Manager would contact the landowner to begin negotiations. If a landowner refuses ministry staff entry onto the property, contact FOR Forest Land Acquisitions for further advice on how to proceed or how to negotiate short-term access.

Do not assume that the occupant of a site is the landowner. Obtain information on the name of current landowners from the FOR Forest Land Acquisitions in Victoria.

2.3.6 Government Interests

Based on potential conflicts that become evident during the road layout process, consider any concerns from the following government agencies, both provincial and federal, about the area and information to be included in plans for development of access for the timber resource:

- Ministry of Environment & Climate Change Strategy (provincial);
- Environment and Climate Change Canada (federal);
- Ministry of Transportation and Infrastructure (provincial)
- Transport Canada (federal; *Navigation Protection Act*);
- Ministry of Energy, Mines & Petroleum Resources (provincial; placer leases and mining claims);
- BC Oil and Gas Commission (provincial); and
- Ministry of Agriculture (provincial; Agricultural Land Reserve).

2.4 Field Reconnaissance

The process of field reconnaissance has three primary objectives:

1. investigate potential route corridors considering all of the elements, including reviews of optional locations and the constraints of the harvesting system that would contribute to the final location of the road;
2. gather information for subsequent use by the road survey and design contractor, and to access the need for any additional information or assessments; and
3. flag the reconnaissance line of the preferred road location using field traverse Survey Level 1 standards as required. See Survey Level 1 for field traverse.

2.4.1 Field Reconnaissance Procedures & Records

Ensure that the person conducting field reconnaissance has established skill sets.

Carry out the following reconnaissance steps:

1. Walk the proposed routes.
2. Mark the centreline (P-line or L-line) of all proposed routes with intervisible flagging tape, using hand instruments for direction and grade control. Maintain horizontal control with a hand-held compass and a hip chain; and maintain vertical control with clinometer readings. Handheld GPS units may be used to establish the centreline (P-line or L-line) where road grades are not an issue and the operator ensures that sufficient satellite coverage is available. Measure side slopes with a clinometer, and record average readings for consistent topographic sections.

3. Note the grades between control points. Keep road gradients within specifications.
4. Mark cumulative chainages and TP numbers on the flagging tape with felt pen. Mark curves with flagging by approximating the best alignment.
5. Mark control points used as photo ties on the ribbon line, noting the air photo tie number and the air photo numbers.
6. Where a location survey is not required for the project because of the easy terrain, reference all control points and flag the right-of-way boundaries.
7. Record side slopes between control points.
8. Provide detailed notes on soils and topographic features, including:
    - stream crossings where channel and bank disturbances can be prevented or mitigated, locations that require site plans, and data required for minor stream crossings;
    - forest cover (species composition, timber quality, and volume per hectare);
    - recommended slash and debris disposal methods and additional clearing widths required for the slash and debris disposal;
    - soil types based on visual observations of exposed cuts, shallow hand-dug test holes and probing, and the location of these soils on maps or aerial photos;
    - maximum road grades and minimum curve radii;
    - location and extent of bedrock, if rippable, and the potential as ballast;
    - location and extent of gravel sources and the potential for use as subgrade and surfacing materials;
    - endhaul sections and potential waste areas;
    - recommended construction methods and potentially appropriate alternatives; and
    - recommended survey level or levels appropriate for the terrain. See Survey Levels.
9. Note harvest opportunities and access requirements. As part of any field reconnaissance, confirm or evaluate the need for any additional information or assessments, including:
    - terrain stability field assessments for roads;

      A terrain stability assessment **must** be conducted by a qualified professional to determine whether measures are required to reduce the likelihood of a landslide occurring, or to reduce the likelihood of a landslide affecting forest resources, in the following situations:

        a. terrain stability mapping indicates that the road is located on terrain that is unstable or potentially unstable;
        b. the mapping referred to in paragraph (a) has not been done, and the road is located on terrain with slopes greater than 60%; or
        c. the road is located on terrain where there are indicators of slope instability.

      Ensure that the professional carries out the assessment in accordance with the EGBC [Guidelines for Terrain Stability Assessments in the Forest Sector (PDF, 1.9MB)].

    - riparian classification of streams, wetlands, and lakes;

- identification of fish streams;
- visual impact assessments;
- applications of general wildlife measures, and protection of resource features and wildlife habitat features;
- fan destabilization and a gully process (for coastal BC) (see fans and gully);
- archaeological impact assessments; and
- soil erosion field assessments.

2.4.2 Specific Concerns

Consider the following items during reconnaissance:

1. **Vertical alignment:** The grades that result in the best combination of haul and construction costs should be selected. See Table 3-2: Summary of alignment controls for forest roads (PDF).
2. **Horizontal alignment:** The speed limits for various degrees of curvature are given in Table 3-3: Curve Widenings.
3. **Junctions:** A high level of safety must be maintained in selecting a site for a junction. The following factors should be incorporated as much as possible:
    - adequate sight distance in both directions in accordance with the normal travel speed (up to 65km/h, 100m; and 65–80km/h, 150m);
    - near-level ground conditions (2% plus or minus);
    - right angle T-junctions rather than Y-junctions; and
    - only gradual change in horizontal or vertical alignment.
4. **Soils:** For locating roads, landforms can be excellent guides to desirable areas or to areas to avoid. Alluvial terrains, lacustrine deposits, water melt channels, colluvial deposits, alluvial fans eskers, and kames are strong indicators of the types of soils to be found below the surface. Easily accessible gravels, found in alluvial fans or kames, are an economical source of surfacing material. Glacial moraines, which contain relatively unsorted material, are a good source of subgrade material. Other glacial deposits that can provide subgrade or surfacing materials are basal tills and drumlins.
5. **Riparian Management Areas:** Ensure that riparian classifications are identified for streams near the road location, and that the road layout places the road beyond the riparian management area for each stream, except as provided in section 50 (1) of FPPR.

Plan on obtaining any large, fragmented rock required for road ballast or rip rap from rock outcrops (quarries) or talus slopes. Avoid very fine-grained soils of lacustrine origin, particularly for sidehill construction.

Illustrations of the landforms mentioned here are found in Terrain Classification System for British Columbia (PDF, 8.21 MB).

2.4.3 Drainage Structures

Some of the most important control points reviewed during a field investigation are those used to locate bridges and culverts.

Bridge Location

Locate a bridge site to provide an acceptable horizontal and vertical alignment for the road, considering:

- stream width;
- upstream and downstream watercourse alignment;
- streambank stability;
- whether streambanks are fairly even in height on both sides;
- availability of local materials for construction;
- access to both sides of watercourse during construction phase;
- potential for ice and debris buildup; and
- potential for streambank erosion.

Ideally, locate the crossing of a waterway at right angles to the centreline (P-line or L-line) of the waterway and include approach tangents of a minimum 15m in length. Limit the maximum grade on a bridge deck to 4%, but preferably less.

Major Culvert Location

In planning for major culverts, use much of the same location criteria as used for bridges. Refer to the Fish-Stream Crossing Guidebook (PDF, 4.2MB).

2.4.4 Harvesting Requirements

As the field investigation proceeds, consider the harvesting systems that will affect on block roads. For detailed information on total chance plans and mainline roads, see FPInnovations (FERIC) Handbooks No. 4: Timber Development Planning for the British Columbia Interior: The Total Chance Concept (PDF, 4.19 MB), and No 9: Forest Harvesting and Renewal Planning for the British Columbia Interior: An Extension of the Total Chance Concept, which cover planning considerations and logging methods for various types of terrain.

2.4.5 Use of Appropriate Professionals

To adequately manage and conserve forest resources, ensure that qualified professional specialists are consulted where appropriate. Site-specific conditions will dictate what the critical impacts and risks will be, but in general specialists might include those in the fields of terrain stability, stream morphology, structural engineering, aquatic and marine habitat, archeology, wildlife, botany, visual impacts, and forestry. To ensure that the professional specialists who have been retained to do the work are in fact qualified, consult with the ministry engineering professionals and have them:

- assess a consultant's qualifications prior to retaining the consultant under a service contract; and
- assist with service contract language.

2.5 Reconnaissance Report

Regardless of the complexity of the project, incorporate critical factors that will influence the final road location in a reconnaissance report. The CM must review and accept this Report before the road project moves to the next activity/phase, whether that be the survey and design, the road plan or the construction.

Depending on the site, prepare a reconnaissance report that ranges in size and detail from a map showing route locations, a one-page summary and field notes to a multiple page document outlining in detail the various options for route locations. The determining factor is the level of comfort with the quality of information, given the risks and potential impacts of the project. In general, ensure that each reconnaissance report includes a map showing route locations and addresses the following:

- the need, if any, for any additional information or assessments to be carried our by the appropriate professionals;
- terrain conditions and road sections that are in unstable or potentially unstable terrain;
- road sections with side slopes over 60% or where slope instability indicators are found;
- control points and topographic features (e.g. rock bluffs, swamps, avalanche paths, landslides, and debris slides), including those that may be used as photo ties;
- the sections of road that encroach on public utilities;
- the sections of road that are adjacent to or cross private property, Crown leases, or mineral and placer claims or leases (where possible, alienated lands should be avoided);
- all continuous and intermittent drainage flow channels, springs, seeps, and wet areas;
- riparian areas;
- stream crossings where channel and bank disturbances can be prevented or mitigated;
- locations of springs and licensed waterworks in community watersheds;
- locations that require site plans;
- minor stream crossings;
- forest cover (species composition, timber quality, and volume per hectare);
- potential landing locations;
- soil type, based on visual observations of exposed cuts, shallow hand-dug test holes, and probing, and the location of these soils on maps or aerial photos;
- maximum road grades and minimum curve radii;
- location and extent of bedrock, if rippable, and the potential as ballast;
- location and extent of gravel sources and the potential for use as subgrade and surfacing materials;
- endhaul sections and potential waste areas;

- recommended construction methods and potentially appropriate alternatives;
- recommended survey level or levels appropriate for the terrain; and
- harvesting system requirements.

By addressing the foregoing, a Reconnaissance Report prepared by BCTS, for the purposes of *FRPA section 10 and 11*, also addresses the requirements for a road site plan.

2.6 Resources & Suggestions for Further Reading

Technical solutions to field problems or recommended processes can generally be found in the following publications as well as various other technical bulletins and handbooks commonly used by the forest industry and the BC Ministry of Forests.

- BC Ministry of Forests. 1999. Mapping and Assessing Terrain Stability Guidebook. For. Prac. Br., B.C. Min. For. Victoria, B.C.
- 1996. Forest inventory manual: forest classification, sampling and environmentally sensitive areas. Vol. 2. Inventory. Br., B.C. Min. For. Victoria, B.C..
- BC Ministry of Sustainable Resource Management. 1996. Terrain Stability Mapping in British Columbia. For. Prac. Br., B.C. Min. For. Victoria, B.C.
- Braedon, R.E. 1990. Forest Harvesting and Renewal Planning for the British Columbia Interior: An Extension of the Total-Chance Concept (PDF, 5.27 MB). FERIC handbook No.9. For. Eng. Research Inst. Can. (FERIC). Vancouver, BC. 49 p.
- Braedon, R.E. 1983. Timber Development Planning for the British Columbia Interior: The Total-Chance Concept (PDF, 4.19 MB). FERIC handbook No.4. For. Eng. Research Inst. Can. (FERIC). Vancouver, BC. 73 p.
- Chatwin, S.C., D.E. Howes, J.W. Schwab, and D.N. Swanston. 1994. A Guide for Management of Landslide-Prone Terrain in the Pacific Northwest. 2nd ed. B.C. Min. For., Victoria, BC. Land Manage. Handb. No. 18. 220 p.
- Holmes, D.C.. 1989. Manual for Roads and Transportation. British Columbia Institute of Technology (BCIT). Burnaby, BC

2.7 Appendices

2.7.1 Project Tracking Checklist

Use this checklist to prepare a paper trail of key outputs prepared by consultants and signoffs by the ministry. Project Tracking Checklist (PDF)

3 Road Survey & Design

Route reconnaissance is usually the first on the ground location work used to define the general position of a road. Based on the reconnaissance and reconnaissance summary, further investigations and surveys may be required, including field traverses and surveys to an established standard or Survey Level. The level is determined primarily by the complexity of the terrain and end results required. Once the survey has been completed, the road design can be carried out.

Road design varies in complexity and can be as simple as providing basic road dimensions and grades required to a more detailed design to establish excavation and fill volumes, grades and alignments. In most cases, road design is usually an office process utilizing computers and road design software. Again, depending on the complexity and end results required, further road survey work may be required to establish the road location.

This chapter presents the ministry's standards related to road location survey and road design practices, and to the associated output. It is intended to provide the reader with enough detail to be able to understand the mandatory procedures, as well as carrying out appropriate best practices to address the applicable regulatory requirements.

For any FSR, the road will be:

- Surveyed with appropriate detail and accuracy for the terrain and complexity of the layout; and
- Designed in a manner that:
    - Is commensurate with the level of survey and expected use, cost and potential impacts on other resources by the road construction; and
    - Incorporates the results of any required assessments.

3.1 Mandatory Procedures & Best Practices

The Forest Planning and Practices Regulation (FPPR) requires the government to construct a Forest Service road in a manner that achieves certain resource protection objectives or meets specific criteria. One component of a road's development that addresses such objectives or criteria is its survey and design.

To address safety, and resource protection and mitigation measures related to road layout, it is necessary to provide appropriate levels of expertise and resources to pre-construction of a road, and suitable checks and balances to ensure that the work is proceeding according to plan.

The following is a table that summarizes in approximate chronological order the mandatory procedures and best practices with respect to the survey and design of Forest Service roads.

Table 3-1 Road Survey and Design

Results to be achieved: Do not cause landslides or gully processes that would have a material adverse effect on forest resources (FPPR s. 37, 38)

Maintain natural surface drainage patterns (FPPR s. 39) No construction of a road in a riparian management area (FPPR s. 50) No fan destabilization that would have a material adverse effect on forest resources (FPPR s. 54) Protection of fish passage (FPPR s. 56) No deposition or transport of deleterious materials into licensed waterworks drinking water (FPPR s. 59) No road construction within a specified distance from a spring in a community watershed, or within 100m upslope of a licensed water intake or spring in a community watershed (FPPR s. 60, 62) Road is safe for industrial use (FPPR s. 72)	
Legislation supported: FPPR sections 37, 38, 57, 59, 69, 70, 72: do not cause landslides or gully processes that will have a material adverse effect on forest resources	
M1	A geometric road design must be carried out for all roads that will cross areas with a moderate or high likelihood of landslides. [see Geometric Road Design Requirements]
B1	Ensure that at least a location survey level 3 is carried out for road crossing landslide prone terrain. [see Survey Level 3]
B2	Ensure a geometric road design is carried out for other roads that need to be accurately constructed. [see Geometric Road Design Requirements]
B3	Ensure that the road design incorporates any measures prepared by an appropriately qualified professional to protect worker and user safety, fish, fish habitat, water quality, wildlife, wildlife habitat features, visual and heritage resources. [see Geometric Road Design Requirements]
Legislation supported: FPPR section 39: maintain surface drainage patterns	
B4	Ensure that locations of proposed cross drain culverts are marked on the road plans, subject to on-site modification. [see Cross Drain]
Legislation supported: FPPR section 50: no construction in riparian management areas, except as provided.	
B5	Ensure that the road is designed in the location identified by the layout, and where no exception has been provided in accordance with FPPR, the design places the road beyond the riparian management areas for each stream. [see riparian]
Legislation supported: FPPR sections 38 and 54: no gully process or fan destabilization on the coast	
B6	Ensure that a road design on the Coast incorporates any protective measures prepared by an appropriately qualified professional as part of a gully process or fan stability assessment. [see ensure]
Legislation supported: FPPR section 56: protection of fish passage	

B7	Ensure that any crossing design does not result in a material adverse effect on fish passage in a fish stream [see fish stream]
Legislation supported: FPPR sections 59, 60, 62: no construction near (1) licensed waterworks in community watersheds or (2) springs that are a source of water for licensed waterworks in community watersheds	
B8	Ensure that the road design places the road at least 100m distance from any (1) licensed waterworks in community watersheds or (2) springs that are a source of water for licensed waterworks in community watersheds.
Legislation supported: FPPR section 72: roads and structures are safe for industrial users	
B9	Ensure that the road design incorporates professional design measures related to landslides [see slope stability considerations]
B10	Ensure that the road design incorporates horizontal and vertical road alignments that provide for equipment use and for user safety. [see road alignment]
Legislation supported: FPPR section 78: minimize clearing width	
B11	Ensure that clearing widths marked on the road plans provide for the minimum clearing width considering operational requirements, safety, drainage, stability and topography [see clearing width]
Legislation supported: FPPR sections 37, 38, 39, 50, 54, 56, 57, 59, 60, 62, 69, 70, 72	
M2	Road plans must be reviewed and accepted by the Coordinating Member [see Survey & Design Outputs]
M3	The Coordinating Member must sign (and seal as appropriate) the Road Project Assurance Statement [see Chapter 8: Professional Responsibilities & Considerations]
B12	Ensure that the necessary steps in the road layout process were undertaken and issues addressed [see Project Tracking Checklist]

3.2 Road Survey & Design Professional Responsibilities & Considerations

Road survey and design includes applying the appropriate level of survey to achieve the required accuracy of field measurements, and preparing a geometric road design (including plans, profiles, cross-sections and mass graphs) based on the survey measurements, data and assessments, to tie the location of the road to the land base. Practices include:

- carrying out a location survey;
- incorporating professional assessments from the road site plan, including any strategies or objectives that are necessary;
- marking locations of cross drain culverts;
- locating roads outside of riparian management areas;

- consideration of sediment transport and deposition;
- locating roads appropriate distances from licensed waterworks in community watersheds; and
- providing for suitable clearing widths to address topographic and operational needs; and
- preparing a road plan that serves as or includes the road site plan under an FSP.

The CM is responsible for:

- choosing the survey methods and instrumentation in accordance with the information contained in this Manual, based upon the accuracy and type of data required to facilitate the planning and design of the
- determining where a geometric road design is required;
- modifying the design and construction standard or adopting additional measures to protect workers during construction, users and resource and habitat features.

To achieve the foregoing, the CM:

- where the design is prepared using a computer application, must review the design to ensure that it is reasonable, correct, suitable for the ground conditions and constructible;
- may rely upon the geometric road design procedures contained in this manual; and
- may use specialist input to revise locations, to incorporate special design measures, to specify special construction techniques, or to develop specific measures that are to be employed during or following construction to protect the environment or address worker or user safety. Examples include:
    - evaluating potential safety issues that are beyond the expertise of the CM, such as landslides, rockfalls, avalanches, karst features, danger trees;
    - assessing terrain related concerns for road construction such as slope stability hazards, gullies, fans, floodplains, erosion or avalanches;
    - identifying fish habitat and sensitivity;
    - identifying and addressing other forest and non-forest resources (e.g. archaeological sites);
    - structural elements such as retaining walls;
    - fords or fish stream culverts;
    - bridges, including approach alignments;
    - engineered fills or cut slope treatments;
    - construction techniques such as overlanding or full bench excavation and endhaul;
    - engineered rock cuts;
    - measures to protect fan or floodplain stability;
    - specialized erosion protection; and
    - measures to protect resource and wildlife habitat features.

3.3 Road Location Survey

In forestry road applications, there are two general types of surveys: a field traverse and a location survey. To determine which survey type and level is required, consider the physical characteristics of the terrain, the design complexity, and the desired road prism geometry.

The two terms most commonly associated with survey and design are P-line (the Preliminary Line) and L-line (the Location Line). Despite a common assumption, the P-Line is not the original, flagged reconnaissance line, but a traversed survey based on the results of the reconnaissance. The P- line is established in the field and shown as a plotted line on a drawing to provide the horizontal and vertical control for the roadway centreline.

The L-line, is the designed roadway centreline shown on a drawing with tangent Point of Intersection (PI), Beginning of Curve (BC), and End of Curve (EC) chainages. The L-line is often established in the field as offsets to the P-line based on the road centreline design. Where close control of cut and fill slopes is required, the L-line is established after grubbing and stripping operations by setting grade stakes.

3.3.1 Types of Survey

Field traverse

Carry out a field traverse for road layout and design to collect data and measurements for the road location. A field traverse is also sometimes referred to as Survey Level 1, see Survey Levels following. This level of survey is appropriate only for roads with no geometric road design, such that the road layout is tied down and can be mapped and reproduced in the field.

Location survey

Carry out a location survey to obtain information and measurements necessary for a detailed design, or to obtain information when geometric road designs are required. Compared with a field traverse, a location survey is carried out at a higher level of survey (i.e., Survey Level 2, 3, or 4) to capture more information at a level suitable for detailed drawings.*

If as-built surveys are required for volume determination or to check conformance to the design, use a location survey level that is suitable for accurately re- establishing the road centreline location.

If construction surveys are required, use a location survey level that is suitable for accurately re-establishing the construction control points.

The accuracy achieved with any survey level depends, in part, on the type and condition of survey equipment used the competence of the crew, and the field methods used. Global Positioning System (GPS) receivers, like other survey equipment, are acceptable when they can achieve the required horizontal and vertical accuracy for the appropriate survey level.

Stream crossings require special consideration. Site information requirements for bridge and culvert planning and design are provided later in:

- Road Design Criteria
- Site Data & Survey Requirements for Bridges & Major Culverts
- Site Survey for Stream Crossings

***Note:** EGBC discourages the use of the terms "as-built drawings" or "as-constructed drawings" as they imply that the drawings show exactly what was built or constructed. The terms may also suggest a level of certification or impose inappropriate liability. For this reason, EGBC recommends and uses the term "record drawings." For more information:

- [EGBC.ca Quality-Management-Guides]

3.3.2 Survey Levels

This section outlines practices for field traverses and location surveys. Although considerable gains have been made in survey instrumentation technology, use of the technology does not preclude the need to follow standard survey practices as outlined in the Manual for Roads and Transportation (BCIT 1984).

Use Global Positioning System units only where the specified accuracy can be achieved to establish GPS waypoints and tracks necessary to accurately locate the road centreline and stream culvert crossings.

Use the following criteria to determine the appropriate survey level for a field traverse (Survey Level 1) or location survey (Survey Levels 2, 3, or 4). Note the equipment may be appropriate for the level but, more importantly, the skill of the surveyor is paramount in achieving the accuracy required. Geo-reference any survey that is carried out on an FSR.

Survey Level 1 (for field traverses)

Application: Where a low likelihood of landslides, and for situations where geometric road design, construction surveys, and as-built surveys are not required. Equipment may include hand compass, recreational GPS and hip chain.

Horizontal accuracy: Turning points are to be established to a relative accuracy of 1:100.

Vertical accuracy: Within equipment precision for slope corrections.

Survey Level 2 (for location surveys on stable terrain)

Application: For location surveys on stable terrain with a low likelihood of landslides and for situations where a geometric road design, construction surveys, or as-built surveys are desired. Equipment may include a hand compass, clinometer and steel or fiberglass chain.

Horizontal accuracy: Turning points are to be established to a relative accuracy of 1:300.

Vertical accuracy: = 1.0* √total distance in kilometers, expressed in meters. For example, the vertical accuracy for a 1km road is 1m. For a 2km road, the vertical accuracy is 1.41m.

Survey Level 3 (for location surveys within areas of moderate or high likelihood of landslides)

Application: For location surveys, construction surveys, geometric road design, and as-built surveys in areas of moderate to high likelihood of landslides, as determined by a terrain stability field assessment. This is also the appropriate level of survey for material volume determination and detailed-engineered estimates. May also be used for bridge and major culvert planning and design, but greater vertical accuracy might be necessary. Equipment may include a staff compass, rod and steel chain.

Horizontal accuracy: Turning points are to be established to a relative accuracy of 1:1,000.

Vertical accuracy: = 0.5 * √total distance in kilometers, expressed in meters. For example, the vertical accuracy for a 1 km road is 0.5 m. For a 2 km road, the vertical accuracy is 0.71 m.

Survey Level 4 (for high-order survey requirements)

Application: A high-order survey for location surveys, construction surveys, construction contracting on a cost-per-unit basis, check surveys, placement of permanent bridges, as-built surveys through Crown leases, mineral and placer claims, and leases, private property, and surveys to re-establish private property lines. Equipment may include transits, rod and steel chain, or total station instruments.

Horizontal accuracy: Turning hubs are to be established to a relative accuracy of 1:5,000.

Vertical accuracy: = 0.3* √total distance in kilometers, expressed in meters. For example, the vertical accuracy for a 1 km road is 0.3 m. For a 2 km road, the vertical accuracy is 0.42 m.

3.4 Survey Procedures

3.4.1 Survey Level 1

Where a geometric road design is not required (e.g., where a proposed road will not cross areas with a moderate or high likelihood of landslides as determined by a terrain stability field assessment), carry out the following as part of a field traverse:

1. Clearly identify the beginning and end of the road.
2. Clearly flag the proposed centreline of the road.
3. Using an appropriate method (such as aluminum plaques and tree blazes), mark and record control points, noting the control point number, station, bearing, and horizontal distance from the proposed centreline.
4. Measure the bearing, slope gradient, and distance between the TPs and mark the cumulative changes and/or point number in the field.
5. Geo-reference the end points by double occupying the stations.
6. Record notes describing forest cover, vegetative types, soil types, rock, groundwater seepage, streams, and other related factors.

3.4.2 Survey Level 2 & 3

Carry out the following where a geometric road design is required:

1. Clearly identify the beginning and end of the road.
2. Establish intervisible stations (called turning points [TPs] if done with a compass, or traverse hubs [THs] if done with a transit) along the preliminary centreline (P-line). Use manufactured stakes or local material (blazed saplings) driven into the ground.
3. Measure the bearing, slope gradient, and distance between TPs and mark the cumulative chainages and/or point number in the field. Take both foreshots and backshots to verify the readings and to protect against booking errors.
4. Measure the slope gradient and distance to additional grade breaks between TPs as intermediate fore shots to facilitate taking cross-sections at those locations.
5. Using an appropriate method (such as aluminum plaques and tree blazes), mark and record control points, reference points, and benchmarks. Note the number, station, bearing, and horizontal distance from the P-line.
6. Geo-reference the end points by double occupying the stations.
7. Record notes describing forest cover, vegetative types, soil types, rock, groundwater seepage, streams, and other related factors that were not identified on the reconnaissance report.
8. Obtain enough information to ensure that road junctions can be designed and constructed. This includes capturing a minimum of 50 m of the existing road in the traverse (horizontal and vertical alignments and side slopes) to ensure that the road junction is adequately designed. Switchbacks located on steep slopes also require detailed data for proper design and construction.
9. The final design road location centreline (L-line) should be close to the P-line and generally within 3 m of the P-line if the road will cross areas with a moderate to high likelihood of landslides as determined by a terrain stability field assessment, or if bedrock is present, or switchbacks are encountered.

Cross-sections

Carry out the following:

1. Take cross-sections at all TPs and intermediate foreshots perpendicular to the back tangent or bisecting the interior angle of two tangents. Ensure that the recorded information is compatible with computer design software requirements.
2. Ensure that cross-sections are not more than 15m apart in rock or 30m apart in other material. A longer spacing will not provide sufficient cross-sections for the accurate earth volume calculations required for geometric design. Exceptions to this guideline may be considered for Level 2 surveys conducted in uniform terrain.
3. Extend cross-sections at least 15m horizontally on either side of the location line or farther to accommodate the road prism and in areas considered for waste disposal.
4. Measure and record slope breaks (over 10%) on the cross-section profile to the nearest 0.1m in distance and nearest 1% in slope gradient.

5. Take additional cross-sections to record features that may affect the road prism on each side of the proposed centreline. Examples of such features are rock outcrops, flat topography (benches), lakeshores, fences, streams, back channels, and existing roads.

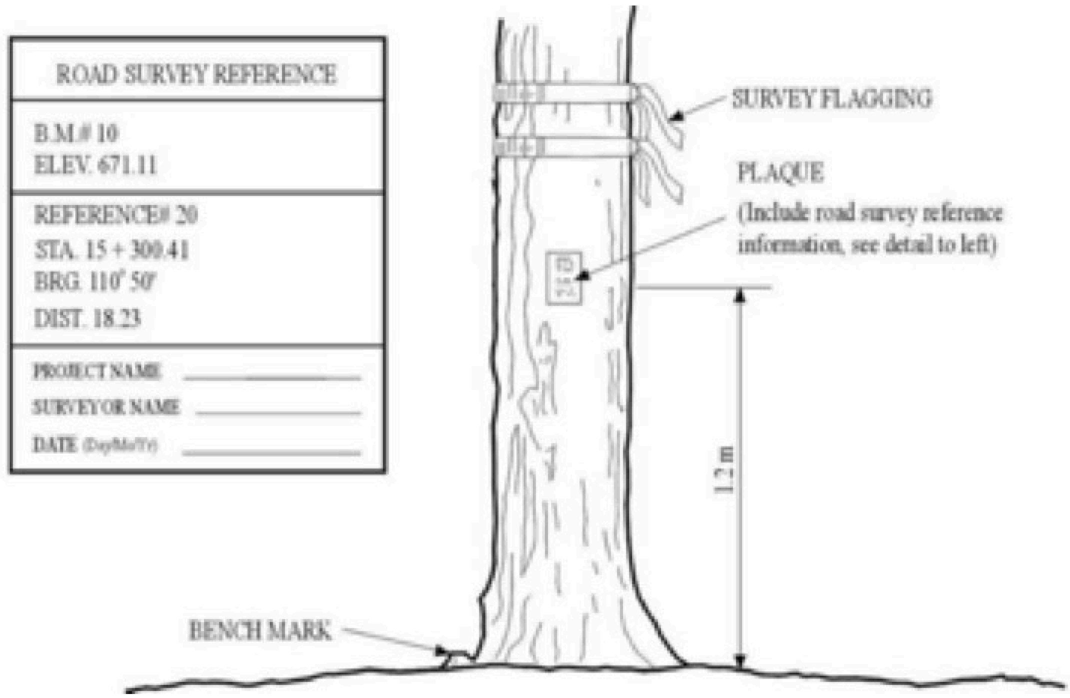
Referencing and benchmarks

Use a reference tree or other fixed object (e.g., bedrock outcrop) for the horizontal control, and use a benchmark for the vertical control of the road traverse. Both are important for re-establishing the designed location line (L-line), as well as for construction surveys and those surveys necessary to complete as-built documentation.

Carry out the following:

1. Reference the beginning and end of the location line traverse. When switching from one survey level to another, reference this point in accordance with the higher survey level accuracy.
2. Establish references at least every 300m and at control points established during the field traverse.
3. Use two trees to establish references outside the proposed upslope clearing limit. Set the angle from the TP to the two reference trees between 60° and 120° from the centreline tangent. Make horizontal measurements to the center of the reference marker (plaque). (The use of two reference trees improves the accuracy of relocating the traverse station and provides for a back-up if one tree is destroyed.) Use the same level of survey accuracy to establish references and benchmarks.
4. Record the diameter at breast height (dbh) and species of the reference trees so that they can easily be found.
5. Establish benchmarks outside the clearing width no more than 1km apart, at major structures and at existing references for control points established during the field traverse.

Figure 3-1 Typical benchmarks and road survey reference information (source: Forest Road Engineering Guidebook)



3.4.3 Survey Level 4 (For High-Order Survey Requirements)

As noted earlier, this high-order survey is also suitable for alienated lands such as private property (Note: coordinate this with FOR Forest Land Acquisitions, Victoria).

Carry out the following:

1. Before starting work on alienated lands, contact the owners and explain the nature of the work. The owner may be able to provide the location of corner pins and other useful information.
2. When working on alienated lands, keep the clearing (tree falling, line slashing, etc.) and marking of lines to a minimum.
3. Record the following information and tie it to the location line traverse:

- all existing legal markers;
- improvements and utilities that may be affected by the right-of-way;
- fences and buildings; and
- parts of the existing road, if applicable, including the top of cut, toe of fill, grade, and ditchline.

4. If possible, close traverses onto at least two legal posts to ensure accuracy and to establish correct orientation of the survey with respect to the legal lot or lots.
5. Geo-reference the end points by double occupying the stations.

Survey on private property, Crown leases, and mineral and placer claims and leases

For such road location surveys, carry out the following:

- Notify, in writing, owners of private property and holders of leases and claims before conducting survey work.
- Carry out a P-line survey to a relative precision of 1:5,000 horizontally and a vertical accuracy of +0.3m per 1km of traverse.
- Keep the clearing and marking of lines to a minimum.
- Locate all existing legal markers and tie them into the traverse.
- Tie into the P-line, including those for buildings, fences, and existing roads

Ties to existing property boundaries

Traverse ties the location survey to existing property markers or other evidence of legal boundaries that may be near the location survey. Complete sufficient investigations to establish the location of the property line and determine whether the road right-of-way will encroach on the property line. If possible, relocate the centreline and right-of-way if there is an encroachment.

Site survey for stream crossings

A sketch is generally sufficient for non-fish and non-major stream culverts, showing the culvert and the foundation locations with enough detail so the locations can be accurately re-established in the field. Basic Drainage Site Report Requirements describes works and standards for data collection, site planning, and plan details.

To establish site survey specifications for all bridges and for the planned installation of any culvert 2,000mm or greater in diameter, or with peak flow greater than 6 m3/s. (see Chapter 4: Design & Construction of Bridges & Major Culverts).

3.5 Geometric Road Design

The purpose of road design is to produce specifications for road construction by determining the optimum road geometry that will accommodate the design vehicle configuration for load and alignment, traffic volume and provide for user safety, while minimizing the cost of construction, transportation, maintenance, and deactivation during the expected life of the road.

Road design is an art that takes the survey information and essentially connects the field data to produce the desired road profile showing the grade, alignment, designed cross sections, excavation and embankment volumes, location and size of drainage structures, turnouts, and surfacing requirements. The optimum road design reduces impacts on other resources by minimizing clearing widths and excavations and specifying proper drainage structures. Also consider the equipment anticipated for use during construction, since the equipment type impacts material movement distances and balance points. Incorporate construction techniques such as rolling grades, full and partial benching, end haul, road width, cut and fill slope angles, and horizontal and vertical control angles with consideration given to climatic, terrain and soil conditions.

Geometric road design (see Geometric Road Design Requirements) includes plans, profiles, cross-sections, and mass haul diagrams showing the optimum balance of waste, borrow, and endhaul volumes. Generate the designs from the route selection process and the location survey. From the location survey information, design a road centreline (L-Line) for vertical and horizontal alignment, calculate earthwork quantities, and produce a mass haul diagram to show the optimum placement of excavated material.

Road standard drawings

Figure 3-5: Dwg. No. 13-757 - Sample Right-of-Way Through Private Land (PDF)

Figure 3-6: Dwg. No. 13-758 - Sample Plan & Profile (PDF)

Figure 3-7: Dwg. No. 13-759 - Sample River Crossing Plan 1 of 2 (PDF)

Figure 3-8: Dwg. No. 13-759 - Sample River Crossing Profile & Cross-Section 2 of 2 (PDF)

Figure 3-9: Dwg. No. 13-760 - Sample Railway Crossing for Existing Road (PDF)

Figure 3-10: Dwg. No. 13-761 - Sample Pipeline Crossing (PDF)

Figure 3-11: Dwg. No. 13-762 - Sample Powerline Crossing (PDF)

Figure 3-12: Dwg. No. 13-763 - Sample Structure of Compliance with Navigable Waters (PDF)

Figure 3-13: Dwg. No. 13-768 - Sample Highway Junction (PDF)

3.5.1 Design Planning Considerations

In order to meet the ever-increasing demand for access, be apprised of any multi- user needs: for example, oil and gas exploration, mining, power project, recreational, and public uses. These factors may influence the design widths, alignment, and grades beyond those required for forest access during harvesting. Use additional and/or larger turnouts if heavy traffic is anticipated or there is potential for high recreational use of the road. Restrict utilities to only one side of the road to ensure that the road right-of-way has room to expand and be upgraded in the future.

Road maintenance can also be a significant factor to be recognized during road design. For example, access to retaining and catchment walls and spillways may be required once the road is built and, if the structures are inaccessible, this may increase the chance of being overlooked during inspections which may increase the cost of maintenance.

Allow adequate room for equipment operation including snow removal and logging equipment. Large equipment or operations often require additional road width and in the case of snow removal, for example, a place to relocate snow and ice away from the roadway without damaging surrounding forest resources caused by trapping and diverting meltwater on sensitive slopes and not damaging signs, fences, and bridge guardrails.

When designing a road prism that includes excavation into side slopes or the placement of loads on the fill slopes, consider the nature of the soil and ground conditions, so that slope stability can be maintained. In addition to the immediate factors related to the slope, consider the road in the context of the overall area.

Ensure that the road is designed in the location identified by the layout and, where no exception has been provided in accordance with FPPR, the design places the road beyond the riparian management areas for each stream.

Incorporate other information in the design, including prescriptions and assessments that relate to the road location and design. These may include professional designs such as deep or steep excavations, retaining walls, designs for stream crossings, bridge design and alignments, designs included in or based on terrain stability assessments, and specialized designs in rock cuts. For example, if a proposed road will cross areas with a moderate or high likelihood of landslides as determined by a TSFA, incorporate measures to maintain slope stability into the geometric road design. Also, ensure that a road design on the Coast incorporates any protective measures prepared by an appropriately qualified professional as part of a gully process or fan stability assessment.

As a result, be aware of the intended use of the road, the timing of such use, construction techniques and other surrounding design considerations as well as the following road design criteria.

3.5.2 Road Design Criteria

Consider the following factors in the road design:

Clearing Width

Keep the clearing widths as narrow as possible, to minimize impacts on other resources, but wide enough to accommodate:

- the road prism;
- user safety;
- decking of right-of-way timber;
- turnouts;
- subgrade drainage;
- subgrade stability;
- waste areas and endhaul areas;
- pits and quarries;
- landings;
- slash disposal;
- equipment operation;
- snow removal;
- fencing and other structures; and

- standing timber root protection, especially on cut banks.

Move to a disposal site organic debris, rock, or other excess material that cannot be placed in the road prism and within the clearing width because of terrain stability or other factors. Ensure such areas are of suitable size to accommodate the estimated volume of waste material and identify the areas in the road design.

Calculate clearing widths on a station-by-station basis as part of a geometric road design. In situations where geometric road design is not required, use other methods as shown on page 179 in the Forest Road Engineering Guidebook June 2002

Road alignment

Road design incorporates horizontal and vertical road alignments that provide for equipment use and for user safety. This involves establishing:

- appropriate travel speeds;
- appropriate maximum road grades;
- suitable stopping and sight distances;
- junctions with existing roads;
- road widths;
- turnouts; and
- appropriate traffic control devices.

Designed travel speeds often vary along forest roads due to terrain conditions or changing road standards. The cycle time or distance from the logging area to the dump or processing area may be an important economic factor to consider in establishing an overall design speed. In other cases, topography and terrain may dictate alignment, with little impact from other factors. In general, base the safe vehicle speed for a road on:

- horizontal and vertical alignment of the road;
- vehicle size and configuration;
- road width; and
- sight distance and traffic volume.

Use the the following table to determine appropriate travel speeds and stopping and sight distance requirements along the road.

- Table 3-2 Summary of alignment controls for forest roads (PDF)

Maximum road grades

Ensure that the following design conditions are considered in developing maximum road grades:
- road surface;
- anticipated vehicle types;
- vehicle speed;

- length of pitch;
- curve radius; and
- specific terrain hazards to negotiate.

Subgrade widths

Forest roads widths are categorized as either single or double lane roads based on subgrade width. Roads less than 8m in subgrade width are classified as single lane roads. Double lane roads do not require turnouts. Where road surfacing is not used, the stabilized road width is the width of the road subgrade.

Curve widenings

Design minimum subgrade widths for roads on curves or design widenings in accordance with the following table and the following notes:

Table 3-3 Curve Widenings

Radius of Curve in meters (m)	**Minimum Subgrade Width in meters (m)**
180	4.3
90	5.3
60	5.8
45	6.0
35	6.5
25	7.5
20	8.0
15	9.0

Double lane all blind curves or provide adequate traffic control devices.

Allow extra width to accommodate for side tracking of truck-trailer units. Note that the subgrade widths in the table do not make accommodation for the overhang of long logs or any slippage of the truck or trailer because of poor road conditions.

Apply the widening to the inside of the curve unless the curve has a 60m long taper section on each end. For widening on the inside, provide a minimum 20m section on each end of the curve. Apply the full widening at the beginning of the curve (B.C.) and end of the curve (E.C.).

Turnouts

A turnout is a short auxiliary lane of sufficient width to provide space for safe passage of industrial vehicles. They are used on single lane roads and located in suitable numbers to accommodate user safety. Design them such that the running surface of the turnout is 4m in width, in addition to the stabilized road width.

Make the overall turnout length a minimum 30m, including a 7.5m taper at each end. Increase the turnout length to accommodate longer truck configurations, where the turnout length may increase to as much as 50m. Figure 3-2 illustrates examples of turnout configurations (PDF).

Slope stability considerations

If a proposed road will cross areas with a moderate or high likelihood of landslides, a conventional cut and fill road construction technique may not be an adequate type of measure to maintain slope stability, and alternative measures incorporated into the geometric road design may be needed to prevent road- induced slope failures and landslides.

Examples of types of measures include:

- road relocation;
- site specific road construction techniques;
- methods to cross gullies and fish streams
- cut and fill slope angles;
- location and design of waste areas and endhaul areas;
- drainage control or installation of subsurface drainage; and
- road maintenance (including upgrading and modification), and deactivation strategies.

Examples of different road construction techniques that may be used in conjunction with appropriate deactivation measures, include:

- bench construction with no endhaul;
- oversteepened fills for single season use of the road;
- use of wood for fill support for short term roads;
- oversteepened cuts with modified drainage control to manage minor sloughing;
- bench construction with endhaul and replacement of finer material with coarse rock fill;
- full bench construction with 100% endhaul;
- retaining wall structures to support cut or fill slopes; and
- engineered fills that incorporate special requirements for compaction of the fill and reinforcement of the fill with geosynthetics.

Fill slope & cut slope angles

Design stable cut slopes, road fills, borrow pits, quarries, and waste areas in a manner that will not contribute directly or indirectly to slope failures or landslides over the expected design life.

- Table 3-4 General guidelines for cut and fill slope angles for use in forest road design (PDF)

Fill slopes

The stability of a fill slope depends on several variables, including the forces that tend to cause instability (gravitational and water pressure forces), and the forces that tend to oppose instability (e.g., shear strength resistance of the soil or rock materials expressed as an internal friction angle or cohesion). The stability of fill slope can be increased by incorporating various design and construction techniques.

Design fill slopes at or less than the “angle of repose.” The term “angle of repose” should be used in the context of loose, cohesionless soils only (e.g., non- plastic silt, sand, sand and gravel). Flatter side slopes in all types of soil will reduce the gravitational forces that tend to cause slope instability. For a fill slope in cohesionless material, the angle of repose is about the same as the minimum value of that material’s angle of internal friction. Steeper fill slopes are more likely to cause a road-induced slope failure or landslide than flatter fill slopes.

Compact the fill materials to increase the density and shearing resistance of the soil. The angle of internal friction depends primarily on the relative density (loose versus dense), the particle shape (round versus angular), and the gradation (uniformly graded versus well graded). For relatively loose cohesionless soils, the minimum value of the angle of internal friction will range from about 27 degrees (2H : 1V) for rounded uniform soil grains to 37 degrees (1⅓H : 1V) for angular, well-graded soil grains. For relatively dense cohesionless soils, the maximum value of the angle of internal friction will range from about 35 degrees (1.5H : 1V) for rounded uniform soil grains to 45 degrees (1H : 1V) for angular, well-graded soil grains.

Note: Fill slopes that are constructed at or less than the angle of repose (minimum angle of internal friction) will not necessarily remain stable if partial or full saturation of the fill occurs. Such saturation can result from surface and subsurface water flows during spring melt or after heavy periods of rainfall.

Expect that poorly drained fill materials will be prone to a greater likelihood of slope failure or sloughing than well-drained fill materials. Additionally, the slopes of poorly drained fills at locations of significant zones of ground water seepage may experience larger and greater frequency of slope failures or sloughing problems. The significance of observed seepage zones might dictate the application of special drainage measures to reduce the likelihood of slope failure during construction and the intensity of maintenance activities over the operating life of the road. As a general rule, without special drainage measures, design the side slopes of poorly drained fills (e.g., fills composed of silty soils) at angles that are flatter than the angle of repose to minimize the likelihood of slope failures.

Cut slopes

In the design of cut slopes, consider and address factors such as:

- the desired performance of the cut slopes;

- types of cut slope materials;
- overall terrain stability;
- engineering properties of soils;
- seepage conditions; and
- maintenance.

In general, cut slopes will remain stable at slightly steeper angles than fill slopes constructed from like soil materials. The reason for this is the undisturbed soil materials in a cut are often in a denser state than similar type materials placed in a fill; and may contain sources of cohesive strength that further increases the shearing resistance of the soil.

Cut slopes designed at too flat an angle can be uneconomical in steep ground because of the large volumes of excavation. Steeper cut slopes may be more economical to construct in terms of reduced volumes of excavation. However, they can also be more costly from an operational standpoint because they require more maintenance due to sloughing and slumping.

For most forest roads, design cut slope angles to favour steeper angles to:

- reduce the length of cut slopes;
- minimize visible site disturbance; and
- reduce excavation costs;

provided that a somewhat higher level of road maintenance and likelihood of slope destabilization is acceptable for the site.

In the latter case, prepare and implement a maintenance schedule that addresses the erosional processes acting on the exposed cut slope face (such as splash, sheet, rill, and gully erosion) and reduces the threat to:

- drainage systems (as a result of cut bank slope failure redirecting ditchwater flows onto potentially unstable fill or natural slopes);
- user safety; and
- risk of damage to the environment.

Consider designing flatter cut and fill slopes or using retaining wall structures to support cut slopes or fill slopes, in cases where slope stability problems are expected to be difficult to manage with maintenance measures alone.

3.5.3 Swell & Shrinkage of Materials

The volume of natural in-place material usually expands (swells) or contracts (shrinks) after it is excavated and reworked. Figure 3-3 illustrates how the volume of a material can change during excavation, handling, placement, and compaction in a fill. Soil and rock volumes can be expressed in different ways, depending on whether they are measured in the **bank**, or measured in **loose** or **compacted** conditions.

Bank volume (sometimes referred to as **excavation volume**) is the volume of material in its natural, or in-place, condition.

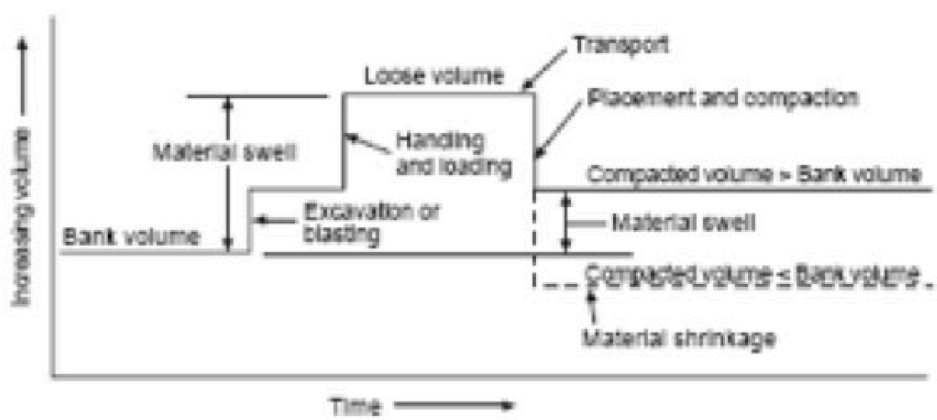
Loose volume (sometimes referred to as **trucked volume**) is the volume of material in a loose, broken, blasted, or otherwise disturbed state that has been excavated and stockpiled or loaded into trucks and hauled (handled). As shown in Figure 3-3, both soil and rock increase in volume (swell) when they are excavated and handled. This occurs because air voids are created in the material during these processes.

Compacted volume (sometimes referred to as **embankment volume**) is the measured volume of material after it has been placed in a fill and compacted. As shown in Figure 3-3, when loose material is placed and compacted, a reduction in volume occurs. The amount of this decrease may be greater or less than the increase in volume due to excavation, depending on several factors explained below. If the compacted volume is greater than the bank volume, the volume increase is called **swell**. If the compacted volume is less than the bank volume, the volume reduction is called **shrinkage**.

The amount of swell and shrinkage depends on several factors, including:

- soil or rock type;
- natural in-place density;
- moisture content of the loose material at the time of placement and compaction; and
- compactive effort applied to the fill material.

Figure 3-3 Example of material volume variation with time for various stages of road construction (not to scale)



3.5.4 Example Correction Factors

If the objectives of road design are to optimize the balance of excavated, fill, waste, and endhaul volumes and to minimize volume movements, adjust material volumes to compensate for swell and shrinkage. Table 3-5 shows example correction factors for various material types, to convert compacted volume to bank volume for use in road design.

In road design, material volumes are most commonly reported in volumes equivalent to bank volumes, because road construction projects are usually estimated, contracted, and paid based on bank volumes. In this system:

- Cut and volumes are both reported as the volumes they would occupy in the bank.
- The cut volume is the bank volume calculated from the road cross-sections, and therefore no adjustment is required.
- To convert the compacted fill volume back to the bank volume, apply a correction factor for swell and shrinkage. The correction factor is <1 to compensate for swell and >1 to compensate for shrinkage. If no net swell or shrinkage occurred during excavation, handling, placement, and compaction, the correction factor is 1.0.

The correction factors in Table 3-5 do not include any effects due to wastage or loss of material. Consider the need to separately account for other potential material losses that might affect achieving a balanced cut and fill design. Typical important sources of material loss, among others, can include material lost (spilled) in transport from cut to fill and subsidence, compression, or displacement of the prepared subgrade or original ground surface caused by the weight of the overlying embankment.

Table 3-5 Correction factors to convert compacted volume to bank volume for various materials

	Swell or shrinkage	**Material when it was IN THE BANK**
0.75 to 0.85	Swell	**Solid rock.** Assumes drilling and blasting is required, resulting in large fragments and high voids.
0.9 to 1.0	Swell	**Dense soil or rippable rock.** In the case of dense soil (e.g., glacial till) or rippable rock, typical compaction during conventional forest road construction will result in swell.

Table 3-5 Correction factors to convert compacted volume to bank volume for various materials

	Swell or shrinkage	Material when it was IN THE BANK
1.0 to 1.15	Shrinkage	**Compact to loose soil.** Lower correction factors are more appropriate for coarse-grained soils (e.g., sand, sandy gravel, or mixtures of gravel, sand, silt, and clay). Higher correction factors are more appropriate for fine-grained soils (e.g., silt and clay). It is more possible to achieve shrinkage during conventional forest road construction if the soil in the bank was in a loose condition. For example, a correction factor of 1.0 (i.e., no shrinkage) may be appropriate for compact sands and gravels, whereas a correction factor of 1.15 may be appropriate for very loose silts.

Notes Table 3-5:

1. The "example correction factors" are applicable to forest road design purposes only. They assume compaction is typically achieved during conventional forest road construction, and different correction factors could apply for engineered fills, placed and compacted to achieve the highest material density possible. Because of the variability of natural materials and their conditions in the bank, the potential for material loss during handling, and the range of road construction methods, correction factors are best determined from experience and local knowledge.
2. The example correction factors are based on swell or shrinkage effects due to an increase or decrease in the density of the soil or rock materials, and do not include any effects of potential wastage or loss of material from other sources.

Example

Bank volume = compacted volume x correction factor.

Example: If the compacted volume of shot rock is 12 m3 measured from drawings, how much bank volume needs to be drilled, blasted, and excavated to achieve this volume? Assume a correction factor of 0.75.

Solution: Bank volume = 12 m3 x 0.75 = 9 m3

Surfacing often depends on the material available within an economic haul distance and intended season of use. Rock ballast roads may require minimal surfacing material while other roads require extensive surfacing for year round use. Consider the surfacing depth during the road design process. The depth of surfacing is dependent on the stabilization of the subgrade and the ability to carry design loads.

3.6 Culvert Design

Culvert drainage design encompasses the selection of culvert materials, backfill requirements, scour protection, roadway alignment and adequate sizing to pass the expected flows. The information contained in this chapter is focused on design considerations, site selection, and design flows relevant to non-major stream crossing culverts.

Log culvert design and ford design are covered in the following sections:

- 3.6.1 Log Culvert Design
- 3.6.2 Ford Design & Construction on Non-Fish Streams

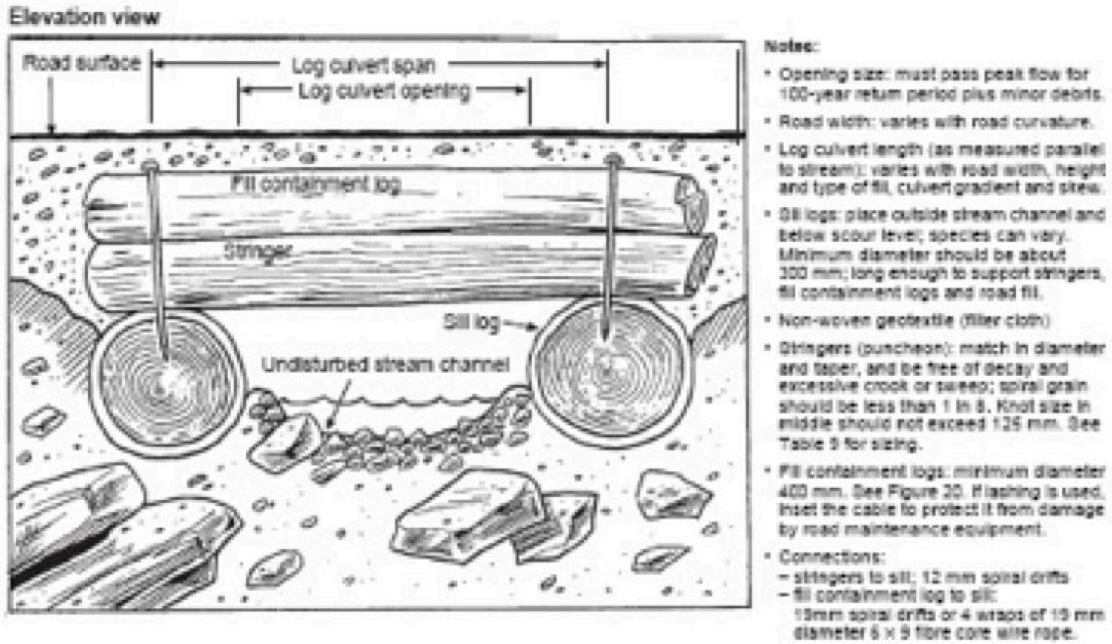
If the site is a fish stream or a potential fish stream, consult the Fish-Stream Crossing Guidebook (PDF, 4.2MB) for site and design requirements.

3.6.1 Log Culvert Design

For the purposes of this manual, the term “log culvert” is interchangeable with “woodbox culvert,” “log stringer culvert,” or “wood stringer culvert.”

A log culvert is a log crossing structure having a span of less than 6m center-to-center of bearing, and an abutment height (if constructed as a log crib) of less than 4m between the underside of the lowest crib log to the underside of the stringers, and is used to carry ephemeral or perennial stream flow in a stream channel from one side of a road to the other. A log culvert structure is covered with soil and lies below the road surface (Figure 3-14).

Figure 3-14 Simple log culvert



Notes Figure 3-14:

- Opening size: passes peak flow for 10-year or 100-year return period, (depending on the anticipated time that the log culvert will remain on the site) plus minor debris.
- Road width: varies with road curvature.
- Log culvert length (as measured parallel to stream): varies with road width, height and type of fill, culvert gradient and skew.
- Sill logs: place outside the stream channel width and below scour level: species can vary. Use minimum diameter of about 300mm; long enough to support stringers, fill containment logs, and road fill.
- Non-woven geotextile (filter cloth).
- Stringers (puncheon): match in diameter and taper, and be free of decay and excessive crook or sweep; spiral grain should be less than 1 in 8. Knot size in middle is less than 125mm. See Table 3-8 for sizing.
- Fill containment logs: minimum diameter 400mm. See Figure 3-15. If lashing is used, inset the cable to protect it from damage by road maintenance equipment.
- Connections:
- Stringers to sill; 12mm spiral drifts
- Fill containment log to sill: 19mm spiral drifts or four wraps of 19mm diameter 6 x 9 fibre core wire rope
- Inlet control: place shot rock to protect against fill erosion below the design flood level.
- Outlet control: place rock as required to prevent outlet scouring and undermining of the sill logs.
- In the case of a skewed log culvert, measure the span of the stringers for design purposes from bearing to bearing along the stringers and not at right angles to the sill logs.

Consider log culverts for:

- streams where other resource agencies require the culvert to be open bottomed; and
- steep gradient streams.

Where the planned service life of the road is less than the life expectancy of the drainage structure components, consider using log culverts:

- as temporary structures on tote roads or pilot trails;
- on roads where ongoing minor debris problems are anticipated; and
- on permanent roads as temporary drainage structures at the clearing or subgrade construction stage, until the permanent drainage structures are installed.

Ensure that a log culvert design addresses the following:

- opening size for design flow and debris management;
- culvert length and fill and surfacing requirements;
- superstructure design (stringer or puncheon sizing);
- substructure design (sills, mud sills, and foundation logs); and
- inlet and outlet protection requirements.

Log culvert opening size

To meet current legislative requirements, design a log culvert to pass the highest peak flow of the stream that can reasonably be expected within the following return periods specified below for the length of time it is anticipated that the log culvert will remain on site (see FPPR section 74). For methods to estimate the value of Q10 and Q100, design discharge of a creek see Figure 3-3: High water estimation method for stream culverts in this chapter and Chapter 4: Design Discharge Criteria.

A log

Table 3-8 Peak flows for various log culvert lifespans

Anticipated period that the log culvert will remain on the site	Peak flow return period
For a log culvert that will remain on site for up to 3 years	10 years (i.e., Q10)
For a log culvert that will remain on site for over 3 years	100 years (i.e., Q100)
For a log culvert within a community watershed that will remain on site for over 3 years	100 years (i.e., Q100)

culvert is a type of open bottom structure, designed to span the stream channel width. This is particularly important on fish-bearing streams to avoid impacts on fish habitat and fish passage - refer to the section on "Open bottom culverts" in the Fish-Stream Crossing Guidebook (PDF, 4.2MB) page 6.

In addition to passing the required peak flow discharge, design log culverts to manage anticipated debris. Options may include, but are not limited to:

- increasing the opening size (height and/or width);
- allowing debris to pass over the approaches;
- trapping debris with a specially fitted trash rack or other device; and
- combining these and other options.

Inspect debris catchment devices frequently and clean them as required. The criteria for design of any debris catchment device are site-specific and may incorporate professional input. Identify debris problems from terrain hazard maps, air photo interpretations, field investigations, and reports for the area - see the Gully Assessment Procedure Guidebook (PDF, 1.8MB).

The convention for specifying the opening size (inside measurements) of a log culvert is height (vertical distance between the deepest point along the channel floor and the soffit of the stringers) followed by the width (horizontal distance measured at right angles between the inside face of the sill logs).

Log culvert length

Culvert length, as measured in the direction of the stream, is determined by the following:

- road width;

- depth of road fill over the log culvert, and fill slope angles;
- type of fill over the log culvert;
- inlet and outlet treatments;
- culvert gradient; and
- culvert skew.

Road width

If the culvert is located within a horizontal curve, provide extra road width to accommodate side tracking of logging trucks and hence additional culvert length. The required width can be found in Table 3-3: Curve widenings.

Depth of road fill

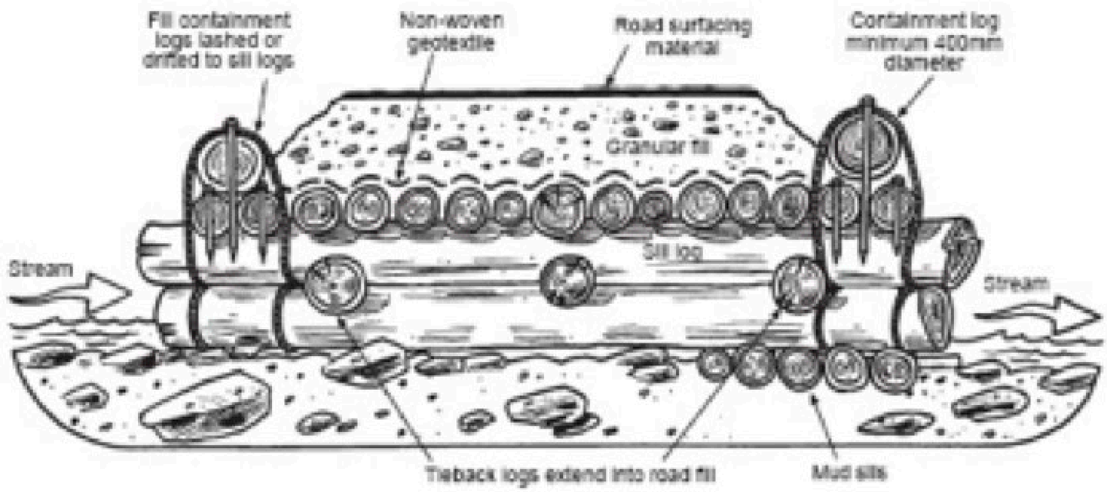
Road fills greater than 2 meters on top of the log stringers should generally be avoided. Should a failure occur, there is a potential for large volumes of sediment- producing materials to enter the stream channel. In addition, deep fills make culvert replacement, repairs or even inlet clean-out difficult. For fills anticipated to exceed depths of 2 meters, ensure that a professional engineer has been consulted or a design table produced by a professional engineer which captures the fill depth is used.

Measures to reduce road fill depth include:

- use of a longer span culvert, or a bridge for V-shaped channels;
- increasing the culvert height, by use of log cribs; and
- relocation of the road to a more suitable crossing.
- Ensure that log culverts are sufficiently long to contain the fill and prevent material from entering the stream. As the fill height increases for a given roadway width, increase the culvert length.

Incorporate road fill containment measures into the design. This can be achieved by making the culvert extra-long (at least 1 m per side beyond the toe of the road fill) and securing a large containment log (at least 400 mm diameter) at the toe (Figure 3-15.).

Figure 3-15 Fill containment for log culvert



In addition, include provisions that prevent road fill materials from encroaching on the design peak flow discharge flood level. For fills up to 1m thickness, use the sill logs-provided they are long enough-for this purpose. For higher fills, incorporate other site-specific measures into the design.

Type of road fill

To maximize fill slope angles and minimize culvert length, use shot rock or granular pit-run material for the fill material placed over a log culvert. Avoid the use of silty and clayey materials because these materials require flatter fill slope angles (and therefore longer slope lengths) to maintain fill slope stability and increase the potential for sedimentation.

Log culvert gradient

For stream gradients less than 10%, place the stringer soffit (culvert soffit) at 0% grade or at or near the same gradient as the stream. Should the proposed culvert soffit gradient (not the stream channel gradient), exceed 10%, then apply other structural considerations.

Channel gradient

Channel gradients less than 10%: A cross-sectional sketch of the culvert, the fill, and a profile of the stream bed provide the best tools for determining log culvert length. Measure the required length directly from a sketch drawn to scale.

Channel gradients greater than 10%: Measure the length directly from the cross-sectional sketch for the stream.

Inlet and outlet treatments

Incorporate headwalls or sill logs into log culvert design, allowing vertical end fills and therefore reduced culvert length.

Length for skewed culverts

Where a culvert crosses the roadway at other than a right angle to the road centreline, allow for the increased culvert length caused by this skew.

Log culvert stringer selection

Stringer sizing involves selection of the appropriate log diameter and species to be used for the stringers. Table 3-9 (PDF) is an example of a log stringer sizing table developed by a professional engineer. Table 3-9 presents stringer sizing for log culverts, as a function of span (see Figure 3-15), total fill depth, logging truck axle loads (e.g., L75), and log species. In this professionally engineered table, the total fill depth is the combined thickness of road surfacing and underlying road fill materials that extend down to the top of the stringers. The log diameters given in Table 3-9 are minimum mid-diameters, which are measured at mid-span under the bark. The total fill depth ranges from a minimum of 300mm to a maximum of 2m for this table.

If the design discharge is 6 m3/sec or greater, or the road fill depth is greater than 2m, ensure that a professional engineer has been consulted or a design table produced by a professional engineer which captures the fill depth is used.

Use oversize logs to account for unseen flaws, to give added strength for overloads and general heavy use, and to extend the service life of the structure. For maximum service life, use sound western red cedar. Fill containment logs contain the fill or road surfacing and can be structural or non-structural. Firstly, place a geosynthetic over the stringers to prevent surfacing or fill material from migrating between the stringers and into the watercourse.

Log culvert substructure design

The substructure required depends on the bearing capacity of the foundation soils and the length and diameter of the logs available. The choice of substructure is based on an estimate of the bearing strength of the soil at the site. From this, determine the diameter and length of the logs needed to support the design loads. Refer to FPInnovations' Log Bridge Construction Handbook (1980) for a detailed explanation of this topic.

Single sill logs

Use single sill logs as culvert foundations if the ground is firm and the sill log provides sufficient clearance for the design flood and debris passage. Use a minimum diameter for sill logs of about 300mm. For short service-life culverts (planned for less than three years use), almost any species of wood will suffice for the sill logs, provided it is sound throughout. However, it is very important that the anticipated life-span of the road be well thought-out. If there is a good chance that the life of the road will be extended, design and construct a culvert with a longer service-life.

The expected service life for sill logs is as follows (subject to site-specific soil and climatic conditions):

- Cedar (sound, with preservatives applied to cut surfaces): 20 years plus;

- Douglas-fir: 8-10 years;
- Spruce, hemlock and balsam: 4-6 years; and
- Hardwood species: Variable but assume it is less than four (4) years.

Table 3-9 Log culvert stringer sizing table (PDF)

Mud sills

If the natural ground will not support the culvert loads on a single sill log, increase the load-bearing area with the use of mud sills. These are short logs, 250mm (or larger) in diameter, and 1m to 6m in length, placed at right angles under the sill log for the entire length of the sill.

For crossings on soft ground, on non-fish bearing streams, another option is to extend the mudsills completely across the channel to and beneath the other sill log. This increases the stability of the structure. It is important that the mudsills be placed below the scour level.

Log culvert inlet and outlet protection

Where the sill logs for log culverts are placed outside the stream channel and bedded below scour level, do not provide additional inlet and outlet protection. If there is a concern about erosion around the inlet or outlet, protect any erodible surfaces with rock to a level equivalent to the design flood. Provide at some sites an individually designed settling or debris catchment basin at the inlet.

Inlet protection for cross-drain log culverts: Inlet protection for cross-drain log culverts will normally be achieved with a ditch block to ensure that ditchwater is directed into the log culvert and not past it. In most cases, use a catch basin to trap sediment and debris. For cross-drain culverts on a steep road grade, consider lining the ditch block, catchment basin, and the bottom of the channel with rock to minimize scouring.

Outlet protection for cross-drain log culverts: Do not consider placing log culverts on top of erodible fills. Direct ditch flows onto erosion-resistant areas or onto outlet protection such as flumes or riprap aprons. Do not direct ditch water flows onto unprotected sidecast material unless it is composed of rock or other erosion-resistant materials. On steeper slopes, erosion control at the culvert outlet is a design challenge. One option is to provide extensive outlet protection down the slope to an erosion-free area.

3.6.2 Ford Design & Construction on Non-Fish Streams

A ford is a dip in a road constructed to facilitate crossing a stream. The objective of a ford is to maintain drainage and provide a safe, erosion-free, and storm-proof crossing that requires little or no maintenance. In the past, inappropriate location and design of fords, and uncontrolled use, has led to a number of negative environmental impacts. These include increased sediment delivery, and degraded water quality downstream.

In isolated locations where maintenance equipment may not be available on a continuing basis, properly designed and constructed fords require little maintenance, and can be effective in reducing adverse impacts in drainage systems that are prone to debris flows or debris floods

(Figure 3-16). Consider the use of fords for areas of low traffic and intermittent use. Consider them as alternatives to bridges or culverts only where the crossings would not result in negative environmental impacts and where traffic use is confined to low-flow periods. Do not consider using a ford if the crossing is expected to be subjected to extensive or year-round traffic.

Figure 3-16 Road profile (stream crossing)

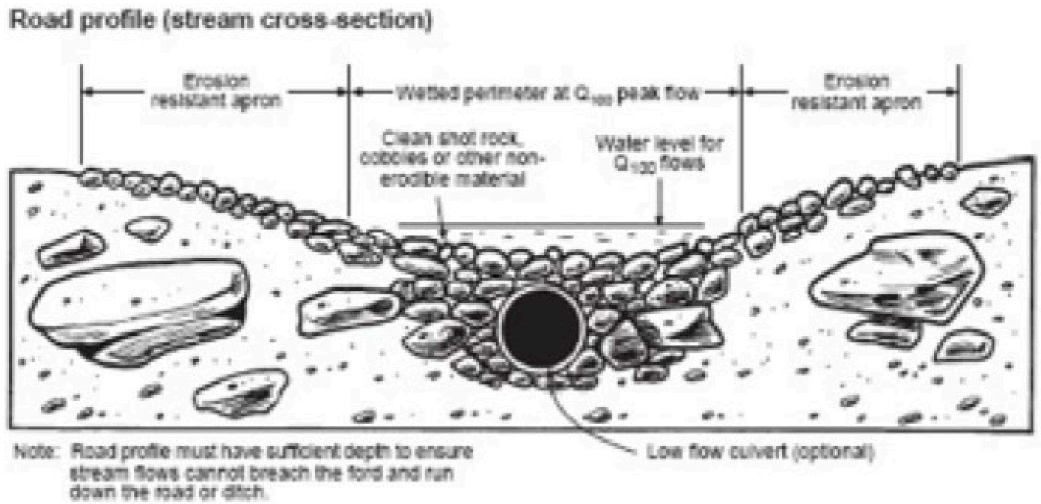
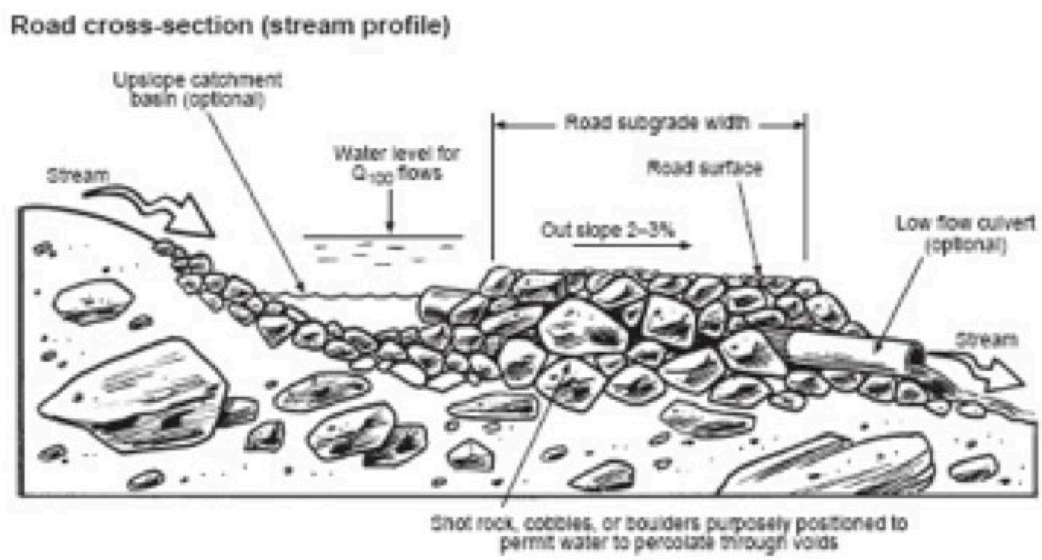


Figure 3-17 Road cross-section (stream profile)



3.6.2.1 Ford Planning

Identify fords in the planning stage of road development to ensure that the required design and measures include appropriate road grades leading into and out of the stream crossing.

Prior to planning a ford, evaluate the stream to ensure that it is not a fish stream. Refer to the Fish-Stream Crossing Guidebook (PDF, 4.2MB) for limitations on the use of fords on fish streams.

When planning a ford, and establishing design criteria, determine if any of the following possible user safety restrictions (or combination of restrictions) will apply to the stream crossing:

- the design vehicle will only be able to cross the ford during certain months of the year;
- the design vehicle will not be able to cross the ford during periods of specific maximum stream flows;
- only certain types of vehicles will be able to cross the ford; and
- only certain specific road uses will be considered for ford applications (such as industrial use).

Each proposed ford design is unique, but the objectives of any design are to:

- pass the design peak flow;
- minimize downstream erosion of the stream;
- prevent sediment input into the stream from the approaches and associated ditches;
- provide a suitable road profile to accommodate safe passage of the design vehicle;
- ensure that the stream remains in its channel and cannot be diverted down the road or ditches; and
- ensure that the ford will either pass channel debris-the preferable option-or trap it.

3.6.2.2 Ford Design

For a ford, the road profile dips into and out of the stream, creating a concave shape sufficient to ensure that the stream cannot be diverted away from its natural channel and down the road.

Ensure that the anticipated design vehicle can negotiate vertical and horizontal curves at the proposed ford. Where it is practical to do so, design the approaches to be at right angles to the stream.

Check the debris flow history of the stream channel:

- on air photos;
- on terrain stability maps or terrain stability field assessments; and
- in the field and considering local knowledge.

For further information, refer to the Gully Assessment Procedures Guidebook (PDF, 1.8MB).

If there is a debris flow hazard, decide whether the ford should be designed to:

- trap the debris, or
- allow the debris to pass over the ford (the preferred option).

The size and shape of the largest cobbles or boulders in the stream channel indicates the minimum size of rock required to resist movement when the stream is in flood, and thus provides a guide to the minimum size of rock to be used to construct the ford. The more angular the rock (such as shot rock), the more resistant it will be to moving.

In some situations, the use of a ford may be restricted to low-flow periods when the flow is subsurface. Design a low-flow culvert to pass the anticipated low flow. With this design, peak flows and debris flow over the top of the ford, resulting in some increased annual maintenance. Use a sufficient size of running surface material to resist erosion.

Design methods are available for determining flow rates through voids in rock fills. Such voids may plug up with sediment and debris, so design the dip in the road profile to accommodate the peak flow discharge based on considerations similar to those applied to the design of a bridge or culvert.

3.6.2.3 Design Approval Requirements

Prepare sketches of the ford design, showing:

- the road profile, extending at least 50 m at each end beyond the wetted perimeter at the design peak flow discharge;
- the width and depth of the wetted surface during;
- those months when use of the road is anticipated;
- design peak flow level and an estimate of debris volumes to be passed or trapped;
- annual low-flow level, or the flow levels for the periods of anticipated use;
- the range and average size of the material in the stream channel and its shape (angular, semi-angular, or rounded);
- the minimum width of the road running surface required to accommodate anticipated traffic;
- the requirements for any erosion-resistant materials for the road running surface, such as shot rock and concrete cross-ties, including use of any geosynthetics, to help separate different types and gradations of road fill materials;
- the rock source, size, and volume requirements;
- the length, width, and depth of the upstream catchment basin if one is proposed;
- the type and dimensions of the low-flow culvert, if one is proposed; and
- the length of apron to be surfaced with erosion resistant material.

3.6.3 Culvert Considerations

Design stream culverts to pass the highest peak flow of the stream that can be reasonably expected based on the anticipated length of time the culvert will remain on the site. For culverts anticipated to remain on site less than three (3) years, design for a peak flow return period of 10 years and all others for the 100-year peak flow return period. Note that there is no consideration of replacing the structure after these periods.

Determine the culvert length (measured along the invert) from the distance between the toes of the embankment, plus 1m in gravelly soils or 2m in silty soils.

3.6.4 Cross Drain Culverts

Cross drain culverts are used to carry ditchwater from one side of the road to the other and spaced at intervals necessary to minimize erosion of the roadside ditchline.

Use the distances in Table 3-6 as a guide to the maximum spacing for cross-drain culverts between established watercourses.

Table 3-6 Guidelines for maximum culvert spacing for forest roads

Erosion hazard	Slight	Moderate	High
More than 50% by soil type	Hardpan, rock, course gravels	Fine gravels	Sands, silts, clays
Road gradient			
0-3%	350m	300m	200m
3-6%	300m	200m	150m
6-9%	250m	150m	100m
9-12%	200m	100m	75m
12%+	150m	100m	100m + rock line the ditch

Reduce the spacing between culverts as required to prevent excessive accumulation of water in the ditches, particularly at road junctions, along road segments with steep uphill side slopes, and along areas of seepage or piping in cuts.

Determine the composition of the slope on which the culvert will discharge. If extensive erosion or mass-wasting may occur, change the location to suit the situation.

Skew cross-drainage culverts to the road centreline by 3° for each 1% road gradient that the road exceeds 3% (to a maximum of 45°).

3.6.5 Culvert on Non-Fish-Bearing Streams

For stream culverts not classified as major culverts or those installed on non-fish- bearing streams, record a minimum amount of information during the road location survey to assist in sizing such a stream culvert for the maximum design flow. In deeply incised channels, ensure that the culvert width is at least the same as the stream channel width. Prepare site plans where conditions are such that there are complex horizontal and vertical or other control issues requiring higher level design and installation procedures.

In planning the layout of the structure:

- Choose an appropriate location, along a stream reach with uniform or uniformly varying flow close to the proposed crossing, to measure a cross- section. Sketch the cross-section of the stream gully, showing evidence of the high water level, present water level, and the depth of the stream across the bottom. Extend the cross-section back from the stream an appropriate distance to show the terrain that affects the proposed crossing and road alignment.
- Note any visual evidence of high water.
- Measure and record the average gradient of the stream at the crossing and at the cross-section if the two are taken at different locations.
- Record the soil type, soil profile, parent material, and substrate material at the crossing and describe the stream bottom.
- Describe the stream channel (debris loading, bank stability, crossing location on a fan, bedload problem, etc.).

3.6.6 Factors Affecting Runoff

The runoff and behavior of a stream depends on many factors, most of which are not readily available or calculable, such as:

- rainfall (cloudbursts; hourly and daily maxima);
- snowpack depth, distribution, and snowmelt;
- contributory watershed area, shape, and slope;
- topography and aspect;
- ground cover;
- soil and subsoil;
- weather conditions;
- harvesting and road or other upslope development;
- drainage pattern (stream order, branchiness; lakes and swamps); and
- stream channel shape, length, cross-section, slope, and "roughness."

Because topography, soil, and climate combine in infinite variety, design drainage structures individually from available data for each site. In addition, consult those individuals who have long experience in maintaining drainage structures in the area.

3.6.7 High Water Estimation Method for Small Stream Culverts Using 3 X Bankfull Stage Area

This method estimates required culvert area, for a Q100 return period flood, as 3 times the bankfull cross sectional area of a representative, non-road disturbed stream reach. The application of this method should be limited to non-major stream culverts and 1200mm diameter or less. It is not appropriate for use as the sole method for "professional" designs. Studies suggest that this method may underestimate flows for Coastal areas.

This method assumes that the high water width represents the mean annual flood cross-sectional flow area for the stream (Q2); and that the Q100 cross-sectional flow area is three times this. It also assumes that the discharge is not sensitive to influences from pipe slope, roughness, or other factors.

The high water width is defined as the horizontal distance between the stream banks on opposite sides of the stream, measured at right angles to the general orientation of the banks. The point on each bank from which width is measured is usually indicated by a definite change in vegetation and sediment texture. Above this border, the soils and terrestrial plants appear undisturbed by recent stream erosion. Below this border, the banks typically show signs of both scouring and sediment deposition. Determine the high water width from recent visible high water mark indicators, which would approximate the mean annual flood cross- section. This point is not necessarily the top of bank, particularly in the case of an incised stream.

- Locate a relatively uniform stream reach in close proximity to the proposed culvert location. Note that this is not an averaging process that would be used for determining the stream channel width for the purpose of assessing stream habitat impacts. A uniform stream reach would have a consistent cross- section, bed materials, and channel slope. It would also be relatively straight.
- Estimate the visible high water stream width and cross-sectional area.
    a. Measure (in meters) the high water width at a relatively uniform reach of the stream, representative of the mean annual flood (W1) and at the stream bottom (W2). See Figure 3-4: High water width cross-sectional area.
    b. Measure the depth of the stream at several spots across the opening to obtain the average depth (D) in meters.
    c. Calculate the cross-sectional area of the stream, A = (W1 + W2)/2 x D.
- Calculate the area of the required culvert opening, Ac = A x 3.0.
- Size the pipe (see Table 3-7), using the smallest pipe area that exceeds the required area, or select an opening size for a log culvert that will be greater than Ac.

Cross check the high water width method if field or other evidence of an approximate 10-year flood is available. In this case, the area of the Q10 flood can be multiplied by 2 to estimate the minimum culvert area for the Q100 flood.

Example

If	W1 = 1.2 m W2 = 0.8 m D = 0.5 m stream cross-sectional area A = 0.5 m2
Then	Ac = 0.5 x 3.0 = 1.5 m2
Therefore	(from Table 3-7), the required pipe culvert size = 1400 mm.

Figure 3-4 High water width cross-sectional area

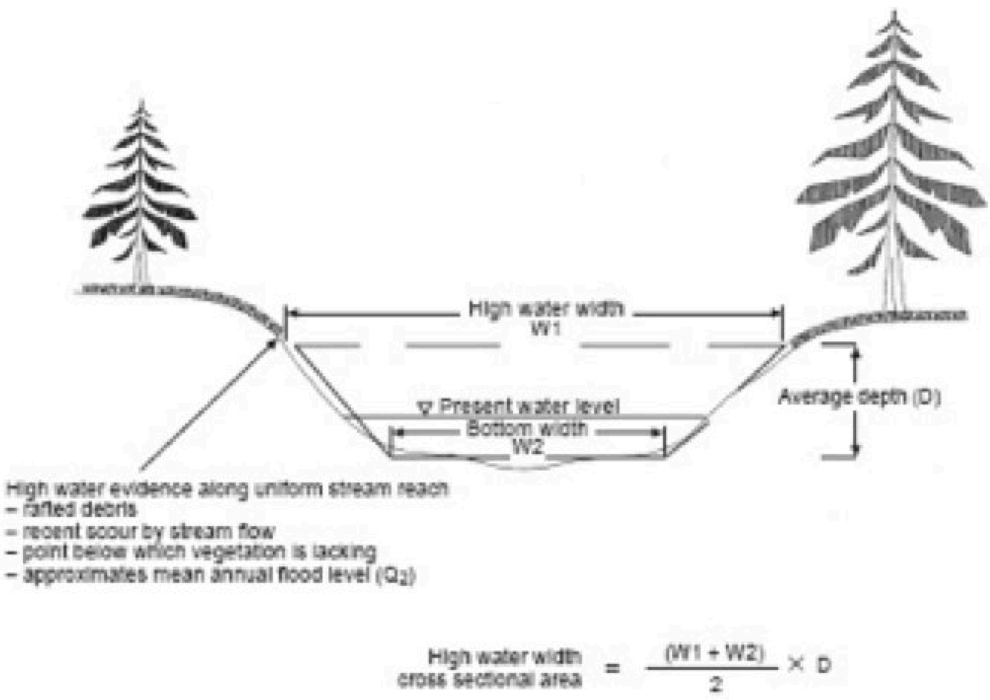


Table 3-7 Round pipe culvert area (Ac) versus pipe diameter

Ac (m2)	Pipe diameter (mm)
1.0.13	400
0.20	500
0.28	600
0.50	800
0.64	900
0.79	1000
1.13	1200
1.54	1400
2.01	1600
2.54	1800

3.6.8 Road Junctions

Ensure that a junctioning road has a minimum vertical curve with a K value of 1, and a minimum horizontal curve radius of 20 m or widening for sidetracking of vehicles. Where possible, design roads that junction other roads at right angles whenever possible to allow traffic to turn both ways and provide adequate site distance for oncoming traffic based on the road design speeds. On steeper slopes where a perpendicular junction cannot be obtained, ensure that the junction is designed so that the existing road width is not reduced.

For showing junctions and railway and utility crossings, use the road standard drawings, subject to any variations required by the appropriate agency.

3.6.9 Other Structures

The design of bridges, major culverts, cattleguards, retaining walls and other specialized structures that fall within the practice of a professional engineer are covered in Chapter 4: Design & Construction of Bridges & Major Culverts. Incorporate these designs into the road design.

3.7 Geometric Road Design Requirements

A geometric road design must be carried out for all roads that will cross areas with a moderate or high likelihood of landslides. In those areas of potentially unstable terrain, incorporate measures to maintain slope stability into the geometric road design (including where necessary for protecting workers in excavations greater than 6m). These measures rarely allow for the most optimum balance of waste, borrow, and endhaul volumes.

In addition to the above, carry out a geometric road design:

- other than the foregoing situations, on side slopes greater than 50%, to facilitate construction and control materials movements during construction, or to minimize impacts on alienated land and other resources. It is recognized that when encountering short sections (i.e. <100 meters) of stable terrain along a corridor where a geometric road design would not otherwise be required, it may be impractical to mobilize a survey crew just for those short sections. In such situations, information from the field reconnaissance report would be utilized.
- on higher order roads or road sections where alignment constraints are particularly important to achieve, particularly for addressing the safety of road users.

In geometric road design, select specifications for road width, cut and fill slope angles, and horizontal and vertical control angles to match the required road standard. Design a road centreline location (L-Line) based on information from the location survey and reconnaissance report. Calculate earthwork volumes or quantities.

In addition to the design requirements previously mentioned, ensure that a geometric road design provides:

- plans and profiles (see the road standard drawings for recommended content and layout);
- cross-sections with road prism templates;
- mass diagrams with balance lines;
- appropriate expansion and shrinkage factors for the material types;
- a schedule of quantities and units of measure for clearing, grubbing, excavating (other material and rock), and graveling;
- planned movement and placement of materials (balancing of design);
- the location and size of required drainage structures such as culverts and bridges;
- the location and size of retaining walls or specialized roadway structures;
- clearing widths (generally tabular in variable widths);
- construction equipment considered in the design for material movements;
- estimated material costs;
- location survey alignment and designed centreline (L-Line) offsets, and clearing width offsets shown on the site plan;
- slope stake information (note that this information is only a guide and slope/grade stakes should be calculated and placed based on design or re- design cuts and fills at centreline).

- measures required for reducing potential impacts on other resource values;
- site-specific design and construction notes and prescriptions on, for example, the location of endhaul sections, borrow pits, waste and slash disposal areas, and full bench cut areas, and any other information that the designer considers useful to the road builder;
- measures to maintain slope stability if the road will cross areas with a moderate or high likelihood of landslides as determined by a TSFA; and
- information that the designer considers useful to the road builder or owner.

Whenever possible, allow for the use of waste or spoil material in ways that reduce endhauling requirements. For example, some material types may be used for the road subgrade, base course, turnouts, curve widenings, and embankment (fill). If these options are not available, or if the excess material consists of overburden and debris, then identify spoil sites as close to the construction area as possible. Abandoned quarries, gravel pits, and roads are some possibilities for spoil sites. Alternatively, evaluate stable areas in gentle or benched terrain for use as spoil sites.

3.8 Survey & Design Outputs – Road Plans

The output of survey and design is the road plan, which may include:

- a list of documents that make up the road plan;
- a map showing the road location with key control points;
- project specific road design and construction standards or reference to an appropriate design and construction standard;
- any special conditions on use of certain road sections; for example, seasonal or weather limitations beyond normal operating conditions;
- assumed or documented ground conditions;
- cross-sections displaying road width, cut and fill slopes and surfacing depth;
- plan and profile views displaying:
  - vertical and horizontal alignment
  - location of field reference points (for example, private property boundaries)
  - location, type and size of drainage structures
  - locations of special design sections (for example, retaining structures)
  - locations and dimensions of turnouts
  - locations of landings, pits, quarries and spoil sites
  - sites of specific concern for construction; for example, potentially unstable terrain, fish streams, karst features
  - locations of nonconventional construction sections such as endhaul sections
  - clearing width
- excavation and embankment volumes;
- probable material type (soil, rock, organic overburden etc);
- mass haul diagrams;
- surfacing requirements, where applicable;
- locations of signs, fences and roadside barriers;

- specialist assessments, recommendations or designs (e.g. TSAs, crossing designs and engineered structures);
- identification of required field reviews (e.g. confirmation of assumed ground conditions, reviews to ensure conformance to specialist assessments, recommendations or designs);
- notification requirements required by others such as regulatory agencies or other parties;
- descriptions of any field surveys to be done before or during construction;
- communication of assumed ground conditions and protocol if unexpected ground
- conditions are encountered;
- provisions for worker safety as required by applicable Occupational Health Safety Regulations or as required to mitigate other potential hazards;
- instructions for specific construction procedures required to implement any aspects of the design; for example, traffic control measures and timing of the works;
- written procedures or references to SOPs that are intended to be followed during construction;
- locations of sensitive features and instructions for any special procedures around sensitive features, including construction methods, scheduling constraints and timing windows;
- instructions for creating access specifically for maintaining structures after construction is completed; and
- instructions for future maintenance.

Design details for special design sections may be incorporated into the general design or may be provided as separate documents. In either case, each Member must sign (and seal as appropriate) the work that they are responsible for as required by the by-laws of their professional organization.

Note that the road plan serves as the road site plan for BCTS roads built under FRPA.

The plotting data, plan profile information in Appendix 3, page 171 of the Forest Road Engineering Guidebook June 2002.pdf lists the basic information from a field survey and road design. Depending on the level of survey and road design requirements, the information may vary somewhat. For example, with a geometric design, mass haul diagrams would be present. The road plan **must** be reviewed and accepted by the Coordinating Member, usually the BCTS/District engineering technician. The intent is to ensure that a quality assurance review for acceptance, by a qualified ministry staff person, is carried out as a mandatory procedure. The intent is to avoid receipt of deliverables on the sole basis of it being signed and sealed by a registered professional, to avoid the practice of "blind" reliance.

3.9 Field Reviews

Field reviews means field reviews conducted at the project site [and / or at fabrication location(s)] of the implementation or construction of the engineering work by a Professional Engineer or his or her subordinate acting under his or her direct supervision, that the Professional Engineer in his or her professional discretion considers necessary to ascertain whether the implementation or construction of the work substantially complies in all material respects with the engineering concepts or intent reflected in the engineering documents prepared for the work.

3.10 Resources & Suggestions for Further Reading

BC Ministry of Forests. 2002. Fish-stream Crossing Guidebook (PDF, 4.3MB). For. Prac. Br.,B.C. Min. For. Victoria, B.C.

2. Forest Practices Code of British Columbia Forest road engineering guidebook 2nd edition June 2002 .pdf. . Br.,
B.C. Min. For. Victoria, B.C.

Holmes, D.C.. 1989. Manual for roads and transportation. British Columbia Institute of Technology (BCIT). Burnaby, BC

The Geometric Design Guide for Canadian Roads, 2007. published by the Transportation Association of Canada (TAC) provides design standards that can be used for forest roads.

3.11 Appendices

3.11.1 Drawing & Map Legends

As a general rule, primarily in the interest of time and money, pencil fair drawings are an acceptable presentation. However, there may be occasions where inked final drawings are required. For that purpose, it will be noted that "template" information is shown.

Symbols and markers

- Drawing and map legends (PDF)

North arrow symbol

Compass readings will be accepted in areas where legal boundaries are not or cannot be defined. The drawings prepared in such areas will show the North arrow as well as the declination arrow, amount of declination, and the year.

In all other areas where a firm tie has been made to a legal boundary, the commencement bearing is the boundary bearing, and only the true North arrow needs be shown on the related drawings.

3.11.2 Basic Drainage Site Report Requirements

Stream crossing data collection

Carry out the following:

1. Take at least two cross-sections to measure flow. Divide the width of the stream into four equal parts. Measure the flow velocity at each of the four sections.
2. In planning the layout of the structure:

- Choose an appropriate location, along a stream reach with uniform or uniformly varying flow close to the proposed crossing, to measure a cross-section. Sketch the cross-section of the stream gully, showing evidence of the high-water level, present water level, and depth of the stream across the bottom. Extend the cross- section back from the stream an appropriate distance to show the terrain that affects the proposed crossing and road alignment.
- Note any visual evidence of high water.
- Measure and record the average gradient of the stream at the crossing and at the cross-section if the two are taken at different locations.
- Record the soil type, soil profile, parent material, and substrate material at the crossing and describe the stream bottom.
- Describe the stream channel (debris loading, bank stability, crossing location on a fan, bedload problem, etc.).
- If the site is a fish stream, consult the Fish-Stream Crossing Guidebook (PDF, 4.2MB) for site and design requirements.

1. For the flow measurement cross-sections, sketch a graph of surface velocity across the channel and estimate average surface velocity (Vs) from the graph. Compute cross-sectional area (A), wetted perimeter (WP), and hydraulic radius (R) for each section. Average these values for two sections and use the slope of the reach between them to obtain discharge (Q) at present water level (PWL) and estimated high water level (HWL).

Centreline profiles

- Take a centreline profile showing streambed, PWL, HWL (if possible), and top of bank (if well-defined), extending 50-100 m on each side of centreline.
- Tie in all cross-sections and profiles to a traverse.

Photographs

Take stereo pairs of photos looking upstream and downstream, with the centreline in the foreground. Note the sizes of any other culverts on the same stream or its tributaries, and record their past performances, if known.

Benchmarks and references

Establish a minimum of one benchmark and two reference points.

Additional information

- Note the size, amount, and description of debris, and photograph debris accumulation.
- Make soil tests - at least one at the culvert site and one downstream where scour is expected. Drive a bar into the bottom of each hole and note its behaviour.
- Note all topographic control features that may affect culvert design.
- Note possible sources of compaction-zone backfill, riprap, and road fill.

Plan Details

At a scale of 1:200, with 0.5 m contours, show the following:

- present waterline (give date) and estimated high waterline;
- boundaries and descriptions of rock, soil, and vegetation types;
- large boulders, beaver dams, or debris accumulations (describe);
- any use of private property that might be affected, with status and right-of-way lines (if known);
- flow pattern, by arrows with appropriate length and direction;
- soil test holes and their logs;
- stream cross-section locations or their direction and distance if they are off the plan;
- control traverse;
- declination;
- topography points;
- reference points and benchmark, including elevation datum; and
- the key map.

3.11.3 Survey & Design Contract

Refer to Corporate Services for the Natural Resource Ministries (CSNR) Procurement and Contract Management support Intranet Download the current Consulting and General Services Contract FS1 and associated template types and Guidance as required.

4 Design & Construction of Major Structures

This chapter describes key activities and practices related to addressing safety, environmental, structural and professional responsibility issues in the design and construction of bridges, major culverts and retaining structures on Forest Service roads (FSRs). The topics covered include:

- professional responsibilities and considerations;
- design requirements and considerations;
- types of structures;
- site data and survey requirements;
- estimating design discharge for streams;
- construction drawings and specifications;
- construction materials, quality assurance, and fabrication; and
- statement of general conformance and construction documentation.

Definitions

- Coordinating Registered Professional (CRP), Professional of Record (POR) and specialists are defined in the *Guidelines for Professional Services in the Forest Sector – Crossings.*
- Bridge means a temporary or permanent crossing structure carrying a road above a stream or other opening and includes a log stringer/gravel deck structure with i) a span length equal to or greater than 6 m or ii) an abutment height of 4m or greater.
- Major culvert means a i) culvert having a pipe diameter of 2,000 mm or greater; ii) a pipe arch with a span greater than 2,130 mm; iii) an open bottom arch having a span greater than 2,130 mm, v) a log stringer/gravel deck structure (log culvert) with a span less than 6 m, or iv) any of the above structures that do not meet the minimum size requirements given but with a design discharge of 6 m3/sec or greater.
- Retaining structure means any retaining structure greater than 1.5 m high.
- Portable bridge superstructure is a bridge superstructure that is designed and fabricated, in accordance with the Bridge Standards Manual, for ease of movement and installation.
- Permanent materials: steel, concrete or treated wood.
- Temporary materials: untreated logs or untreated timbers.
- Permanent bridge is a bridge that has its stringers or girders and abutments comprised of permanent materials (even though it may have an untreated timber deck or untreated timber sills bearing on an abutment comprised of permanent materials). Rail car structures are an exception to the foregoing and will be considered a temporary bridge regardless of the abutment type.
- Temporary bridge is a bridge that has its stringers or girders, or abutments, comprised of temporary materials.

Refer to the Bridge Standards Manual for the Ministry of Forests' Bridge Guidelines, Standards and Specifications for bridges on Forest Service Roads

Refer to the Bridge Standards Library for a collection of non-mandatory bridge related reference materials..

Note: Log / wood box culverts, defined as those with gravel decks, spans less than 6m, abutment heights less than 4m, and design discharge less than 6 m3/s, are covered in Chapter 3: Road Survey & Design and Chapter 5: Road Construction of this manual.

Policy

All bridges, major culverts and retaining structures on Forest Service roads will be designed and constructed to:

- be safe for users;
- minimize the impacts on forest and other resources;
- be cost-effective; and
- be appropriate for the site.

4.1 Mandatory Procedures & Best Practices

Table 4-1 Design & Construction of Bridges, Major Culverts & Retaining Structures

Results to be achieved: bridges, major culverts and retaining structures safe for industrial user (FPPR s. 72) meet or exceed bridge design standards (FPPR s. 73) bridges and culverts designed to pass peak flow (FPPR s. 74) culvert materials standards (FPPR s. 76) retaining as-built information (FPPR s. 77) standards for FSR bridges built by licensees [FPPR s. 79(8)]	
Note: All references to bridges, major culverts and retaining structures includes those bridges, major culverts and retaining structures built under Road Permit (BCTS) and designated in that permit to be an FS bridge to be used for harvesting after completion of the Timber Sale License. Insert the appropriate clauses in the Road Permit to achieve the results described herein.	
M1	A professional engineer registered with the Engineers and Geoscientists British Columbia (EGBC) must prepare designs and take responsibility for retaining structures (associated with the road prism) that are greater than 1.5m high. [see Structure Design Responsibility]
M1a	A professional engineer must prepare a geotechnical report for retaining structures associated with the road, and that it evaluates and addresses possible (1) foundation and construction difficulties, (2) effects on existing adjacent structures or slope stability, and (3) methods of overcoming any identified difficulties during the construction stage, or other requirements. [see Geotechnical Report]
M2	A ministry engineer must review all detailed designs of retaining structures for conformance with ministry standards and other site specific requirements and accept the designs prior to the construction phase on FSRs. [see Ministry Review of Externally Prepared Designs]
M2a	The POR must carry out field reviews and during construction of the structure and prepare the POR Construction Assurance Statement.
M3	The CRP/CM must coordinate and ensure materials fabrication and construction field reviews are carried out during the construction of a crossing or a retaining structure on an FSR, and must sign, seal (as appropriate), and date a Crossing Assurance Statement/Project Assurance Statement (see Section 4.17) for submission to the ministry. [see Construction Documentation]
M4	Bridge and major culvert construction drawings for any FS bridge project must be signed and sealed by a qualified professional, to clearly identify the Coordinating Registered Professional and Professional of Record [see Design Responsibility]
M5	Where portable bridge superstructures or other structural components are used for any FS bridge project, the components must have been designed or structurally analyzed by a

	professional engineer, to demonstrate adequacy for the intended use. [see Portable Bridge Superstructures]
M6	Bridge components assembled or manufactured off the construction site (such as treated timber, steel girders, and precast concrete footings, girders, footings or deck panels) must be inspected during fabrication to provide quality assurance that all materials and procedures meet the materials specifications as well as the applicable codes and standards. [see In-Plant Inspection]
M7	Record drawings of bridges and major culverts must be signed and sealed by the Professional of Record, in addition to providing a statement of conformance for the design and construction of the crossing. [see Construction Documentation]
B1	During the conceptual design phase and well in advance of any detailed design work or procurement of materials, ensure that a ministry engineer is given an opportunity to review and comment on the suitability of a retaining structure proposed for construction on an FSR by the ministry. [see Concept Review Phase]
B2	In consultation with the Ministry Engineer, determine the design parameters for a bridge, major culvert or retaining structure [see Design Implementation]
B3	Where a Road Use Permit holder on an FSR will replace a bridge, major culvert or retaining structure on that road, ensure that the policies regarding Significant Road Work are followed.
B4	Ensure that a detailed site survey is carried out for bridge, major culvert and retaining structure projects. [see Site Data]
B5	Ensure that general arrangement drawings clearly depict the proposed components and configuration of the bridge or major culvert in relation to the forest road, stream, and streambanks. [see General Bridge Arrangement]
B6	Ensure that the construction drawings clearly show all construction details and provide for installation in general conformance with the design intent. [see Construction Drawings]
B7	Ensure that for log superstructures on log cribs, the drawings address layout of the structure and its elements, required component sizing, and connection details. [see Log Bridge]
B8	Ensure that final bridge drawings are signed off by the Ministry Engineer as acceptable. [see Construction Drawings]
B9	Obtain and keep on file all relevant material documentation, such as mill test certificates, in-plant test results, field test results, and all reports or comments made by field or in-plant inspectors. [see In-Plant Inspection]
B10	Ensure that all structural field welding and field grouting is carried out in accordance with the Ministry Bridge Guidelines, Standards and Specifications (BGSS) website. [see Field Welding and Field Grouting]

B11	Retain an environmental monitor when specified by the environmental agencies on a site specific project basis. [see Environmental Monitors]
B12	Ensure that after construction of a bridge or major culvert, the Coordinating Registered Professional signs and seals the Structure Assurance Statement (PDF) indicating that the entire structure is in general conformance with the design drawings and specifications. [see General Conformance]
B13	Where a structure project on an FSR will be constructed by a timber sale licensee, ensure that the timber sale licensee provides copies of the pertinent assurance statements completed and signed off by the CRP/POR (as appropriate);
B14	Ensure that a BCTS/District engineering technician inspects the completed bridge for acceptability/assurance of the structure; and a Ministry Engineer reviews the as-built information and field inspection note. [see General Conformance]
B15	Ensure that the necessary steps in the bridge and major culvert design and construction processes were undertaken and issues addressed [see Project Tracking Checklist]

4.2 Structure Design & Construction Professional Responsibilities & Considerations

4.2.1 General

The *Guidelines for Professional Services in the Forest Sector - Crossings* (the Guidelines) are intended to establish standards of practice for forest road crossings that members should meet to fulfill professional obligations, including the duty to protect the safety, health and welfare of the public and the environment. Failure to meet the intent of these guidelines could be evidence of unprofessional conduct and may give rise to disciplinary proceedings by FPBC or EGBC. Delivery of professional services for a crossing can involve the practice of professional forestry and professional engineering.

Consistent with the Guidelines, for any forest road crossings, a CRP **must** take overall responsibility and accountability for planning and coordinating all the professional services for the project, including the design, field reviews, record drawings and Crossing Assurance Statement. Also, this manual applies the same rationale to determining professional practices and responsibilities for the design and construction of retaining structures greater than 1.5 m high, whereby the CRP must direct those activities with sufficient oversight and supervision such that they can take overall responsibility and accountability for the retaining structure, including preparing a Road Project Assurance Statement that accounts for the structure.

A suitably qualified engineering professional or forestry professional may be the CRP for a crossing. As to who can be a POR for crossings:

- for those bridges that meet the tests provided in the Guidelines for simple crossings, the POR may be either a suitably qualified forest professional or engineering professional;
- for those bridges that meet the tests provided in the Guidelines for complex crossings, the POR must be a suitably qualified engineering professional.

An engineering professional or a forest professional in a structure project may be involved in some or all of the following:

- project organization and assignment of responsibilities;
- planning and design;
- general considerations;
- hydrology and hydraulics;
- plans and supporting documents;
- approaches and alignment;
- foundations and substructures;
- superstructures;
- materials fabrication and construction field reviews; and
- Structure Project Assurance Statement (see Appendix 8.2).

For forest road crossings and retaining structures greater than 1.5 m high, often the major volume of work applied to such projects is the structural design, materials and construction field reviews and resulting conformance assurances. This work is carried out by or on behalf of a professional known as the Professional of Record (POR) for crossings or the Retaining Wall Specialist for retaining structures. Their responsibilities include:

- preparation of the general arrangement and construction drawings;
- completion of field reviews; and
- completion of the POR or Retaining Wall Specialist Construction Assurance Statement (see Appendix 8.3), including preparation of record drawings;

The CRP for a crossing may or may not also be the POR for the project, and the CM for a retaining structure may or may not also be the Retaining Wall Specialist for the project.

A project may require the use of one or more specialists in addition to the POR or Retaining Wall Specialist. The specialist will obtain relevant project information from the CRP/CM or the POR/Retaining Wall Specialist and carry out the specific duties and tasks that have been assigned to them.

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4.2.2 CRP Skill Sets for Crossings

Some proficiency is required in all facets of a simple crossing project, including:

- layout
- site data collection
- site plan
- hydrology/hydraulics
- determining span length
- selecting substructure type

For simple bridge crossings, a CRP must have appropriate training in subjects such as:

- crossing structure design;
- forest road design;
- terrain analysis;
- soil strength and other soil properties;
- stream flood hydrology and hydraulics; and
- route and site surveying.

For CRPs having limited university/technical school level academic equivalents for the above subjects, but having successfully completed applicable courses and seminars, ensure that the Understanding and Familiarity applies, and that the Experience is particularly applicable and complete.

A CRP needs to be generally familiar with guidebooks and professional guidelines applicable to:

- fish stream identification;
- fish stream crossings;
- forest road engineering;
- terrain stability management and assessment;
- riparian management; and
- other relevant manuals.

A CRP also needs to be familiar with the following items on a region or area-specific basis:

- methods of bridge construction;
- common road construction practices;
- factors affecting workability/stability/performance of fills and cut slopes;
- relevant regulatory requirements for bridge design and construction;
- assessing environmental impacts; and
- worker and bridge user safety.

A CRP should have sufficient bridge project experience, derived from several projects a year spread over a period of at least three years, such that the experience would include:

- working under the supervision or mentorship of a Professional Engineer seasoned in this area of practice;
- a range of ground conditions and design complexity; and
- time spent with bridge foremen and machine operators carrying out bridge construction and maintenance.

The CRP’s work experience and responsibilities during that period should be a combination of **all** of the following:

- planning;
- field layout of bridges;
- bridge site data collection and site plan preparation;
- general bridge design, and coordination of specialist design components;
- bridge construction; and
- bridge use and maintenance.

4.3 Design Requirements for Retaining Structures

4.3.1 General Design Requirements

The FPPR requires BCTS and Timber Operations and Pricing Division to construct or maintain an FSR in a manner that ensures the road and the bridges, culverts, fords and other structures associated with the road are structurally sound and safe for use by industrial users.

Retaining structures associated with the **road prism** may be required at some locations to stabilize cut and fill slopes exceeding the natural angle of repose. They can be an important component of the road infrastructure to (1) optimize road layout and design and reduce overall construction costs, and (2) ensure slope stability and a stable road prism over the life of the road. To address safety and resource protection, retaining structures installed on FSRs will be suitably planned in layout and design of a road, and properly designed and built to ensure structural integrity, durability and serviceability.

This section describes the design requirements for conceptual and detailed design of retaining structures **greater than 1.5m high**, installed within or adjacent to the road prism to stabilize road cuts and fills or natural slopes. This section also describes the associated ministry acceptance / approval processes for such structures. Similar requirements and processes should be considered for retaining structures 1.5 m high and less.

The types of retaining structures captured by these design requirements include:

- conventional retaining walls that do not incorporate geosynthetic reinforcement, such as inter locking concrete block walls, gabion walls, steel bin walls, log cribs, and cast-in-place concrete cantilever walls;
- reinforced soil retaining walls using mechanically stabilized earth (MSE)1 or geosynthetic reinforced soil (GRS)[2]design methodologies;
- reinforced slope retention systems (no wall) using MSE or GRS design methodologies.

Structure design responsibility

A professional engineer registered with Engineers and Geoscientists of British Columbia (EGBC) **must** prepare designs for retaining structures that are **greater than 1.5m high**.

Conceptual design

During conceptual design and prior to detailed design, and based on a site visit, the design engineer will recommend a retaining structure type, and also facing materials for MSE[1] and GRS[2] retaining structures, to the ministry engineer for review. Selection of appropriate retaining structure type is typically based on an assessment of the design loading, depth to adequate foundation support, presence of deleterious environmental factors, physical constraints of the site, cross- sectional geometry of the road and natural slopes, foundation settlement potential, desired aesthetics, constructability, maintenance, and cost. Recommended retaining structure types (including facing materials for MSE and GRS retaining structures) will meet the performance, durability, and serviceability requirements established for the project by the ministry engineer.

[1]MSE technology uses a tied-back approach to the design of the geosynthetics and typically uses a wider spacing of the geosynthetic reinforcement compared to GRS technology.

[2]GRS technology consists of closely spaced layers of geosynthetic reinforcement and compacted fill materials to produce a composite reinforced soil mass.

Detailed design

Analysis and design calculations of retaining structures will conform to best engineering practices as outlined below:

- define project requirements, considerations, constraints, performance, durability and serviceability criteria; determine design methodology (analytical and design procedures), and confirm design service life;
- define structure geometry, design loads, lateral earth and water pressures, and effects of surcharge loads;
- assess external stability, and internal stability (if applicable), and facing material stability (if applicable);
- check global stability;
- produce design and construction drawings to show road site and general layout, retaining structure profile, existing and finished grades, cross-sections and details, materials specifications, connection details, guardrails or barriers (if applicable), construction guidelines, maintenance requirements;
- make reference to any supporting documentation.

Design variations

Variations from the design requirements described herein may be acceptable in certain special situations. All such variations will be documented and require approval from the ministry engineer prior to use.

Design service life

The design service life is potentially affected by the long-term effects of people, machinery, component material deterioration, seepage, flowing water, and other potentially deleterious environmental factors. Design retaining structures for a service life based on consideration of the potential long-term effects of material deterioration on each of the material components comprising the structure. Design drawings will clearly specify (1) whether the structure is permanent or temporary, and (2) the design service life of the structure.

- **Permanent** retaining structures installed on roads to stabilize road cuts and fills or natural slopes will have a minimum design service life of 45 years (same design service life as permanent bridges for FSRs) or longer service life as otherwise specified by the ministry engineer. Permanent retaining structures will be comprised of durable materials and will not incorporate any components having a lesser service life than the specified design requirement service life.
- **Temporary** retaining structures installed on roads to stabilize road cuts and fills or natural slopes will have a minimum design service life of 15 years unless a lower design requirement service life is specified by the ministry engineer after consideration of operational objectives and durability of material types contemplated for structure components. The installation of temporary retaining structures on permanent term FSRs should only be permitted if sound justification (supported by cost effectiveness analysis)

is provided and approval is given by the ministry engineer. The design of temporary retaining structures will not incorporate any components having a lesser service life than the specified design requirement service life.

Design lateral forces

In addition to lateral earth pressures from level or sloping backfill, the design of retaining structures will consider the effects of water pressure, surcharge loading (uniform area loads, point or line loads), compaction-induced pressures, frost-induced loads, and other forces acting behind the structures as appropriate.

Vehicle live load surcharge: As a minimum requirement, any in-service vehicle live load surcharge for engineering design of retaining structures will be based on a specific standard bridge design vehicle. For more information refer to the Bridge Standards Manual .

Alternatively, to meet specific operational access needs, it may be required to design for a vehicle live load surcharge that is possibly greater than a ministry standard bridge design vehicle to allow for safe passage of heavy equipment or non-standard vehicles (in a normal transport configuration) that can reasonably be expected to regularly use the FSR, now or in the future. In this case, obtain relevant manufacturers' equipment / vehicle data for design.

Design methodology

Retaining structure systems installed steeper than 70 degrees will be designed as retaining walls.

Unless otherwise specified herein or approved by the ministry engineer, the design engineer will analyze the applied loads and induced stresses using the design methodologies provided in the reference documents below:

For both conventional retaining structure design (with no geosynthetic reinforcement) and MSE retaining structure design:

- Canadian Foundation Engineering Manual, **or**
- AASHTO Standard Specifications for Highway Bridges, Seventeenth Edition 2002, Section 5 "Retaining Walls."

For GRS retaining structure design:

- Canadian Foundation Engineering Manual (chapter sections as applicable), **and**
- Chapter 4 of US Department of Transportation, Federal Highway Administration (FHWA), Publication No. FHWA-HRT-11-026 (*Geosynthetic Reinforced Soil Integrated Bridge System Interim Implementation Guide*). http://www.fhwa.dot.gov/publications/research/infrastructure/structures/11026/11026.pdf (PDF, 8.68 MB)

Design factors of safety

Use the following minimum factors of safety for external stability calculations:

Minimum factors of safety for external stability:

Condition	Minimum Factor of Safety
Bearing capacity	2.5
Sliding	1.5
Overturning	2.0
Global stability	1.5

On some forestry road applications, it may not be feasible to achieve some of these factors of safety, especially the global factor of safety on cut slope retention on steep slopes. For design, where a factor of safety is lower than shown in the above table, the design engineer will document the risks and benefits associated with a lower value and provide a recommendation to the ministry engineer for review and decision.

Minimum factors of safety for internal stability (MSE and GRS designs):

For MSE and GRS retaining structures, apply the minimum factors of safety for internal stability calculations of allowable reinforcement strength (or strength of the GRS composite mass) provided in the following guidelines or standards, unless the design engineer provides a rationale for using alternative factors of safety acceptable to the ministry engineer:

For MSE retaining structures:

- Canadian Foundation Engineering Manual, or
- AASHTO Standard Specifications for Highway Bridges, Seventeenth Edition 2002, Section 5 “Retaining Walls.”

For GRS retaining structures:

- Chapter 4 of US Department of Transportation, Federal Highway Administration (FHWA), Publication No. FHWA-HRT-11-026 (Geosynthetic Reinforced Soil Integrated Bridge System Interim Implementation Guide). http://www.fhwa.dot.gov/publications/research/infrastructure/structures/110 26/11026.pdf (PDF, 8.68 MB)

Maximum vertical spacing of geosynthetic reinforcement for GRS retaining structures: The maximum vertical spacing between horizontal layers of geosynthetic reinforcement used in GRS retaining structures will not exceed **300mm**.

4.3.2 Factors to Consider in Selecting Facing Materials for MSE & GRS Retaining Structures

Prior to final design, the ministry engineer will approve the type of facing materials for all MSE and GRS retaining structures proposed for installation on FSRs. To address durability and serviceability, the selection of facing element for a retaining structure will consider various factors:

- design service life
- economic implications of the structure length and potential environmental impact
- road safety considerations and traffic barricade requirements
- life cycle cost considerations, future maintenance and serviceability
- drainage requirements of the backfill
- durability for given exposure
- tolerances to movement during and after construction settlement, deflection, and rotation
- exposure of uncovered geosynthetic materials to potentially deleterious environmental factors or the loss of geosynthetic strength due to the long-term effects of ultraviolet (UV) light
- likelihood of possible damage to facing elements from stream abrasion and scour hazards
- likelihood of possible damage from grading and snow removal operations and vandalism
- aesthetics
- anticipated potential future transfer of the FSR to other agencies possibly necessitating the installation of specific materials for facing elements
- availability of materials
- horizontal alignment restrictions and space limitations.

4.3.3 Geotechnical Report

A geotechnical report will be prepared to assess and address possible:

1. foundation and construction difficulties,
2. effects on existing adjacent structures or slope stability, and
3. methods of overcoming any identified difficulties during the construction stage, or other requirements.

The report should include a recommendation of the preferred type of foundation, and methods of scour protection (if applicable for the site).

4.3.4 Detailed Design Drawings & Specifications

The design engineer will prepare detailed design drawings prior to construction of any retaining structures. The detailed design drawings will be signed, sealed, and dated by the design engineer taking responsibility for the design. Produce drawings at a scale and format that are usable in the construction process and include any explanatory notes, details, illustrations and specifications for the materials and construction. This content may include, but is not limited to, the following:

- site location, site plan, and general notes to specify:
  - site location coordinates;
  - name of FSR, forest district and region;
  - whether the retaining structure is temporary or permanent, and design service life of the structure;
  - design surcharge loading (uniform area loads, point or line loads), including the vehicle live load surcharge and the specific design vehicle or equipment configuration and loads used in the structure design;
  - design methodology and considerations, assumptions, constraints, any performance design criteria, and other project requirements;
- longitudinal views and existing ground profile, cross-sections, site location coordinates, construction working points and elevations, finished ground profile and elevations (if applicable);
- specifications for soil / rock materials, erosion protection of backfills, adequate foundation preparation, including scour protection (if applicable), and provisions for drainage of backfill materials and all soil reinforced zones (if applicable);
- material specifications for all components (including connection hardware), and including specification of corrosion protection of component materials to meet the design service life;
- facing material specifications and associated connection details, and geosynthetic layer layout, spacing and length in the case of MSE and GRS retaining structures;
- preparation of foundation areas, installation and assemblage of structure components, sizing and extent of riprap (if applicable), and other important requirements to ensure proper construction of the retaining structure;
- reference to design aids, specific constraints dictated by the ministry, or works of others which significantly impacted the resulting design.

All engineering reports and detailed design drawings and specifications, and engineered cost estimates related to the design of retaining structures (if applicable) will be signed, sealed, and dated by the design engineer.

It is the responsibility of the design engineer to ensure that appropriate quality assurance (QA) measures have been included in the design process. This may include engaging a qualified QA reviewer to check the design assumptions, calculations, notes and final design drawings consistent with the requirements of EGBC Bylaw Quality Management 14(b) (PDF).

4.3.5 Ministry Review of Externally-Prepared Designs

Concept review phase: During the conceptual design phase and well in advance of any detailed design work or procurement of materials, ministry staff will ensure that a ministry engineer is given an opportunity to review and comment on the suitability of a retaining structure proposed for construction on an FSR by the ministry. Failure to do this could delay acceptance of the detailed design drawings and/or project.

Review and acceptance of detailed designs: Design engineers that prepare retaining structure designs for the ministry will consult with ministry professional engineering staff during the detailed design stage. A ministry engineer **must** review all detailed designs of retaining structures for conformance with ministry standards and other site specific requirements and accept the designs prior to the construction phase on FSRs.

Accepted design drawings (for a retaining structure that will be constructed on an FSR) are to be stamped "For Construction."

4.4 Design Requirements for Crossings, Including Bridges & Major Culverts

4.4.1 Project & Design Responsibility & Considerations

A "bridge" includes the superstructure, substructure, connections, approach road fills, and scour protection works. A "major culvert" includes the culvert materials, compacted bedding and backfill, embedment materials for embedded culverts, scour protection, and the roadway.

Where pertinent in the design of any bridge or major culvert, consider:

- user safety;
- accommodation of pedestrian traffic where required;
- site selection, including assessment of stream geomorphology and geotechnical (global and local) considerations;
- environmental integrity;
- fish habitat and fish passage;
- impact of the proposed structure on the stream during and after construction;
- site revegetation requirements;
- structure alignment and location (vertical and horizontal) relative to the road and stream channel;
- complete structure combination (substructure, superstructure, connections, and scour protection);
- suitability of selected foundations for the specific site;
- design flood development;
- navigation (*Navigable Waters Protection Act*), if applicable;
- debris potential and passage;
- scour protection;
- design vehicle configuration for load and alignment;
- design traffic frequency;
- design service life influence on selection of bridge type and composition;
- construction layout, methodology, and timing; and
- economics.

The design of bridges and major culverts encompasses more than just the design of structural components. Consider the composition and interaction of all the components, as well as their relationship and impact on not only the users, but also on the road and stream components and other resources.

A key concept in a successful project is continuity of professional oversight and output reviews. The professional that is charged with retaining a close familiarity with the progress of the project, and with coordinating the various specialist inputs, is known as the Coordinating Registered Professional (CRP), who carries overall responsibility for the delivery of the professional aspects of the project.

Guidelines for Professional Services in the Forest Sector - Crossings describes the roles and responsibilities of the CRP related to bridge planning as follows:

- confirm that the necessary assessments for the project have been completed;
- utilize specialists in the planning;
- gather site information, including the site plan and other information;
- take overall responsibility for the conceptual plan and general arrangement drawings;
- address environmental considerations in the plan;
- coordinate activities relating to the crossing project in the context of the overall development;
- understand all generally accepted uncertainties inherent in the crossing project and assumptions made in relation to the project, including assumptions made by the specialists;
- have an understanding of the roles and responsibilities of all the people involved in the planning of the crossing project; and
- consider information received from specialists and where appropriate incorporate the information into the plan.

To address these planning issues, the CRP ensures that a qualified professional has addressed the need, if any, for specialist assessments for a new bridge or a bridge replacement, including those as part of a BCTS road site plan for new construction as described in FRPA, to provide results and strategies to meet the objectives of the FSP. In practical terms for bridges and major culverts, this means a map showing the proposed road location (and approximate crossing locations) together with the results of any specialist assessments that may have been required along or adjacent to the road, such as:

- riparian;
- fisheries values;
- wildlife corridors;
- archaeological;
- terrain stability;
- soil and sediment transport;
- visuals;

- invasive plants;
- range barriers;

and how they might impact the selected road (and hence) crossing location. The CRP uses the results of the assessment information to determine:

- what if any additional information may be required for the bridge crossing; and
- how to implement the bridge project to address the assessment outcomes.

The CRP undertakes the subsequent engineering project-specific roles and responsibilities such as carrying out or overseeing the preparation of the conceptual and final design and drawings, acquisition of materials and construction of the structure. Finally, the CRP will complete the general conformance sign-off and preparation of as built drawings.

For the CRP to practice due diligence with respect to the project operations and oversight, the CRP determines that any specialists involved in the bridge project:

- are qualified to do the work;
- are used in an appropriate manner; and
- have access to any project information and to any other project personnel.

The Crossing Guidelines provide limitations as to the types of bridges (simple crossings) that may be undertaken by an RPF as the CRP. The bridge elements that may be restricted include footings, substructures and superstructure types. However, the bridge types can generally be characterized as single, simple span log stringer or other short span non-composite superstructures on cribs <4m high or interlocking concrete blocks < 2m high. The usual scenarios for bridge projects are described below..

Scenario 1: Where a P.Eng will be the CRP for a bridge

The CRP has addressed the need, if any, for specialist assessments for a new bridge or a bridge replacement, or in a BCTS road site plan for new construction as described in FRPA, to provide results and strategies to meet the objectives of the FSP. A Professional of Record, who is a P.Eng and may or may not also be the CRP, carries out some or all of the subsequent engineering project-specific roles and responsibilities, including:

- the preparation of the conceptual design and general arrangement design drawings;
- quality assurance of materials fabrication;
- construction inspections;
- addressing required design revisions that become evident during construction;
- compiling materials and construction documentation; and
- preparation and sign-off of as-built drawings and statement of construction conformance.

Those items not carried out by the POR are done by the CRP, and the CRP signs off that the completed crossing structure has adequately addressed any other resource issues that were identified at the outset of the project.

Scenario 2: Where a forest professional will be the CRP for log stringer bridge superstructures

The CRP has addressed the need, if any, for specialist assessments for a new bridge or a bridge replacement, or in a BCTS road site plan for new construction as described in FRPA, to provide results and strategies to meet the objectives of the FSP.

The CRP uses design aids as required for stringer arrangement and sizing, needle beam sizing where appropriate, lashing of stringers and connections to sills or caps, placement, arrangement and sizing of crib members or concrete block sills

The CRP is responsible for:

- the preparation of the conceptual design and general arrangement design drawings;
- construction inspections;
- addressing required design revisions that become evident during construction;
- compiling construction documentation; and
- preparation and sign-off of as-built drawings and statement of construction conformance.

Scenario 3: Where a forest professional will be the CRP for re-use for portable bridge superstructure

The CRP has addressed the need, if any, for specialist assessments for a new bridge or a bridge replacement, or in a BCTS road site plan for new construction as described in FRPA, to provide results and strategies to meet the objectives of the FSP.

The CRP ensures that a professional engineer has carried out the design analysis to ensure adequacy for the intended use, and the structure has been inspected before re-use by a qualified inspector.

If any additional structural analysis is to be carried out by a professional engineer due to any potential issues raised by the inspection prior to re-use, that engineer will generally be the POR and as such will likely provide the necessary drawings, specifications, connection details, etc. for any structure that requires remedial work prior to re-use.

The CRP uses design aids as required for placement, arrangement and sizing of crib members or concrete block sills.

CRP is responsible for:

- the preparation of the conceptual design and general arrangement design drawings;
- construction inspections;
- addressing required design revisions that become evident during construction;
- compiling construction documentation; and
- preparation and sign-off of as-built drawings and statement of construction conformance.

Scenario 4: Where a forest professional will be the CRP for other short span steel girder bridge superstructures

The CRP has addressed the need, if any, for specialist assessments for a new bridge or a bridge replacement, or in a BCTS road site plan for new construction as described in FRPA, to provide results and strategies to meet the objectives of the FSP

A POR who is a P.Eng carries out (under the project oversight of the CRP) the subsequent engineering project-specific roles and responsibilities, including:

- the preparation of the conceptual design and general arrangement design drawings;
- quality assurance of materials fabrication;
- construction inspections;
- addressing required design revisions that become evident during construction;
- compiling materials and construction documentation; and
- preparation and sign-off of as-built drawings and statement of construction conformance.

Note that if the superstructure is composite, the POR or another professional engineer will necessarily become the CRP, in accordance with the Crossing Guidelines.

The CRP signs off that the completed crossing structure has adequately addressed any other resource issues that were identified at the outset of the project.

4.4.2 Skill Set for CRP for Simple Crossings

Knowledge requirements

1. be members in good standing with FPBC or EGBC;
2. have appropriate education, training and experience within the discipline of forestry or engineering that are congruent with CRP bridge design services;
3. have considerable recognized specialization in the layout and conceptual design of forest road bridges;
4. be familiar with forest road and bridge planning, construction considerations and techniques, design vehicle configurations and assessment, scour and scour protection, design flood hydrology determination, and bridge component properties and fabrication;
5. be thoroughly familiar with the Guidelines for Professional Services in the Forest Sector - Crossings prepared by the Engineers and Geoscientists British Columbia and the Association of BC Forest Professionals;
6. be thoroughly familiar with stream crossing requirements and procedures of the Department of Fisheries and Oceans Canada and the British Columbia Ministry of Environment;
7. have a working knowledge of related riparian and aquatic environmental issues (such as stream classification and fish passage requirements) and associated construction mitigation techniques;
8. have a working knowledge and understanding of the principles and best management practices related to stream crossings provided in the following publications:

- Forest Practices Code of BC Forest Road Engineering Guidebook (June 2002) (PDF, 7.61 MB)
- Forest Practices Code of BC Fish-Stream Crossing Guidebook (PDF, 4.2MB)
- Forest Practices Code of BC Riparian Management Area Guidebook
- Forest Practices Code of BC Fish-Stream Identification Guidebook (PDF)

Experience requirements

All CRPs require a minimum of 4 years of direct bridge experience in forestry or related industries in British Columbia within the past 10 years, including at least three years of professional experience at a level contemplated by the Crossing Guidelines. Such work experience includes:

1. Preparation of conceptual designs of forest road bridges, including analysis for log, timber, and steel components.
2. Development of general bridge arrangement drawings with consideration for:

    - design flood estimation;
    - design flood and debris passage;
    - bridge configuration alignment in relation to the road and stream;
    - road approach and alignment considerations;
    - crossing alignment to the stream;
    - scour and scour protection;
    - substructure and connection component alternatives including consideration for geotechnical conditions and construction parameters;
    - cost effectiveness of bridge options;
    - construction equipment and practices in the forest sector.

1. Preparation of reports, drawings, specifications and cost estimates.
2. Field reviews during construction of bridges to provide quality assurance and confirmation of conformance to drawings and specifications, including:

    - field monitoring of construction activities during critical phases;
    - assessing actual field conditions for consistency with design assumptions and recognized “changed conditions”;
    - assessing alternatives, and providing revisions to designs for “changed conditions”;
    - preparing as-built drawings, and providing statements of construction conformance.

4.4.3 Development & Use of Professional Engineer Forest Road General Arrangement Bridge Design Aids

Design aids may be utilized by qualified individuals producing general arrangement forest road bridge designs. The “Guidelines for Professional Services in the Forest Sector – Crossings”, Section 3.1, “Simple Crossings” requires where the Coordinating Registered Professional (CRP) is a Registered Professional Forester that - “plans **must** be prepared using structural details provided in drawings, tables, charts and other design aids that have been prepared by a Professional Engineer”.

These guidelines are applicable to: a CRP, an individual working in support of a CRP, a limited license holder with Engineers and Geoscientists BC, or anyone taking responsibility for a bridge general arrangement design and utilizing design aids.

Definition and content of a design aid

A design aid is a tool, produced by a professional engineer, which will provide an unambiguous result tied to clear parameters, and can be applied to a site-specific situation. An example of a design aid is a log stringer design table specifying log stringer diameters, subject to species and other identified limitations, for particular spans for specific design loads. A manual such as the FPINNOVATIONS Log Construction Handbook is not considered a design aid because a manual cannot be applied to a specific situation. However, individual stringer tables within that manual may be design aids.

When preparing design aids, a professional engineer should clearly state:

- the intended purpose, authorized users and application for the design aid;
- requirements and restrictions for those using the design aid (such as specific material or site conditions, specific aspects requiring higher level oversight, materials or connection requirements);
- assumptions made; codes referred to; and where applicable, Factors of Safety used in producing the design aid;
- limitations for application of the design aid;
- the name of the professional engineer having professional responsibility for the design aid; and
- except for those design aids in the public domain, the signature and seal of the professional engineer having professional responsibility for the design aid, the date the design aid was signed, and a date when the design aid is no longer valid (as applicable).

Use of design aids

A person should undertake the following best professional practices when using a design aid produced by others:

- are authorized by the “owner” of the design aid to use the design aid (note that some tables such as FPINNOVATIONS or Ministry log stringer tables are in the public domain; otherwise, the design aid is usually proprietary and often intended to be used only for client- specific applications);
- have discussed the design aid with the professional engineer that created the design aid to ensure that the individual using the design aid understands the limitations of the design aid and to ensure that they have the latest applicable version of the design aid;

- reference the specific design aid(s) in drawings and documentation when used for specific projects;
- provide copies of the design aid(s) used (that are not in the public domain) with the design documentation provided to the client; and
- seek specialist assistance (usually from a professional bridge engineer) when applicability of the design aid is in question or unforeseen circumstances make the design aid not applicable or questionable.

4.4.4 Typical Bridge Design Approach

Bridge and major culvert designs and construction approaches for FSRs have evolved into industry standards. Typical details and arrangements are described in the Ministry Bridge Guidelines, Standards and Specifications (BGSS) website and in guidelines and requirements for ministry bridges. The most common components have been structurally pre-engineered and are well known by bridge designers, fabricators, and erectors.

Bridge Standards Manual

The standard drawings in the Bridge Standards Manual include ministry-approved component configurations and details. Detailed designs for various components, such as concrete decks, slab girders, and various footing arrangements, are also provided in the manual.

The Bridge Standards Manual lists proprietary bridge components (consisting of conceptual drawings with minimal details) that have been approved by the ministry. Proponents whose proprietary systems have been accepted by the ministry have provided proof that their components will meet the stringent requirements laid out in the manual for structural integrity, durability, and other relevant aspects pertaining to the product's usage.

Design implementation process

Where a person or an entity other than the government of British Columbia construct or replace a bridge or major culvert on a Forest Service Road, ensure that the design implementation process follows Ministry policy for Significant Road Work as per FRPA 23.1.

For most other situations, utilize the following bridge or major culvert design implementation process:

- determine if a consultant retained by BCTS/District will be the CRP or whether this role will be taken by staff from the Ministry (Engineering Branch, District, or BCTS)
- in consultation with a Ministry Engineer, determine the design parameters for a bridge or major culvert structure (see Appendix 4.3 DESIGN CHECKLIST) and determine whether the conceptual designer will be the Ministry Engineer or a consultant professional engineer retained by BCTS/District;
- convey the design parameters and the performance requirements for the crossing to the conceptual designer;
- have the conceptual designer conduct a site visit and make note of the physical site parameters, including observations on design flood hydrology, foundation evaluation,

vertical and horizontal alignment and crossing location opportunities, and construction limitations (such as equipment and materials access);

- have the conceptual designer evaluate the options for the crossing given the available information and make a recommendation for the development of a site plan and oversee its completion (generally a detailed site plan for all but the simplest crossings [see Site Data & Survey Requirements for Bridges & Major Culverts].

Conceptual design / general arrangement drawings

A conceptual design illustrates how the proposed crossing structure addresses the site-specific operational requirements. Typically, the general arrangement drawings consist of one or more drawings showing the components and configuration of the proposed bridge or major culvert crossing, as well as construction details overlain on a site plan and profile [see Construction Drawings & Specifications], making reference to specific ministry standard drawings and details laid out in the Ministry Bridge Guidelines, Standards and Specifications (BGSS) website.

Ensure that the conceptual designer signs and seals the General Arrangement drawings.

Detailed structural design

For all but the most complex structures, a detailed structural design is typically not completed as part of the development of general arrangement designs. The final superstructure arrangement is best left to the fabricator or erection contractor, who can provide the most cost-effective and efficient design based on their materials availability and erection schemes. As part of the design/build process for the typical, simply supported forest road bridge structures, the detailed structural design of the superstructure components is completed by the bridge fabricator or the contractor who is the successful bidder to construct the bridge. In such cases, the contractor’s or fabricator’s engineer will normally be the structural design engineer, and the professional that prepared the conceptual design will be the POR as described earlier in this chapter.

4.4.5 Design Opening

Base the design flood requirements for bridges and major culverts on the anticipated life of the structures. Structures to be in place for a relatively short life pose reduced risks (compared with those expected to have longer life), and thus reduced design flood concerns can be considered.

In addition to design flood passage, make allowances for anticipated debris. For bridges, incorporate freeboard above the design highwater to allow for passage of floating debris. In the case of major culverts, also accommodate debris (floating or submerged) in the design process.

4.5 Types of Bridge Structures

4.5.1 Bridge Superstructures

Unapproved superstructures or systems

Before an unproven system or product is implemented, bring it to the attention of Engineering Branch for evaluation. If the branch determines that products or systems provide efficiencies and meet stringent performance requirements, those components are incorporated into the Bridge Standards Manual as acceptable ministry standards.

Deviation from the requirements of the Bridge Standards Manual and the associated standard drawings is not recommended. Where an unapproved structure or system is being considered for a project before the branch has completed its review and acceptance of such structures, contact the Ministry Engineer for input into the implementation requirements.

Approved superstructures or systems

Approved ministry superstructure configurations, identified in, Bridge Standards Manual provide for numerous construction options such as:

- timber decks on steel;
- precast concrete slabs;
- non-composite concrete decks on steel girders;
- composite concrete decks on steel girders;
- all steel portable bridges;
- Compo-Girders™; and
- steel-free decks (precast concrete arch panel composite deck).

Generally, use the following "rules of thumb" to help guide estimating or evaluating conceptual designs for typical single-lane, simply supported, permanent single-span bridges. Note that these rules of thumb are for completed in-place structures which consider both the materials and installation costs for the finished product. For example, materials for an application may be cheaper than some others, but the finished structure may cost more due to higher installation costs:

- For spans 12m or less, concrete slab structures are typically most economical. They are particularly conducive where there is little vertical distance available between the design opening and the vertical alignment or when there are horizontal alignment issues such as skews or extra width required to accommodate vehicle tracking on curves. Precast concrete slabs are extremely heavy, and as such are expensive to ship and difficult to launch. The equipment that will be used to launch and place them **must** be considered when selecting component size in the design phase.
- For spans between 12 and 18m, non-composite concrete decks on steel girders are typically most economical. They can be set up to allow for bolted deck connections, providing for bridge removal and use elsewhere.
- For spans greater than 18m, composite concrete decks on steel girders are typically the most economical. Concrete composite deck panel installation involves grout work that requires attention to quality control, is labour-intensive and time-consuming, and the deck panels are not easy to dismantle.

In addition to the above, for some configurations, an economical solution might be timber deck on steel girder superstructures, or less likely, all steel portable superstructures. Generally, all steel portable superstructures are much more expensive than other options. All steel portables are recommended only where they are being utilized for temporary situations and moved from site to site.

4.5.2 Bridge Substructures

Several types of substructures are available to support bridge superstructures. When determining the substructure options for a particular site, base the selection on the type of superstructure, operational requirements, and specific-site conditions.

Substructure types range from simple log sills to driven piles. Bridge Standards Manual presents numerous permanent bridge substructures standards. The standard design drawings in the manual typically consist of precast concrete spread footings and are suitable where adequate soil bearing can be obtained. The standard drawings also provide for “T” footings, suited to concrete slab girder superstructures requiring shallow abutments; and steel pipe columns on precast footing standards, suited to steel girder superstructures and concrete slab superstructure requiring higher abutments.

Consult the Bridge Standards Manual for the standards on cap and bearing details for pile foundations.

The following structures are examples of those not captured in standard design drawings in the Forest Service Bridge Design and Construction Manual:

- log cribs (suited to temporary usage);
- interlocking concrete block abutments (typically limited to three blocks high); and
- steel binwalls (numerous steel binwalls exist, but few new ones are being installed).

4.6 Types of Major Culvert Structures

Major culverts are often preferred structures in suitable situations. Their advantages over bridges may include:

- economics – culverts are generally cheaper than bridges for typical sizes used;
- reduced maintenance when installed correctly; and
- greater flexibility in terms of alignment options – culverts are suited to sites with horizontal and vertical curves; they can be fit to suit the road alignment and approaches so as to minimize impacts; and they enable maintenance of road widths and provide for road widenings more readily than bridges.

Steel and aluminum culverts are typically soil-metal structures. The soil and the metal work together to provide the structural integrity to support loads on the structure. The metal without soil is insufficient to support the design loads and would collapse. Soil is compacted in lifts immediately adjacent to and in contact with the culvert bottom and sides, to combine with the metal to support the design loads. Uncompacted fill is not sufficiently dense to combine with the metal to support the design loads.

For most soil-metal culvert installations, the metal is galvanized steel. Some aluminum culverts exist, but they are less common than galvanized steel. For a given installation, aluminum culverts are generally thicker but lighter than galvanized steel. However, the aluminum culverts tend to be more easily damaged during installation.

Culverts come in a variety of shapes and sizes. The selection of appropriate size and shape should be a function of the design parameters. Where floating debris is minimal and regular maintenance is anticipated, consider the use of debris catchers/traps. Where significant volume or size of floating or other debris is anticipated, a culvert may not be an option, and a bridge will be necessary to allow high water and debris to pass.

4.7 Site Data & Survey Requirements for Bridges & Major Culverts

Ensure that a detailed site survey (see Appendix E Bridge and Major Culvert Site Plan Specifications of the Forest Service Bridge Design and Construction Manual) carried out for a bridge or major culvert project. Use the survey information to produce site plan and profile drawings for planning, evaluating, and developing the crossing design. Determine the type and extent of site survey to be completed, including the quality of site information to be collected.

Typically, collect and note on a site plan the following information:

- contours to 0.5 m interval accuracy (may vary depending on complexity of the site);
- the riparian class for streams or lake classification;
- the apparent high-water elevation of the stream, based on visible evidence of recent flooding;
- a description of the composition and size of stream bed materials;
- a description of streambank materials and stream stability;
- cross-sections and a profile of the stream: one cross-section should be along the proposed road centreline and extend beyond the stream channel width, normally to at least 50 m on each side;
- horizontal and vertical location of reference points established during the site survey, which can be used to establish (and re-establish) the structure location during construction;
- the stream flow velocity and direction, if the flow may influence the size or layout of the structure;
- a description of the soil profiles and foundation soil conditions, based on soil explorations appropriate to the level of risk;
- presence (or absence) of bedrock, and depth to bedrock;
- a description of any evidence of stream debris or slope instability that could affect the crossing, based on upstream observations;
- any existing improvements or resource values in the vicinity that may influence the size or layout of the structure;
- location and dimensions of any existing structure, including edge of roadway, abutment, superstructure, stream, edge of clearing information, profile of existing road to the limits of the survey, and location, general description, and extent of vegetation;

- the locations and dimensions of any upstream structures, and a note about whether there is any evidence of damage or disturbance from any sources (erosion, debris damage, etc.);
- potential sources of rip rap, endfill material;
- any other pertinent information: Is the site currently accessible by road? Are there road or bridge restrictions on load length or weight? If so, how can these be overcome? If test drilling seems likely, how much work is required to get a drilling truck (usually not all-wheel drive) to the site?
- if equipment fording or temporary bridge crossings will be necessary for construction, information about possible ford and temporary bridge crossing locations and other considerations such as depth of stream at that point, bottom material, and access gradients; and
- the date of the survey and name of the surveyor.

If a fish stream is involved, consult chapter 3 of the Fish-stream Crossing Guidebook (PDF, 4.3MB) for additional site information requirements.

4.8 Design Discharge Criteria

Determine the design discharge for streams for a particular recurrence interval. Establishing a return period provides a benchmark of the relative risk to be attached to any particular design. The current regulation requires peak flows to be determined in accordance with the anticipated life span of the structure at a site [see FPPR section 74 (1)], and current professional practice requires that designers take into account the potential effects of climate change in their design calculations.

4.8.1 Factors Affecting Runoff

The runoff effect of a stream depends on many factors, most of which are not readily available or easy to calculate, such as:

- rainfall (e.g., occurrence of cloudbursts; hourly and daily maxima);
- snowpack depth and distribution, and snowmelt;
- contributory watershed area, shape, and slope;
- topography and aspect;
- forest and ground cover;
- soil and subsoil composition;
- weather conditions;
- harvesting and road or other upslope development or disturbance;
- drainage pattern (stream order, branchiness; lakes and swamps); and
- stream channel shape, length, cross-section, slope, and “roughness.”

Because topography, soil, and climate combine in infinite variety, design the drainage for specific sites individually from available data for each site. In addition, consult those who have long experience in maintaining drainage structures in the area, as well as observing evidence of local activity/events.

4.8.2 Methodologies to Estimate Design Flood Discharge

There are too many analytical and empirical methods for estimating stream discharge to be discussed at any length in this manual. Professional engineers, who in the course of carrying out their professional functions as designers of a bridge or a major culvert, are ultimately responsible for establishing the design discharge for a structure. Methodologies for determining design flood discharge include:

- working from available evidence of flood flows in the stream in question;
- gathering evidence of flood flows in other streams, relating these to their drainage basin characteristics, and then, from the characteristics of the basin under consideration, estimating a flood flow; and
- relating meteorological data to stream basin characteristics and estimating flood flow through empirical methods.

Obtain the necessary data for these methodologies from various sources:

Site information

Use site-specific data at, and adjacent to, the proposed crossing to estimate the maximum flow. Records of culverts and bridges within the vicinity that have successfully withstood known flood events can provide useful information in the estimation of flood flows.

Stream basin characteristics

Use stream basin characteristics such as length, slope, order, roughness, vegetative characteristics, and elevation band, combined with meteorological data, in empirical approaches to determine design flood flows.

Data from other streams

Use studies done on other streams in the vicinity, with similar characteristics, to provide information on relationships and comparative values.

Hydrometric records

The Water Survey of Canada publishes Surface Water Data (annual reports of readings on hydrometric stations throughout the province), as well as Historical Stream Flow Summaries in which mean values and annual peaks are tabulated. Use these stream flow records to project design flood flows from theoretical analysis.

4.8.3 Comparing Discharges Using Hydrological Information

Determining design flood discharge usually involves applying several different methods and then using judgment to select an appropriate design value. In all stream flood discharge determinations, compare the proposed opening size with historically problem-free existing stream crossings serving similar drainages in the same area.

Compare the flood discharge estimates derived from the site information with other data and theoretical derivations. Base the final selection of design discharge and resulting bridge opening or major culvert size, taking into account these comparisons together with consideration of debris potential, ice jams, and any other local factors that might influence the structure opening.

4.9 Agency Referrals

Once the site plan and preliminary design are completed, decide if applications for permits to construct a crossing need to be made with relevant agencies such as the B.C. Ministry of Environment (MoE), Fisheries and Oceans Canada (DFO), and Transport Canada (*Navigation Protection Act*).

Ministry of Environment

MoE is concerned with protecting water, land and air quality, managing flood and erosion control, and protecting the population and habitat of animals and resident fish species. The ministry administers various Acts that might be relevant to bridge or major culvert construction.

Fisheries & Oceans Canada

DFO is the lead federal government department responsible for protecting anadromous fish species and their habitat by administering the *Fisheries Act* and Regulations. Timing and methods of construction might be stipulated by either DFO or MoE agencies.

DFO Pacific Region has provided some commentary for small clear span bridges: Pacific Region Operational Statement - Small Clear-Span Bridges.

Transport Canada

Transport Canada administers the *Navigation Protection Act*. Its mandate includes protection of the public right of navigation in tidal waters. According to the division, approvals are required for every crossing. However, only refer and apply for crossings where the type and size of the structure or the nature of the stream have a potential for navigation problems.

Formal approvals issued by the Navigable Waters Protection Division require that the work be subjected to an Environmental Assessment in accordance with the *Canadian Environmental Assessment Act*.

Local and regional governments

Where old structures are being removed as part of the new construction process, ensure that proper approvals from local government offices are received for any waste disposal needs, normally dealing with treated wood and occasionally metal culverts.

4.10 Construction Drawings & Specifications

A set of construction drawings consists of the general arrangement drawings supplemented with detailed superstructure and substructure drawings and other fabrication, material, and construction specifications.

It may be appropriate in some cases for the Ministry Engineer to take on the CRP role, given that engineer's familiarity with the initial decisions for the project. However, the bridge engineer's time constraints may preclude this option. If the Ministry Engineer is not the CRP or POR, have the Ministry Engineer review the construction drawings (a combined package of general arrangement and structural drawings, including erection loads) and the FS137 Assurance of Field Reviews and approve them as meeting the ministry's design and construction requirements.

Shop drawings are prepared by material fabricators to detail, and in many cases, complete the structural design of bridge structure components. Ensure that these drawings are retained as part of the as-built documentation. The complete construction drawing set provides comprehensive details on the location, composition, arrangement, design parameters, and fabrication, materials, and construction specifications for the specific proposed structure.

On the construction drawings, clearly show all construction details and provide for installation in general conformance with the design intent.

4.10.1 General Bridge Arrangement Drawing Requirements

Ensure that general arrangement drawings clearly depict the proposed components and configuration of the bridge or major culvert in relation to the forest road, stream, and streambanks. Also, use these drawings during the agency referral process (see the Bridge Standards Manual).

Ensure that the contents for bridge and major culvert general arrangement drawings include:

- site location key map;
- designer's name (and seal);
- name of the stream, road, and station (km) and adequate information to detail the location of the structure;
- design vehicle configuration for load and alignment;
- design code references, specifically those from the most recent version of the CAN/CSA S6 – Canadian Highway Bridge Design Code and the Canadian Foundation Engineering Manual;
- expected life of the structure in place (temporary or permanent);
- design high-water elevation for bridges and design discharge;
- clearances between the design high-water level and soffit (low point of underside of superstructure) of bridges;
- details of debris passage or management strategies, if required;

- road approaches and grades, including width requirements (e.g., allowance for vehicle side tracking) and side slopes, to a sufficient distance back from the bridge to show potential problems, or to the end of the first cut or fill;
- dimensioning and labeling of component parts (to be confirmed with the shop drawings);
- connection requirements for component elements;
- drawings scales;
- relevant site plan and profile data (for suggested contents, see Site Data & Survey Requirements for Bridges & Major Culverts; sample general arrangement drawings are shown following in Figure 4-1 and Figure 4-2);
- location (vertical and horizontal) of proposed structure relative to field reference points;
- deck elevations at bridge ends;
- possible ford or temporary bridge crossing locations;
- road and bridge or culvert signs;
- approach barriers, if required;
- rip rap extents;
- limit of construction for contract purposes;
- special provisions related to the unique nature of the site and crossing, including specific instructions to bidders related to process or results, as appropriate;
- special instructions relating to material erection, installation standards, requirements, or methods as deemed necessary.

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Figure 4-1 Sample of General Arrangement and Layout (simple creek crossing) (PDF, 6.03 MB)

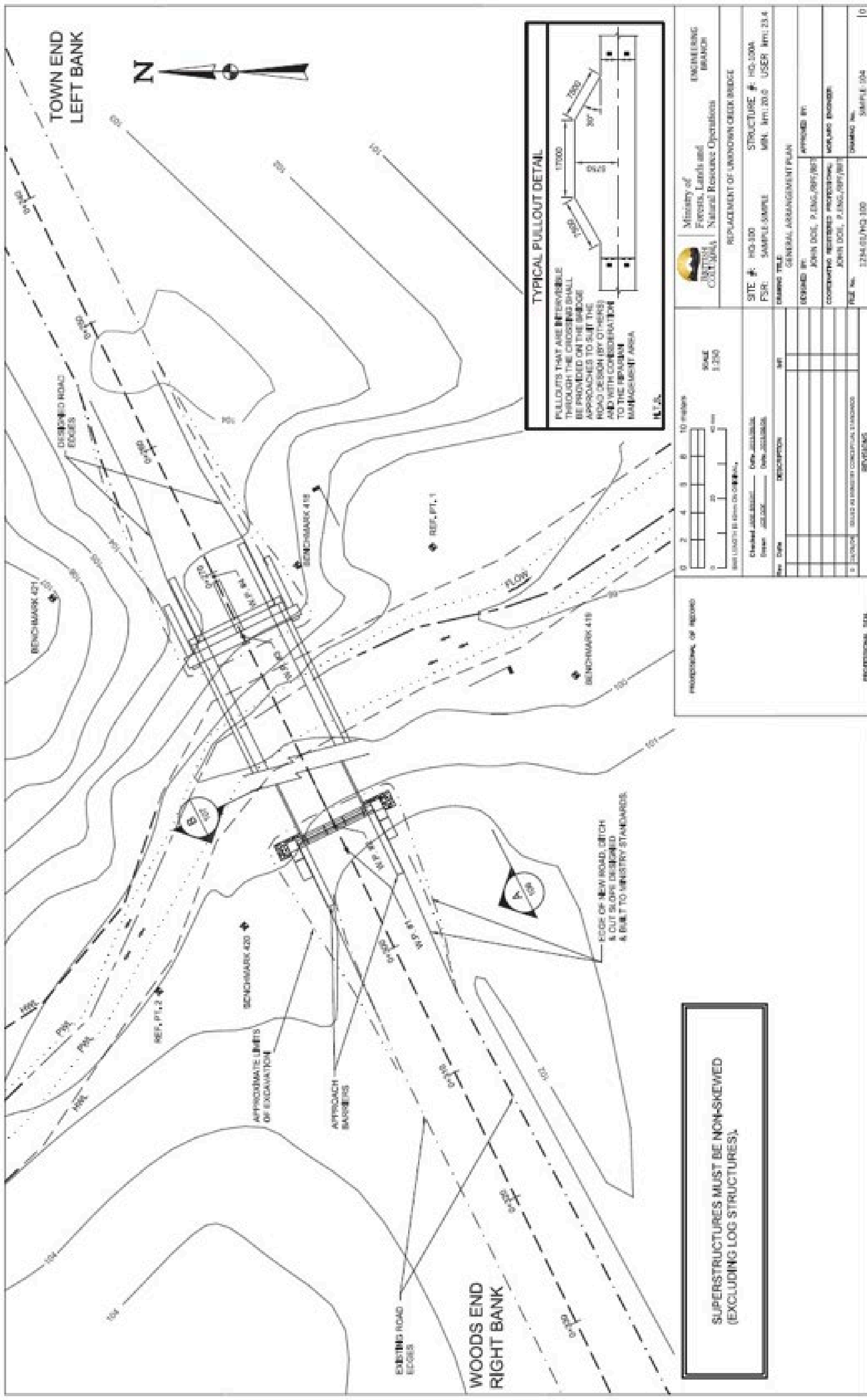
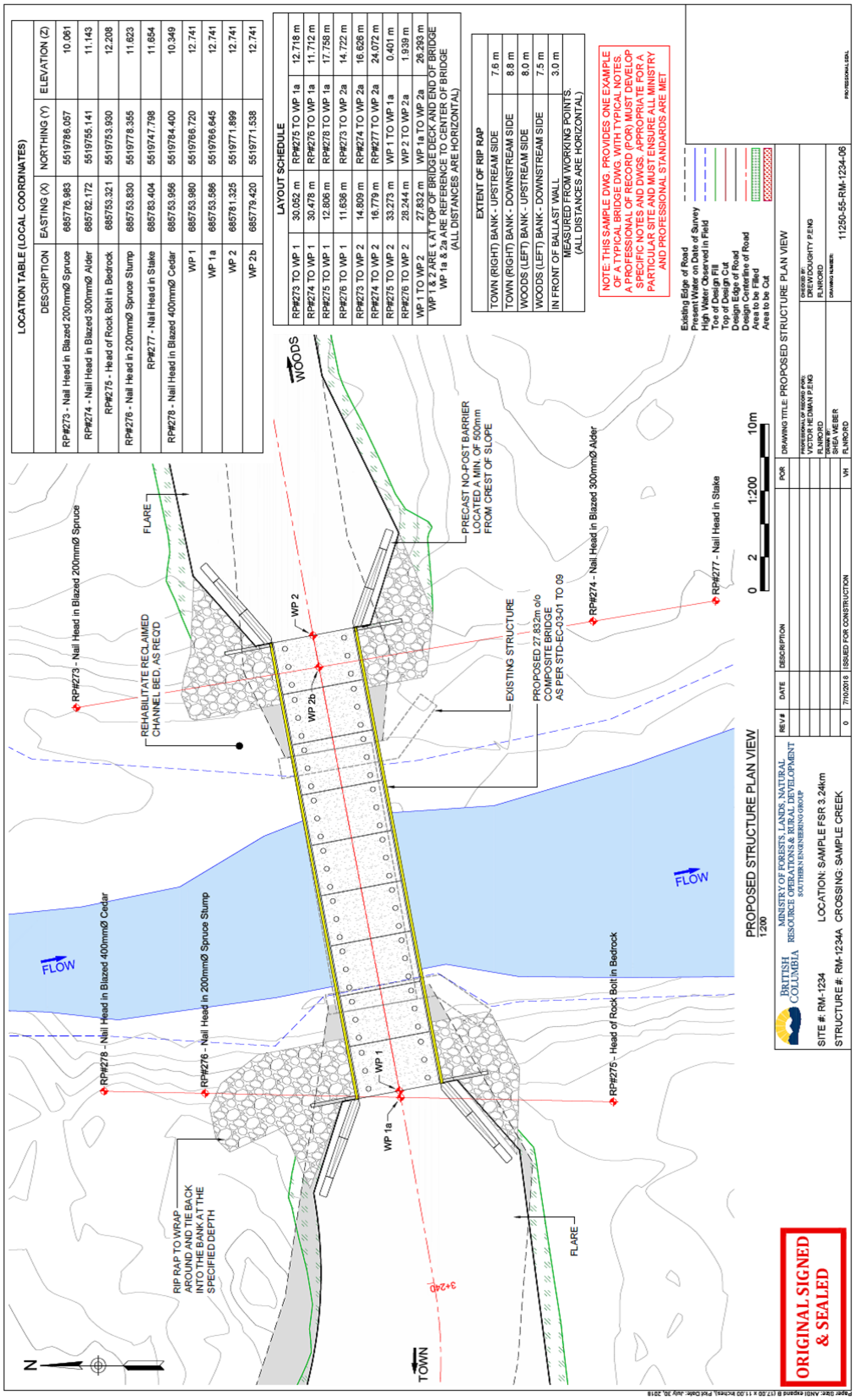


Figure 4-2 Sample of General Arrangement and Layout (complex creek crossing) (PDF, 2.2 MB)



4.10.2 Bridge Superstructure Drawing Requirements

Detail the following elements on bridge superstructure drawings:

- design code references, specifically those from the latest version of the CAN/CSA S6 – Canadian Highway Bridge Design Code and the Canadian Foundation Engineering Manual;
- individual member shapes, dimensions and connection details;
- materials specifications and CSA references, including but not limited to:
    - steel grades, impact category, finish;
    - timber species, grades, preservative treatment;
    - concrete strength, slump, and air entrainment;
    - bearing materials and connections;
    - superstructure elements, configuration, and connections;
    - dimensions and sizes of components;
    - girder or stringer arrangements and connections;
    - span lengths;
    - bridge and road width;
    - curb and rail configuration, connections, and component elements;
    - bridge label with structure number, date of manufacture, and load rating; and
    - field fabrication details.

Note that the superstructure drawings are normally supplemented by shop drawings prepared by the fabricator.

4.10.3 Bridge Substructure Drawing Requirements

Ensure that the following information on foundation requirements is detailed on the bridge substructure drawings:

- abutment elements, configuration, and connections;
- dimensions and sizes of components;
- critical elevations of substructure components;
- scour protection: dimensions, composition, extent of placement, design slope, design high water, and other considerations;
- piers;
- location and sizes of piles or posts;
- pile-driving specifications, minimum expected pile penetrations, set criteria, and required service level capacities;
- field welding requirements;
- bracing and sheathing configurations; and
- foundation requirements, material types and depth, and compaction level.

The above requirements also apply to portable bridge superstructures.

4.10.4 Log Bridge Superstructure on Log Crib Drawing Requirements

Since log stringer and crib materials are variable in nature and finished dimensions are not uniform, log bridge drawings are somewhat schematic. Ensure that the drawings address layout of the structure and its elements, required component sizing, and connection details.

Ensure that the following are indicated on the log bridge superstructure and log crib drawings:

- schematic layout indicating width and span;
- reference source for stringer and needle beam sizing;
- minimum stringer, curb, and needle beam dimensions;
- stringer, curb, needle beam, and crib logs specifications, including species, quality characteristics of acceptable logs, and seasoning;
- stringer-to-cap bearing details, including shim types and stringer and cap- bearing width and surface preparation;
- dap details at log connections;
- needle beam locations and connection details, if applicable;
- space to add stringer, curb, and needle beam sizes as part of the as-built record;
- deck layout, indicating tie sizes and spacing, plank thickness, and connections;
- other materials specifications, including sawn timber, hardware, and shims;
- excavated depth relative to scour line for mudsill or bottom bearing log;
- general layout and arrangement of front, wing wall, deadman, and tieback logs, and their connections to each other and to the bearing log or cap;
- description of crib fill material;
- layout and description of in-stream protection, if applicable; and
- rip rap protection layout and specifications (as required).

4.10.5 Major Culvert Drawing Requirements

Ensure that drawings and notes for major culverts portray and describe the following:

- site plan (see Site Data & Survey Requirements for Bridges & Major Culverts)
- location of the culvert, such as a key map;
- design vehicle load;
- fill height, depth of cover, and maximum and minimum cover requirements;
- design slopes of fill and rip rap;
- culvert invert elevations at the inlet and outlet;
- culvert specifications and dimensions: opening dimensions, length, corrugation profile, gauge, material type, and inlet bevel specifications;
- site preparation requirements;
- embedment requirements, including a description of the substrate and any rock used to anchor the bed material in the pipe;

- foundation details;
- backfill and installation specifications;
- installation camber;
- culvert gradient;
- seepage barrier details if required;
- special attachments or modifications;
- inlet requirements (rip rap layout, stilling basin, etc.);
- outlet requirements (rip rap layout, stilling basin, backwater weir for fish passage);
- rip rap specifications, including dimensions and configuration;
- design high-water elevation and design discharge, inlet or outlet control;
- connection details for pipe sections; and
- any existing improvements and resource values in the vicinity of the culvert that would influence or be influenced by the structure.

Combine any of the above requirements may where appropriate. For example, drawings for a log stringer bridge on timber piles may include the details from Log Bridge Superstructure on Log Crib Drawing Requirements, plus those from Bridge Substructure Drawing Requirements.

Include any additional requirements for a fish stream culvert, as specified in the Fish-Stream Crossing Guidebook (PDF, 4.2MB).

4.10.6 Portable Bridge Superstructures

Where portable bridge superstructures or other structural components are used for any FS bridge project (including those bridges built under Road Permit (BCTS) and designated in that permit to be an FS bridge to be used for harvesting after completion of the Timber Sale License), the components **must** have been designed or structurally analyzed by a professional engineer, to demonstrate adequacy for the intended use.

Record the ministry portable bridge superstructure number or, if there is no current superstructure number, contact the ministry engineer so that one can be assigned.

Once the components have been reviewed and approved by a professional engineer, re-use the components at new sites without specific professional engineer review of the superstructure, provided that:

- a qualified inspector has inspected the bridge at the new site before any use and does not detect any damage or deterioration of the structure; see Chapter 6 Engineered Structured Inspections - Types of Inspections;
- the design loads to be carried are equal to or lower than the original design loads for the superstructure;
- the bridge is suitable and has been specifically designed or analyzed for the new site, and signed and sealed design drawings and specifications have been prepared; and
- the superstructure has been fabricated and constructed in compliance with the appropriate legislation.

4.11 Bridge & Major Culvert Materials Acquisition

Materials for FSR bridges and major culverts are acquired in two ways:

- a requisition for materials through the Purchasing Commission and BC Bid; and
- through a works contract which includes supply and installation of bridges and major culverts.

In either case, all rules of government public tendering apply, and specifications and standards for bridge and culvert materials are the same.

Standard bridge material Requisition templates for acquiring bridge materials have been developed for use and are available in the Bridge Standards Manual Chapter 19.

The ministry's standard bridge material requisition templates are intended to be used primarily by Ministry Engineers and/or the professional engineer taking responsibility for bridge structure design or installation. Bridge material requisitions need to be consistent with the design. Consult the Ministry Engineer when a bridge material requisition is being developed for a specific project.

Incorporate the language in the requisition templates into ministry contracts where bridge material supply is included in the contracted works. The design and quality assurance requirements for bridge material supply under direct requisition or through a design, supply, and construct contract are identical.

4.12 Bridge & Major Culvert Materials Quality & Fabrication

Modern permanent structures have design lives that exceed 40 years. To achieve this longevity, ensure that the components are fabricated to detailed standards. Many important details (e.g., rebar placement, concrete design, and welds) can only be inspected during the fabrication process.

Ensure that bridge and major culvert materials and fabrication meet minimum requirements, by requiring materials and fabrication standards be met, including those of Canadian Standards Association (CSA) and the American Society for Testing and Materials (ASTM). This provides a means of ensuring the quality and consistency of materials, and provides equitable parameters for competition for supply, fabrication, and erection. The requirements, as defined in the standards, provide for a suitable blend of cost-effective and durable products. Ensure that the standards for bridge and major culvert materials and fabrication are adhered to. In exceptional circumstances, there may be a reason to vary from the standards but consult with a Ministry Engineer and Engineering Branch beforehand.

Ensure that all materials used for constructing bridges are new and conform to applicable CSA or ASTM material standards in the Bridge Standards Manual. In particular:

Concrete

Ensure that concrete is designed, mixed, transported, cast, and cured according to CSA Standard A23.1 – Concrete Materials and Methods of Concrete Construction and tested to CSA Standard A23.2 – Methods of Test for Concrete.

Precast concrete bridge elements conform to CSA Standard A23.4 – Concrete Materials and Construction, which means fabrication by a CSA-certified precast concrete plant.

Unless otherwise required by the designer, precast concrete blocks are exempt and may be supplied by non-CSA-certified precast plants provided they meet the following specifications:

- minimum 20 MPa concrete strength unless otherwise specified by a professional engineer;
- single pour (**must** not have any cold joints); and
- a finish free of honeycombing.

For higher risk structures, those that consist of multiple levels of interlocking concrete blocks, or those with significant bearing pressures, ensure that quality requirements of precast concrete blocks are more rigorous and are specified by the engineer taking responsibility for the design.

Structural steel

Structural steel for permanent and portable bridges complies with CSA Standard CAN3-G40.21-M – Structural Quality Steels. Primary tension members of welded structures are of type AT, grade 350 or better.

Weathering steel, type 350 AT, is not to be used for permanent bridges in marine or coastal areas or in areas where there is potential for road de-icing salts to come in contact with the bridge. Alternatively, specify galvanized or painted steel.

Steel fabrication is carried out by firms certified by the Canadian Welding Bureau (CWB) to Div 1 or 2. A list of CWD companies can be found on the Canadian Welding Bureau (CWB) website.

Timber

Timber used for bridge construction is graded in accordance with the standard grading rules of the Canadian Lumber Standards Administrative Board. Timber is grade-stamped, with the exception of unfinished or rough timber (in which case grading certificate may be requested), or local log stringers.

Structural timbers are Douglas-fir/larch #2 grade or better, except timber curbs may be any species #2 grade or better. Note that the structure strength and other characteristics, such as durability, make Douglas-fir/larch a superior product to other species.

Corrugated steel & hardware

Ensure that corrugated steel culverts are manufactured in accordance with CAN/CSA 3-G401 standard, Corrugated Steel Pipe Products. Steel culverts fabricated from steel sheets need to meet all requirements of ASTM A444, “Standard Specifications for Zinc Coated (Galvanized) Iron and Steel Sheets for Culverts and Underdrains.” Ensure that all hardware conforms to applicable standards (that is, rivets are galvanized, and bolts and nuts are Grade C, galvanized, meeting the requirements of ASTM standard A563.

4.12.1 In-Plant Inspection of Bridge Materials & Fabrication

For any FS bridge project (including those bridges built under Road Permit (BCTS) and designated in that permit to be an FS bridge to be used for harvesting after completion of the Timber Sale License), bridge components assembled or manufactured off the construction site (such as treated timber, steel girders, and precast concrete footings, girders, footings or deck panels) must be inspected during fabrication to provide quality assurance that all materials and procedures meet the materials specifications as well as the applicable codes and standards. The costs associated with inspection are more than balanced off in terms of off- setting future problems with the fabricated components. The ministry engages a contractor to provide the in-plant inspection services at the various fabrication plants around the province. The in-plant quality assurance inspection contract is coordinated by the Engineering Branch.

Ensure that the fabricator producing the bridge materials provides copies of detailed shop drawings to the in-plant inspector. The inspector confirms that the strength of materials and details of fabrication are consistent with the shop drawings and applicable specifications, as accepted for the project, standards, and codes. Where discrepancies occur, the inspector notifies the appropriate Ministry Engineer for input on acceptability or required modifications.

For more detailed information regarding material and fabrication requirements, refer to the Bridge Standards Manual

The inspector completes an in-plant inspection report for each bridge and submits it to the Ministry Engineer.

Obtain and keep on file all relevant material documentation, such as mill test certificates, in-plant test results, field test results, and all reports or comments made by field or in-plant inspectors.

4.12.2 Structural Field Welding

Welding is a specialized field and the ministry requires minimum qualifications for companies and personnel involved in bridge construction.

Typically, there are two types of structural welding on resource road bridges:

(a) shop fabrication of primary steel load bearing members and structural components, and

(b) field fabrication welding required for erection, assembly, and installation of bridge components (e.g. connection of bearings to pipes and girders, steel braces and diaphragms, and welded shear connectors for precast members).

Both types of structural welds are critical to the long term performance and integrity of the structure. Structural welding on ministry bridge structures is required to conform to Canadian Standards Association (CSA) Standard W59, **Welded Steel Construction (Metal Arc Welding)**. Firms carrying out welding on ministry structures are required to conform to CSA Standard W47.1, **Certification of Companies for Fusion Welding of Steel Structures**.

The Canadian Welding Bureau (CWB) is accredited by the Standards Council of Canada as a Certification Body for the administration of CSA Standards including W47.1, for:

- Certification of companies involved in welding
- Certification of Welding Inspection Companies
- Certification of Welding Inspectors
- Certification of Welding Electrodes

The CWB qualifies welders and welding procedures. The activity of the CWB contributes to the high level of competence enjoyed by industries employing welding and joining and the consistent progress in welding technology, and the reliability of welded products.

All CWB certified companies are required to have certified welders and written welding procedures for each specific type of weld produced (Weld Data Sheets). A list of CWB certified companies is found on the Canadian Welding Bureau website.

The minimum welding certification requirements, for ministry bridge work, is CWB Certification Division 2 for shop fabrication and Div 3 for field welding. A Ministry Engineer or designer may elect to specify a higher certification requirement for complex welding. Note that provincial welding qualification is not adequate as it is different and not equivalent to CWB certification. CWB certification of the firms employing the welders, as well as conformance to CWB procedures and standards, is required for all ministry bridge projects involving structural welding.

4.12.3 Structural Field Grouting

Structural field grout is a critical component to the safe performance and structural integrity of ministry bridges. Where structural field grouting is required, such as for composite concrete decks or shear connections for concrete slabs, mix and place the grout to attain the required bridge design compressive strength, and in accordance with manufacturer's specifications. The age of the grout should also be checked. Ideally grout should not be more than 6 months since manufacturer and absolutely not older than 12 months.

Manufacturer's specifications provide for varying amounts of water which will significantly affect the attainment of the design compressive strength within a specified time frame. Do not exceed manufacture's maximum amount of water. It is recommended to have a vessel to measure the water. When mixed properly, is usually somewhat fluid and is difficult to pour. Mixed grout should be packed and can be vibrated into place. Where excessive water is used in mixing grout, the cure time, strength and durability of the grout are compromised. This is a serious problem where the grout is intended to be a structural connection, which is almost always the case for ministry bridge projects. Monitor grout mixing and placement procedures and ensure adherence to manufacturer's specifications. Utilize a minimal amount of water in order to attain the required design strengths.

It is also noted that other factors influence set time such as the ambient temperature over which there is limited ability to control. Additional precautions are required for mixing and placing concrete or grout in cold or hot weather extremes. Placing of concrete products during extreme cold or hot weather has the potential to affect both the long term strength and durability and procedures should be reviewed by a Ministry Engineer.

Low temperatures during the placement and curing of grout can affect the ultimate strength and durability of gout both temporarily and permanently. Grout cures slower in cold temperatures and develops ultimate strengths over longer periods of time. Exposure of fresh concrete to temperatures below freezing may actually stop the curing (hydration) process.

Hot weather can have a negative impact on both plastic and hardened state of concrete. Hot weather affects all of the major components of grout including water, cement and aggregates. Hot weather also has an impact on batching, mixing and placing grout.

Precautions ***must*** be taken in advance of grouting operations that are anticipated to be affected by cold or hot weather.

Cold weather grout procedures

In “cold weather” conditions it is important to protect the concrete from freezing and to maintain curing conditions to ensure sufficient strength and durability to satisfy intended service requirements. When temperatures drop or will potentially drop below 5 degrees Celsius, cold weather procedures should be implemented. Cold weather procedures may extend beyond heating the water used to mix the grout and will need to address forecast temperature conditions. Preheating and continued heating for the initial set period for the concrete or grout may be required to ensure that the curing of concrete or grout is not affected by cold temperatures and kept from freezing. If the concrete deck panels or slabs are not pre-heated, they will draw the heat out of the grout and will increase the possibility of the grout freezing in subzero temperatures. If the grout is not preheated, it will dramatically reduce the temperature of the heated water when mixed. The heat of hydration of the grout is not sufficient to keep the grout from freezing in subzero temperatures particularly if the concrete deck panels or slabs are cold. If the grout freezes, it will most likely need to be extracted and redone which is a highly labour intensive and laborious process to be avoided.

Precautions may include some or all of the following:

1. Pre-warm the dry mix grout and components being grouted to above 10 degrees Celsius. The temperature during the initial 24 hours of cure time should be maintained above 10 degrees centigrade. The components’ temperature should be kept above freezing for a minimum of 72 hours subsequent to grout placement. Ensure compliance with the manufacturer’s specifications in order to meet the specified compressive strength within the required time frame.

   Practices that have been typically implemented consist of wrapping the structure in tarps and heating from beneath the structure using suitable heaters. Various types of tarps and covers have been used including: plastic sheeting, construction tarps, lumber wrap and even non-woven geotextile. The basic concept is using the wrapping to contain the heat from a heat source such as a tiger torch or propane heater and to warm the components that are being grouted. The wrapping would cover the deck and drape below the bridge to capture the rising heat. The dry mix grout can be placed on the deck, under the wrap and be heated with the deck or slabs. For steel girder bridges, it may be sufficient to have a heat source between the girders to keep the deck sufficiently warm through the grouting placement and initial setting. Exercise caution to ensure that any heat source be directed away from any bridge components to avoid adversely warping steel components or cause cracking of concrete.

1. Use warm water (20 degrees centigrade) to mix the grout.
2. Provide sufficient labor to minimize the time required to place and finish the grouting process, to minimize the handling time of the grout and resulting heat loss.

Hot weather grout procedures

Higher temperatures cause water to evaporate from the surface of grout at a much faster rate and cement hydration occurs more quickly, causing the grout to stiffen earlier, lessening workability, increasing the chances of plastic cracking and reducing ultimate strength.

Precautions may include some or all of the following:

1. Moisten precast components, steel reinforcement, and form work prior to grout placement.
2. Keep the grout cool prior to mixing, store in a cool location. Use cold water or ice, as a part of the mixing water. Ice should be crushed, shaved or chipped form and ***must*** be considered as part of the mix design. Mixing should continue until all of the ice is completely melted.
3. Use a grout consistency that allows rapid placement and consolidation within acceptable tolerances to achieve the required design strength.
4. Provide sufficient labor to minimize the time required to place and finish the grouting process, as hot weather conditions substantially shorten the times to initial and final set.
5. Maintain moisture for the curing process by covering with damp burlap, and periodically rewetting, to maintain moisture as the grout sets, as soon as possible after the grout finishing processes have been completed.
6. In extreme conditions consider adjusting the time of concrete placement to take advantage of cooler temperatures, such as early morning or nighttime placement.

Grout field sampling during field placement

Acquiring samples to allow for compressive testing of field placed structural grout is standard practice for Ministry bridges. The Ministry procedure for grout sampling of in-situ placed structural grout, used for composite precast concrete decks on steel girders and precast concrete slab bridges with grouted shear connections, is in Appendix 4.5. The sampling procedure is to be provided to and followed by the individuals tasked with taking the grout samples in the field for each particular bridge project placing structural grout in the field during construction. The grout sampling procedure may also be implemented for other structural grout applications as may be appropriate.

This Ministry procedure provides instructions on how to take representative samples of the grout that has been placed in the field. The cured grout samples will provide the ability to later test for compressive strength attained at appropriate times to assess the adequacy of the grout. This sampling and testing procedure is not fully consistent with various published Canadian or American standards for grout testing, but rather it is a hybrid of standards to accommodate Ministry 's particular needs. Various standards (e.g., ASTM, CSA) specify that grout would typically be tested using 50mm cubes. However, the cube molds are costly and would not be readily distributed where required for our needs. The cylindrical molds are applicable to our utilization and their shape allows them to be tested for compressive strength in a laboratory. Local material testing laboratories will have the capability to test the samples and the testing costs range from $20 – $30 per sample.

Taking grout samples

The initial set time for the sampled grout is a critical factor. Allowing the samples to cure in-situ, at minimum, overnight, will provide an approximate representation of the field conditions. These samples are not precise replicas of the grout in the field but should provide a very good indication of quality and strength. Increasing the minimum number of required samples or specifying longer field curing times shall be at the discretion of the Ministry Engineer.

Distributing grout sample molds

Suggested approach for distributing the cylinders – provide an envelope with an adequate number of cylinders, labels and one page instruction sheet included, to the party responsible for obtaining the samples. Would suggest discussing the procedure with the individual, identifying how the sample should be handled and placed subsequent to casting and who the sample should be provided to subsequent to initial set.

Testing grout samples

Testing of the grout samples is a recommended procedure as there should be some objective basis from which to gauge when the grout has attained sufficient strength to place the related structure in-service. The number of samples to be tested is at the discretion of the Ministry Engineer. For example, if the first sample attains or exceeds the required design strength, it may not be necessary to test additional samples.

In the event that tested grout samples are found to be deficient in compressive strength, further investigation would be required. Depending on the nature of the test results, coupled with observations in the field, it may be required that test samples would need to be cored for testing from the actual bridge. Where grout sample test results are deficient, the Ministry Engineer will specify the necessary steps to assess the problem in order to establish the safe use of the structure of concern.

Ministry bridge field grouting sampling procedure

This section provides procedures for making and curing cylinder specimens from representative samples of fresh grout being placed on Ministry of Forests bridges in the field.

Samples shall be taken during the field grouting processes for all ministry (including BCTS) bridges incorporating field grouted structural connections. These include:

- precast concrete deck panels on steel or concrete girders, and
- precast concrete slab girders with grouted shear key details.

Requirements:

Sampling of the grout shall occur at various times through the field grouting process, at roughly even intervals as the field grouting process progresses.

The samples shall be taken using the Ministry supplied 50mm diameter X 100mm long cylindrical plastic molds.

A minimum of 3 samples of each type of grout being used shall be taken using these procedures or as directed by the responsible Ministry Engineer.

Where Target Traffic Patch is used, a minimum of 3 samples of each of the coarse and fine grout shall be taken. Typically, coarse grout is used in the shear connections on slab bridges and for stud grout pockets and fine grout is used in deck panel joints for precast deck panel and girder composite action structures.

Grout samples shall be provided to the Ministry Engineer or provided to the individual identified in contract documents or specifications.

Procedure:

1. A sample of representative fully mixed grout that is ready for placing shall be taken.
2. Fill a cylindrical mold approximately halfway with grout.
3. Using a blunt nonabsorbent rod, approximately 10mm in diameter and 250mm in length (such as a spike head), uniformly over the cross section, rod the grout to the bottom of the mold 15 times.
4. Slightly overfill the mold with the second layer of grout and rod 15 times, evenly distributing over the cross section, and approximately 13mm into the bottom layer.
5. Strike off the top surface of the mold with a flat edge trowel, or other suitable straightedge, to remove excess grout and create a flat top surface.
6. Cover the mold with a damp cloth or paper towel and set the sample aside on site in a safe, flat location where the mold will not be disturbed for a minimum of 12 hours or overnight. The location should be representative of the conditions of the placed grout such as on the deck of the grouted surface or on the inside flange of a steel girder. Longer field curing times shall be at the discretion of the Ministry Engineer.
7. Ensure that a supplied, self-adhesive, label is completed and placed on each grout sample.

4.13 Major Culvert Construction

Ensure that major culvert installations receive compaction to obtain adequate structural integrity of the installation because culverts are generally soil-steel structures. The culvert itself will not support the design load without the soil-steel interaction. In order for the soil to work with the steel to support the design load, the culvert is adequately “bedded” and the soil appropriately compacted to be “structural.” The flexible steel is designed to distribute loads to the bedding and backfill surrounding it. Soil is most compactable when it is composed of select granular, free-draining material. Ensure that the backfill conforms to a specified size gradation.

Typical backfill compaction is the minimum Standard Proctor Density of 95%. To achieve that level of compaction, use hand tools to work smaller areas (between corrugations); mechanical compactors such as plate and jumping jack tampers; or rollers and vibrating compactor equipment.

Typical construction practices include the following:

- Provide adequate bedding before culverts are installed and backfilled. Where subgrade material is unsuitable, remove it and replace it with select granular, free-draining material compacted to support the culvert.
- Place and compact backfill in uniform layers, about 150–300 mm thick (compaction equipment and layer thickness as specified by the designer) of select granular, free-draining material on each side of the culvert in a balanced and progressive manner, to avoid potential distortion or displacement of the culvert.
- Remove cobbles and boulders from the backfill, particularly where they could contact the culvert. Use hand tools to compact the material immediately adjacent to the culvert within the corrugations. Fully compact each layer before the next layer is placed on top.
- Monitor compaction and complete compaction testing as specified by the designer.
- Avoid over-compaction of the backfill to prevent distorting the culvert. Continue backfill and compaction above the culvert, as specified in the design. Establish minimum culvert cover before any equipment loads are applied.

4.14 Use & Role of Environmental Monitors

An environmental monitor inspects site activities for:

- conformance with construction work plans that incorporate measures to protect forest resources in accordance with legislative requirements; or
- during active development operations in sensitive habitats and ecosystems.

Retain an environmental monitor on a site specific project basis when specified in an environmental management plan or where required by an environmental agency (such as where bridge or major culvert construction occurs in critical or important fish habitats, or where instream work is approved outside of the fisheries timing window).

Where an environmental monitor may be warranted, the scope of duties may include:

1. liaise with ministry staff or other regulatory agencies;
2. observe, record, and photograph the baseline site conditions before work commences and identify any significant (material adverse) changes in site conditions during and after work;
3. attend the pre-work meeting and other project meetings as necessary, and provide assistance to the Licensee/Permittee/Contractor or ministry to assess conformance with the construction contract work plans, contract conditions, and BCTS EMS requirements (e.g., EFPs; Hazardous Materials Spill Preparedness Responsibilities and Spill Action Steps; Landslide and Major Erosion Event Response and Erosion Action Steps; and EMS documentation requirements);
4. conduct on-site field visits either continuously or periodically to observe active operations; the timing and duration of field visits will depend on the type and complexity of the work, and on the sensitivity of the site and forest resource values at risk of damage or loss;
5. during field visits, evaluate the adequacy of erosion and sediment control techniques, including work procedures for instream work, construction and diversions on watercourses, and observe, record, and photograph site conditions and work procedures;

6. provide practical and appropriate options to protect or minimize harmful effects to fish and fish habitat if changes to the work occur due to unforeseen circumstances;
7. modify or stop operations if the following occurs:

    - site activities do not conform with approved construction contract work plans and contract conditions;
    - work activities lead to harmful levels of sediment entering a stream;
    - work activities may harmfully alter, disrupt, or destroy fish or fish habitat or other forest resources;
    - unforeseen circumstances related to the work cause or may cause environmental problems;

8. assist the Licensee/Permittee/Contractor or ministry with documentation requirements;
9. if applicable, confirm that the completed work activities meet the requirements of the fisheries agency that grants a variance on the timing window and/or approval for the planned works;
10. provide a brief written report to the ministry (and other agencies if requested) within two to four weeks after completion of the project; the report includes the following information:

    - background project information;
    - summary of Licensee/Permittee/Contractor's work procedures and environmental protection strategies;
    - description of pre-works activities, works activities, and post- works activities;
    - conclusions; and
    - appendices, including copies of stop work orders (if any) and photographs (with time and date) of all important phases of the work showing site conditions before, during and after the work.

4.15 Construction Documentation

After construction of a bridge or major culvert, ensure that the following as-built records are obtained and kept on file:

- actual log stringer, curb, needle beam and crib log sizes (diameter and length for each member);
- pertinent construction data including, but not limited to, any pile driving records, hammer type, penetration, set criteria, and any critical dimensions;
- final in-plant quality assurance report, including mill test certificates and concrete test results;
- structural design drawings or as-built fabrication drawings;
- geosynthetic material identification;
- concrete and grout test results;
- field compaction results;
- rip rap extents, depth, thickness and size;

- footing base elevation, deck elevation, and alignment location;
- other pertinent fabrication, field, and construction data; and
- Record (as-built) Drawings authenticated by the Professional of Record (POR) responsible for construction field reviews.

Authenticated Record (as-built) Drawings are typically the “issued for construction” general arrangement drawings that have been marked up to show all significant variations from the original design. When a professional is authenticating a document or report, they should be making it clear as to the limitations and noting appropriate qualifiers of what they are taking professional responsibility. In the case of Record (as-built) Drawings, a POR taking responsibility only for the construction field review (not the general arrangement design) should qualify their signature and seal accordingly. It is appropriate for a POR taking responsibility for field reviews and construction to authenticate (apply their signature and seal) a general arrangement design that has been produced by another professional, as long as it is clear who is taking professional responsibility for what. Link to EGBC Guide to the Standard for Authentication of Documents for more information on authentication of documents.

Ensure that the Record Drawings see sample (PDF) are authenticated by the POR responsible for the construction field reviews.

Where the original general arrangement design has been modified, these drawings should have been amended accordingly by the general arrangement designer before the as- built notes and details are inserted.

Compile the construction documentation including the general arrangement design, record (as-built) drawings, construction assurance statement and crossing assurance statement, along with the above mentioned construction documentation and forward the package to the Ministry Engineer for review for completeness and acceptability.

Add all completed FSR bridges to the appropriate file records and road and bridge database.

4.16 Resources & Suggestions for Further Reading

Handbook of steel drainage and highway construction products, 2007 (PDF, 13.3MB). Can. ed. Corrugated Steel Pipe Institute, Cambridge, Ontario.

bridge_standards_manual.pdf (gov.bc.ca). 1981. Log bridge stringers and needle beam sizing - Metric Edition (PDF, 3.96 MB). Design Section, Engineering Branch. Victoria, BC.

Canadian Geotechnical Society. 1993. Canadian Foundation Engineering Manual. Richmond, BC

Canadian Standards Association. R2005. Canadian highway bridge design code (CAN/CSA S6-00). Mississauga, Ont.

Nagy, M.M., J.T. Trebett, G.V. Wellburn, and L.E. Gower. Second Edition. 1989. Log bridge construction handbook. For. Eng. Research Inst. Can. (FERIC), Vancouver, BC.

4.17 Appendices

4.17.1 Project Tracking Checklist

Use this checklist to prepare a record of key outputs prepared by consultants or maintainers and sign-offs by the ministry.

- Project Tracking Checklist (PDF)

4.17.2 Forest Service Bridge Design Checklist

- Forest Service Bridge Design Checklist (PDF)

4.17.3 CRP Crossing Assurance Statement

This document is for bridges, major culverts and other crossing structures. It must be submitted with the POR Construction Assurance Statement (and associated documents) and all other professional documents for the crossing project after construction.

CRP Crossing Assurance Statement (FS1414) (PDF)

4.17.4 POR Construction Assurance Statement

This document is for bridges, major culverts and other structures. It should be submitted with record drawings and documents after construction.

- POR Construction Assurance Statement (FS138) (PDF)

4.17.5 Acceptance of Bridge & Major Culvert Drawings & Specifications

This document is to be completed by the ministry engineer prior to construction.

- Acceptance of Bridge & Major Culvert Drawings & Specifications (PDF)

5 Road Construction

Successful construction involves building Forest Service roads that are appropriate for their expected service life while at the same time minimizing impacts on forest resources and other values.

The purposes of this chapter are to provide:

- the mandatory requirements for road construction on FSRs; and
- practices for forest road construction activities that will assist ministry staff in achieving the statuary and regulatory requirements in the *Forest and Range Practices Act* and the Forest Planning and Practices Regulation.

All Forest Service roads will be constructed in a manner that considers road user safety, values at risk of damage or loss and cost efficiency.

5.1 Mandatory Procedures & Best Practices

Following is a table that summarizes in approximate chronological order the mandatory procedures and best practices with respect to the construction of Forest Service roads. Links are provided to direct the reader to the location in the manual text where the tabular item is discussed.

Table 5-1 Road Construction

Results to be achieved: minimize the clearing width (FPPR s. 78) do not cause sediment transport through mass wasting processes that would have a material adverse effect on forest resources (FPPR s. 37, 38, 57, 59, 69, 70, 72, 106.2) maintain natural surface drainage patterns (FPPR s. 39) no construction of a road in a riparian management area (FPPR s. 50) no fan destabilization that would have a material adverse effect on forest resources (FPPR s. 54) protect stream channel and banks (FPPR s. 55) protection of fish passage and fish habitat (FPPR s. 56, 57) protection of water quality (FRPA s. 46, FPPR s. 59) no construction near licensed waterworks in community watersheds or springs in a community watershed (FPPR s. 60, 62) address general wildlife measures, and resource or wildlife habitat features (FPPR s. 69, 70) road is safe for industrial use (FPPR s. 72)	
Legislation supported: FPPR sections 37, 38, 39, 40, 50, 54, 55, 56, 57, 59, 60, 62, 69, 70, 72, 76, 78, 84, 106.2: all road-related items	
M1	Road construction must be carried out in accordance with the road plan, subject to changes necessitated by site conditions and approved by the designer [see General Road Construction Practices].
Legislation supported: FPPR section 78: minimize clearing width	

B1	Minimize the clearing width, while accommodating the topography, user safety and operational requirements [Establishing Clearing Widths].
Legislation supported: FPPR sections 37, 38, 57, 59, 69, 70, 72, 106.2: do not cause sediment transport through mass wasting processes that will impact user safety or have a material adverse effect on forest resources	
B2	Do not deposit debris resulting from grubbing and stripping within the clearing width in areas where the debris could have a material adverse effect on forest resources and other values [see Disposal of Debris].
B3	In areas of moderate to high landslide potential, remove all organic debris from within the road prism width [see Disposal of Debris].
B4	Locate disposal sites and place debris at a disposal site to ensure that activities do not cause a landslide, gully processes on the Coast, or uncontrolled erosion and sediment transport that have a material adverse effect on forest resources and other values [see Disposal of Debris].
B5	To maintain slope stability in areas having steep slopes or unstable (or potentially unstable) terrain, consider applying full bench and partial bench construction techniques [see Full Bench].
B6	Ensure that rock drilling and blasting techniques minimize the potential for landslides or slope instability [see Rock Excavation].
B7	Shut down road construction work before slope stability is in question, or landslides occur [see Shutdown Indicators].
Legislation supported: FPPR section 39: maintain surface drainage patterns	
B8	To maintain surface drainage patterns, keep water in its own drainage area, unless moving it to another area is necessary to avoid unstable or sensitive soils [see Maintaining Surface Drainage Patterns].
Legislation supported: FPPR section 50: no construction in riparian management areas, except as provided	
B9	B9. Do not locate borrow pits or disposal sites in a riparian management area [see Location of Disposal Sites].
B10	Ensure that there are no subgrade construction works within a riparian management area, unless otherwise exempted from this requirement by regulation [see Riparian].
Legislation supported: FPPR section 54: no fan destabilization on the Coast	
B11	Ensure that road construction works do not cause fan destabilization on the Coast that will result in material and adverse effects on other resources [see Fan Destabilization].
Legislation supported: FPPR section 55: protect stream channel and banks	
B12	Ensure that the disturbance to the stream channel and the stream bank at the crossing are mitigated to the extent that the original conditions are reasonably restored. Also, ensure that despite the works at the crossing, the stream banks above and below the crossing are

	protected. Ensure that the disturbance to the stream channel and the stream bank at the crossing are mitigated to the extent that the original conditions are reasonably restored. Also, ensure that despite the works at the crossing, the stream banks above and below the crossing are protected [see Culverts].
B13	Use culvert outlet protection where discharge velocities and energies at the outlets of culverts, conduits or channels are sufficient to erode the immediate downstream reach [see Culverts].
Legislation supported: FPPR sections 56 and 57: protection of fish passage and fish habitat	
B14	Ensure that any culverts constructed on a fish stream do not impede fish passage or harmfully alter fish habitat [see Culverts on Fish Streams].
B15	Ensure that roads on fans are constructed to account for identified hazards on a fan [see Fan Destabilization].
Legislation supported: FRPA section 46: protection of the environment and FPPR section 59: protection of water quality	
B16	To minimize sediment delivery to streams, do not discharge the water conveyed in ditches and cross-drain culverts directly into streams [see Maintaining Surface Drainage Patterns].
B17	For snow and winter roads, do not mix soil with snow in the riparian management area of stream crossings [see One-Season].
B18	Ensure that debris is placed at disposal sites so as to protect against sediment transport that will have a material adverse effect on forest resources and other values [see Disposal of Debris].
B19	When constructing permanent roads, minimize the placement of snow, ice, and frozen material in the road fill [see Winter Construction].
B20	When constructing fords, consider: armouring ditches with non-erosive material; directing runoff into sediment basins or other sediment trapping devices; and capping the road surface with erosion-resistant material on either side of the ford for an appropriate distance [see Ford Construction]
B21	To minimize sediment transport away from the road prism and disposal sites, consider using sediment control techniques [see Sediment Control].
B22	Ensure that roads on fans are constructed to account for identified hazards on a fan [see Fan Destabilization].
B23	Surface the subgrade with pit-run gravel or crushed rock aggregate where subgrade material is highly erodible and needs to be protected from water or wind action [see Surfacing].
B24	Determine when forest road operations are to be shut down because the works are causing, or may imminently cause, environmental damage [see Shutdown Indicators].

Legislation supported: FPPR sections 60, 62: no construction near licensed waterworks in community watersheds or springs in a community watershed	
B25	Unless there is an exception in accordance with FPPR, ensure that the road is constructed so as not to damage a licensed waterworks and to achieve at least 100m distance from any such waterworks or springs in community watersheds [see Licensed Waterworks].
Legislation supported: FPPR sections 69, 70: general wildlife measures, and resource or wildlife habitat features	
B26	Ensure that a road is constructed in accordance with any general wildlife measures that may be in place (as identified in the road layout process), and the construction activities do not damage and resource or wildlife habitat features [see Wildlife].
Legislation supported: FPPR section 72: roads and structures are safe for industrial users	
B27	Construct turnouts and widenings at locations and to specifications in accordance with the road design to allow safe passage of expected vehicles types on single lane roads [see Turnouts].
B28	Should a ford become unsafe for traffic during high water, take measures to warn and exclude users for that period [see Ford Operating Constraints].
Legislation supported: FPPR section 76: culvert materials	
B29	Ensure that any permanent culvert materials are fabricated in accordance with the current Canadian Standards Association specifications [see Road Drainage].
Legislation supported: FPPR section 40; revegetation	
B30	To minimize surface soil erosion after road construction on all soils exposed that are subject to weathering, cover them with grass and legume vegetation [see Soil Erosion].
Legislation supported: FPPR sections 37, 38, 39, 40, 50, 54, 55, 56, 57, 59, 60, 62, 69, 70, 72, 76, 78, 84, 106.2: all road-related items	
B32	Ensure that the necessary steps in the road construction processes were undertaken and issues addressed [see Project Tracking Checklist]
M2	The Coordinating Member must sign (and seal as appropriate) the Road Project Assurance Statement (PDF).
B33	Ensure that there is a field inspection to monitor the completeness of the professional certification and to incorporate as-built information into the applicable data base [see General Road Construction Practices].
B34	For those roads identified as becoming FSRs after construction: ensure that a BCTS engineering technician carries out a minimum of a final field inspection of those roads built by a TSL holder under road permit to confirm the suitability of the road construction; and similarly, ensusre that a District engineering technician inspects roads built by others [see General Road Construction Practices]

5.2 Road Construction Professional Responsibilities & Considerations

After a road plan has been completed and signed off, it may then be appropriate to commence road construction in accordance with that plan. Note that this phase of the road project does not include those engineered structures described in Chapter 4 of this manual.

Those professionals taking part in the road construction works may include the CM, other Members or other persons working under supervision of the CM, and professional specialists where there may be terrain stability issues and corresponding design requirements. Other responsibilities related to road construction that may be undertaken by a Member are project management, quality control, quality assurance, contract administration or construction supervision. The CM must clarify the roles and responsibilities of each Member including the CM, and their reporting relationships, at the outset of the project.

As with other road and structure phases, there must be a CM in place to provide oversight and undertake professional responsibility for the construction of a forest road. Accordingly, a CM **must**:

- ensure that the road plan has been signed off by a Member;
- exercise professional judgment to determine that there are no changed conditions that could affect safety or the suitability of the road plan;
- identify and bring forward any special issues that may impact worker safety during construction;
- prescribe any field surveys (e.g., center-line, slope staking) that may be required before and during construction;
- determine the number and timing of field reviews during the construction process;
- carry out field reviews or delegate them to another person working under the CM's direct supervision;
- ensure that professional specialists and designers carry out field reviews of those portions of the project for which specialist analysis or design was required;
- confirm that the completed road construction works are in general conformance with the road plan, and
- complete the Road Project Assurance Statement (PDF) for road construction.

5.2.1 Field Reviews

Identify what field reviews are required and what notification should be given to allow the field reviews to be carried out. If the road plan includes specialist designs or incorporates recommendations from a TSA, there may also be a need for field reviews by terrain specialists or design specialists. The timing and extent of such reviews are established by those specialists and confirmed by the CM.

5.2.2 Changed Conditions

If the CM becomes aware of changed conditions during construction, the CM for construction must either:

- take responsibility for any changes needed to the road plan (this may involve obtaining input from other Members or specialists to re-assess the changed conditions); or
- contact the CM who prepared the road plan, inform him/her of the changed conditions, and obtain instructions on what changes may be needed to the road plan (in this case, the original CM would take responsibility for the changes, including preparing an updated road plan).

5.2.3 Modifications During Construction

Changed conditions or modifications may affect the road plan, and examples include:

- changes in ground conditions (material characteristics or drainage) that require changes to the road design;
- identification of sensitive features or resources at risk that were not previously known.

If modifications are made during construction, the CM for construction must document the changes, and indicate the reasons for the changes and their implications on:

- the safety of road users;
- impacts to other resources;
- the planning objectives;
- intended use of the road; and
- costs.

5.2.4 Project Assurance

The Road Project Assurance Statement **must** include or be accompanied by drawings that document the completed works. At the discretion and direction of the CM, these can vary from annotations or revisions shown on the original road plan documents through the completion of post construction surveys and preparation of record drawings.

Upon completion of construction, ensure that there is a field inspection to monitor the completeness of the professional certification and to incorporate as-built information into the applicable database.

For those roads that are built by TSL holders under road permit, and have been identified as becoming FSRs after construction, it may be appropriate for a BCTS engineering technician to carry out a final inspection to confirm the suitability of the works. Similarly, for those rare situations where other roads are to become FSRs, the district engineering technician should carry out the suitability inspection.

Suitability inspections may be carried out at key points in the construction, and at least at the completion of the works. Refer any issues to the constructor, the constructor's CM and, where appropriate, to Compliance and Enforcement.

5.3 Road Corridor Preparation

5.3.1 Preparing the Site

Site preparation along the road corridor includes all works associated with logging the timber within the right-of-way, including development of pilot trails and skid trails, skidding or yarding, and loading and sorting. Such work may also include the relocation of timber decks or other logistical operations to facilitate construction activities. Grubbing, stripping, and disposal of all unsuitable materials not used in subgrade construction are also considered part of site preparation.

Assess the right-of-way corridor for the presence of any dangerous trees and remove any such trees.

5.3.2 Establishing Clearing Widths

Establish clearing widths to facilitate the construction, use, and maintenance of forest roads. For natural slopes up to 60% slope angle, determine clearing widths from the Tables to Establish Clearing Width. For slopes greater than 60% slope angle, or in areas of moderate or high likelihood of landslides, determine clearing widths from the geometric road design.

Consideration **must** be given to not create hazards for any subsequent potential operations not only within the right of way but in operational forest areas outside this area and especially on the downhill side. (i.e. hazards might include timber decks supports by standing timber, rock supported on slopes by timber to be felled or otherwise in unstable positions. Should hazards be created inadvertently then mitigation strategies and communication to subsequent employers **must** be arranged.

The objective when establishing clearing widths is to minimize the width of the clearing, yet accommodate:

- the road prism;
- user safety;
- decking of right of way timber;
- turnouts;
- subgrade drainage;
- subgrade stability;
- waste areas and endhaul areas;
- pits and quarries;
- landings;
- slash disposal;
- equipment operation;
- snow removal;
- fencing and other structures; and

- standing timber root protection, especially on cut banks.

Figure 5-1 Typical roadway on gentle slopes with no additional clearing

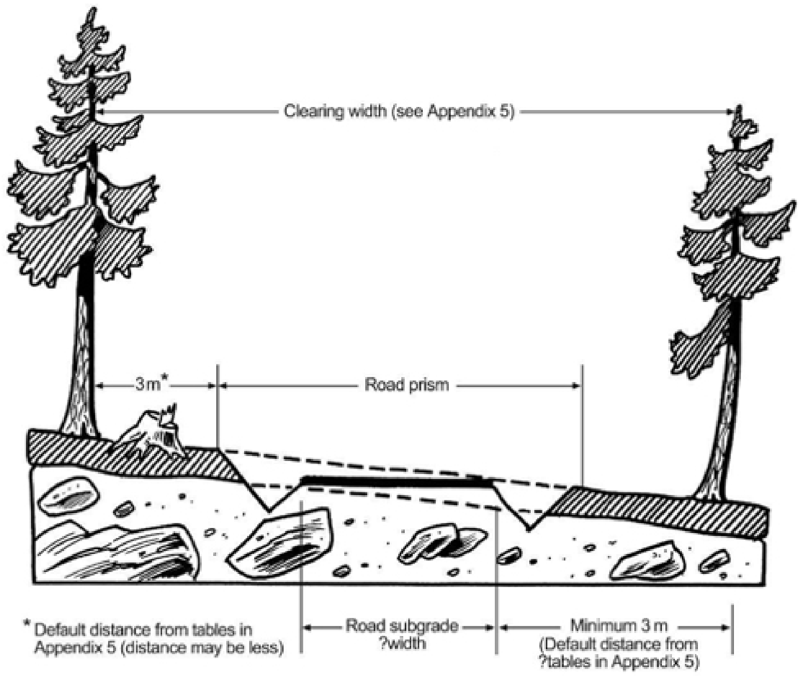
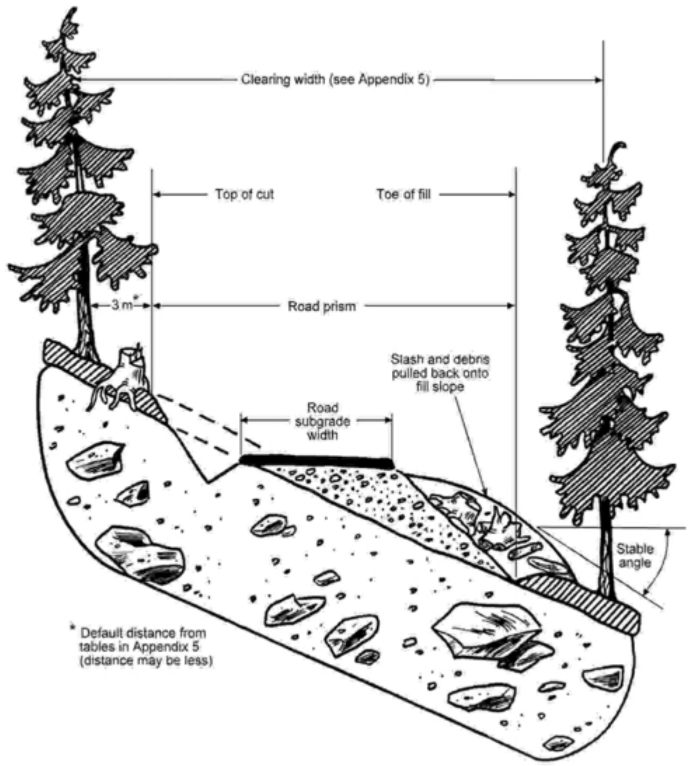


Figure 5-2 Typical permanent roadway on moderate slopes (best practice)



5.3.3 Marking Clearing Widths

Mark clearing widths in the field, usually with flagging tape, so that the clearing boundaries are clearly visible for machine operators or hand fallers to follow.

Ensure that trees that are marked to establish the clearing width remain after the clearing operation is completed. Leave standing those trees that are on the boundary unless the roots will be undermined by operations within the clearing width. Where slope staking is not required, use the flagging as an offset line to establish the top of cut for grade construction.

5.3.4 Establishing Pilot Trails

Frequently, pilot trails or tote roads are built within the clearing width before falling begins. These trails provide access for the faller (hand or mechanical), a route for skidding felled timber to a landing or collection point, and temporary access along the road corridor.

Terrain and soil conditions govern the location of the pilot trail within the clearing width. Generally, construct the trail below the flagged centreline on side hills, near the lower clearing width limits. This allows for easy access to skid-fallen timber and allows for the toe of the road fill to be keyed into the slope. Where drilling and blasting are required, build the trail above the road centreline, just below the upper clearing limit, to permit vertical drilling of the rock cut.

Ensure that care is taken to remove debris from the downslope during the right-of-way logging phase unless the debris can reasonably be reached by equipment operating on the surface of the pilot trail or final road subgrade.

Install drainage structures concurrently with pilot trail construction, including temporary stream crossings that may be required during the road construction phase until the permanent crossing is constructed. For further details, see Road Drainage Construction.

5.3.5 Felling & Yarding Within the Clearing Width

Felling methods

Several methods for falling trees within the clearing width are available depending on terrain, soil conditions, timber size, and total volume.

Fell all standing merchantable and non-merchantable timber along any section of road subgrade remove the timber before construction. Ensure that timber does not become buried under soil, rock, and debris, and the wood is accessible for future retrieval from the road subgrade.

Further information about falling is contained in the British Columbia Occupational Health and Safety Regulation (Sec. 26.11 and 26.21 to 29.30) and the WorkSafe Guidelines (Part 26).

Landings

Locate landings within the clearing width so as not to interfere with other operations. Ideally, show landing locations on the construction drawings and mark them in the field.

Protecting streambanks during felling operations

Before falling begins, ensure that streams and their associated riparian management areas and the "machine-free zones" identified on operational plans have their buffer zones flagged in the field. Use appropriate directional falling techniques to protect these areas. For further information, refer to the Riparian Management Area Guidebook.

Protecting streambanks during yarding operations

Yarding operations can result in streambank destabilization. Prevent this damage by yarding away from streams, not across them.

Removing debris from streams

Where debris is accidentally introduced into the stream, carry out clean-up concurrently with clearing operations. Mitigate without delay any stream bank damage, outside of designated crossings.

Dangerous trees

Identify all dangerous trees outside the clearing width deemed hazardous to road workers or users and fell them as part of the falling phase of site preparation. See Preparing the Site.

5.4 Grubbing & Stripping

Grub and strip the road prism area of all topsoil and unsuitable mineral soils after all standing timber has been felled and removed, unless the following are applicable:

- between the tops of cuts and adjacent standing timber (other than trees and stumps with exposed roots or roots that overhang the top of cut);
- between the toes of fills and adjacent standing timber; and
- where short-term roads – that is, one-season winter use roads or snow roads— are constructed or where overlanding techniques are applied.

"Grubbing" means the removal of stumps, roots, buried logs, and logging slash (downed logs, tree branches and tops, and uprooted stumps, trees, and shrubs) and other debris left on the ground from clearing operations. "Stripping" means the removal of topsoil or other organic material, and mineral soils unsuitable for forming the road subgrade.

Where grubbing operations have removed all organic soil, stripping is not required unless other unsuitable soils are encountered.

5.5 Disposal of Debris

Disposal of debris consists of the disposal of material resulting from grubbing and stripping operations within the clearing width. (For ease of reference, this material is simply called "debris" in this chapter.)

Accomplish disposal of debris by:

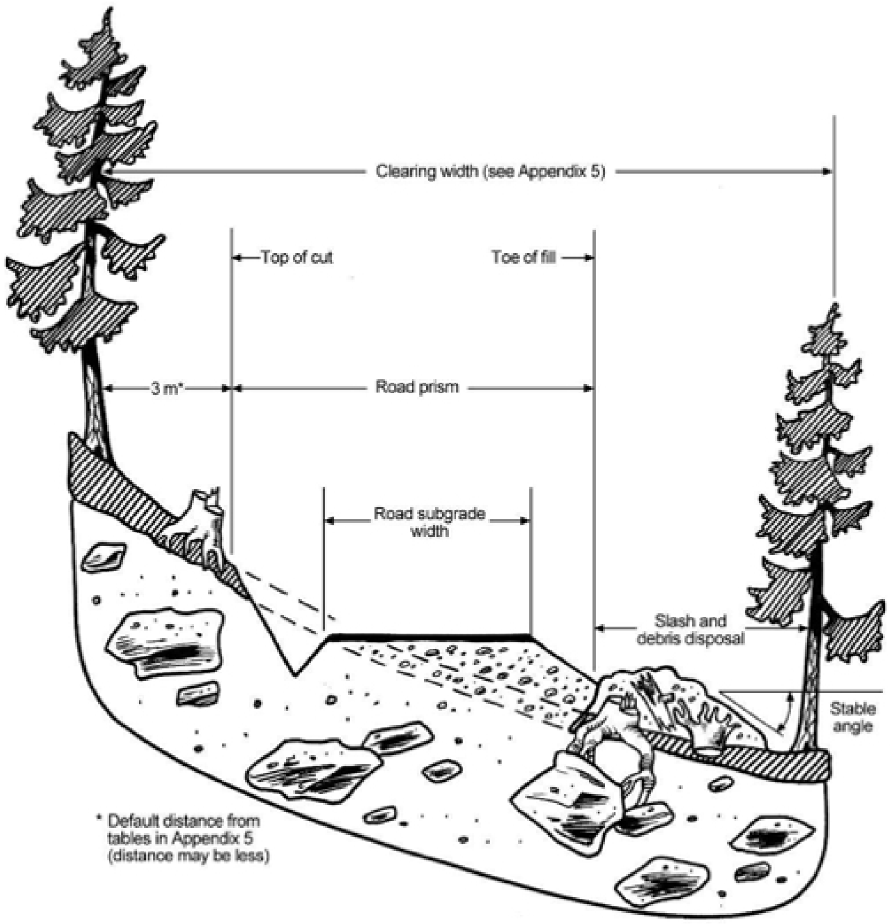
- piling and burning;
- scattering;
- burying; or
- endhauling it to a suitable disposal site for debris.

Do not deposit debris resulting from grubbing and stripping within the clearing width in areas where the debris could have a material adverse effect on forest resources or create hazards for any subsequent operations and/or adversely affect other values. In addition to any other required mitigation actions to prevent damage, immediately remove any debris that is deposited in such areas.

Ensure that the selected method of debris disposal:

- meet objectives of higher-level plans (such as those for smoke management, aesthetics, or pest management);
- are compatible with terrain conditions;
- consider the slash volume, loading, species, and piece sizes;
- do not alter natural drainage patterns; and
- are compatible with other resource values.

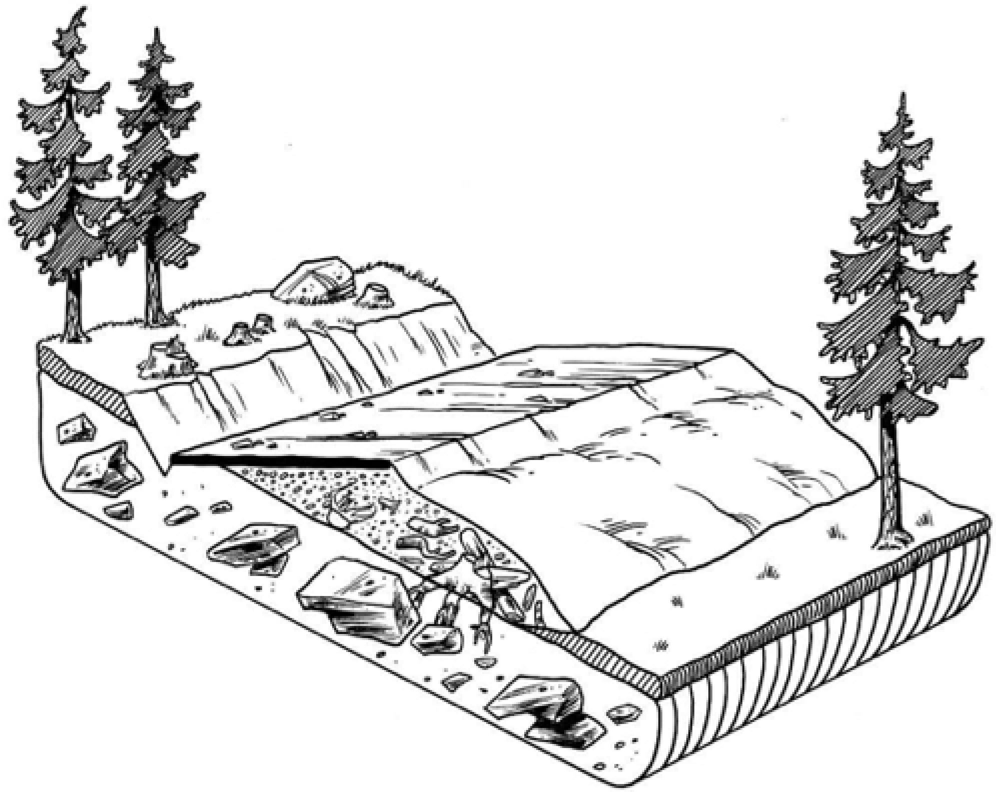
Figure 5-3 Debris placement for permanent road on terrain having a low likelihood of landslides (acceptable practice)



Carefully plan and locate disposal sites for debris and suitably place material to:

- provide for adequate support of the debris;
- maintain natural surface drainage patterns; and
- ensure that activities do not cause a landslide, gullying, or uncontrolled erosion and sediment transport that have a material adverse effect on forest resources and other values.

Figure 5-4 Debris placement on typical short-term road



Do not place debris within the high-water mark of a water body (stream, wetland, lake) or in a manner that is likely to cause the debris to fall into a water body.

Generally, remove all organic debris from within the road prism width (Figure 5-2). However, where the road crosses areas not having a moderate or high likelihood of landslides, then incorporate stumps, roots, and embedded logs in the road prism as follows:

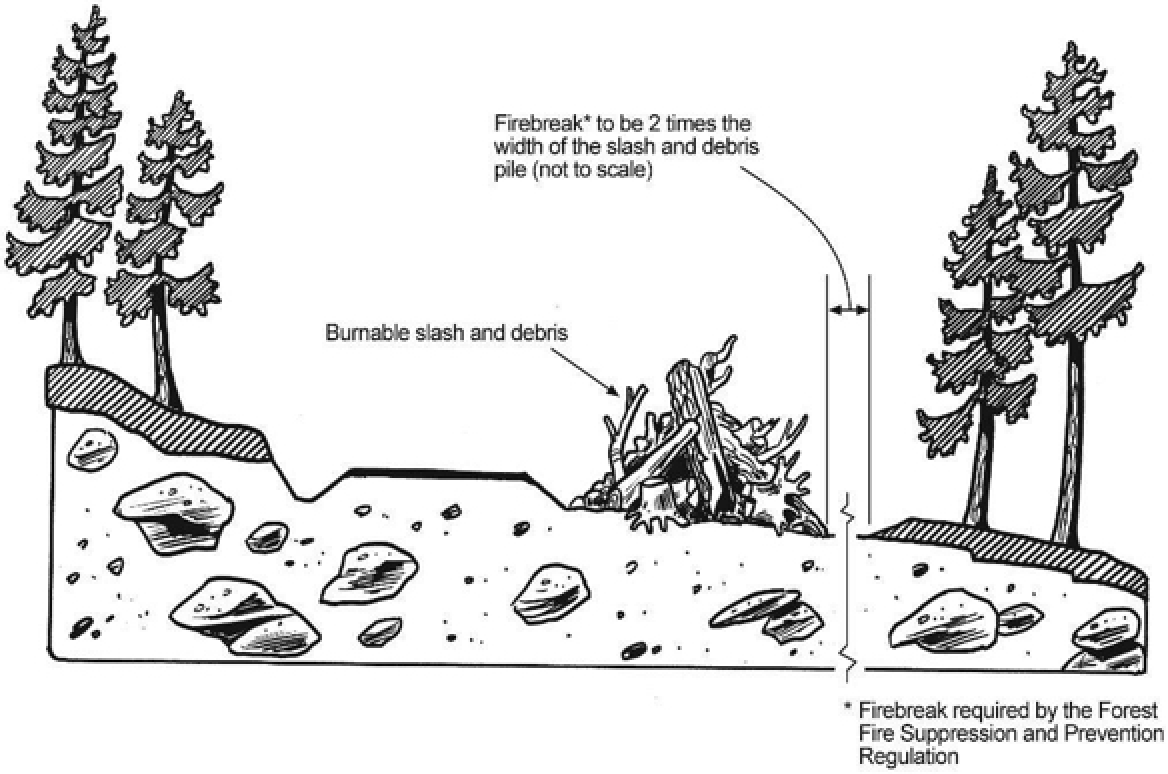
- leave or place stumps, roots, and embedded logs outside the road subgrade width on the downhill side (Figure 5-3).
- for a short-term road (Figure 5-4), leave or place stumps, roots, and embedded logs within the road subgrade width. For more information about short-term roads, see Construction of Short-Term Roads.

For either of the two situations above, report the presence of stumps, roots and embedded logs in the road prism as a part of as-built information. See: Occupational Health and Safety Regulation (Sec 26.79).

5.5.1 Piling & Burning

Consider piling and burning (Figure 5-5) in areas with heavy slash loading and moderate to high pest or fire hazard, and where smoke management objectives can be met.

Figure 5-5 Debris disposal by piling and burning



5.5.2 Scattering

This process is similar to mounding and windrowing but does not require the debris to be buried (Figure 5-6). In low-density stands, spread debris among the standing timber in natural openings along the cleared area, thus reducing the clearing width required for disposal. Take care to avoid damaging the standing timber or eliminating plantable spots if the road is being constructed through an area proposed for eventual planting.

Place logs and stumps away from adjacent timber stands, positioned so they will not roll and so that they do not lie on top of one another.

Consider scattering where:

- side casting debris will not increase the likelihood of landslides;
- fire and pest hazards are low; and
- aesthetic concerns are not an issue.

Incidental burying may occur but is not an objective. If the debris is bunched or spread, breach any continuous accumulations to accommodate drainage, snow removal, and wildlife passage.

Consider chipping or grinding up debris and then blow it along the cleared area or into the standing timber, away from watercourses, to help limit erosion of exposed soils and facilitate revegetation.

Breach accumulations of debris at all culvert locations to facilitate drainage. Remove debris accumulations at some locations where needed to permit the natural passage of livestock and wildlife.

Figure 5-6 Debris disposal by scattering

5.5.3 Burying

There are three methods for burying debris with soil materials:

- trenching;
- mounding or windrowing; and
- creation of pushouts.

Place all debris between the edge of the structural fill and standing timber (Figure 5-7), unless otherwise indicated in the construction drawings. Arrange the surface profile of the debris so as to imitate existing ground profiles. Next, compact the debris and then cover it with a layer of soil at least 300 mm thick. Compaction minimizes the hazards to livestock and wildlife stumbling in holes in the buried debris.

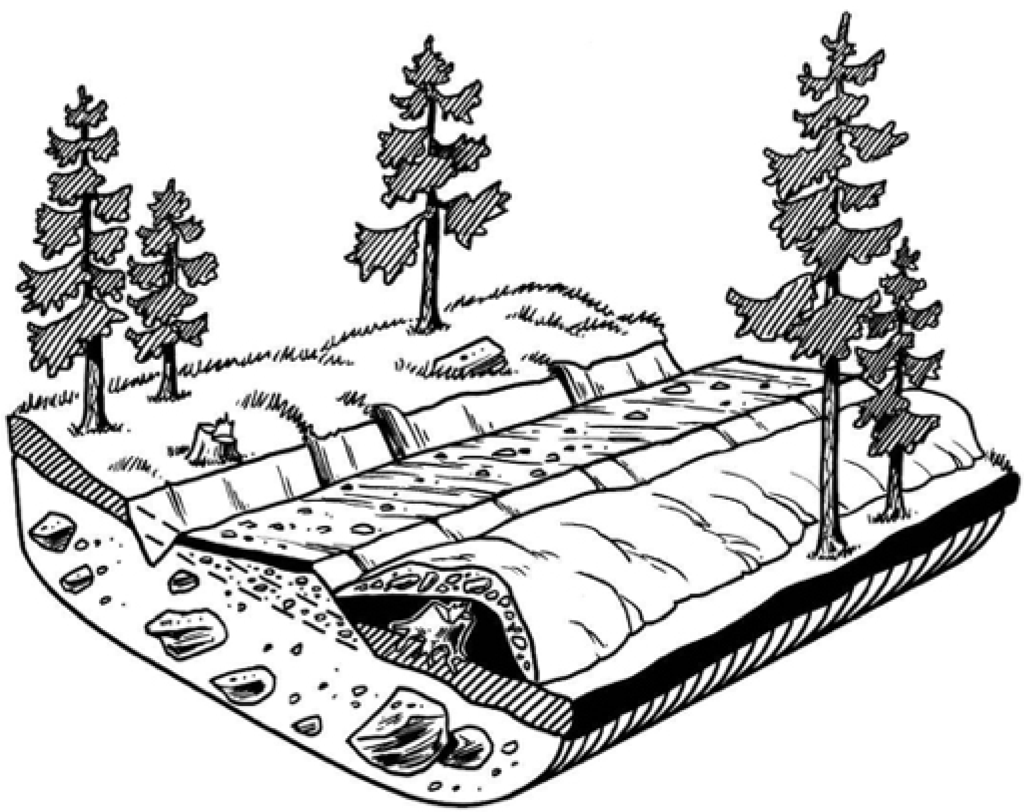
As well, place buried debris so as not to interfere with:

- roadway drainage, utilities, planned road improvements, snow removal, design sight distance, future developments, or standing timber; and
- any watercourse.

Furthermore, breach any resulting berms at each culvert location to facilitate drainage, and at other specified locations to permit the usual passage of livestock and wildlife.

Calculate the volume of debris and of soil cover per lineal metre of road. Generally, for every cubic metre of debris, utilize a metre of clearing for its disposal. When excessive debris volumes are encountered, consider other disposal methods.

Figure 5-7 Debris disposal by burying



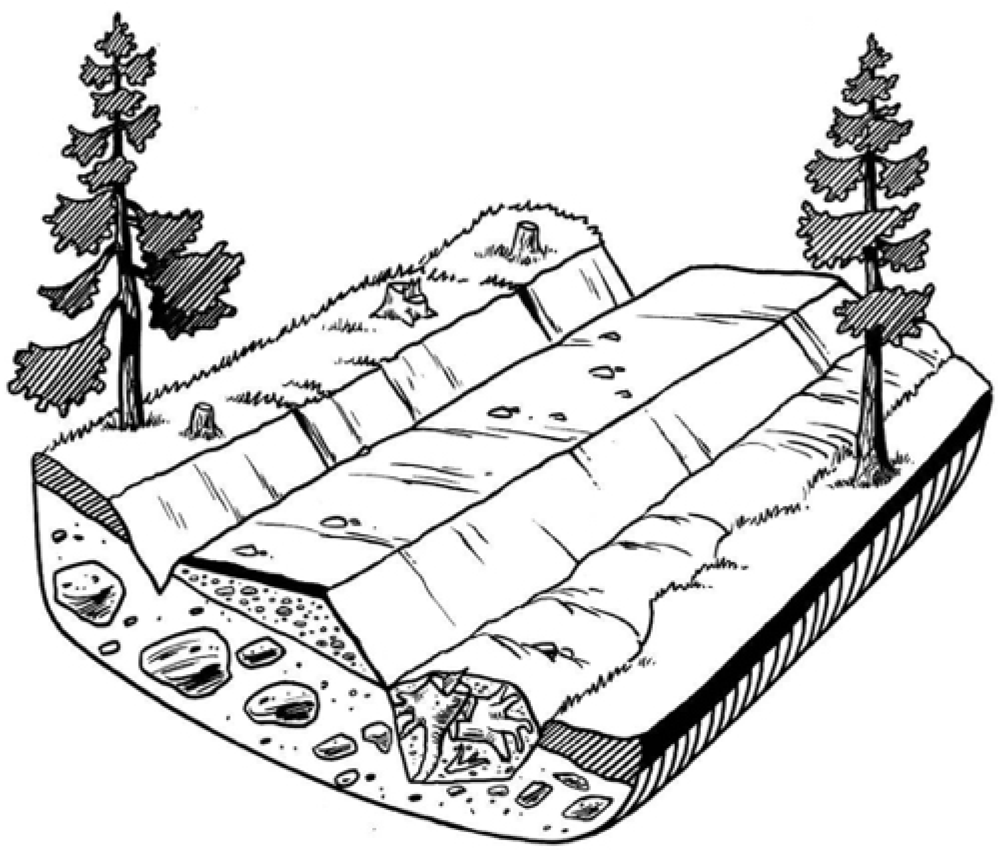
Trenching

This method takes advantage of trenches that usually result from a particular subgrade construction technique, and not normally where a trench is dug solely for the purpose of burying debris. It works well where usable subgrade material occurs fairly continuously below a veneer of unsuitable soil. Use the excavated trench material to raise the subgrade above the normal ground line. Do not use trenching on natural slopes with greater than 20% slope angle, because it could undermine the road surface and cause long-term subgrade instability.

Place the debris in the resultant trench rather than spreading it over the ground surface. Determine the required size of the trench from the volume of debris to be buried. However, to minimize the size of the cleared area overall, use a deep, narrow trench instead of a shallow, wide trench (Figure 5-8).

To prevent undermining tree roots, leave 3m of cleared width between any standing timber and the trench. Ensure that the trench lies parallel to the roadway and is either continuous or intermittent, depending on the volume of debris. Place the woody debris on the bottom of the trench and compact it before covering it with soil and other strippings from the road prism.

Figure 5-8 Debris disposal by trenching



Mounding or windrowing

With this method, accumulate all debris along one side of the cleared width between the road prism and the standing timber. Put into place the woody debris and then compact it with the grubbing equipment. Use stripped material from the road prism to cover the debris with additional mineral soil, as required, to ensure coverage by at least 300mm thickness of soil. Because of the difficulty of maintaining an adequate thickness of soil cover on the downslope side, the results of this method are not easy to control on natural slopes with greater than 50% slope angle.

Creation of pushouts

Locate pushouts in natural openings along the cleared area and ensure that they are appropriate for the volume of material to be disposed. Do not push debris into standing timber and properly groom the piles to be stable and visually acceptable.

5.5.4 Endhauling Debris for Disposal

Where debris or other unsuitable material cannot be disposed of outside of the road prism or within the clearing width, endhaul it (i.e., load and haul) to a suitable disposal site for debris. Endhaul debris from the road corridor in:

- steep or unstable terrain where this material is removed to maintain slope stability; and
- areas with high recreational value where aesthetics may be an issue.

5.5.5 Location of Disposal Sites for Debris

Identify all disposal sites for debris before construction. Ensure that an approved disposal site for debris is stable, well drained, and isolated from streams or wet sites; and does not have a material adverse effect on forest resources and other values. Sometimes, prepare and bench disposal sites in advance to enable stable placement of the endhauled debris. Avoid overloading of slopes. Where possible and practical, stockpile organic and fine-textured debris for placement over depleted borrow and gravel pits, quarries, and disposal sites for excavation spoil, as a means of facilitating revegetation.

Dispose of the debris endhauled to an approved disposal site by piling and burning, scattering, or burying. Whichever disposal method is used, ensure that the top of any remaining debris material is below the road surface (to allow for snowplowing and sight distance) and placed in a manner to allow surface water to drain away from the road.

Carefully place and pile debris to maintain slope stability at all times and take measures control erosion and sediment transport.

5.6 Subgrade Construction

5.6.1 Construction Near Licensed Waterworks

Licensed waterworks have been identified as part of the road layout and road survey and design processes. Based on the information gathered through those processes, and for any other licensed waterworks discovered during construction of the road, unless there is an exception in accordance with FPPR, ensure that the road is constructed so as not to damage a licensed waterworks and to achieve at least 100m distance from any such waterworks or springs in community watersheds.

Additionally, ensure that at least 48 hours' notice of impending construction work is provided to water licensees or water purveyors in community watersheds.

5.6.2 Construction in Riparian Management Areas

Ensure that a road is constructed in accordance with the layout and the design, such that there are no subgrade construction works within a riparian management area, unless otherwise exempted from this requirement under FPPR, section 50.

5.6.3 Fan Destabilization

Fans can be the runout zones for debris flows and can be influenced by over-bank flows during debris floods and floods. These events are not rare and can impact roads on fans. Conversely, roads can exacerbate the effects of these events.

FRPA recognizes fan destabilization on the Coast; province-wide, FRPA recognizes impacts to fish habitat and forest soils—impacts that can result from fan destabilization. There may be a range of causes of fan destabilization as a result of road construction, and a variety of potential mitigative practices (see Land Management Handbook 57 Forest Management on Fans Hydrogeomorphic Hazards and General Prescriptions (PDF, 3.2MB). Ensure that the following practices are carried out when constructing roads on fan landforms that are identified along the proposed route:

- explore each fan for evidence of debris flows, debris floods, and floods,
- build to account for the identified hazards with attention to the specific location of the crossing on the fan, the need, if any, for climbing roads, drainage structure size and configuration, and excavations into the stream channel or banks.

5.6.4 Wildlife Measures & Features

Ensure that a road is constructed in accordance with any general wildlife measures that may be in place (as identified in the road layout process), and the construction activities do not damage resource or wildlife habitat features.

5.6.5 Construction Surveys

Where the location and volumes of road building materials are critical, carry out construction surveys to re-establish the road centerline, to determine the limits of the cut and fill slopes, and to provide grade control during construction.

Preferably, carry out construction surveys after clearing and grubbing operations, but before primary excavation begins.

5.6.6 Modifying the Road Layout & Design

If the road design does not reflect the field conditions actually encountered after the clearing operations, then modify the design to address those unforeseen conditions. Should a professional prescription not reflect actual field conditions, or if the layout and design revisions affect a prescription to maintain slope stability, then ensure that any design changes are reviewed and approved by a qualified registered professional before construction begins.

5.6.7 Sidecast Construction

Where terrain stability is not an issue, cut and fill (sidecast) is a common forest road building technique. During sidecast construction, excavated material from the uphill slope is placed on the downhill slope (using crawler tractors or excavators) to form a fill to support the outside portion of the running surface of the road (Figure 5-2). If this fill material is not properly compacted, settlement will likely occur, leading to slumping at the shoulders and the creation of settlement or tension cracks in the road surface. Refer to the suggested cut and fill slope angles in Chapter 3, Table 3-4 General guidelines for cut and fill slope angles for use in forest road design (PDF).

Do not use topsoil and debris, and saturated and other unsuitable soils, as road fill. Rather, remove them, because they have a very low strength and can readily fail under vehicle loading. In areas having a low likelihood of landslides, however, consider placing stumps, roots, and embedded logs outside of the subgrade width (Figure 5-3).

Key in or notch the fill material into the slope, after all organic material and unsuitable soils have first been removed from the road prism. Ensure that the notch is sufficiently wide to allow equipment to work. Build up the fill in shallow lifts and compact it using the road-building machinery—or, ideally, roller compactors. Properly compacted fills have a higher load-carrying capacity and tend to shed water rather than absorb it. This results in a more stable, erosion-resistant subgrade that requires less maintenance while minimizing the potential for adverse environmental impacts.

5.6.8 Full Bench & Partial Bench Construction

To maintain slope stability in areas having steep slopes or unstable (or potentially unstable) terrain, consider applying full bench and partial bench construction techniques. Base the decision to use these techniques for this purpose on the results of a Terrain Stability Assessment prepared by a qualified registered professional. Refer to Guidelines for Terrain Stability Assessments in the Forest Sector (PDF, 1.87MB) (published by the Association of Professional Engineers and Geoscientists of British Columbia).

Full bench construction involves cutting a bench into the side hill equal to the width of the road (including the ditch). Transport all the excavated material (endhaul) to an approved disposal site for excavation spoil, unless otherwise prescribed by a qualified registered professional.

Partial bench construction is similar to the full bench construction technique except that the bench is less than the full width of the road, with the remaining road width built on sidecast fill. To maintain slope stability, transport (endhaul) the surplus excavated soil and rock material to an approved disposal site for excavation spoil, but do not place it along steep slopes below the road unless prescribed by a qualified registered professional.

Figure 5-9 Full Bench

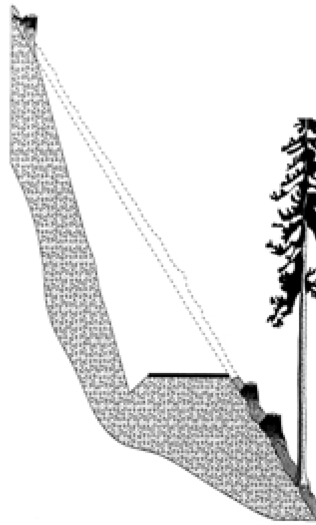
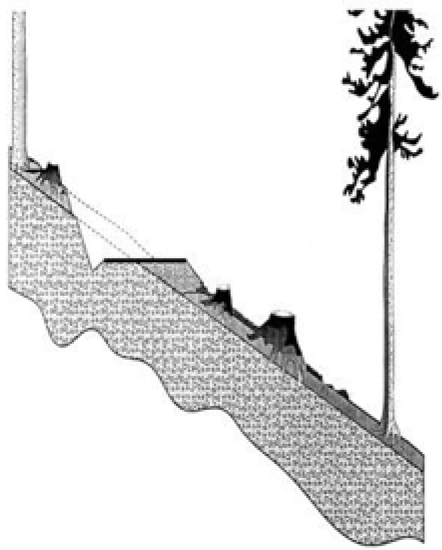


Figure 5-10 Partial Bench



5.6.9 Endhauling Surplus Excavation Materials

"Endhauling" during road building is the loading, hauling, and placing of surplus excavated soil and rock material (excavation spoil) from a construction site either to a different location along the road for use in road fills (if required and if the materials are suitable) or to an approved disposal site for excavation spoil.

5.6.10 Location of Disposal Sites for Excavation Spoil

Identify potential disposal sites for excavation spoil during the field reconnaissance or survey and design and incorporate them into the final road design. Ensure that such sites take advantage of swales, depressions, benches, and shallow slopes—and, ideally, are situated in depleted borrow pits or quarries. Do not locate disposal sites:

- in a riparian management area;
- in an area having a moderate or high likelihood of landslides; or
- at the crest of a slope or top of an escarpment.

Ensure that all disposal sites for excavation spoil maintain natural drainage patterns.

Carefully place and pile debris material transported to a disposal site to maintain slope stability at all times and take measures to control erosion and sediment transport. Consider the following measures:

- placing the coarse material on the bottom and the finer-grained material on the top, and then compacting the pile to eliminate large voids;
- using topsoil to cover the pile to aid revegetation and limit surface erosion;
- not exceeding the natural angle of repose of the soil or rock materials;
- "benching" the sides of the spoil pile when heights exceed 5m;
- crowning, sloping, and grooming the spoil pile to ensure that the surface does not pond water; and
- installing sediment control devices below the disposal site for excavation spoil to capture and prevent sediment transport beyond the site until the spoil pile is revegetated.

5.6.11 Rock Excavation

Where the rock hardness, weathering, and jointing are suitable, consider the use of a backhoe-mounted hydraulic hammer or ripper for rock breaking. Where these techniques are not appropriate, fracture rock by drilling and blasting. Ensure that qualified blasters assess rock and site conditions, formulate appropriate blast designs, learn from previous results, and immediately revise field practices to reflect changing conditions. Use controlled blasting techniques where the cut bank height exceeds 5m. Where site conditions are complex or beyond the experience of the blaster, seek guidance from a specialist professional engineer.

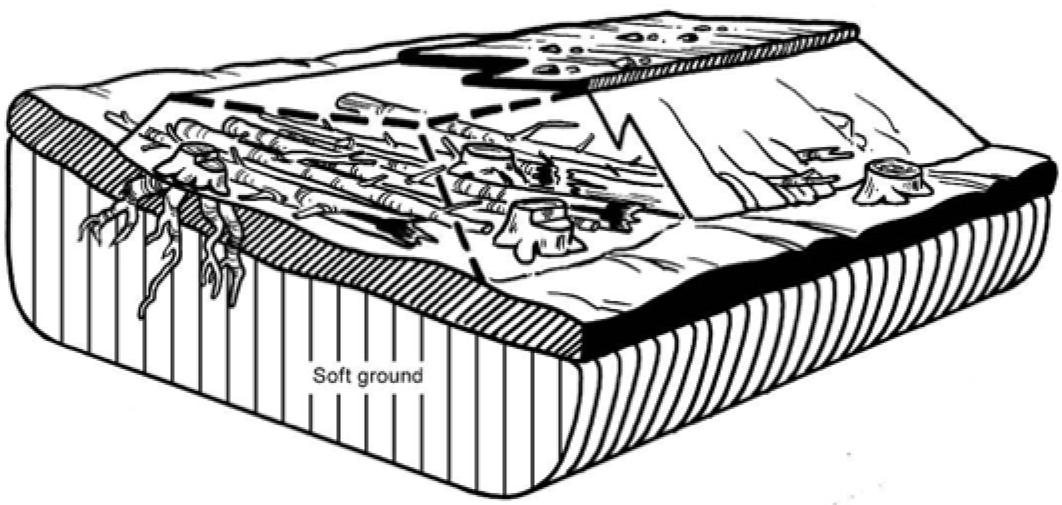
Ensure that the rock cut has a ditch of width sufficient to capture material that may fall from the rock cut, and that drilling and blasting techniques minimize:

- flyrock (airborne rock displaced beyond the road prism by blasting) to avoid damage or disturbance to forest resources and existing improvements;
- the potential for landslides or slope instability; and
- the amount of overbreak (any material that is excavated, displaced, or loosened outside and beyond the designed road prism, regardless of whether it was because of the inherent character of any formation encountered or because of something else).

5.7 Overlanding

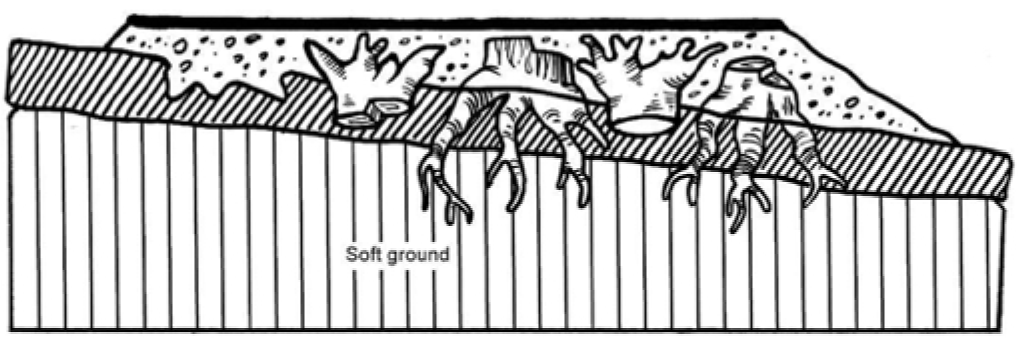
Overlanding is a construction technique used where the underlying soils are too weak to support the road prism (Figure 5-11 and Figure 5-12). The road fill is placed on undisturbed organic soil, stumps, and vegetative material, using geosynthetic fabric, corduroy, or puncheon (small logs and limbs) as the separating material mat. It is important that the vegetative mat remains undisturbed to prevent the unsuitable saturated soils below the mat from mixing with the imported subgrade material.

Figure 5-11 Overlanding cross-section with corduroy



Ensure that the amount of fill that is placed and compacted during overlanding is sufficient for the anticipated loads. The depth of material is a function of soil properties (particularly bearing capacity), vehicle loading, season of use, and life expectancy of the road. Use geosynthetics or puncheon to reduce the amount of road fill required and to also reduce future road maintenance.

Figure 5-12 Overlanding cross-section with inverted stumps



5.7.1 Construction of Short-Term Roads

The introduction of stumps, roots, and embedded logs into the road fill under the traveled portion of the road can reduce the long-term stability of the fill. The buried organic material will deteriorate over time and begin to settle. This removes support for the applied wheel loading and results in rutting of the road surface. Water ponding in the ruts may saturate the road fill and lead to failures. Thus, restrict the use of roots, stumps, and embedded logs in the road fill to the construction of short-term roads (e.g., up to five years), subject to deactivation at the end of their operational lives. Consider extending the life of a short-term road (e.g., up to 10 years) only if regular inspections indicate that the road fill is stable and can still support the design vehicle axle loads.

If the road fill begins to show signs of failure, or after the extended time period has passed, deactivate, or reconstruct the road.

5.7.2 Winter Construction of Permanent Roads

Where another option does not exist, permanent roads may have to be constructed in the winter. Prevent the placement of snow, ice, and frozen material in the road fill. These materials cannot be easily compacted and will settle when they thaw. In turn, this thawing will saturate the fill and create voids that readily collapse. The resulting fill is not only unstable and low in strength, but also highly erodible and often a source of sediment, potentially causing severe damage to streams during the spring break-up period. For more information, see Construction & Use of Snow & One-Season Winter Roads.

5.7.3 Turnouts & Widenings

Construct turnouts and widenings at locations and to specifications in accordance with the road design to allow safe passage of expected vehicle types on single lane roads. Consideration for direction of industrial traffic and adverse versus favorable grades is important for user safety. For design details on turnouts and widenings, see Chapter 3: Road Survey & Design.

5.7.4 Location of Borrow Pits

Borrow pits are developed where additional material for subgrade construction or surfacing is required. Locate them outside of riparian management areas.

5.8 Road Drainage Construction

In this chapter, drainage consists of:

- surface drainage works, including ditches and cross drain culverts as well as any ancillary works; and
- stream crossings, including metal culverts, log culverts and fords.

Ensure that any permanent culvert materials are fabricated in accordance with the current Canadian Standards Association specifications.

5.8.1 Maintaining Surface Drainage Patterns

To maintain surface drainage patterns, keep water in its own drainage area, unless moving it to another area is necessary to avoid unstable or sensitive soils.

Consider the potential for adverse upslope, downslope and downstream impacts before culvert locations and outlet controls are determined. Measures to limit these impacts include:

- installing flumes or riprap; or
- carrying drainage flow farther along the ditchline to discharge it onto stable slopes.

Drainage systems are used to intercept and manage surface or subsurface drainage. If the soils are easily erodible, consider changing the ditch gradient, alignment, or cross-section, or adding extra culverts, to reduce the distance over which water will have to be carried.

To minimize sediment delivery to streams, do not discharge the water conveyed in ditches and cross-drain culverts directly into streams. Allow these flows to settle out through the natural vegetation on the forest floor before reaching any stream. Alternatively, filter these flows in other ways, such as through the use of settling basins or geosynthetics, until vegetation can be re-established. For more information about sediment control techniques, see Soil Erosion & Sediment Control.

5.8.2 Drainage Practices & Water Quality

Install drainage systems, whether permanent or temporary, concurrently with subgrade construction. Consider constructing temporary structures, such as cross- ditches, swales, or open-topped culverts (e.g., cattleguards and similar structures), as appropriate, where water is encountered, to accommodate the peak flows likely to be encountered during construction. Ensure that, if the site is left unattended and a storm takes place, the in-place drainage structures can handle the runoff without damage resulting to the road or other resources. For a pilot trail or tote road, ensure that these can accommodate surface and subsurface drainage runoff throughout the construction period. During road construction, remove any temporary drainage structures that were previously installed to facilitate machine access and install permanent structures in their place.

To ensure proper drainage during road construction:

- stockpile an adequate supply of culverts, riprap, geotextiles, silt fencing, and grass seed on-site for immediate and future use, and to avoid construction delays;
- as water is encountered, establish adequate drainage to ensure flows are controlled and water quality is maintained (where required) should a peak flow event occur;
- construct the final drainage structures as early in the construction process as is practicable;
- construct silt traps, armoured ditch blocks, and aprons as construction progresses or as soon as soil conditions allow.

To protect water quality, utilize the following techniques, where applicable:

- avoid working in areas of ponded water or saturated soils where this could result in negative impacts on resource values;
- construct stable cut and fill slopes;

- avoid in-stream work as much as possible. Where in-stream work is necessary, obtain appropriate agency approval before starting the work;
- ensure that machinery used in in-stream work is free of deleterious materials that might be deposited into the water; clean the machine undercarriage and tracks before doing in-stream work;
- install sufficient cross-drains and ditch blocks to keep ditchwater from eroding the ditchline;
- install erosion-resistant aprons at the inlet and outlet of culverts;
- in ditches, use armouring, geotextile or silt fencing, blocks, or traps to minimize erosion;
- revegetate exposed erodible soils as soon as possible; and
- remove maintenance-intensive temporary construction measures such as silt fencing, straw or hay bales, and silt traps, when not required any longer.

5.8.3 Ditch Construction Considerations

Ensure that surface and subsurface flows do not cause excessive ditch or roadway erosion. Consider such factors as:

- ditch soil conditions;
- gradient;
- alignment;
- cross-section;
- ancillary works;
- ditch stabilization; and
- drainage alternatives where ditching is inappropriate.

Ditch soil conditions

Ditch soil conditions influence erodibility. Finer textured, non-cohesive soils are more readily eroded than coarser materials or cohesive soils.

Ditch gradient

The ditch gradient is largely dictated by the vertical alignment of the road. Ideally, construct the gradient at a minimum of 2% to ensure that water will flow and not pond. Lower ditch gradients can still be effective but may require a higher-than-routine level of inspection and maintenance. Under certain conditions, ponded water can lead to a saturated subgrade. This can contribute to severe roadway rutting, siltation, and possible failure of the roadway prism, as well as sediment deposition and plugging of cross-drain culverts. Such negative impacts can occur in both gentle and steep terrain.

However, keep ditch gradients in granular soils just steep enough to keep intercepted water moving to cross-drain culverts without carrying excessive sediment. Steeper ditch gradients in erodible soils generally increase the likelihood of erosion and sediment transport. More frequent culvert placement and armouring should be considered.

Ditch alignment

Avoid abrupt water flow changes. Sharp angles in the ditch alignment or flow obstructions in the ditch (such as boulders or rock outcrops) can potentially deflect water into the subgrade or cutbanks and can result in erosion of the subgrade or undermining of the cutbank. Where there are impassable flow obstructions, consider installing additional cross-drain culverts.

Ditch cross-section

Ensure that ditches are of sufficient depth and flow capacity to transport anticipated drainage flows. The ditch should be adequate to provide drainage of the uphill slope, the roadway surface, and minor debris (leaves, twigs, and small woody debris). Slope ditches to a stable angle, design them to have adequate hydraulic and minor debris-carrying capacity, and limit water velocities to prevent accelerated ditch erosion. Obtain additional capacity for water flow, sloughing, and minor debris by widening ditches. Avoid u-shaped ditches because the almost vertical sides tend to ravel or slough, undermining the cut slope and the shoulder of the roadway. Wide ditch bottoms facilitate grading operations where side borrow methods are used.

Ancillary works

The following features are associated with ditches:

Culvert inlet armouring is used to protect the road fill from erosion as the water flows into the cross-drain culvert inlet.

Culvert inlet basins are depressions dug at the inlet of cross-drain culverts. They are intended to trap material that could, over time, restrict the intake flow or infill and plug the culvert. Properly installed, inlet basins can reduce maintenance frequency. Use them where fine-grained sediments are anticipated from ditch erosion or minor sloughing, and where woody debris movement is expected along ditches in harvested openings. Periodically, clean out inlet basins.

Sediment settling ponds differ from culvert inlet basins in that they are designed to allow sediment to settle for later removal. Generally, locate them downslope of the roadway, but in some instances incorporate them into sections of ditchline.

They are only effective under low water velocity conditions. Ensure that the configuration and depth of settling ponds are adequate to allow sediment to settle and to facilitate clean-out. Consider armouring the back slope of unstable settling ponds with placed shot rock or stabilizing them with placed large boulders.

Settling ponds are a temporary measure to protect water quality during construction. If designed for long-term use, ensure that access is provided to facilitate their cleaning out. Consider vegetating settling ponds to assist filtering sediments.

Install **ditch blocks** to direct flows into the culvert inlet. They are constructed of erosion-resistant material, with the crest being approximately 0.3m lower than the adjacent road grade. This elevation difference is critical because if the culvert becomes plugged and the water rises above the ditch block, then the flow will continue down the next section of ditchline rather than being directed onto the roadway surface. Do not provide ditch blocks where ditches converge; however, take into consideration the effects of the increased water volume on the drainage structures.

Use a **take-off or lateral ditch** where a minimum grade is needed for the water to carry fines away rather than depositing them at the culvert outlet and restricting normal flow. They ensure there is a positive flow away from the roadway. However, dissipate or control the flow.

Ditch stabilization

Where it is necessary to carry a ditch farther than what would be ideal to limit ditch erosion, such as in areas of through-cuts, or across gullies or areas of sensitive downslope soils where concentrating water could lead to small or mass failures, limit ditch erosion by:

- armouring the ditch with angular shot rock;
- lining the ditch with an appropriate geosynthetic;
- constructing an erosion-proof check dam, or series of check dams within the ditchline, where velocity is also a concern (note: if not properly designed, however, check dams can create severe erosion holes below the dams and may require a high level of maintenance); or
- vegetating ditches.

Drainage alternatives

Ditches may be inappropriate:

- on sites where there is a need to minimize bench cuts for stability or economic concerns (e.g., to reduce the volume of blasted rock);
- on sites where there is a need to minimize the amount of site degradation;
- on ridge or hilltop roads where, natural drainage occurs; and
- along one-season winter roads.

Nevertheless, accommodate cut slope and roadway drainage in the above situations using:

- subdrains (e.g., French drains) in place of ditches;
- French drains in place of cross-drain culverts;
- road surface drains such as dips and swales;
- road insloping or outsloping;
- open top cross-drain culverts (e.g., cattleguard-like structures); and
- erosion-resistant road surfacing with a material such as shot rock.

5.8.4 Cross-Drain Culvert Location

How far water should be carried in a ditch before being left to dissipate away from the road prism depends on: water volume and velocity, soil types, hillslope aspect, elevation, vegetation, rainfall intensity, the incidence of rain-on-snow events, and downslope conditions.

Typical locations for cross-drain culvert placement are:

- near the top of a steep road gradient – the intent is to prevent accelerated ditch, subgrade, or cutbank erosion by dispersing ditchwater before its volume and velocity increase downgrade;
- at seepage zones;
- at zones that have localized overland flow with undefined channels (ensure that ditchwater is dissipating at the downgrade side of these zones; otherwise water flow will carry on to the next segment of the ditch, increasing the flow at the start of the next section of ditchline and increasing the potential for erosion and natural drainage pattern disruption);
- at any location where accelerated ditch erosion could potentially begin (again, ensure the dissipation of ditchwater volume and velocity to prevent build-up and the risk of adverse impacts on improvements and other resources);
- at low points in the road profile;
- where ditchline bedrock approaches the elevation of the finished grade;
- immediately before sections of cut slope instability or raveling;
- before large through-cuts that may be drainage divides; and
- at any other location found necessary during construction, or evident during maintenance inspections.

Cross-drain culverts and ditches at switchbacks often need site-specific consideration.

5.8.5 Cross-Drain Culvert Installation

Proper installation of cross-drain culverts—regardless of the material used—is critical to ensuring that road stability will not be compromised by ineffective drainage. In wet areas, particularly along steep road segments, consider decreasing the spacing between cross-drain culverts to decrease ditchwater flow volumes and minimize ditch erosion.

Make culverts long enough to ensure that the inlet and the outlet cannot become blocked by the encroachment of road embankment fill. Protect unstable or erodible fill at culvert outlets with flumes or other erosion-resistant material and protect inlets to prevent scour and erosion.

Install cross-drain culverts at a minimum gradient of 1%. Shallower gradients may allow silt to build up inside the pipe. Consider the need to provide outlet protection, particularly if the culvert gradient exceeds 3%.

To encourage smooth entry of ditch flows, skew cross-drain culverts to be perpendicular to the road centreline by 3 degrees for each 1% that the road grade exceeds 3%, to a maximum of 45 degrees. This skew will increase the overall length of the culvert, a fact that needs to be taken into consideration when culverts are being ordered for installation.

Excavate unsuitable materials beneath the pipe and replace them with suitably compacted fill to provide a firm and uniform foundation. Assess whether seepage along the outside wall of the pipe could cause internal piping erosion (loss of fines and gravel, resulting in voids forming channels or “pipes”) that could impair the stability of the culvert installation and road prism. If this is a concern, consider using suitable geotextiles or other seepage control measures (such as sand- bagging or installing prefabricated anti-seep barriers or collars at right angles to the pipe) along the pipe wall near the inlet to retard longitudinal seepage along the pipe. Remove large rocks or ledges and replace them with suitably compacted fill before the pipe bedding is prepared. Backfill and compact around the culvert in the same manner as for stream culverts (see Construction of Open & Closed Bottom Metal Culverts on Non-Fish Streams).

5.8.6 Log Culvert Construction

Proper log culvert construction requires experience, skill, and good workmanship. Before construction begins, the crew should be made familiar with any particular installation requirements, including any design drawings. Ensure that the design is in accordance with the requirements set out in Chapter 3: Log Culvert Design. Use the following procedures to lay out and construct a log culvert:

- mark the location of the substructure on the ground before and after the site- clearing operation;
- particularly for those log culverts with high fills or requiring skewing, ensure that the sill logs be cut to the correct length and placed in the proper position;
- lay two evenly sized sill logs parallel to and clear of the wetted perimeter of the stream, and on solid bearing;
- excavate a trench for the sill logs below the scour depth of the stream or construct a non-erodible foundation pad of large angular shot rock;
- pin the outside stringers to the sills with drift pins or lashing, or place them in neat notches; avoid sharp notches or slabbing of the stringer ends that will result in unacceptable stress concentrations or degradation of the shear strength;
- place a layer of non-woven geotextile filter cloth over the stringers.

5.8.7 Temporary Stream Crossings

Temporary stream crossings are used to provide access until the prescribed access structures are in place. Depending on the season that the stream crossing structure is constructed and used, there are options as to the type of temporary crossings that should be installed. The range of options depending on site conditions and type of road construction may include snow fills, fords, log bundles, log culverts, and log skid or portable bridges. Ensure that a temporary structure can handle peak flows without causing negative impacts on the streambed. Install the permanent structure as soon as conditions permit.

5.8.8 Construction of Open & Closed Bottom Metal Culverts on Non-Fish Streams

Intrusive excavation and local modification of channel conditions may be by- products of the construction of metal culverts on non-fish streams. However, ensure that the disturbance to the stream channel and the stream bank at the crossing are mitigated to the extent that the original conditions are reasonably restored. Also, ensure that despite the works at the crossing, the stream banks above and below the crossing are protected.

For non-fish streams, the choice of open or closed bottom metal culverts is generally one of economics, whether it be the cost of materials or the complexity of installation considering the required opening of the culvert and the streambed gradient and composition.

Use culvert outlet protection where discharge velocities and energies at the outlets of culverts, conduits or channels are sufficient to erode the immediate downstream reach. This practice protects the outlet from developing eroded pools. Protection against scour at culvert outlets varies from limited riprap placement, to protect the channel and redistribute or spread the flow, to complex and expensive energy dissipation devices. Preformed scour holes, approximating the configuration of naturally formed holes, dissipate energy while providing a protective lining to the streambed. When outlet velocities are high enough to create excessive downstream problems, consider using more complex energy dissipation devices. These include hydraulic jump-basins, impact basins, drop structures, and stilling wells. However, for small installations, where riprap will not suffice, it may be financially prudent to consider an open bottom culvert option or small bridge structure. In any event, where the culvert slope exceeds 10%, and scour will be an issue, retain a specialist professional to review the hydraulics at the site and determine the best site-specific solution to the scour issue.

Constructing "in the dry"

Construct culverts “in the dry” whenever possible to prevent or minimize impacts on water quality and other biological resources. This typically enables faster construction of the culvert and reduces the potential for sediment transport into the stream.

Open bottom culvert foundation

Lay an open bottom culvert on a foundation that will prevent differential settlement over time that could compromise culvert functions and cause damage to overlying road. The foundation generally consists of parallel supports through the length of the culvert, and may be:

- continuous spread footings (generally precast or cast in place concrete); or
- footing pads (intermittent supports).

The size and complexity of culvert footings depend on the underlying soil qualities as well as the volume and size of traffic that will pass over the culvert. Bury the footings for open bottom culverts at a depth that will prevent the footing from being exposed by scour.

Limit the disturbance of the steam bed and banks to that necessary to place the structure, embankment protection and any required channel modifications associated with the installation. Revegetate disturbed areas to assist in reducing future surface soil erosion.

Backfilling and compaction

The ability of a pipe to maintain its shape and structural integrity depends on correct selection, placement, and compaction of backfill materials, and adequate depth of cover for the pipe material selected.

The likelihood of a culvert failure increases with a lack of adequate compaction during backfilling. In general, utilize the procedures below:

- select good backfill material;
    - use a granular, non-saturated backfill material; pit-run gravel or coarse sands are usually satisfactory;
    - use cohesive materials as backfill material only if careful attention is given to compaction at optimum moisture content;
    - avoid placing large angular rock, boulders, snow, or ice within the backfill material;
- ensure adequate compaction under haunches;
- maintain an adequate width of backfill;
- for culverts 1200mm diameter and larger, place backfill material in layers to about 150-300mm loose thickness, depending on compaction equipment, materials being placed and the designer's requirements;
- balance the fill height on either side as backfilling progresses;
- compact each layer before adding the next layer;
- do not permit construction vehicles or equipment to cross the structure until the minimum allowable depth of cover established by the manufacturer or by a designer has been placed.

5.8.9 Construction of Open & Closed Bottom Metal Culverts on Fish Streams

Ensure that any culverts constructed on a fish stream do not impede fish passage or harmfully alter fish habitat. Because of the special precautions and limitations on instream work in fish streams, refer to the Fish-Stream Crossing Guidebook for information on the construction of such culverts.

5.8.10 Fords on Non-Fish Streams

Ford construction

For low-flow or ephemeral streams, a properly designed and constructed ford allows the stream flow to pass around and between subsurface rocks. To accomplish this, place the larger size rock across the base and lower portion of the ford cross-section. For perennial streams where appropriate rock sizes are unavailable, consider the following alternatives:

- construct a broad catchment basin, or upstream weirs, to slow the stream flow velocity and thus reduce the size of rock required to enable the ford to resist the erosion forces; and
- for steeper gradient streams, build up the downslope portion of the ford by positioning log cribs, gabions, lock blocks, etc., to contain the rock fill for the ford. In most situations, this will flatten the stream gradient at the crossing, thus reducing the stream velocities and permitting the use of smaller size rock.

Both to prevent sediment delivery where approach drainage cannot be directed away from the stream, and to prevent sediment tracking by equipment and vehicles, consider the following procedures:

- armouring ditches with non-erosive material;
- directing runoff into sediment basins or other sediment trapping devices; and
- capping the road surface with erosion-resistant material on either side of the ford for an appropriate distance, to protect the road and minimize sediment delivery to the stream.

Ford operating constraints

Once a ford is constructed, control its use to ensure that the integrity of the structure is maintained and that any potential adverse impacts on the environment are minimized. Do not drag or skid anything across the ford that could destroy the running surface of the ford. Where possible, ensure that vehicles using the ford are in good working order and not leaking fuel, hydraulic fluids, lubricating oil, or cargo. Remove excess soil heavy equipment before it crosses a watercourse. Do not use the ford if the water depth is greater than the axle height of the vehicle. Consider installing a water-depth gauge and a warning sign that are clearly visible from the road. Should a ford become unsafe for traffic during high water, take measures to warn and exclude users for that period.

Ford maintenance

Properly designed and constructed fords are usually low maintenance structures. Nevertheless, inspect fords at a frequency commensurate with the risk to road users and the environment, and properly maintain:

- running surfaces;
- approach grades and aprons;
- ditches; and
- catchment basins.

5.9 Stabilizing the Subgrade & Surfacing the Road

5.9.1 Ballasting

Ballasting is the use of rock to construct the road subgrade when other available material is incapable of supporting the design traffic load during the period of use.

Generally, ensure that suitable ballast material:

- drains well;
- forms a structurally competent fill;
- compacts well; and
- resists erosion.

5.9.2 Surfacing

Surface the subgrade with pit-run gravel or crushed rock aggregate for one or more of the following reasons:

- where subgrade material is highly erodible and needs to be protected from water or wind action;
- where subgrade material will not support traffic loading during periods of use; and
- to form a drivable and gradable surface.

Surfacing material selection

Surfacing materials include crushed rock and pit-run gravel aggregates. Surfacing materials consist of inert, tough, durable particles that will not deteriorate when worked (handled, spread, or compacted) and combined with suitable fines, or when exposed to water and freeze-thaw cycles. Ensure that aggregate particles are uniform in quality and free from an excess of flat or elongated pieces.

Ensure that the aggregate is well graded (contains a mix of all particle sizes) for compaction and for a durable wearing surface. When the only source material is poorly graded, consider:

- screening the material to remove the excessive particle sizes; or
- blending in the deficient material size.

Because crushed aggregate is expensive to produce, protect it with a base coarse stabilizer (e.g., calcium chloride or magnesium chloride, installed to the manufacturers' specifications) to prevent the loss of fines. Obtain and rigidly apply specifications for high fines crushed gravel when use of a calcium chloride or related stabilizer is being considered. Note that some stabilizers are not acceptable in community watersheds or near licensed water intakes.

5.9.3 Surfacing Compaction

Compaction of the subgrade and surface through the use of equipment designed for this purpose will increase the load-carrying capacity of the roadbed and reduce the volume of surfacing material that will be required to maintain the roadbed during its service life.

For optimum strength, place the surfacing material in uniform lifts compatible with the compaction equipment that is to be used. Uniformly compact each lift before being covered with the next lift. To achieve maximum compaction, ensure that the moisture content of the material is close to optimum. Material that is too dry or too wet will not achieve the best compaction. Therefore, during the spreading phase, add water to dry material, or allow saturated material to dry to achieve the optimum moisture content.

5.9.4 Protecting Erodible Fills Located Within Floodplains

All embankments, dikes, streambanks and channels, culvert inlets and outlets, abutment wings, and structure foundations may require protection by the addition of riprap, or other armouring material.

When constructing embankments within active floodplains, take action to prevent erosion of those embankments by forming the entire embankment of non-erodible material. Where this is not possible or practical, armour the fill.

Table 5-2: Indicates the stream velocities that can erode different size materials.

Table 5-2 Example erosion velocities

Material	Diameter (mm)	Mean velocity (m/sec)
Silt	0.00	0.15
Sand	1.0	0.55
Fine gravel	10.0	1.00
Medium gravel	25.0	1.40
Coarse gravel	75.0	2.40
Cobble	150.0	3.30

If the embankment is to be formed by one of the materials in Table 5-2 and will likely be subject to velocities at least equal to those corresponding to that material, then use armouring. Several forms of armouring material exist:

- angular and durable riprap (see below);
- sand bags (a very short-term solution only, as bags break down over time);
- concrete, including concrete blocks (quick, easy installation), sprayed concrete (shotcrete or gunnite), or poured-in-place concrete (uncured concrete products should be kept isolated from the stream until the concrete has cured);
- binwalls (for velocities less than 1 m/sec or used in conjunction with riprap and where suitable fill material – cobble, coarse gravel – is readily available); and
- other commercial erosion control systems.

For riprap, ensure that the rock selected is sized to resist peak flow velocities, and graded to act as a filter to resist movement of underling soil through the riprap (all in accordance with the approved design). Place the riprap on firm, stable ground, taking care to provide mass stability and a regular surface with a minimum of voids. Place it horizontally to form an apron and trench it below the scour depth. Consider keying it into the bed of a watercourse below the scour depth where acceptable to the environmental agencies.

5.9.5 Litter, Petroleum Products & Other Waste Materials

Ensure that all workers on the site are familiar with the requirements for the use, storage, and disposal of litter, equipment fuel, and servicing products. Those most commonly associated with road construction are:

- waste oil and grease and spoiled fuel;
- refuse: camp garbage, waste paper, old machine parts, and damaged culvert pipe;
- batteries and battery acid;
- sewage and litter: where camps are to be established, sewage disposal via permitted septic systems is required; and
- fuel storage (a permit from the appropriate agencies is required for the establishment of fuel tank farms).

Ensure that all ministry contractors have petroleum product spill response kits on hand, and that personnel are familiar with spill containment procedures. Refer to s BC Timber Sales Environmental Management System and Sustainable Forest Management for s information on environmental policy, training, awareness and competence, emergency preparedness and response and records, among other items. Spill kit contents vary by type of work, potential size of spill, and impact potential, covering a range of incidents, from minor hydraulic leaks to major watercourse spills. At a minimum, ensure that each machine has a spill kit with extra absorbents in the support vehicle.

Dispose of waste and contaminated materials as appropriate and in accordance with the relevant federal and provincial statutes, including:

- burning;
- burying; or
- containing and removing from the site to an approved disposal location.

5.10 Construction & Use of Snow & One-Season Winter Roads

Throughout much of British Columbia, forest operations are best conducted during the winter months. By using deep snow or frozen ground as the running surface, equipment working on snow roads or one-season winter roads has a lower environmental impact than when working on all-weather roads. Fine- textured soils and muskeg ground conditions are especially vulnerable. Construct these seasonal roads during the early part of the winter, so that harvesting can be completed before snowmelt and the break-up of frozen ground in the spring. If there is insufficient snowpack, these road types cannot be constructed.

Snow roads and one-season winter roads use the strength of ice and snow to produce a stable roadbed that will support the design vehicle axle loads. In areas with heavy snowfall, the main reliance is on the snowpack. In either case, weather is the essential and unpredictable factor in the construction process, and logistics are key to constructing and using winter roads effectively. Where mid- winter thaws are common, construct short spur roads, and use and deactivate them in a matter of weeks.

Generally, watercourses are frozen for the life of the road, and in many cases drainage structures may not be required. Compact snow fills across small streams and gullies with the use of log bundles to allow the passage of any seepage that may occur or to reduce the volume of snow required. Where mid-winter thaws are common, install culverts in the snow fill to accommodate possible flowing water.

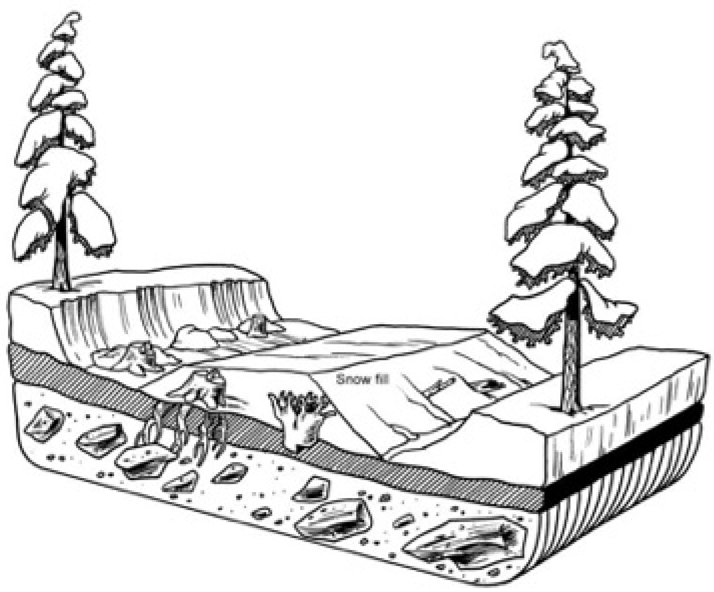
Coordinate deactivation of these road types with operations and complete such work before the spring freshet. Restore all-natural drainage channels while road access is available. Do not leave logs in stream channels, and breach snow fills to prevent the damming of watercourses. Though mid-winter thaws can disable even a well-built road, the high-risk period begins during spring break-up. During that period, snowmelt can occur very quickly, resulting in rapid overland flows of meltwater, high flows in watercourses, and an extreme softness of soil materials that renders them highly susceptible to erosion. Any soils that have been mixed with snow become fluid and highly susceptible to mass erosion. Debris or excavated spoil material piled on top of a snow layer can become unstable on even gentle side slopes. For more information on road deactivation techniques, see Chapter 7: Road Deactivation.

5.10.1 Snow Road Construction

Snow roads are a form of overlanding construction in which clean snow and ice are used as fill (Figure 5-13) and can support the design vehicle axle loads. Snow roads are appropriate for providing access across gentle terrain to winter-harvest- only areas. Snow roads are limited to terrain with slopes less than 20%, unless there is a very deep snowpack. The surface is often built-up with ice by using water in areas of flat terrain with a minimal snowpack.

Excavation is not permitted (cut slopes or ditches) other than the removal of the occasional stump that cannot be readily covered with snow and ice. The road may be reconstructed and re-used each winter in the same location.

Figure 5-13 Typical snow road



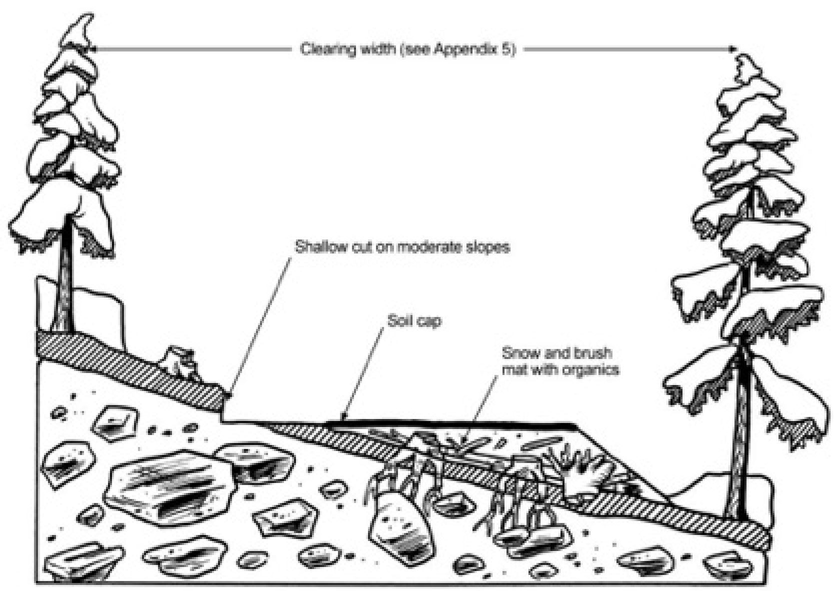
5.10.2 One-Season Winter Road Construction

Similar to snow roads, one-season winter roads are constructed mainly from snow and ice, with a minimal amount of soil (10%-20%) to assist the freezing-in of the road, or to provide a more durable surface where infrequent mid-winter thaws may occur. They are suitable for temporary access to winter harvest areas for one season only and are not intended to be reconstructed.

Because of the high risk of sediment deposition during the spring freshet, do not mix soil with snow in the riparian management area of stream crossings. Only use log bundles and clean snow in gullies and riparian areas.

Limit stripping to the removal of large stumps that cannot be easily covered with snow or ice. For cuts into mineral or organic soil, do not exceed 300mm in depth for sustained distances on slopes greater than 15%, or 500mm in depth for short distances on steeper slopes up to 35%. Figure 5-14 shows a finished one-season winter road.

Figure 5-14 One-season winter road



For one-season winter roads, a mixture of dirt and snow on the road surface can provide a stable roadway when frozen, but it becomes highly liquid during spring thaws. Any appreciable side slopes or gradients may result in mass erosion from the roadway. Debris disposal sites constructed on top of snow can become unstable during melt periods or can create a situation where meltwater on the roadway cannot run off the road but only run down it.

Plan for and install deactivation measures during the design and construction of one-season winter roads. For example, construct swales, inslope or outslope the subgrade, install log-filled cross-ditches, and stockpile coarse rock for use at armoured swales and cross-ditch locations so deactivation requirements after the life of the road will be reduced.

Where possible, overland the road with a brush mat and snow excavated from the clearing width. Use a small amount of unfrozen dirt as a freezing agent to construct the road surface. Breach berms and snowbanks at intervals of not more than 50m. Smooth the road surface at the time of construction to avoid building ruts and other irregularities, and construct waterbars on long grades. Remove fills in natural drainage channels, pull back soil-contaminated snow fills in the vicinity of stream crossings. and take measures to prevent sediment from entering streams around crossings.

5.10.3 Road Use

Mid-winter thaws are commonplace in the Interior and can disable even a well- built winter road. Because of heavy use and adverse weather, rutting and deformation of the road surface can occur as the subgrade begins to thaw. Use these roads only in frozen conditions. For this reason, monitor weather forecasts as far in advance as possible. As well:

- schedule night hauling when temperatures are expected to be above freezing during the day; and
- strictly control all light traffic during unfrozen conditions.

5.11 Soil Erosion & Sediment Control

Soil disturbance is inevitable from most road construction activities. Control of soil erosion and the subsequent transport of sediment during road construction are therefore important concerns where there is direct or indirect connectivity to water. Erosion control addresses the source of soil erosion, whereas sediment control addresses the control and retention of sediment. As erosion control has a generally higher level of effectiveness than sediment control, ensure that the primary goals are, first, to minimize potentially damaging erosion of the disturbed sites; and second, to limit the transport of sediment from these sites.

5.11.1 Soil Erosion Control Techniques

To minimize surface soil erosion after road construction, cover all exposed soils that are subject to weathering (e.g., silty and sandy non-cohesive soils and clayey and other cohesive fine-grained soils) with grass and legume vegetation. A variety of erosion seed mixes are available that provide rapid germination and long- term growth to create a solid sod layer. Take care to ensure that the seed species selected are compatible with domestic livestock. Establish this vegetative cover to protect and hold soil by:

- decreasing the erosive effects of rain drop impact on soil particles;
- decreasing runoff velocity and volumes; and
- promoting water infiltration into the soil.

Apply the cover as soon as slopes are completed, rather than after the entire road project is complete. Prompt revegetation by dry broadcast (by hand or spreader) or by hydroseeding not only assists with erosion control; it also helps to prevent the spread of noxious weeds.

Other soil erosion control techniques include, but are not limited to, the following:

- confinement of sensitive operations to periods of dry weather and selection of equipment that will create the least disturbance;
- compliance with local rainfall shutdown guidelines;
- temporary diversion or impoundment of stream flow using diversion ditches and berms to reduce the exposure of disturbed soil to flowing water during stream-crossing structure construction, or construction of rock-lined ditches or channels to provide a durable erosion-resistant surface; and
- installation of rock, straw bale, or sand bag check dams across a defined ditch or channel, or placement of riprap on a slope, to reduce water velocity and scour potential.

For more detailed information on control of soil erosion and sediment transport, refer to the Ministry of Forests' Best Management Practices Handbook: Hillslope Restoration in British Columbia.

5.11.2 Sediment Control Techniques

To minimize sediment transport away from the road prism and disposal sites, consider using the following sediment control techniques:

- install silt fencing to collect and detain runoff and retain sediment;
- install sediment retention berms (e.g., berm constructed of brush, rock, wood chips, or other material that may be wrapped in geotextile fabric);
- install sediment basins and traps to detain runoff and retain sediment;
- confine sensitive operations to periods of dry weather, minimize traffic through these areas, and select equipment that will create the least disturbance (e.g., rubber-tired or rubber-tracked machinery);
- for stream culvert installations, use temporary diversion or impoundment of stream flow to reduce the exposure of disturbed soil to flowing water – being sure to obtain prior agency approval, if required.

For more detailed information on control of soil erosion and sediment transport, refer to the Ministry of Forests' Best Management Practices Handbook: Hillslope Restoration in British Columbia.

5.12 Road Works Shutdown Indicators

Several visible weather- and soil-related conditions can be used on site to help determine when forest road operations are to be shut down because the works are causing, or may imminently cause, environmental damage. Refer to the BC Timber Sales BCTS Environmental Management System Manual (PDF), which contains information on environmental policy, training, awareness and competence, emergency preparedness and response and records, among other items.

Be prepared to shut down or alter construction activities during periods of adverse weather to avoid uncontrolled soil erosion and sediment transport. In general, work on earth materials in environmentally sensitive areas only during favorable soil moisture conditions. Consider maintaining a rain gauge at the work site and keeping a written record of rainfall levels.

The objective is to reduce potential adverse impacts on forest resources such as:

- erosion of exposed soils;
- sediment transport to fish streams; and
- slope failure originating within the limits of the construction site or in the adjacent terrain.

When a qualified registered professional develops a prescription for a road-related activity in areas having a moderate or high likelihood of landslides, ensure that the prescription contains site-specific, weather-related shutdown indicators and start-up requirements.

In general, and where predictable, shut down work before the following happens:

- sediment transport cannot be controlled;
- slope stability is in question, or landslides occur;
- windfall is happening around or near the site;
- the road surface deteriorates and vehicle traffic damages the road;
- activities damage adjacent stands and plantations;
- activities damage soils and inhibit future reforestation; and
- spills of fuel or explosives occur.

5.12.1 Procedures for Shutting Down Operations

1. Stop the activity. Cease works before soils are visibly soft or muddy and associated silty waters or sediment are flowing toward streams, lakes, or marine-sensitive zones or where such conditions are reasonably anticipated to develop. Equipment operators are usually in a position to first recognize signs of pending soil erosion on site. Emphasize the need for them to communicate their observations to the site supervisor during the project pre-work phase.

2. Take steps necessary to avoid impacts. Before shutdown, control drainage to ensure that subsequent damage does not occur. Carry out protective measures in the work area, primarily on sites where work is not at a completed and controlled stage. Consider the following general practices:

- minimize sediment delivery from stockpiled erodible soils;
- ensure that drainage systems are functional;
- add water control measures (such as cross-ditches and waterbars) and other soil erosion and sediment control measures where appropriate.

3. Document and report the shutdown to the supervisor.

4. Account for all people working in the area before leaving the site.

5. Restarting the works. Establish and convey to the road crew the criteria for restarting works, including any further required mitigation measures.

5.12.2 Limiting Road Use to Minimize Adverse Impacts

Restrict traffic where works are shut down because of saturated soil conditions. Post temporary signs warning of the danger, and advise the appropriate managers, agencies, and local residents of the necessity to close/restrict the road to traffic.

5.12.3 Emergency Road Maintenance

Only in emergencies is it appropriate to carry out maintenance during high water flow or saturated soil conditions because of the potential for creating an adverse impact. For example, if a culvert is plugged or will imminently plug and wash out a road fill or drainage structure, then rectify the problem immediately. Failure to carry out such works may result in the loss of infrastructure and unacceptable impacts to other resources. If adverse impacts indeed occur during such maintenance work, notify the appropriate agencies at the earliest possible time.

5.13 Resources & Suggestions for Further Reading

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5.14 Appendices

5.14.1 Tables to Establish Clearing Width

Clearing width

The clearing width is shown in Table 5-3 and Table 5-4. Since clearing width calculations are straightforward, but very tedious, Tables 5-3 to 5-9 and accompanying Table 5-10 and Table 5-11 have been developed for convenience.

Note that the right-of-way width will not normally exceed 75m and the clearing width will not exceed the right-of-way width; any geometry in the tables in this Appendix that indicates clearing widths that approach or exceed the 75m width should be reconsidered and perhaps other road construction alternatives used.

These tables provide slope distances (not the horizontal distances) for establishing suitable offset distances from road centreline to facilitate easy field marking of the upper and lower clearing width boundaries. Note that the offset slope distances in the tables depend on several factors:

- unstabilized subgrade width;
- side slope angle of the natural ground surface; and
- angles of the fill and cut slopes.

On the tables in this appendix, the **clearing width** is the sum of the width determined from the tables and any additional width to account for special circumstances (see below, "Additions to Clearing Width"). The clearing width established from these tables may be expressed as:

Clearing width = offset distance on cut side of centreline (from tables) + offset distance on fill side of centreline (from tables) + additional width (if necessary)

For a specific subgrade width, these tables assume:

- no horizontal or vertical adjustments at the road centreline;
- 0.3m overburden thickness;
- 3.0m clearing allowance above the top of the cut slope to standing timber;
- selection of the appropriate cut and fill slope angles [Refer to the suggested cut and fill slope angles in Chapter 3, Table 3-4 General guidelines for cut and fill slope angles for use in forest road design (PDF)];
- a ditch depth of 0.5m;
- sidecast road construction with little or no longitudinal movement of material; and
- a minimum 3.0m distance from the road shoulder to the lower side clearing width boundary.

As well, it is assumed that where there is road fill, the toe of the fill slope demarcates the lower clearing width boundary. Therefore, to establish the clearing width when using these tables, include additional width allowances as required (e.g., additional width will be required for debris disposal on the lower side of the road below the toe of the fill slope).

Where the offset slope distance from the road centreline to the upper or lower clearing width boundaries exceeds 50m, consider using alternative construction methods, such as retaining walls, to reduce the clearing width requirements.

Determining clearing width from tables in this appendix

The following procedure is suggested:

Select the appropriate unstabilized subgrade width table (the tables have been developed for unstabilized subgrade widths of 4, 5, 6, 7, 8, 9, and 10 m). Do this after:

- adjusting the road subgrade width to compensate for cuts or fills (see following: Adjustments to Road Subgrade Width in Tables to Compensate for Cuts and Fills at Road Centreline); and
- adjusting the road subgrade width to compensate for road surfacing materials (see following: Additions to Clearing Width).

Choose the appropriate natural side slope angle in the selected subgrade width table. Based on the expected soil type to be encountered during road construction, choose the appropriate cut and fill slope angles for application in the tables. Details about selecting cut and fill slope angles for road design are given in Forest Road Engineering Guidebook (7.8MB) (Appendix 1: Field Identification of Soils).

To establish the upper clearing width boundary, read the offset slope distance from the appropriate cut slope angle column (the offset distance given in the cut slope angle column is a slope distance between the road centreline and the upper clearing width boundary).

Use a two-step procedure to establish the lower clearing width boundary. First, read the offset slope distance from the appropriate fill slope angle column (the offset distance given in the fill slope angle column is a slope distance between the road centreline and the toe of any fill slope). Second, include any additional width allowances (such as those for debris disposal on the lower side of the road below the toe of the fill, and to accommodate sight distance), as explained following in Additions to Clearing Width).

Adjustments to road subgrade width to compensate for cuts and fills at road centreline

Limit the use of an adjusted road subgrade width in these tables for short sections of anticipated cuts or fills at the road centreline to the obvious locations in the field, such as where cuts are required through small ridges or fills across linear slope depressions of less than 3.0m deep. For longer sections of road through areas with deep gullies or high ridges, complete a geometric road design and determine the clearing width from these drawings.

To compensate for a cut at the centreline, adjust the road subgrade width as follows: Add 1.0m to the subgrade width for every 0.3m cut increment at centreline to determine the offset slope distance on the cut side of centreline. Subtract 1.0m from the subgrade width for every 0.3m cut increment at centreline to determine the offset slope distance on the fill side of centreline. For example, consider a 0.6m deep cut at centreline on a 6.0m wide unstabilized subgrade (assume surfacing material is not applied to the subgrade). Assume a natural side slope angle of 35% above and below the road centreline, and fill and cut slope angles of 1½H : 1V and 1H : 1V, respectively. In this case, adjust the unstabilized subgrade width by 2.0m as follows:

- choose the appropriate cut slope angle column from Table 5-7 (8.0 wide unstabilized subgrade) to determine the offset slope distance on the cut side of centreline; the offset slope distance from this table is 12.0m;
- choose the appropriate fill slope angle column from Table 5-3 (4.0m wide unstabilized subgrade) to determine the offset slope distance on the fill side of centreline; the offset slope distance from this table is 5.0m.

In this cut example, the clearing width (magnitude) is unchanged, but is shifted upslope with respect to the road centreline.

If, because of shallow side slopes, the 0.6m cut resulted in a through-cut instead of a fill slope, use the appropriate cut slope angle column from Table 5-3 (4.0m wide unstabilized subgrade) to obtain the required offset slope distance from centreline to the lower clearing width boundary.

To adjust for fills at the centreline, reverse the above procedure. For example, to allow for a 0.6m fill at centreline on a 6.0m wide road, adjust the unstabilized subgrade width by 2.0m as follows:

- choose the appropriate cut slope angle column from Table 5-3 (4.0m wide unstabilized subgrade) to determine the offset slope distance on the cut side of centreline;
- choose the appropriate fill slope angle column from Table 5-7 (8.0m wide unstabilized subgrade) to determine the offset slope distance on the fill side of centreline.

Additions to clearing width

Compensate for Surfacing or Ballasting Material

Before selecting the appropriate unstabilized subgrade width table, compensate for the thickness of surfacing or ballasting material anticipated to be placed over the unstabilized subgrade surface. For example, where surfacing material is needed to provide a finished road running surface, select a wider unstabilized subgrade width when determining the clearing width from Tables 5-3 to 5-9. For every 0.3m of surfacing depth, allow for an additional 1.0m of unstabilized subgrade width.

For example, to obtain a 4.0m wide finished road running surface on subgrade soils that will require a 0.3m thickness of gravel, select Table 5-4 (5.0m wide unstabilized subgrade).

Compensate for Other Requirements

Calculate the extra width needed for turnouts, sight distance, snow removal, debris disposal, and similar needs on the fill side of road centreline. To determine the lower clearing width boundary, add this extra width to the offset slope distance (fill side of centreline) given in the tables.

For example, if winter use of the road requires snowplowing, the standing timber should be at least 4.0m or more away from the road shoulder. Since the tables will only provide for a minimum of 3.0m from the road shoulder to the lower clearing width boundary, simply add the additional 1.0 or 2.0m to the offset slope distance. Where natural side slope angles are greater than 20%, convert the extra width allowance to a slope distance, rounded up to the nearest meter, and then added to the offset slope distance determined from the tables.

Tables 5-3 to 5-9

Offset slope distances (m) from road centreline to upper (cut side) clearing width boundary and lower (fill side) clearing width boundary.

Table 5-3 Unstabilized Subgrade Width = 4m

Natural Side Slope Angle	**Fill Slope Angle**			**Cut Slope Angle**				
%	**1H : 1V**	**1½H : 1V**	**2H : 1V**	**¼H : 1V**	**¾H : 1V**	**1H : 1V**	**1½H : 1V**	**2H : 1V**
0-20	5	5	5	6	7	7	8	10
21-30	5	5	5	6	7	8	9	14
31-35	5	5	5	6	8	8	10	18
36-40	5	5	7	6	8	9	11	Use Table 5-11
41-45	5	5	Use Table 5-10	7	8	10	13	
46-50	5	7		7	9	10	15	
51-54	5	10	Use alternative construction methods	7	10	12	26	Use alternative construction methods
55-57	5	13		7	10	12	34	
58-60	5	19		7	10	13	48	

Table 5-4 Unstabilized Subgrade Width = 5m

Natural Side Slope Angle	**Fill Slope Angle**			**Cut Slope Angle**				
%	**1H : 1V**	**1½H : 1V**	**2H : 1V**	**¼H : 1V**	**¾H : 1V**	**1H : 1V**	**1½H : 1V**	**2H : 1V**
0-20	5	5	5	7	7	8	9	11
21-30	5	5	6	7	8	9	10	16
31-35	5	5	8	7	8	9	11	20
36-40	5	6	10	7	9	10	12	Use Table 5-11
41-45	5	7	Use Table 5-10	7	9	10	14	
46-50	5	9		7	10	12	17	
51-54	5	12	Use alternative construction methods	7	10	13	29	Use alternative construction methods
55-57	5	16		7	11	14	37	
58-60	6	23		8	11	15	54	

Table 5-5 Unstabilized Subgrade Width = 6m

Natural Side Slope Angle	Fill Slope Angle			Cut Slope Angle				
%	1H : 1V	1½H : 1V	2H : 1V	¼H : 1V	¾H : 1V	1H : 1V	1½H : 1V	2H : 1V
0-20	6	6	6	7	8	9	10	12
21-30	6	6	6	7	9	10	11	17
31-35	6	6	8	7	9	10	12	22
36-40	6	7	13	8	9	11	14	Use Table 5-11
41-45	6	9	Use Table 5-10	8	10	12	16	
46-50	6	11		8	10	13	18	
51-54	7	15	Use alternative construction methods	8	11	14	32	Use alternative construction methods
55-57	7	19		8	12	15	41	
58-60	8	29		8	12	16	60	

Table 5-6 Unstabilized Subgrade Width = 7m

Natural Side Slope Angle	Fill Slope Angle			Cut Slope Angle				
%	**1H : 1V**	**1½H : 1V**	**2H : 1V**	**¼H : 1V**	**¾H : 1V**	**1H : 1V**	**1½H : 1V**	**2H : 1V**
0-20	7	7	7	8	9	9	10	13
21-30	7	7	8	8	9	10	12	19
31-35	7	7	10	8	10	11	13	Use Table 5-11
36-40	7	8	Use Table 5-10	8	10	12	14	
41-45	7	11		8	11	12	16	
46-50	7	14		8	11	14	20	
51-54	8	18	Use alternative construction methods	9	12	15	35	Use alternative construction methods
55-57	8	23		9	13	16	44	
58-60	9	33		9	13	17		

Table 5-7 Unstabilized Subgrade Width = 8m

Natural Side Slope Angle	**Fill Slope Angle**			**Cut Slope Angle**				
%	**1H : 1V**	**1½H : 1V**	**2H : 1V**	**¼H : 1V**	**¾H : 1V**	**1H : 1V**	**1½H : 1V**	**2H : 1V**
0-20	7	7	7	8	9	10	11	14
21-30	7	7	9	8	10	11	12	20
31-35	7	8	11	8	10	12	14	Use Table 5-11
36-40	7	10	Use Table 5-10	8	11	13	16	
41-45	8	12		8	11	14	18	
46-50	8	16		8	12	15	22	
51-54	9	21	Use alternative construction methods	10	13	17	38	Use alternative construction methods
55-57	10	27		10	14	18	49	
58-60	11	39		10	14	19		

Table 5-8 Unstabilized Subgrade Width = 9m

Natural Side Slope Angle	**Fill Slope Angle**			**Cut Slope Angle**				
%	**1H : 1V**	**1½H : 1V**	**2H : 1V**	**¼H : 1V**	**¾H : 1V**	**1H : 1V**	**1½H : 1V**	**2H : 1V**
0-20	8	8	8	9	10	11	11	14
21-30	8	8	10	9	11	12	13	21
31-35	8	10	13	9	11	13	15	Use Table 5-11
36-40	8	12	Use Table 5-10	9	12	14	17	
41-45	9	15		10	12	15	20	
46-50	10	19		10	13	16	23	
51-54	10	24	Use alternative construction methods	10	14	18	41	Use alternative construction methods
55-57	11	31		10	15	19	53	
58-60	12	45		11	16	20		

Table 5-9 Unstabilized Subgrade Width = 10m

Natural Side Slope Angle	Fill Slope Angle			Cut Slope Angle				
%	**1H : 1V**	**1½H : 1V**	**2H : 1V**	**¼H : 1V**	**¾H : 1V**	**1H : 1V**	**1½H : 1V**	**2H : 1V**
0-20	8	8	8	9	10	11	12	15
21-30	8	8	11	9	11	12	14	Use Table 5-11
31-35	8	11	15	10	12	14	18	
36-40	9	13	Use Table 5-10	10	12	14	18	
41-45	10	16		10	13	16	21	
46-50	11	21		10	14	17	25	
51-54	12	27	Use alternative construction methods	11	15	19	45	Use alternative construction methods
55-57	13	36		11	16	21	58	
58-60	14	50		11	17	22		

Tables 5-10 & 5-11

The following two tables are referenced in Tables 5-3 to 5-9.

Table 5-10 Offset slope distance for 2H:1V fill slope angles

Natural Side Slope Angle	**Unstabilized Subgrade Width**						
%	**4m**	**5m**	**6m**	**7m**	**8m**	**9m**	**10m**
36-38	Use tables above			13	15	17	19
40				16	18	21	23
42	9	13	16	19	22	25	28
44	12	17	22	26	30	34	37
46	20	28	35	41	46	50	
48	44	Use alternative construction methods					

Table 5-11 Offset slope distance for 2H:1V cut slope angles

Natural Side Slope Angle	Unstabilized Subgrade Width						
%	4m	5m	6m	7m	8m	9m	10m
21-25	Use tables above			Use tables above			17
26-28							20
30							22
32				20	21	23	24
34				22	24	25	27
36	19	21	23	25	27	29	31
38	22	24	27	29	32	34	36
40	26	29	32	35	38	41	
42	32	36	39	43	47	50	
44	42	52	Use alternative construction methods				

6 Road Inspection & Maintenance

This chapter presents the Ministry's mandatory requirements and best practices related to an annual FSR Maintenance Plan **(road maintenance plan)** which includes inventory, risk assessment, inspection and maintenance schedules, and maintenance activities. It is intended to provide enough detail to be able to understand the processes and mandatory procedures, as well as carrying out appropriate best practices to address Ministry policy and regulatory requirements for maintenance of the FSR Network.

Maintenance activities are to provide user safety commensurate to current or expected use during service life cycle of a FSR until discontinued or otherwise transferred to another authority. Consideration related to plans, assessments, works, and reports, includes the following:

- Professional responsibilities and considerations;
- Understanding the different required levels of maintenance, and vehicle access objectives;
- Preparing a FSR Maintenance Plan;
- Assigning frequency of inspections road and engineered structures maintenance priorities based on risk analysis;
- Road inspections; and,
- Road maintenance activities as appropriate, including the clearing width, ditch and culverts, road prism, subgrade and the road surface.

Policy

Government has the maintenance responsibility for FSRs that are not subject to a Road Use Permit holder's responsibility, to maintain by an order as per the Forest Planning and Practices Regulation Sec. 79(4)).

FSR maintenance activities, including planning and road inspections, should be commensurate to the level of public use, integrity of the prism and its clearing width, and respect potential impacts on user safety, and stewardship values at risk of adverse impacts.

6.1 Mandatory Procedures & Best Practices

The mandatory procedures within this section describe Ministry policy for processes and practices considered to be government's responsibility related to statutory requirements for maintenance of the FSR network. The best practices are for consideration of continuous improvement under the results based model of the *Forest and Range Practices Act* (FRPA).

Table 6.1 Summary of Mandatory Procedures and Best Practices

The following table approximates, in chronological order, the mandatory (M) procedures and best (B) practices with a numbering convention M1, M2…. and B1, B2…respectively. Links are provided for quick access to the location in the manual where the topic is discussed. A District Manager (DM) or Timber Sales Manager (TSM) may decide to delegate their responsibility.

6.1.1 General

M1. The DM/TSM ***must*** designate [see CM designate] a Coordinating Member (CM) to prepare and deliver the FSR Maintenance Plan and oversee the professional requirements for the roads that the Ministry is directly responsible for maintaining (responsibility for maintenance has not been transferred to a RUP holder).

B1: Prepare a project tracking checklist [see **Tracking**] to address whether or not the necessary steps in the inspection and maintenance processes were undertaken and any identified issues issues addressed.

6.1.2 Road Inventory

M2. The DM ***must*** ensure [see DM inventory] that:

- A current road inventory is prepared annually for all FSRs, or, failing this, there is a plan to complete the inventory within the current fiscal year; and current road inventory data (or changes to the database) is accessible to Ministry staff including BCTS.

M3: The DM and TSM jointly ensure that there is a written agreement [see road split] on BCTS/Resource District(s) Administrative Responsibility for FSR maintenance. The Agreement must identify the responsibilities and associated FSRs and must be reviewed annually for confirmation.

B2: Where BCTS and the Natural Resource District cannot reach an agreement on the split of administrative responsibility, implement a dispute resolution process for roads in dispute, that is an escalating process such that the ultimate decision would be made by a person with the authority to direct a decision to both parties. Any existing agreement shall be considered confirmed and ongoing pending resolution or an agreed to change occurs.

6.1.3 Forest Service Road Maintenance Plan

The FSR Maintenance Plan is prepared annually, and includes inventory, risk assessment, proposed inspection and maintenance schedules, and proposed physical maintenance activities.

The proposed road maintenance plan is delivered to the DM or TSM responsible for administration of the FSR who then reviews, modifies (as appropriate), and finalizes the inspection and maintenance schedule for the year. Upon completion of inspection and maintenance activities for the year the CM amends the proposed road maintenance plan with the DM/TSM approved schedule of inspection and maintenance activities, rationale for any changes to the approved schedule that occurred throughout the year, and appropriate records of the actual road inspection and maintenance activities that were carried out. The CM also provides a signed (and sealed if appropriate) assurance statement to accompany the completed road maintenance plan.

M4. The CM ***must*** review the proposed FSR Maintenance Plan [see maintenance plans] for those FSR's that the Ministry is responsible for directly maintaining, to ensure that the plan addresses:

- A road inventory;
- Inspection and maintenance activities risk ratings of the FSR's in accordance with the provincial risk rating process;
- The current year of the inspection schedule;
- The current year of the maintenance schedule; and
- Postponing inspections or maintenance activities, or the carrying out of placement of signs, road closures and barricades.

B3: Prepare a Standard Operating Procedure(s) (SOP(s)) to identify the local process for modifications to inspection and maintenance schedules.

B4. Where it is necessary to utilize more than one CM for the preparation and implementation of a road maintenance plan, the DM or TSM, as appropriate, will ensure that there is a documented transfer process [see] to provide for continuity in professional responsibility.

6.1.4 Road Inspection Schedule and Activities

M5. The CM ***must*** [see inspection schedule] :

- Prepare a proposed road inspection schedule annually in accordance with the risk rating and submit it to DM/TSM or delegated manager for review and approval; and

Provide documented rationale for any recommendations for variances to risk rating(s) or scheduled inspection(s) dates.

M6. DM/TSM ***must*** review, modify (as appropriate) and finalize an approved road inspection schedule, and ensure that modifications, including postponement or changes in priority or timing, have a documented rationale.

M7. The CM ***must*** ensure that the road inspection schedule has been documented on approved corporate records.
M8. The CM ***must*** ensure that road inspections are completed in accordance with the DM/TSM approved inspection schedule or as modified through an agreed-to process, and the modifications recorded.
M9. The CM ***must*** ensure that the results of the road inspections [see inspection records] are documented and filed on the approved corporate records.

B5: For determining the timing of the inspections (from 1 to 5 years) take into consideration potential for existing hazards that have been noted and recorded during previous inspections.
B6: In addition to any scheduled road inspections, Ministry staff that travel on FSRs have a responsibility to report to the TSM/DM, or C&E as appropriate, any significant road maintenance or safety problems that they observe in the course of their duties.

6.1.5 Road Maintenance Schedule of Activities

M10. The CM ***must*** ensure that the road maintenance schedule: • Provides for safety to road users commensurate to anticipated use and addresses known hazards with mitigative maintenance actions including warnings, restrictions and closures. The *Occupiers Liability Act* provides for limited liability; and • Addresses material adverse effects on forest resources or other elements at risk.
M11. The CM ***must*** ensure [see maintenance priorities] that a proposed road maintenance schedule is prepared annually based upon the inspection data and maintenance risk assessment (reference Table 6.5.2) and submitted with appropriate rationale to DM/TSM for review and approval.
M12. DM/TSM ***must*** review, modify (as appropriate) and finalize an approved road maintenance schedule, such that the approved works: • Reflect available funding and staff resources; • Include changes in priority or timing together with documented rationale; and include any decisions to postpone activity, install warning signage, restrict road use, temporarily close the road, or deactivate the road, including any such decisions on BCTS managed roads that must be made by the DM.
M13. The CM ***must*** ensure that the proposed maintenance schedule has been documented and filed on approved corporate records.

M10. The CM ***must*** ensure that the road maintenance schedule:

- Provides for safety to road users commensurate to anticipated use and addresses known hazards with mitigative maintenance actions including warnings, restrictions and closures. The *Occupiers Liability Act* provides for limited liability; and
- Addresses material adverse effects on forest resources or other elements at risk.

M11. The CM ***must*** ensure [see maintenance priorities] that a proposed road maintenance schedule is prepared annually based upon the inspection data and maintenance risk assessment (reference Table 6.5.2) and submitted with appropriate rationale to DM/TSM for review and approval.

M12. DM/TSM ***must*** review, modify (as appropriate) and finalize an approved road maintenance schedule, such that the approved works:

- Reflect available funding and staff resources;
- Include changes in priority or timing together with documented rationale; and include any decisions to postpone activity, install warning signage, restrict road use, temporarily close the road, or deactivate the road, including any such decisions on BCTS managed roads that must be made by the DM.

M14. The CM ***must*** determine the level of involvement of a Specialist for road maintenance works where there is a significant risk of detrimental effects to forest resources or people, a Specialist prepares a prescription as required [see specialist prescriptions] for the works to be carried out at a site.

M15. The CM ***must*** ensure that:

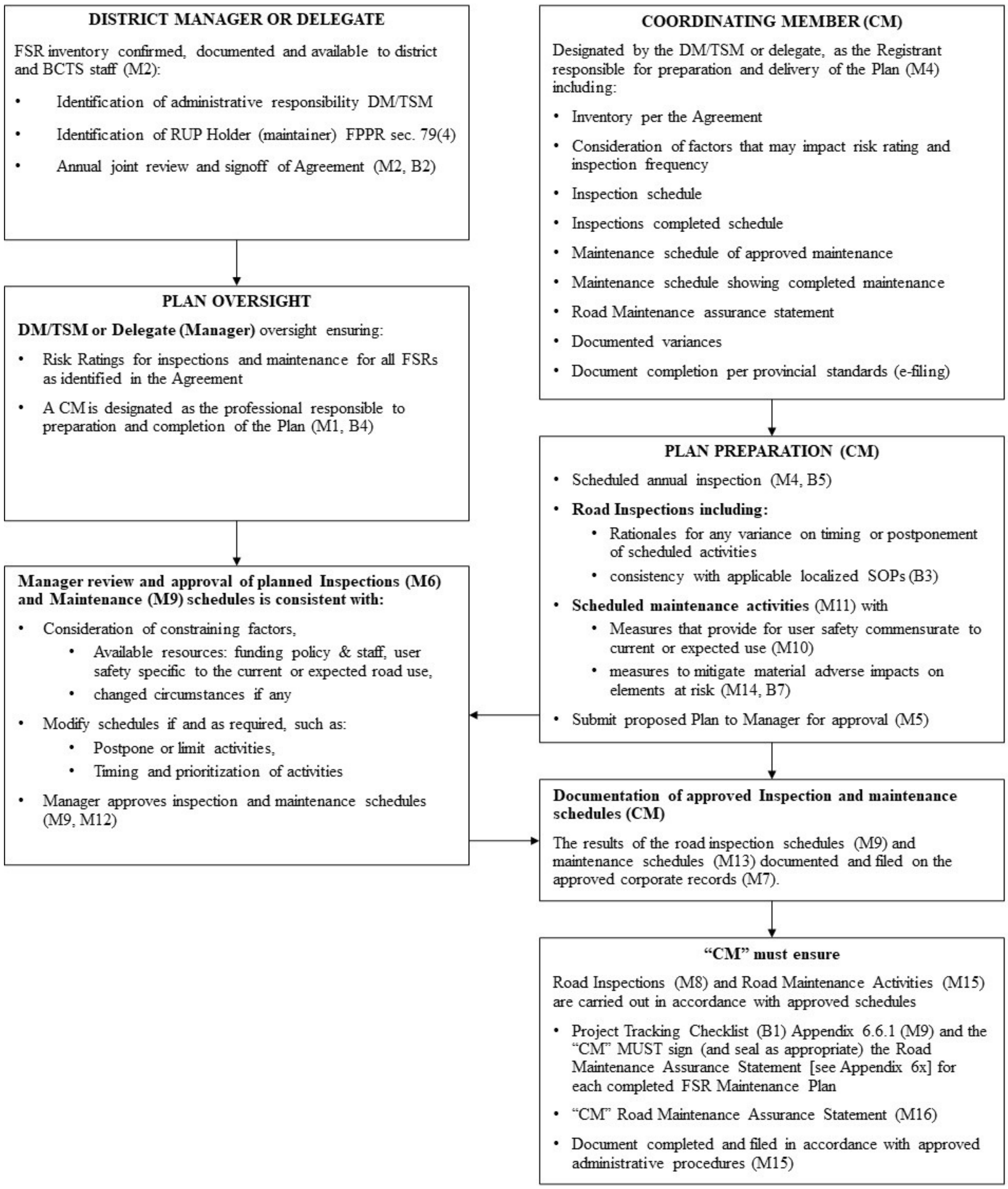
- Road maintenance activities are carried out as per the approved maintenance schedule (or exceptions noted); and
- The results of the road maintenance activities are documented and filed on approved corporate records.

B7: The CM should prepare, or review and approve, SOPs [see maintenance SOPs] to apply to surface road maintenance works where there is no significant risk of detrimental effects to the environment or people, and as such, a prescription prepared by a Specialist is not required.

6.1.6 Forest Service Road Maintenance Plan Completion

M16. The CM ***must*** sign (and seal as appropriate) the Road Maintenance Assurance Statement for each completed FSR Maintenance Plan.

FLOW CHART 6.1 referencing Table 6.1: Mandatory



6.2 Road Inspection & Maintenance Professional Responsibilities & Considerations

Professional accountability is required for all forest road activities related to road inspections and road maintenance and are governed under the *Professional Governance Act* and guided by Guidelines for Professional Services in the Forest Sector - Forest Roads 4.6 Inspections and Maintenance Plans for Road Use. The DM or TSM with administrative responsibility for the FSR assigns a CM the respective role and responsibility for one or more road activities related to maintenance, including preparing a FSR Maintenance Plan, oversight of road inspections, accountability and professional sign-off for completion of a FSR Maintenance Plan; oversight of maintenance activities and accountability with professional sign-off for completion of maintenance activities under the plan maintenance schedule.

For professional road activities, the CM can delegate the completion of professional activity to an assisting subordinate Registrant or non-Registrant working under their direct supervision. Direct supervision means taking responsibility for the control and conduct of the activities of a subordinate. Accordingly, the CM must ensure that the subordinate person is qualified to do the activity and must review and approve that person's output. Note that this ability to delegate does not extend to signing off the FSR Maintenance Plan and the Road Maintenance Assurance Statement.

While it is preferable for one person to be the CM for both the preparation of a FSR Maintenance Plan and the implementation of that annual plan, there will be situations where a CM may not be available to provide such continuity. In those instances, the DM or TSM, as appropriate, ***must*** provide for a documented process and sign-off when one CM completes their work, and another CM assumes project responsibility.

6.3 Forest Service Road Maintenance Plan

The CM must prepare a FSR Maintenance Plan at an appropriate time of the year before new inspections are scheduled to start. The FSR Maintenance Plan includes (at a minimum):

- The road inventory;
- Risk assessments for prioritizing inspection schedules and maintenance activities;
- A road inspection implementation schedule;
- A maintenance implementation schedule;
- Descriptions of maintenance activities; and
- A signed assurance statement.

Accordingly, the CM that prepares a FSR Maintenance Plan must determine the level of detail required and ensure that the plan includes an inventory of FSRs which the respective manager is in agreement on the administrative responsibility for maintenance and the plan. The plan must:

- Consider current or expected road use, at least subjectively to link to the program funding policy;
- Provides risk ratings for prioritizing inspection schedules;

- Establishes the frequency and scope of inspection schedules;
- Contains inspection results, including documentation of maintenance issues noted and recorded for each road;
- Provides risk ratings for prioritizing maintenance activities as determined from inspections;
- Provides for surface maintenance activities to be carried out in accordance with approved SOPs, or recognizes where other Registrant or Specialist input is required for site specific remedial activity, and incorporates the results of such input;
- Identifies inspection and maintenance activities that require professional involvement need for Specialist involvement and professional sign-off upon completion;
- Includes a completed Road Maintenance Assurance Statement with confirmation that the inspections and maintenance activities are in substantial compliance with the FSR Maintenance Plan.

6.4 Road Inventory

The DM must ensure the inventory of FSRs within the respective resource district is kept current throughout the year, and identifies FSR sections that:

- Have been deactivated but have not been closed and discontinued;
- A Road Use Permit (RUP) holder has been issued an order to assume the responsibility for maintenance; and
- The Ministry is responsible for maintenance.
- The DM must also ensure:
  - that an agreement on the administrative responsibility and road split between the DM and the TSM is in place and reviewed annually at minimum; and
  - The road inventory information is made available to Ministry staff including BCTS.

6.5 Road Inspections

6.5.1 Risk Rating for Road Inspections

Roads that are planned to be inspected must be evaluated qualitatively for risk in accordance with Table 6.5.1A and Table 6.5.1B and associated descriptions:

Table 6.5.1A Risk Rating for Road Inspections

RISK *(Likelihood x consequence)*		**CONSEQUENCE**		
		Minor	**Moderate**	**Major**
LIKELIHOOD	**Likely**	Medium	High	High
	Possible	Low	Medium	High
	Unlikely	Very Low	Low	Medium
	Not Likely	Very Low	Very low	Low

LIKELIHOOD = the chance of a hazardous event or incident happening during the carrying out of the work if those events or incidents were not properly addressed during maintenance activities.

- Likely = will almost certainly happen
- Possible = could happen
- Unlikely = might happen
- Not Likely = not likely to happen

Hazardous event: sources of potential harm, or a situation with a potential for causing harm, in terms of human injury; damage to health, property, the environment, and other things of value; or some combination of these. Examples include:

- Slope instability – landslide, rockslide, slump
- Flooding or erosion
- Avalanche
- Damage to the structural road surface by users

CONSEQUENCE = severity of the impact to the road that may occur resulting of a hazardous event. Impacts include:

- Use;
- Stability or drainage system;
- Effect on associated forest resources or other values

Severity of impacts are as follows:

- Major: serious impact
- Moderate: moderate impact
- Minor: limited impact

RISK = Likelihood of Occurrence x Consequence

This refers to the likelihood that a hazard will occur without proper attention being applied to the maintenance activities and practices, as well as the severity of possible impact to the roads use, stability, drainage, associated forest resources or other values. For the purposes of qualitative risk assessment, it is assumed that:

- High = is almost certain that the road event is expected to occur and adversely affect adjacent forest resources;
- Medium = it is possible that the road event is expected to occur and adversely affect adjacent forest resources;
- Low = it is unlikely that the road event is expected to occur and adversely affect adjacent forest resources;
- Very Low = it is rarely that the road event is expected to occur and adversely affect adjacent forest resources [note: this category of risk will likely apply to any FSR that has been deactivated but not discontinued and closed].

Table 6.5.1B Inspection Frequency

Risk Rating from Table 6.5.1A	**Frequency of Inspections**
High	Annually And After Major Weather Events
Medium	Every 3 Years
Low	Every 4 Years
Very Low	Every 5 Years

6.5.2 Road Inspection Schedule

The CM must ensure the road inspection schedule:

- Includes those roads identified in the FSR Inventory that are scheduled for inspection based on risk rating in accordance with Table 6.5.1A risk rating for road inspections and Table 6.5.1B frequency of road inspections;
- Prioritizes inspections in accordance with the risk rating outcomes;
- Provides supporting rationale for variances to frequency of scheduled inspections;
- Is reviewed and approved by the DM/TSM or delegate;
- Includes the results of road inspections;
- Is documented and filed in accordance with corporate record keeping procedures; and

- Completion of the DM/TSM's finalized inspection schedule is integral to the FSR Maintenance Plan Assurance Statement.

6.5.3 Carrying Out Road Inspections:

Any FSR that has a vehicle access constraint such as a washout, structure removal or has been deactivated, will need consideration for the timing of an inspection and potentially from means other than a truck.

Before road inspections are carried out on FSRs, determine the level of road maintenance required on the road (e.g., wilderness road, recreation access, community access, safe for industrial use). FSRs are maintained to address the requirements of forest legislation, such that roads are to be maintained to protect forest resources and other values, and to provide for safe industrial use. However, in addition to such this requirement, there is a further onus on the Ministry to provide for public users to be reasonably safe while using the road, in accordance with the *Occupiers Liability Act.*

Road inspections should be focused on the structural integrity of the road prism and clearing width, the effectiveness of drainage systems, and the condition of the road surface. Consideration must also be given to road user safety, including signage, and any values at risk. As part of the road inspections, a cursory examination of stream crossing structures should be included to capture any visible signs of structural problems, abutment and pier scour, fish passage impediments or sediment deposition.

The CM must ensure that the roads have been inspected in accordance with the accepted inspection schedule, or as per a modified schedule as provided for in local SOP's that are in place. Any such modifications must be recorded in the annual FSR Maintenance Plan.

In addition to the formal approved inspection processes, there will be situations where ad hoc information will be provided by Ministry staff who are responsible for reporting road issues that they may encounter in the course of carrying out their normal duties.

The CM must ensure that the results of road inspections, carried out in accordance with the inspection schedule or because of additional site data provided by staff or others, are recorded on approved corporate records.

6.5.4 Road Inspection Data

The DM/TSM must ensure:

- Road inspection results include:
    - Location of inspections (road project#, km, etc.)
    - Proposed and actual inspection dates;
    - A record of issues and any recommendations noted for each road; and
    - The name of the inspector.
- Road inspection data is accessible to relative Ministry staff as required.

6.6 Road Maintenance

6.6.1 Road Maintenance Activities

Although road maintenance cost estimates are not necessarily a component of a FSR Maintenance Plan, it is expected that the cost information will eventually be incorporated into the service plan for road maintenance. As such, cost estimates of road remediation works may optionally be tabulated in the road plan itself, or a link provided for the costs and any comments on such costs, all that would be readily accessible by individuals other than the CM who require such information.

6.6.2 Road Maintenance Schedule and Works

The CM must prepare a schedule proposing maintenance activities for the FSR maintenance plan for the fiscal year with consideration to future years. The schedule is based upon the results of the road inspections, subsequent review, concurrence on proposed maintenance activities using the risk rating process described in Table 6.6.1 Risk Rating for Road Maintenance Activities.

Table 6.6.1: Risk Rating for Road Maintenance

RISK	**ACTION**
High	Action must be taken as soon as practicable to reduce risk to a tolerable level. Major consequences to elements at risk are occurring or anticipated within 1 year if no action is taken.
Moderate	Works are urgent to prevent damage to elements at risk. Moderate consequences are anticipated within 1 to 3 years if no action is taken.
Low	Works are important to prevent damage to elements at risk. Moderate consequences are anticipated if no action is taken within 5 years.
Very Low	Works are not urgent. Re-evaluate at the next scheduled inspection.

The CM must ensure the maintenance schedule reflects prioritization of maintenance activities determined by the Risk Rating for road maintenance activities required to address user safety and mitigative measures for elements at risk. The proposed maintenance schedule must be submitted to the DM/TSM for review and approval.

The DM/TSM or delegate, as applicable, must review the maintenance schedule and modify as necessary to ensure the schedule provides for maintenance activities variances and decisions to postpone maintenance activities, temporarily close or deactivate roads are supported by documented rationale.

Funding availability for maintenance activities are determined by Engineering Branch or BCTS funding policies.

The CM must ensure that the approved road maintenance schedule is recorded on approved corporate records.

6.6.3 Surface Maintenance SOP's:

Surface maintenance activities means activities where there is no significant risk of detrimental effects to people, forest resources or other values and typically include:

- Brushing and vegetation control, and removal of dangerous trees;
- Grading;
- Ditch clean-out and shaping;
- Ditch block repair;
- Culvert inlet and outlet repairs;
- Seeding exposed soils;
- Frost heave repairs;
- Winter maintenance (snow ploughing and sanding);
- Spot surfacing;

- Dust suppression; and
- Locating and constructing water bars and cross ditches.

Generally, the scopes and levels of activities for surface maintenance activities can be provided in a compendium of guideline practices known as Standard Operating Procedures (SOP's). It is expected that standardized procedures and outcomes will be drawn from the contents of available guidelines, including the Engineering Manual. SOPs may be modified by the CM as needed to suit local conditions.

A person determined by the CM to be suitably qualified to inspect the roads must carry out the inspections under the direction of the CM, and then sign off on the inspections.

6.6.4 Road Maintenance Specialist Prescriptions:

For those road maintenance activities where there is a significant risk of detrimental effects to people, forest resources and other values, the CM must determine whether there is a need to provide for a Specialist to review the site conditions and develop a plan or prescription to address the remedial works required. The need for Specialist inspections may be determined prior to or after a scheduled road inspection, depending upon the extent of data available before the scheduled road inspection. Where such Specialist work is necessary, the CM ***must*** select the Specialist and assign the work to that person in a timely manner to allow for a suitable site-specific determination by the Specialist.

Examples of works where there may be a need for Specialist input to a FSR Maintenance Plan are:

- Stabilization of failing cut or fill slopes;
- Replacement of drainage structures under high fills;
- Road widening on steep slopes; and
- Evaluation of suitability of road grades or surface conditions, particularly in inclement weather, for specific vehicle configurations.

As with other Specialist oversight, there is an expectation that field reviews by the Specialist to confirm the activities is carried out in accordance with the prescription and reported in writing to the CM to provide that confirmation.

The CM must ensure that the maintenance activities were carried out in accordance with the road maintenance schedule (or exceptions noted), and descriptions of the road maintenance activities are recorded on approved corporate records.

6.6.5 Road Maintenance Project Conclusion

Once the FSR maintenance plan project has been completed for the year, the CM must sign a Road Maintenance Assurance Statement providing assurance that completion is in accordance with the approved road inspection schedules and approved road maintenance schedules for the FSR Maintenance Plan.

6.7 Engineered Structure Inspection & Maintenance

A maintenance plan also includes engineered structures (bridges, major culverts and retaining structures over 1.5m in height). These elements must be routinely inspected at least every two or three years, depending upon site specific issues and the type of materials used in the construction of the structures (see Engineered Structure Inspection Frequencies). The CM responsible for the road maintenance plan must:

- incorporate into the maintenance plan the schedule and details of structure inspections consistent with the requirements in the bridge register, and separately from the road maintenance issues;
- ensure that the structures are inspected by qualified individuals, including professional specialists where necessary, and the results are reviewed and accepted by the Ministry bridge engineer; and
- include in the maintenance plan any remedial measures for structures as specified by professional specialists.

Collision-related road and bridge inspections

Where a District Manager (DM) or a Timber Sales Manager (TSM) learns that a serious motor vehicle collision has occurred on a Forest Service Road (FSR), it is recommended that the manager holding administrative responsibility for the road, direct engineering staff to conduct and document a road and or bridge inspection for the identified road. The road inspection should occur as soon as possible, especially if there has been a report of injury or death. It is important to note that road inspections are not intended to be “collision investigations” to determine causal effects. Collision investigation is a specialized area of expertise and ministry engineering staff would not be typically trained in this area. Collision investigations may be conducted by the RCMP, WorkSafe BC, insurance agency or others who have the expertise to do so.

The focus of ministry road and bridge engineering program inspections is to assess the road and/or bridge for safe travel and use, and to identify and address any observed maintenance or safety issues. Road inspections should extend in both directions well beyond the area that may be causal to an investigation of the scene of the reported collision. The inspector must document inspection observations and findings and place the report on the appropriate corporate file. Inspection reports should contain detailed descriptions and photographs of what the local road and/or bridge and weather conditions were like at the time of the collision. It may be the case that this inspection report will be referenced in future litigation.

In some instances, Worksafe BC (WSBC) may order FOR to undertake an investigation subsequent to an incident. While WSBC has the authority to compel any employer to undertake an investigation these orders do not generate any authority for FOR to compel or access information. Accordingly, FOR may only explore the circumstance from the perspective of its own role as road administrator, maintainer or as a workplace owner, according to the circumstances. Most commonly we would be the road administrator or possibly the maintainer.

Note resource roads that are being used for transportation or travel do not constitute a workplace however construction sites on the road are workplaces as are vehicles traveling on the road. Investigative authorities of WSBC, coroner's office, insurance agency and the RCMP must be respected including acknowledging the limitations these authorities may have on sharing of information that is under investigation.

Where industrial maintenance issues are found on FSRs, they should be brought to the attention of the maintainer. Where there is no maintainer, the DM or TSM will need to be addressed as appropriate in consideration of industrial, public and environmental safety. For serious maintenance issues of potential non-compliance, it may be appropriate to refer the findings to Compliance and Enforcement for follow-up.

Consistent with the Safety Management System, Incident Response Guide, for serious incidents, an Information Note should be developed and provided to the Assistant Deputy Minister such that senior managers and the ADM are apprised and not caught off-guard.

6.7.1 Mandatory and Best Practices

Following is a table that summarizes in approximate chronological order the mandatory procedures and best practices concerning the inspection of bridges on Forest Service roads.
Bridge Inspections:

M1. The CRP ***must*** prepare a proposed bridge inspection schedule annually and submit it to DM/TSM for review and approval;
M2. DM/TSM ***must*** review and approve (with modifications as appropriate) the bridge inspection schedule based on available funding and staff resources, such that the modifications include changes in priority or timing together with documented rationale;
M3. The CRP ***must*** ensure that the bridge inspection schedule has been approved by DM/TSM and documented on file;
M4. The CRP ***must*** ensure that the bridge inspections are carried out by qualified persons in accordance with the planned and prioritized schedule reviewed and approved by the DM/TSM, to address at a minimum: • component materials types (durable or non-durable); • ages of the existing structures; • known defects that may adversely impact forest and other resources, as well as safety for anticipated users.
M5. The CRP must document the results of the bridge inspections and file those results in the approved corporate records;

B1: In addition to any planned engineered structure inspections, Ministry staff that travel on FSRs have a responsibility to report to the District Manager any significant safety or maintenance problems that they observe in the course of their duties.

Bridge Maintenance Schedule and Works:

M6. The CRP ***must*** ensure that a proposed bridge maintenance schedule is prepared annually for each bridge based upon the inspection data, and submitted with appropriate rationale to DM/TSM for review and approval;

M7. DM/TSM ***must*** review and approve (with modifications as appropriate) the bridge maintenance schedule based on available funding and staff resources, such that the modifications include:

- changes in priority or timing together with documented rationale; or
- decisions to temporarily close the bridge, or deactivate the road

M8. The CRP ***must*** ensure that the proposed maintenance schedule has been approved by DM/TSM and documented on file;

M9. The CRP ***must*** prepare, or review and approve, Standard Operating Procedures [see **SOPs**] to apply to routine bridge maintenance works where a site-specific prescription is not required;

M10. The CRP ***must*** ensure that for non-routine bridge maintenance works, a specialist prepares a prescription for the works to be carried out at a site

M11. The CRP ***must*** ensure that for those bridges that are not structurally capable of safely carrying the design load and may not be repaired immediately, that:

- a load rating is calculated for the bridge and provided to the DM/TSM; or
- a recommendation is provided to the DM/TSM to temporarily close the bridge to traffic.

M12. Based on the inspection reports, DM/TSM ***must*** ensure that for all engineered structures that are scheduled for repairs, the works are prioritized for implementation, and for those structures that will not be repaired immediately, ***must*** approve one of the following actions to be carried out:

- a bridge will be downrated and signs posted;
- the structure will be temporarily closed to traffic and barricaded; or
- the work will be postponed (if the risks to users and forest resources is not significant); and DM/TSM ***must*** record the decisions and follow-up actions are recorded in the approved corporate records.

M13. The CM ***must***:

- carry out bridge maintenance works as per the approved maintenance schedule (or exceptions noted);
- document the results of bridge maintenance works and file those results in the approved corporate records;

M14. Based on the inspection reports for structures on FSRs maintained by an RUP holder, the District Manager ***must:***

- where there is a change in the designated maintainer, advise the new maintainer in writing of any chronic or current engineered structure maintenance issues on that road;
- advise the maintainer of the repairs/remedial actions to be carried out;
- request details of the maintainer's completed works;
- update the Ministry records of any completed repairs; and
- notify Compliance and Enforcement of any repairs that have not been implemented.

6.7.2 Roles and Responsibilities

As stated under legislation or otherwise delegated by the Minister, District Managers and Timber Sales Managers are responsible for the operations of their respective FSRs including the associated bridges and major culverts (see Chapter 1).

By policy, the ministry retains the responsibility for bridge and major culvert inspections on Forest Service Roads (FSRs) given the significant value of these structures and their implications on access and safety. Engineering Branch provides professional and technical engineering advice and support in the management of FSRs and associated bridges and major culverts.

Scheduling and coordination of routine inspections of FSR bridges and major culverts is typically coordinated by the Engineering Branch, in consultation with the District Manager and/or Timber Sales Manager. The review and determination of load ratings on Forest Service Road bridges and major culverts is the responsibility of the Engineering Branch.

Where there are industrial users on FSRs, a District Manager will assign responsibility for maintenance to one of the Road Use Permit (RUP) holders, as advised in the covering letter for RUPs (FS102A) which states:

The Ministry of Forests will continue to carry out its inspections of Forest Service bridges and major culverts. If responsible for maintenance, please note that you are required to comply with any applicable requirements in the Act and regulations around maintenance, including bridge inspections.

For FSRs without industrial users, and therefore no designated maintainer, the maintenance of the road, including bridges and major culverts, is the responsibility of the Ministry.

The following is a summary of the primary roles and responsibilities of the:

- District Manager (DM)
- Timber Sales Manager (TSM)
- Road Use Permit Holder – “Designated Maintainer”
- Bridge and Major Culvert Inspector
- Engineering Branch (EB), and
- Engineering Branch Ministry Engineer.

District Manager (DM)	Timber Sales Manager (TSM)	Road Use Permit Holder (RUP)	Ministry Inspector	Engineering Branch
Collaborate with TSM to determine which FSRs and thus structures are the responsibility of DM and TSM. Administration of all FSR bridges and major culverts, except those on FSRs that have been agreed upon with the TSM as being the responsibility of BCTS. Barricade and/or close structures and post load rating signage as recommended by EB professional Engineer that has reviewed structure. Notify TSM and RUP holders of structures that require temporary closure of the structure and those that have been downrated. Communicates to the RUP holder responsible for maintenance (designated maintainer): Ministry-approved inspection reports Identified maintenance and safety hazards (e.g., structural defects or deficiencies, down-rated structures). Approves significant works, including where appropriate permit conditions recommended by District Engineering Officer or Professional Engineer with the EB. Requests details of completed maintenance items from RUP holder, as per the “District Manager Guidance for Road Use Permit Holders”. Where repairs are not implemented by the designated maintainer, notifies Compliance and Enforcement as appropriate. Provides the EB with completed repairs or issues that change the functionality of a structure. Roads with No RUPs Issued - Addresses repairs, restrictions, or closures as recommended in the reviewed inspection reports, in consideration of user safety, values at risk of loss (e.g., environmental impact), and current and future road use (wilderness or industrial maintenance standard).	Collaborate with DM to determine which FSRs and thus structures are the responsibility of DM and TSM. Incorporates communication of known identified safety hazards (e.g., structural defect or deficiencies, down-rated structures) into timber sale bid postings. For down-rated structures, posts load rating signs within a reasonable time frame commensurate with accessibility of the road. Roads with No RUPs Issued - Addresses repairs, restrictions, or closures as recommended in the reviewed inspection reports, in consideration of user safety, values at risk of loss (e.g., environmental impact), and current and future road use (wilderness or industrial maintenance standard). Informs the District Manager, or designate, when repairs to structures are completed. Notifies all TSL holders of scheduled close proximity inspections that require temporary closure of the structure.	Follows “District Manager Guidance for Road Use Permit Holders” issued by the DM. Carries out cursory examinations as part of ongoing use of the road, and reports to the DM any potential issues. Carries out required maintenance and repair activities as advised by the DM if the RUP Holder is the designated maintainer. Informs the District Manager, or designate, when repairs and maintenance to structures and signage are completed.	Completes field inspections and reports results in the bridge register with specific details of any identified safety concerns arising from structural defects or deficiencies. Field mark urgent hazards and/or immediate safety risks and notifies the Ministry Contact within 48 hours of inspection.	As the CRP is responsible for developing the strategy, scheduling, and developing contracts for routine and close proximity bridge and major culvert inspections. Schedule bridge inspections from the Corporate Bridge Register (CBR). Consult with DM and TSM on inspection list. Provide professional advice to DM and TSM on recommended actions to structures. Notifying the DM and TSM of scheduled close proximity inspections that require temporary closure of the structure. Ensure inspections are performed before the end of field season, if they are not completed then mitigation plan will be created. Reviews inspection and reports to assign a recommended load rating to the structure. Notifying the DM and TSM of structures recommended to be downrated. Update CBR with completed repairs or issues that change the functionality of a structure.

6.7.3 Types of Bridge and Major Culvert Inspections

Bridge and major culvert inspections can be broadly categorized into four types:

- Cursory Inspection;
- Routine Inspection;
- Professional Inspection;
- Close Proximity Inspection.

The Engineering Branch assigned bridge inspection CRP, is responsible for developing the strategy, scheduling, and developing contracts for routine and close proximity bridge and major culvert inspections.

6.7.3.1 Cursory Inspections

Ad hoc visual inspections of bridges and major culverts. These inspections may be carried out as a byproduct of road use by field staff, in conjunction with routine road maintenance inspections. They can also be a result of aerial reviews of inaccessible structures. The individuals carrying out these cursory inspections may not be qualified to carry out routine inspections, but they can provide timely information to the Engineering Branch and District staff regarding the condition of bridges and major culverts. If a perceived structural or safety problem is noted during a cursory examination an Engineering Branch Ministry Engineer should be notified. The Ministry Engineer must determine what action is necessary depending on the nature of the issue with the structure. This may include determining if a subsequent routine inspection, detailed professional inspection, or close proximity inspection is required.

6.7.3.2 Routine Inspections

The purpose of routine inspections is to determine necessary maintenance and repairs by reviewing the condition of a bridge or major culvert and determine if any deterioration of the structure is affecting its load capacity or negatively impacting user safety, the environment, or assets adjacent to the structure.

Routine inspections must be completed and certified by qualified inspectors who take professional responsibility for the inspection and are familiar with visual inspections and non-destructive testing methods. The mandatory knowledge and skills requirements for qualified inspectors are listed under the service category T07 Technical Bridge and Major Culvert Condition Inspection of the Ministry's Engineering Equipment and Services (EES) Directory.

6.7.3.3 Detailed Professional Inspections

Detailed Professional inspections are intended to provide a further review of bridges or culverts where potential defects or deficiencies have been noted in cursory or routine inspections that require the expertise of a specialist to confirm the condition of the structure and provide potential direction for remedial works.

The purpose of the inspection is to analyze specific bridge components with reported issues to determine the extent of the reported damage or deterioration to assess and determine a revised load rating or determine when a component will require repair or replacement.

All detailed professional inspections must be carried out by a qualified Engineering Professional or under their direct supervision. The mandatory knowledge and skills requirements for qualified professional inspectors are listed under the service category P06 Professional Condition Inspection and Evaluation of Forest Road Bridges and Major Culverts of the Ministry's Engineering Equipment and Services (EES) Directory.

6.7.3.4 Close Proximity Inspections

Close proximity inspections are a form of detailed professional inspection and are performed on bridges or major culverts that require the use of specialist access equipment to effectively inspect each component of the structure. Close proximity inspections may be warranted for bridges with limited or no access to the abutments, piers, or girders due to steep drops, high clearances, or long spans.

6.7.4 Routine Inspection Frequencies

Bridges and major culverts on FSRs can have routine inspections occur at any time, particularly if there is an identified or potential problem noted through a cursory inspection or road inspection. At a minimum, routine condition inspections on accessible bridges and major culverts on FSRs must be carried out at a frequency of every three years.

Routine Inspections must be carried out by a qualified inspector and a record of the inspection made in the Bridge Register.

Where warranted, routine condition inspection frequencies can be increased to better monitor situations in which a structure is nearing the end of its service life, or where conditions exist that merit more frequent inspections. The increase may be suggested by an inspector and confirmed by a Ministry Engineer.

6.7.4.1 Inaccessible Structures

Maintaining the routine condition inspection frequency is encouraged but not mandatory in situations where access to a structure is prevented by a man-made or naturally occurring barricade or blockage. Where an inspection is not carried out due to inaccessibility by vehicles and vehicular traffic is not anticipated, documentation should be placed on file and in the corporate bridge register indicating the rationale for why a routine inspection is not being completed.

Routine condition inspections are not to be postponed for more than a total of six years.

In cases where condition inspections are not conducted in accordance with the routine condition inspection frequency:

Document the rationale for not conducting a routine condition inspection indicating the level of anticipated risk for the environment and users.

District or BCTS Engineering staff must carry out cursory examinations by incorporating aerial reviews of the structure and site when flights are being carried out in the vicinity for other purposes, particularly after severe storm events to determine evidence of damage to or failure of the approaches and the substructure that may lead to impacts on adjacent forest resources.

Consider closing an inaccessible structure when the condition of the structure is unknown.

A routine condition inspection must be carried out prior to vehicular access being re-established.

In cases where structures are not anticipated to be inspected for long time periods, signage should be installed at the entrance of the road advising of road closure due to hazards.

6.7.5 Repair Priority Rating

Repair items identified during inspections shall be assigned a priority ranking by the inspector.

6.7.5.1 Urgent Priority

Any repair item must be addressed immediately as they threaten the safety or the environment. Typically, Urgent Priority repairs will require a down-rating of the structure or some other means to ensure the repair is completed before the bridge is returned to service.

Urgent Priority repair items can include, but are not limited to:

- Sections of curbs are missing, causing a break in the visual guide along the outside of a bridge.
- Cracking or section loss in primary steel bridge components.
- Significant decay in load-carrying members like deck ties, sub-deck members, timber stringers, or timber sills.
- Significant scour that is compromising the load capacity of the structure.
- Holes in the timber bridge deck.
- Failures at connection points affect the load capacity of the structure.
- Missing load-rating signs for bridges that have been previously down-rated.
- Significant abutment issues such as major settlement, deflection, or separation between components.

Road surface irregularities or issues that affect road users’ transition on or off a structure.

When Urgent Priority repair items are identified in the field by the inspector the bridge should be marked with a sign or flagging that it is unsafe to use. The Ministry Engineer and District staff should be notified as soon as reasonably possible and no later than 48 hours after the item has been identified.

6.7.5.2 High Priority

Repair items that need to be addressed may be an immediate threat to the load capacity of the structure or the environment. Typically, High Priority repairs should be completed before the next field season, or when there is an expected change in service level (i.e., wilderness road being used for active hauling).

- High Priority repair items can include, but are not limited to:
- Sections of curbs that are significantly rotten or decayed.
- Large debris accumulation on piers that imposes large side loading on the structure.
- Timber running services that are significantly damaged or decayed.
- Significant levels of brush, affecting sightlines up to a structure.
- Minor levels of scour that could worsen if not addressed.
- Minor abutment issues, such as settling lock blocks, that could affect the safety of the structure if not repaired.
- Missing hazard markers.
- Missing narrow structure signs.
- Misaligned or damaged fenders.

6.7.5.3 Medium Priority

Any repair item that needs to be addressed but is not an immediate threat to the load capacity of the structure or the environment. Typically, Medium Priority repairs should be completed before the next routine bridge inspection, or when there is an expected change in service level (i.e., wilderness road being used for active hauling).

Medium Priority repair items can include, but are not limited to:

- Minor safety concern.
- Structure’s capacity is reduced to a minor extent.
- Remediation is required to maintain the asset over the long term.

6.7.5.4 Low Priority

Any repair item that should be addressed but is not affecting the load capacity of the structure or the environment. Typically, Low Priority repairs should be completed along with other maintenance items on the structure or road.

Low Priority repair items can include, but are not limited to:

- Minor debris accumulation.

- Road grading.
- Minor brushing.

6.7.6 Bridge and Major Culvert Inspection Documentation

Every inspection, of any type, of a bridge or major culvert must have documentation supporting the findings of the inspection. All documentation must be filed and placed on the bridge register and an approved official government filing system for access and review in the future.

Under legislation, inspection and documentation must be retained for bridges and major culverts for one year beyond the actual life of the structure, or in the case of portable and salvaged superstructures, the records must be retained for a minimum of ten years beyond the actual life of the superstructure.

6.7.6.1 Cursory Inspections

Documentation from a Cursory Inspection may include photos and an email to the Ministry Engineer to make them aware of an issue or hazard. Photos should be included to assist the engineer when deciding on how to proceed. The Ministry Engineer should add the Cursory Inspection, repair and motoring items, and photos in the Corporate Bridge Register.

6.7.6.2 Routine Inspection Reporting

Routine Inspections shall be accompanied by thorough documentation outlining the findings of the inspection. Ministry standard inspection paper forms, electronic data collector for tablets, or CBR Offline Client are to be used to ensure all relevant components are inspected. These reports shall include:

- Date of the inspection.
- A condition assessment of the structure detailing the individual components and noting any issues with said components.
- Photos illustrating the condition of the structure, individual components, deficiencies, required repairs, and monitoring items.
- Recommendations for repairs and items to be monitored. Repair items must be accompanied by a priority rating of high, medium, or low.
- Inspector, or another professional responsible for the inspectors' work, signature and seal on the individual inspection or inspection summary report showing that they are taking professional responsibility for their work, and it can be relied upon by others.

6.7.6.3 Detailed Professional and Close Proximity Inspection Reporting

Documentation from a detailed professional inspection may include a variety of information depending on the structure and components being inspected. Reports contain professional advice, recommendations, recommendations for load ratings, or analysis. Photos must be included to assist document the findings. The Detailed Professional Inspection Report must be authenticated by the engineer.

6.7.6.4 Inspection Photos

Photos are a key component of an inspection report and must adequately illustrate the condition of the bridge and its components. For typical sites the following individual photographs are recommended:

- Road approach - viewed from the bridge, (2 photos)
- Bridge/culvert - viewed from each approach (2 photos)
- Structure elevation views – from upstream and from downstream (2 photos)
- Abutment elevation views – both ends of bridge (2 photos)
- Culvert elevation views – both inlet and outlet (2 photos)
- Underside of the bridge (minimum 1 photo)
- Visible fabrication stamps or tags containing structure identification, load rating, and any manufacturing identification information
- Any significant defect of the structure
- Any bridge capacity load posting signs at the site

6.7.7 Ministry Engineer Inspection Review

All bridge and major culvert inspections and subsequent reports must be reviewed by the Ministry Engineer, who provides professional oversight and recommendations to the District Manager. When reviewing the inspection, the Ministry Engineer shall:

- Assess the current inspection observations, previous inspection reports, record information, and documented maintenance or repairs.
- Decide whether to add, amend or augment the recommended actions.
- Determine the need, if any, for further professional or close proximity inspections.
- Verify the load rating for the structure is appropriate or recommend a change in the load rating if it is not.
- Ensure appropriate authenticated documentation is on file showing a record of a professional engineer taking responsibility for the load rating. For example, this could be structural designs, record drawings, load analysis, rational for load rating (serial plate, historic hauling, etc.)
- Provide comments on repairs identified and identify if structural repairs require professional review when being completed.

- Assign the date of the next required routine inspection.
- Authenticate the inspection report once the review is complete and ensure it is put on file and saved to the bridge registry.

6.7.7.1 Timing of Scheduled Routine Inspection Review

Routine inspections typically occur during the summer months of a given year.

Inspection reports should be submitted to the Ministry Engineers no later than November 1st.

All inspection reports should be reviewed by a Ministry Engineer no later than February 28th of the year following the completion of the inspection. If this date will not be attained, a mitigation plan will be created outlining why the timeline was not met and what steps are being undertaken to expedite the inspection reviews.

6.7.8 Structure Load Rating

The district manager is ultimately responsible for assigning load ratings on structures on Forest Service Roads.

Ministry Engineers are required to provide recommendations for load ratings on structures to the District Manager based on their knowledge and review of the structure's information. Load ratings are typically recommended based on original structural design drawings, a load rating completed and authenticated by a professional engineer or assigned by the Ministry Engineer based on historical knowledge of the structure and area.

After a load rating of a structure is initially established, the condition of the structure must be reviewed during each routine inspection by the Ministry Engineer, or another suitably qualified professional engineer. The engineer must determine if a change in condition has occurred that warrants a change in load rating. If a load rating change is required, the professional engineer shall prepare authenticated documentation confirming the condition of the structure and recommending the new load rating. The documentation must be submitted to the District Manager, or their delegate, for an official decision.

The load rating of a structure must be re-evaluated by the Ministry Engineer or another qualified engineer anytime that:

- Structural defects are identified with a structure.
- The use of the structure is being put into service for industrial use, or a licensee is changing vehicle configurations on a hauling route.
- A repair has been completed that remediated a known structural deficiency.

Whenever the load rating of a structure is changed, corresponding documentation outlining the rationale for the change must be completed, authenticated, and filed to the bridge registry and an official government filing system. When changing the load rating on the bridge registry, the rationale should be stated.

6.7.8.1 Down-Rating Structures

If a Ministry Engineer recommends reducing the load rating of a structure to less than the design load rating of the bridge, the following must be completed:

Notify the District Manager or their delegate. Typically, the District Engineering Officer is the delegated first point of contact for the District Manager.

The notification must be in writing and authenticated by the Ministry Engineer.

The District Manager is responsible for ensuring the structure has a sign posted showing the updated load rating, if less than original design load rating.

6.7.8.2 Closing Structures

In situations where structures have a high safety risk or environmental issue, the structure should be closed to all traffic. The road must have appropriate signage, MoTI Bridge Closed sign number R-032 and checkerboard W-14, and a physical barrier to prevent traffic from using the structure. Physical barriers can include gates, no post barriers, berms, or others. Once a road is closed, the site status can be changed in the Bridge Register to "Barricaded/Closed" with the addition of documentation and photos.

6.7.3 Clarification of GVW as Applicable to Bridge Load Rating

Gross vehicle weight (GVW) is the total weight of the vehicle including cargo. Load rating for a structure typically involves complex calculations and judgement and then distilling the results down to a simple number (typically a maximum GVW). Because of the limited information included on a load rating sign, users can often misinterpret the load restriction.

Gross vehicle weight (GVW) load ratings for bridge structures are typically based on the BCFS L-series design vehicles, the Canadian Highway Bridge Design Code (CHBDC) CL- series of vehicles, and the BC Ministry of Transportation and Infrastructure (MoTI) Supplement to CHBDC BCL-series design vehicles. These design vehicles are not "real" vehicles but are intended to be "envelope" trucks which capture the force effects of the population of "normal" logging trucks and other trucks used in the resource sector. The CL-625 and BCL-625 highway vehicle design configurations were adopted by the Ministry of Forests to be consistent with MoTI design configurations for highway loads, such that bridges designed to these loads are considered to have sufficient capacity to support provincial highway legal loads.

Force effects from load configurations consisting of other types of vehicles such as yarders, excavators and other tracked construction equipment, and heavy short wheelbase vehicles like articulating rock trucks are not typically captured by the design vehicles.

Equipment crossings of this nature should be evaluated by an engineering professional on a bridge by bridge basis.

The L-series design configurations were founded on imperial (“short”) tons (as opposed to “long” metric tonnes and kilograms). For example, a BCFS L-75 has a GVW of 75 imperial tons which is equal to 68 tonnes or 68,040 kilograms. The CL- and BCL-series design configurations were founded on kilonewtons, so a BCL-625 has a GVW of 625 kilonewtons which is equal to 64 tonnes or 63,710 kilograms.

There are a number of design vehicle configurations which have been utilized over time. Some of these are no longer used to design new structures. There are, however, existing structures which were designed using these configurations that are still in service. Primary examples include the BCFS L-45 and BCFS L-60.

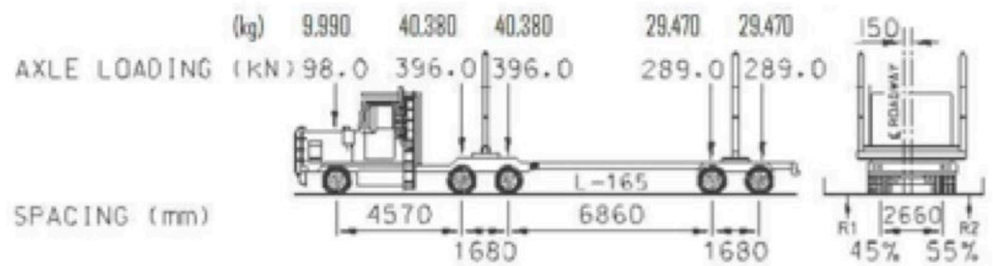
The following table provides a comparison of different design vehicle GVWs for short (English) tons, kilonewtons, kilograms and long (metric) tonnes.

Gross vehicle weights for design vehicle configurations

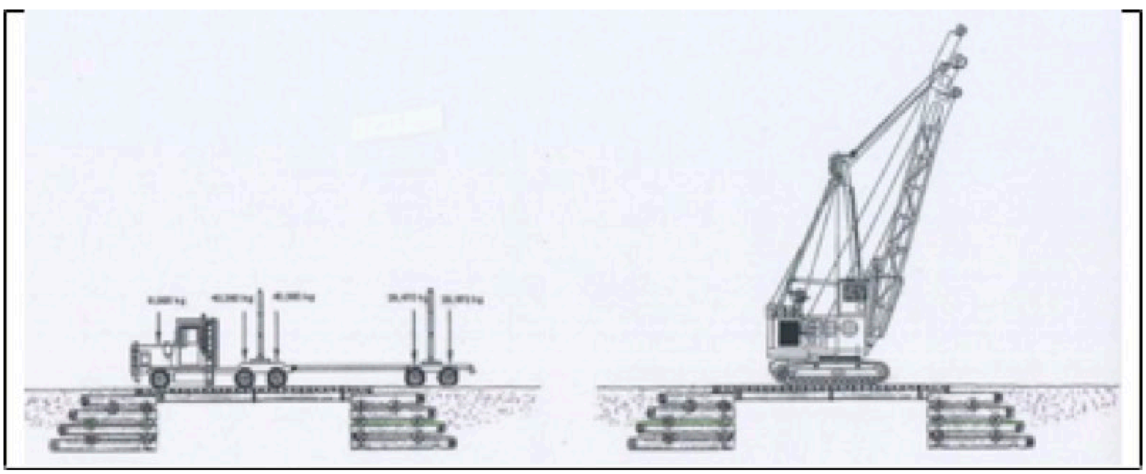
Design Vehicle Configuration	**Gross Vehicle Weight**			
	Tons (imperial)	**Kilonewtons (kN)**	**Kilograms (kg)**	**Tonnes (metric)**
BCFS				
L-45	45	408.2	40,820	41
L-60	60	533.8	54,430	54
L-75	75	667.2	68,040	68
L-100	100	889.6	90,680	91
L-150	150	1334.6	136,090	136
L-165	165	1468	149,700	150
CSA-S6 Canadian Highway Bridge Design Code				
CL-625	70	625	63,732	64
BC Ministry of Transportation and Infrastructure - modified from CSA-S6				
BCL-625	70	625	63,732	64

A bridge structure that is load rated to a specified GVW does not mean that the structure can safely pass any vehicle with a weight equal to or lesser than the GVW. A load rating is dependent on the assumed axle configuration and weight distribution between axles. The design vehicles on which the GVWs are based have their load distributed over a number of axles over the length of the vehicle. A bridge that is shorter than the design vehicle would not have all of the axles of the vehicle on the bridge simultaneously and thus the full vehicle GVW would not be on the bridge. The force effect is dependent on the axle or axle group loads on the bridge rather than the overall GVW. Further, the bridge may not have the capacity to support a concentrated load of equal weight to the posted maximum GVW, such as a large tracked machine or an articulating rock truck.

Example Design Vehicle Loading Diagram - BCFS L-165 (GVW 149,700 KGs)

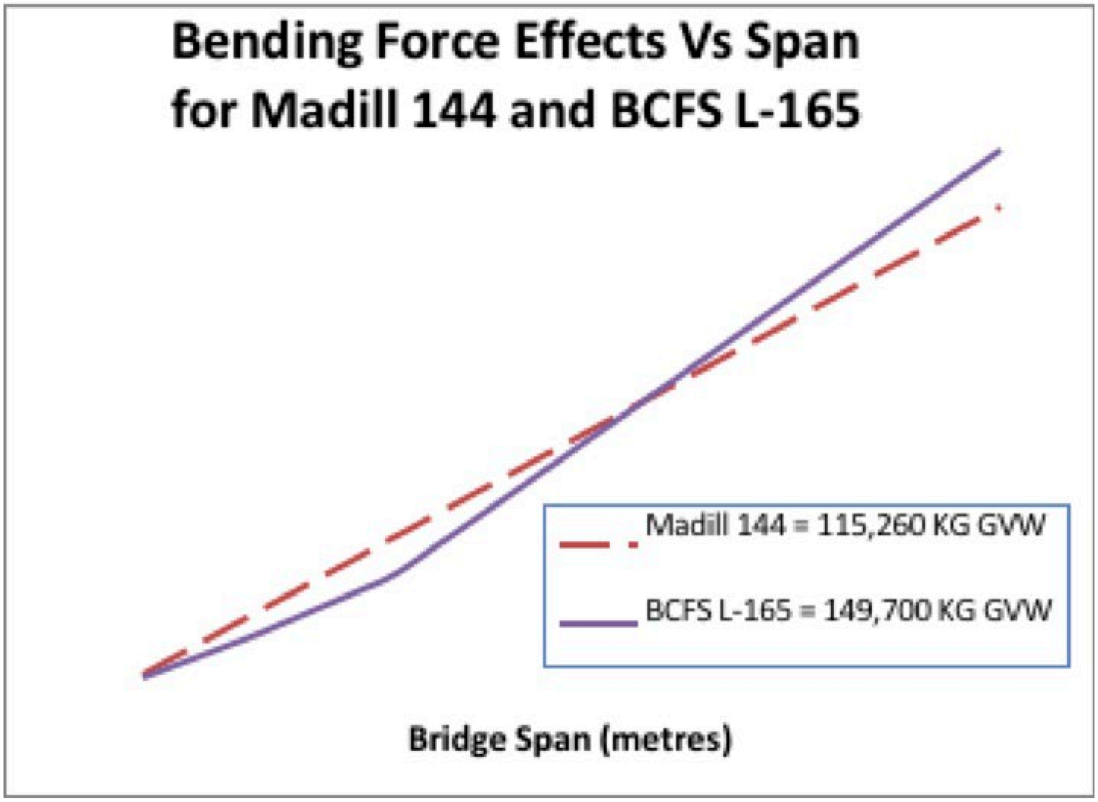


Forest effects of design vehicles versus concentrated equipment loads



The graphic above shows a 10-metre span bridge with a L-165 truck on the left and a 144 Madill Yarder on the right. The vehicles are positioned where the maximum bending force effect would occur on the bridge. As you can see, the truck only has the front three axles (with a combined weight of 90,680 kilograms) on the bridge, whereas the full yarder (GVW 115,620 kilograms) is on the bridge at its center. The yarder generates a force effect of 2,168 KN*m while the truck only generates 1,670 KN*m. The yarder bending force effect is 130% of the logging truck. A 10 meter bridge designed for L-165 loading would not have adequate capacity for a Madill 144 yarder.

Note: The following graph of bending force effects versus bridge span is provided for illustrative purposes only and is **not to be used to interpret allowable loads** for application to any actual structure.



The graph shows the bending force effects arising for a 144 Madill yarder with a GVW of 115, 260 kilograms as compared to a BCFS L-165 logging truck configuration with a GVW of 149,700 kilograms. Although the yarder has a significantly lower GVW, the resulting bending force effects are significantly greater than that of the heavier L-165 logging truck for shorter span bridges. This result is due to the concentration of the weight of the yarder over a shorter length. In contrast, the logging truck does not have all of its axles on the shorter span bridges. As the bridge length increases, more truck axles come into play on the bridge, resulting in the bending force effects of the logging truck surpassing those of the yarder.

Road network design vehicle load rating

Typically, road networks have a specified design vehicle load configuration identified. All bridge structures would be designed for the specified design vehicle load. There have been incidents where a bridge with a lower design load has been installed at the beginning of the road network. This can effectively result in the lower design load restricting access on the full road network.

The design vehicle load configuration for Forest Service Roads would ideally be posted at the commencement and other entrances to the road. Only bridges which were not capable of meeting that design vehicle load would be posted with a sign specifying an allowable safe GVW which has been determined by a Professional Engineer. New guidance is being developed for road signage and will be available in the foreseeable future.

Safe vehicle passage

Any concerns for safe capacity of bridge structures should be brought to the attention of the ministry engineer. Where it is uncertain whether a particular vehicle can safely cross a bridge, an engineering professional should be consulted to assess the structure for the specific vehicle. For any structure that has been down rated, professional engineering advice is critical to avoid errors in interpretation. Failure to assess the carrying capacity of a bridge can have disastrous results as exemplified in the picture below.

6.8 Road User Safety Considerations During Maintenance Works Operations

Where FSRs are open to traffic during maintenance, post high-visibility, reflective "Crew and Equipment Working" signs or other applicable signs from the BC MoTI Traffic Control Manual for Work on Roadways (specified as the standard reference by WorkSafeBC) at appropriate locations along the road to warn approaching traffic of any maintenance operations.

Place the signs in such a manner that they provide drivers with sufficient lead time to react – particularly when the road has many blind curves. Consider installing an additional warning sign at the beginning of the road. Remove these signs whenever crews are not working.

Erect and maintain temporary signs and barricades, with lights or traffic cones if necessary, at the site of any hazards and where any maintenance works are left uncompleted or unattended.

Advertise locally any maintenance projects that will require closing an FSR to traffic, both in advance of the project starting and during the project term, in the form of newspaper advertisements or radio announcements. Provide the public with key information such as the exact location of the work, travel restrictions if any, start and completion dates, and the name of a ministry contact for further information.

If the local ministry office has a “road conditions” page on its public website, update the page to reflect the changed conditions.

6.9 Routine Types of Structure Maintenance Works: Bridges & Stream Culverts

6.9.1 Bridge Maintenance

Bridge maintenance involves two main categories of works: structural maintenance and surface maintenance. These two categories are reasonably consistent with the maintenance items contained in the Coast and Interior Appraisal Manuals under Detailed Engineering Cost Estimate and Road Management respectively.

Structural maintenance of bridges

Structural maintenance involves repairing or replacing structural members of a bridge, based on the results of inspections made by a qualified Inspector. In some critical circumstances where the intended work may need to be adjusted due to unpredictable site conditions, carry out the maintenance works under the supervision of an engineering professional. In any event, carry out a follow-up inspection of structural repairs to confirm that the work has been done in conformance with the proposed repairs in the inspection report.

Examples of structural maintenance are:

- tightening the bolts connecting timber members;
- installing shims to ensure adequate load transfer where there is loss of contact between piles, pile caps, stringers, crib timbers, needle beams, or other structural elements;
- replacing stringers or girders;
- repairing or replacing damaged bridge structural members (e.g., abutments, piers, ties, stringers, needle beams, structural curb beams);
- repairing stream channel and scour protection;
- repairing or replacing damaged guardrails or curbs

- replacing dilapidated bridges and major culverts that are unable to carry the service loads; and
- repairing major culvert headwalls and spillways.

Surface maintenance of bridges

Surface maintenance involves repairing or protecting parts of the bridges and approaches that do not directly affect structural integrity.

Examples of surface maintenance:

- repairing and replacing bridge signage including hazard markers;
- keeping the waterway opening free of logs and debris;
- keeping the girder flanges and bearing surfaces, including plates, anchor bolts, and neoprene pads, free of gravel and dirt;
- keeping wood stringers free of dirt accumulations;
- resetting nails protruding from running planks;
- replacing missing or damaged running planks;
- eliminating pot holes on bridge approaches; and
- removing gravel build-up on concrete or timber decks.

Do not allow gravel and debris to accumulate on the deck. Remove build-up of soil material on the bridge decking in a manner that prevents it from entering the waterway below.

In accordance with any deficiencies noted in the inspections, repair or replace all deteriorated running planks, and check and retighten all fasteners and replaced any that are missing or damaged.

Note that other engineered structures may be sufficiently diverse that maintenance works will need to be determined for each specific structure.

6.9.2 Stream Culvert Maintenance

In addition to the guidelines for maintenance related to fish habitat set out in the Fish-stream Crossing Guidebook (PDF, 4.3MB), carry out stream culvert maintenance to ensure that a structure maintains its capability to pass fish and convey stream flow.

Examples of stream culvert maintenance:

- repairing damaged inlets and outlets;
- repairing armouring around inlets and outlets to reduce sediment transfer, particularly near licensed waterworks;
- removing debris blocking or obstructing culvert inlets;

- replacing culverts where the bottoms are rusted out and where damage has occurred from water seepage; and
- repairing major culvert headwalls and spillways when necessary, to protect the structures and the streams.

Note: Before beaver dams are removed, contact the Ministry of Environment for appropriate procedures. Consider installing beaver protection devices.

For additional information in replacing culverts at stream crossings, refer to the Fish-stream Crossing Guidebook (PDF, 4.3MB).

6.9.3 Bridge & Major Culvert Replacement

Where maintenance responsibility has not been delegated to a permittee, bridge replacements can generally only be accomplished by the local Natural Resource District/BCTS. The current funding policy for road and structure maintenance, road deactivation and closure will identify the requirements for bridge replacements by Natural Resource Districts.

For requirements and guidance on bridge or major culvert replacements carried out by Districts/BCTS, please refer to Chapter 4: Design & Construction of Bridges & Major Culverts.

6.10 Other Maintenance Works Along Roads

6.10.1 Fords

Remove debris and sediment build-up on fords and approaches to minimize the impact on downstream resources. Where a ford is exhibiting signs of failure, establish or restore those site conditions that are vital for the successful operation of a ford. For additional information on fords, refer to Ford Design and Construction on Non-Fish Streams in Chapter 3, Road Survey and Design.

6.10.2 Weirs

Where weirs are installed in a stream to maintain water levels for fish passage, inspect and maintain them to ensure that the fish passage objectives are being met.

6.10.3 Fences

Repair or replace range fences that have been damaged as a result of activities on the road. The Range Section in the local District office can advise on acceptable fence construction specifications and practices.

6.10.4 Cattleguards

Carry out the following steps:

- Repair broken welds or tie rods promptly.
- Check and replace sills and foundations if any crushing has occurred.
- Keep rails, fences, posts, and gates in good condition to ensure that the cattleguard fulfils its function.
- Clean the pit under the cattleguard periodically.
- Clean cattleguards in those situations where the Ministry has agreed with the landowner to do so, repair them, or replace them if repair is neither practical nor cost-effective.

6.10.5 Signs

Repair or replace damaged or vandalized signs and posts. Carry out sign maintenance, including cleaning and regular hand brushing and snow removal around them, to ensure they can be seen in all conditions. Replace illegible signs at the earliest opportunity.

One of the ways that sign maintenance can be reduced is to install signs high enough so that they are difficult to reach. While this cannot be done in all instances (such as with bridge hazard markers) it has been effective in reducing damage from spray paint or gunshots. This method also limits the impact that vegetation and accumulations of snow can have on sign visibility.

6.11 Resources & Suggestions for Further Reading

British Columbia Institute of Technology (BCIT). 1995. Surface maintenance: course manual. RRET 3328. Burnaby, B.C.

2001. Bridge maintenance: course manual. RRET 3324. Burnaby, B.C.

2001. Culvert maintenance: course manual. RRET 3322. Burnaby, B.C.

BC Ministry of Forests. 2002. Fish-stream Crossing Guidebook (PDF, 4.3MB). For. Prac. Br., B.C. Min. For. Victoria, B.C.

7 Road Deactivation

The intent of road deactivation is to place a road in a self-maintaining state that will indefinitely protect adjacent resources. Road deactivation requirements typically include removing bridges and stream culverts, stabilizing the road prism, and barricading the road surface width in a clearly visible manner to prevent access by motor vehicles (other than all-terrain vehicles).

This chapter describes the objectives of road deactivation, as well as professional responsibilities, mandatory procedures and best management practices for developing deactivation prescriptions and carrying out the works. It also presents a number of road deactivation techniques that address the province-wide range of terrain, soils, and climatic conditions, and assists ministry staff in achieving the statutory and regulatory requirements in the *Forest and Range Practices Act* and the Forest Planning and Practices Regulation.

Policy

When no longer required, Forest Service Roads (FSRs) that are the responsibility of either Timber Operations and Pricing Division or BC Timber Sales (BCTS) will be deactivated in a planned manner that considers future access needs, road user safety, cost efficiency, and values at risk of damage or loss.

7.1 Mandatory Procedures & Best Practices

Following is a table that summarizes in approximate chronological order the mandatory procedures and best practices with respect to the deactivation of Forest Service roads. Links are provided to direct the reader to the location in the manual text where the tabular item is discussed.

Table 7-1 Road Deactivation
Statutory/regulatory results to be achieved: do not cause landslides that would have a material adverse effect on forest resources (FPPR s. 37) no gully processes or fan destabilization on the Coast that would have a material adverse effect on forest resources (FPPR s. 38, 54) revegetate exposed soils where sediment may enter streams or otherwise have a material adverse effect on other forest resources (FPPR s. 40) protection of fish passage and fish habitat (FPPR s. 56, 57) protection of water quality (FPPR s. 59) no deposition or transport of deleterious materials into licensed waterworks drinking water (FPPR s. 60) address general wildlife measures, and resource or wildlife habitat features (FPPR s. 69, 70) deactivation measures achieved (FPPR s. 82) road is safe for industrial use during deactivation works (FPPR s. 83)

notice of works to licensed water users or purveyors in community watersheds (FPPR s. 84)	
B1	Notify road users about proposed significant changes to road access and to solicit input [see Planning].
B2	For FSRs that are the responsibility of Timber Operations and Pricing Division, carry out the deactivation in accordance with the ministry's business area funding policy [see Planning].
Legislation supported: FPPR sections 37, 38, 40, 50, 54, 56, 57, 59, 60, 70, 82, 83, 84: all road deactivation – related items	
M1	A CM must sign and seal (where appropriate) the deactivation prescription for the project [see Prescription].
B3	For more complex or higher risk cases, the CM may specify and incorporate input from other members or specialists [see Complex]
B4	For straightforward low-risk conditions, the CM may prepare a prescription that consists of Standard Operating Procedures (SOPs) [see SOPs]
B5	Ensure that any deactivation prescription is reviewed by the District engineering technician for conformance to objectives [see Prescription].
B6	Ensure that any concerns about residual risk that are identified in a deactivation prescription are brought to the attention of the District Manager [see Residual].
Legislation supported: FPPR sections 37, 38, 54, 57, 59, 70: do not cause sediment transport that will impact user safety or have a material adverse effect on forest resources	
B7	Intercept road surface and ditchline water and convey it across the road onto stable, non-erodible slopes below the road [see Road Deactivation Techniques].
B8	Consider insloping the road surface to direct road surface water toward the road cut and away from unstable or erodible road fill materials, or outsloping the road surface to direct water across the road and onto the road fill in a dispersed fashion [see Insloping/Outsloping Road Surface].
B9	Remove existing culverts while creating the least amount of sedimentation possible [see Stream Culvert Removal].
B10	During road deactivation works, minimize sedimentation while short-term vehicle access is required [see Armoured Swales].
B11	Ensure that road deactivation works do not cause fan destabilization on the Coast that will result in material and adverse effects on other resources [see Soil Erosion].
B12	Where there is potential for unstable road cut or fill slopes to develop during periods of inattention, consider using partial or full road fill pullback and gully restoration [see Road Fill Pullback Techniques]

Legislation supported: FPPR section 40: revegetation	
B13	Consider using soil bioengineering systems to: drain excess moisture that may be creating slope instability; reduce slope angles relative to the growth of vegetation and prevent raveling of fill slopes; or control erosion along watercourses. [see Revegetation Techniques]
B14	Seed or plant, in the first growing season after deactivation, all exposed soils that will support vegetation[see Revegetation Techniques].
Legislation supported: FPPR section 83: hazard warning	
B15	Erect warning signs at appropriate locations during the period of road deactivation activities to warn potential users of the road of the hazards that can be expected on the whole road or at a particular location [see Deactivation Hazard Warning Signs].
Legislation supported: FPPR sections 37, 38, 40, 50, 54, 56, 57, 59, 60, 70, 82, 83, 84: all road deactivation – related items	
B16	Ensure that a CM completes the Road Project Assurance Statement (PDF) for those projects identified in the deactivation prescription as needing such sign-off.
B15	Based upon the risk to other resources as a result of poor deactivation work, consider carrying out a subsequent field inspection of the completed project [see Subsequent].
M2	The Coordinating Member must sign (and seal as appropriate) the Road Project Assurance Statement (PDF).
M3	The road must be barricaded after deactivation unless specifically exempted by the District Manager [see Barricade].
B16	Ensure that the necessary steps in the road deactivation processes were undertaken and issues addressed [see Project Tracking Checklist].

7.2 Road Deactivation Professional Responsibilities & Considerations

A decision to deactivate a road may be an outcome from:

- resource planning;
- a road plan; or
- an evaluation of risk.

A member may be involved in determining the need for deactivation, by analyzing items such as

- risk;
- cost-benefit considerations; and

- silvicultural objectives.

As with other road elements, a CM takes professional responsibility for the development of prescriptions and the field implementation of the prescriptions. As such, the CM **must** provide direction as to what deactivation measures are required, considering:

- the level of hazard;
- the risk to downslope values; and
- the complexity of terrain and road conditions.

There may be a need for the CM to specify and incorporate input from other Members or Specialists for more complex or higher risk cases. Examples of such deactivation works include:

- removal of structures such as bridges, cribs or retaining structures;
- removal of drainage structures under large fills;
- removal of drainage structures where the work could have an impact on other resources such as fish habitat or water quality for a community water supply;
- stabilizing fills on steep slopes; and
- road sections on or above steep slopes where drainage management is important for stability of slopes below the road.

Where, in the opinion of the CM, road deactivation is to be carried out in straightforward low-risk conditions, the CM may prepare a prescription that consists of Standard Operating Procedures (SOPs) that match practices to be followed with existing road conditions. Generally, for these projects, the deactivation prescription would not require the completion of a Road Project Assurance Statement, unless there were sections of road works that could not be addressed through application of an SOP.

In those cases where the applications of SOP's are not adequate, a CM **must** prepare a detailed site specific road deactivation prescription and carry out field reviews of the work (or delegate field reviews) as appropriate during or following the site work. Additionally, the CM **must** ensure that the prescription requires the completion of a Road Project Assurance Statement.

The CM ensures that any road deactivation prescription contains sufficient information so that the measures to be carried out are clearly understood by the road personnel carrying out the work, including references to field markings where needed. A road deactivation prescription could range from simple maps or references to field markings to detailed procedures with drawings and survey controls.

7.2.1 Involvement of Specialists in Road Deactivation

Use the services of a Specialist professional to carry out a terrain stability assessment and prepare the applicable portion of the road deactivation prescription if any of the following apply:

- terrain stability mapping indicates that the road is located on terrain that is unstable or potentially unstable;
- terrain stability mapping has not been done, and the road is located on terrain with slopes greater than 60%;
- the road is located on terrain where there are indicators of slope instability;
- the areas downslope or upslope of the road (or adjacent to or connected to it) contain elements at risk of damage or loss from a landslide, and the road crosses areas having a moderate or high likelihood of landslide occurrence;

7.2.2 Professional Field Reviews

Generally, for the more complex projects, state the rationale for field reviews by or on behalf of the CM in the deactivation prescription, and describe any specific concerns and the potential consequences of not carrying out professional field reviews. As well, identify in the rationale the timing and number of the professional field reviews.

Note: The cost to carry out road fill pullback a second time to repair deficiencies can be much higher than the cost of the original pullback work. Thus, thorough field reviews are prudent where full road fill pullback is being planned for areas located above high-value resources such as highways and residential development.

Unanticipated subsurface conditions may be encountered during deactivation works. In such an event, and if potential material adverse impacts to adjacent resources are identified, ensure that the CM conducts a field review before the project continues.

7.2.3 Project Assurance

Based upon the risk to other resources as a result of poor deactivation work, consider carrying out a subsequent field inspection of any completed project.

For those projects identified in the deactivation prescription as needing sign-off of the FS1366 Road Project Assurance Statement (PDF), the CM **must** sign off the assurance statement, and **must** ensure that the statement includes or is accompanied by drawings that document the completed works after completion of the works,.

7.3 Planning Road Deactivation

Consider carrying out road deactivation projects on non-industrial use FSRs where a planning process identifies the roads as being candidates for road deactivation, or where the roads need to be closed to protect public safety and the cost of deactivating these roads is less than the cost of carrying out maintenance to a wilderness road level of maintenance over the period of expected closure. Deactivation of FSRs is usually limited to in-block roads and cutblock access roads, or to roads that provide duplicate access to areas. Ensure that for FSRs that are the responsibility of Timber Operations and Pricing Division, deactivation is carried out in accordance with the ministry’s business area funding policy.

Notify road users about proposed significant changes to road access and to solicit the public's and First Nations' input into road closure and related access issues. Ensure that the District Manager solicits and considers input from local stakeholders (e.g., licensees, public, First Nations, miners) before deciding on whether to deactivate an FSR.

Deactivation is typically carried out with the expectation that a road will receive no further field inspections or maintenance, and due to the inherent risk to vehicle users and to any deactivation structures along the road, deactivation is expected to result in the elimination of motor vehicle access. This will be particularly applicable along road segments where unstable road fill is pulled back and where stream culverts and bridges are removed, or deep cross-ditches are installed across the road running width. However, for roads that cross flat or gentle terrain with no stream crossings, little work may be necessary to deactivate the roads. In this case, motor vehicle access may be both possible and acceptable, provided that the District Manager approves the variance from legislative requirements to barricade the road.

A deactivated FSR that has fulfilled all legal requirements reverts to the status of vacant Crown land or provincial forest. In other words, after the FSR is deactivated, it has no road status and the responsibility for stability of the area shifts to the Crown, instead of FOR as the representative of the Crown. Retaining the old road location (with expired tenure) on atlas maps does no harm, as the former route may be useful in some emergency.

For FSRs that are the responsibility of Regional Operations , deactivation **must** be carried out in accordance with the Engineering Program Funding Policy .

7.4 Deactivation Prescriptions

7.4.1 Prescription Requirements

A CM **must** prepare and sign and seal the deactivation prescription for the project, and provide the results of any assessments in the letter or report that accompanies the deactivation prescriptions. Ensure that the deactivation prescription is reviewed by the District engineering technician for conformance to objectives.

A deactivation prescription is a written document that clearly communicates the objectives and the works to be performed, in accordance with the regulatory requirements in the Forest Planning and Practices Regulation (Sec. 82). Ensure that any deactivation prescription:

- defines the objectives of the planned deactivation work, the vehicle access requirements (if an exemption under legislation has been granted to permit access by motor vehicles), and the techniques to be performed by station; and
- reports special requirements (e.g., worker safety and slope stability issues).

When a prescription is being prepared, ensure that the following are retained:

- original field notes;

- final deactivation maps, tabular summary, and letter or report, as applicable; and
- any relevant correspondence.

Site specific information, detail and complexity of a deactivation prescription varies with site conditions and the work required to achieve the deactivation goals. Such prescriptions may be as simple as providing directions to an operator with a basic map or may be as complex as having a detailed prescription of individual steps and site specific work requirements.

Use simple deactivation prescriptions where there are no perceived hazards from the deactivation to worker safety and public infrastructure, or where the prescribed work is not expected to create adverse environmental impacts. In these situations, provide Standard Operating Procedures (SOPs) in the form of basic directions to an operator with a signed and sealed map of the prescribed work area.

As the complexity of the site increases where there are fish streams, terrain stability hazards along or adjacent to the road system, or potential consequence to public infrastructure, provide a greater detailed and prescriptive signed and sealed report with definitions/sketches, as well as maps/drawings referenced to stations in the field to assist an operator in completing the work. In such situations, the CM **must** carry out or delegate field reviews as the work progresses to confirm site conditions and to provide quality assurance of the work.

A detailed road deactivation prescription may include:

- a station by station description of conditions and mitigation measures prescribed;
- a map showing the locations of the measures prescribed;
- identification of site conditions that may be a concern for worker safety;
- identification of special concerns that affect the timing or conduct of the work; and
- recommendations for equipment or special work procedures necessary to complete the work.

Carry out all required referrals to other government agencies at appropriate stages during development of prescriptions, and incorporate, where feasible, the requirements of those agencies including authorization for the diversion of water as provided under the *Water Sustainability Act (Sec. 9.)*] and authorization from Department of Fisheries and Oceans Canada (migratory fish). For information related to deactivation of crossings of fish streams, refer to the Fish-stream Crossing Guidebook (PDF, 4.3MB).

7.4.2 Phases of Prescription Development

Base road deactivation prescriptions on suitable office review of available relevant information and on field assessment. Prescriptions include a deactivation map, as well as other documentation necessary to ensure that the works are successfully conducted and the objectives of deactivation are achieved. These phases are discussed briefly below.

Office review

Prior to field work, conduct an office-based review of existing information including local knowledge to help identify the potential resources at risk, terrain stability/landslide concerns (especially below the road corridor), sediment hazards, and consequences at and adjacent to the road.

Field assessment

Carry out a field assessment and prescribe deactivation techniques at specific locations. This task typically involves:

- traversing the road corridor and identifying potential stability and drainage hazards;
- evaluating the risk to resources; and
- marking prescription activities in the field.

When developing prescriptions, consider both the landslide hazard associated with the road and the risk to downslope and downstream resources.

Before choosing a deactivation technique (or combination of techniques), evaluate the following items:

- if any access by motor vehicles is permitted, the type of vehicle access following deactivation;
- the stability of the road cuts and fills, the condition of culverts and bridges, the performance of the existing road drainage system, existing sediment sources, and the potential for further deterioration of road structures and prism;
- the stability of the terrain below (and, in some cases, above) the road corridor; and
- any existing access problems that may prevent or impede equipment access to the end of the road to start the deactivation work (e.g., locations where large landslides have destroyed the road grade in gully areas, large cut slope landslides, existing deactivation work, etc.).

Collect and record other useful site data that provides rationale for the prescriptions, including, for example:

- surficial materials and geomorphologic processes;
- angles of natural and constructed slopes;
- length of fill slopes;
- height of cut slopes;
- road gradient;
- existing structures;
- streams, seepages, and road drainage controls.

Consider using a standard field data form to enhance the consistency and quality of data gathering.

- Example Data Form for Deactivation Field Assessments (PDF)

Preparing maps, tabular summary, letter or report

Provide a deactivation map (or work plan) to scale to accompany a deactivation prescription, plus one or more of the following:

- a summary (in table form) of prescribed techniques, by station; and
- a letter or report.

These requirements are more fully discussed below. Also, the following examples show the linkage between various site and project conditions and the minimum content of a road deactivation prescription:

- Examples: prescription content requirements (PDF)

Content of Deactivation Map (Work Plan)

Provide a map at 1:5000 scale or other suitable scale. Consider the following for illustration on the map, as deemed appropriate to effectively communicate the design requirements to equipment operators and supervisory personnel:

- proposed vehicle usage after deactivation (4-wheel drive (with no barricades), all-terrain vehicle, no access);
- topographic information;
- additional relevant planimetric information (e.g., streams, bodies of water, legal boundaries, landslides, utilities, highways);
- additional supporting information such as stream classifications, and timing windows and measures for work in and around stream crossings (where applicable);
- special site access requirements;
- sites of potential concern for worker safety;
- requirements for terrain stability field reviews by a Specialist;
- special requirements for work carried out within a community watershed;
- location of all prescribed deactivation techniques by station (road chainage and prescription symbol), including the type and locations of hazards (e.g., record road segments that may be unstable before, during, or after road deactivation work);
- legend for prescription symbols;
- date of the assessment;

- name of the assessor; and
- scale bar and north arrow.

Note: Provide some of the items above in a tabular summary rather than on the 1:5000 scale map if this would more clearly depict the work.

Content of Tabular Summary

Use a tabular summary where:

- more detail is given to communicate the requirements of the project to forestry operations personnel;
- the risk of damage to adjacent resources is moderate or high; or
- it may be necessary to re-establish the field markings.

In the tabular summary, provide:

- the measured chainage along the road;
- the associated recommended actions; and
- detailed comments about such items as:
  - site conditions;
  - worker safety issues;
  - key reference points;
  - rationale for road fill pullback; and
  - depth and width of cross-ditches.

Use the tabular summary as a tool to assess the results of the risk analysis, and to help estimate the costs of road deactivation works.

Content of Letter or Report

Provide a report to accompany and complement deactivation maps and tabular summaries if:

- there is a high risk to the environment;
- the project is large or complex; or
- the road traverses areas of moderate to high likelihood of occurrence of landslides.

In the report, provide an estimate of the expected level of residual risk at the project site if the works are carried out in overall conformance with the prescriptions. Residual risk is the amount of risk remaining following the implementation of all hazard or risk control measures specified in the prescriptions, because it cannot practically be further reduced. Ensure that any concerns about residual risk are brought to the attention of the District

Manager, who determines if and how the district may manage the residual risk after the road is deactivated.

Generally, for small projects, use a brief letter rather than a report. Provide in a letter or report the following topics, as relevant:

- geographical location information (watershed name and number, harvesting tenure);
- background information;
- description of deactivation objectives;
- prescription methodology;
- road reactivation considerations (such as road reconstruction, wet crossings, and safety issues);
- site level information;
- results and recommendations; and
- site plans and illustrations.

7.4.3 Modification of Prescriptions

To address unforeseen site conditions, it may be necessary to modify the prescription. If there are reasonable grounds to believe that the changes to the prescription would not adversely impact forest resources or other values, the required changes can be made without further approval. At the start of the project, it is often useful to establish a protocol for the types of changes that can be made on site. Where such changes are made, the CM ***must*** approve all changes to the prescription.

7.5 Road Deactivation Works

7.5.1 Project Management

Ensure that the person carrying out deactivation project management has the appropriate training and experience to coordinate and manage projects, including carrying out the following activities:

- making all required referrals to government agencies, obtaining all required approvals and permits, and providing all required written notification at appropriate stages of the project;
- if applicable, retaining and coordinating the activities of the appropriate team of technical and professional consultants as required for the project;
- if applicable, preparing suitable contract documents for technical and professional services related to activities such as prescription development, field reviews, and post-works inspections; and preparing suitable contracts for works and supervision of the works;
- if applicable, coordinating purchase and delivery of required materials for the project;
- administering and retaining copies of all required documentation;

- coordinating and appropriately scheduling the timing of works; and
- undertaking other administrative and technical project duties as necessary.

7.5.2 Cost Estimate of the Planned Works

Include in the prescriptions for road deactivation a cost estimate for the works, with the appropriate extensions of unit costs or phase lump sum costs.

7.5.3 Carrying Out the Works

All road deactivation works **must** be carried out in accordance with the requirements of a road deactivation prescription that has been accepted by the appropriate manager.

Ensure that suitable on-site inspection is provided as required during the deactivation works, and upon completion of the works.

7.5.4 Submission Requirements After Completing the Works

Upon completion of the works, place a hard copy of all as-built prescriptions on file, including the Road Project Assurance Statement, deactivation maps, tabular summaries of prescriptions, letters, and reports. In addition, incorporate as-built information into the applicable database.

Note: If there are not any substantive changes to the prescriptions, mark the original prescriptions, maps, reports, etc., as the “as-built” information.

Ensure that the person who signs the Road Project Assurance Statement provides a letter to confirm or clarify where required:

- the level of residual hazard or residual risk following completion of the deactivation work if it is different from estimates provided in the prescriptions;
- the limitations of the works; or
- other site-specific explanatory information not covered in the Statement of Works Conformance form.

7.5.5 Inspections After Deactivation

The district can accept the recommendations of the TSM as to the adequacy and suitability of the works. No further inspections are necessary. Proceed with close and discontinue after this point in time.

7.6 Deactivation Hazard Warning Signs

Before deactivation activities begin, erect warning signs at appropriate locations during the period of road deactivation activities to warn potential users of the road (either open or closed to traffic) of the hazards that can be expected on the whole road or at a particular location. Where an entire drainage or system of roads is being deactivated, post the signs at the earliest location to warn of the upcoming hazards. Repair or replace damaged or missing signs as required during the period of the works. There is no legal requirement to leave signs in place upon completion of deactivation works. Normally the deactivation works (barricading, water barring etc.) can serve as sufficient warning to potential users that a road has been deactivated.

7.7 Road Deactivation Objectives

For elements at risk – including forest resources and social and economic values – within and adjacent to the road location, ensure that deactivation minimizes the risk from hazards such as landslides, gully processes, fan destabilization, uncontrolled soil erosion, and sediment transport. Ensure that prescriptions and works for road deactivation consider a range of techniques (see Road Deactivation Techniques) to meet the following objectives:

- place the road in a self-maintaining state that will protect indefinitely the elements at risk;
- stabilize the road prism and clearing width;
- maintain natural surface drainage patterns on the area within the road right-of-way and in adjacent or connected areas affected by the works both during and after deactivation activities;
- minimize the impact of silt and sediment transport on other forest resources;
- prevent adversely impacting water quality in community watersheds or in streams diverted for human consumption by a licensed waterworks (also, ensure that at least 48 hours' notice of impending deactivation work is provided to water licensees or water purveyors in community watersheds)
- for a fish stream, provide for safe fish passage and protection of fish habitat immediately upstream and downstream, both in the timing and extent of the works;

7.7.1 Achieving Deactivation Objectives

The choice of water management, road fill pullback, and revegetation techniques to stabilize the road prism or clearing width depends on the terrain, slope gradient, soils, and climatic conditions of the area. Apply deactivation measures most aggressively where roads traverse areas of steep terrain or erodible soils, especially in geographical areas that receive high levels of precipitation.

Water management

Maintain surface drainage patterns so that they are consistent with natural drainage patterns. Achieve this by applying some or all of the following techniques:

- Remove cross-drain culverts and replace them with cross-ditches to re- establish drainage patterns, especially on steep road grades and side hills. If the likelihood of failure is minimal or the consequences of a failure are low, consider leaving the cross-drain culvert intact, provided it is backed up with a cross-ditch or armoured swale as necessary.

- Install cross-ditches or waterbars where there are steep grades, heavy groundwater seepages, switchbacks, or road junctions, ditches prone to plugging, places where ponding may occur, and other potential drainage problem areas.
- Remove or breach windrows on the road surface.
- Outslope or inslope the road surface as appropriate.
- Install trench drains, blanket drains, French drains, fords, and armoured swales.

Soil erosion and sediment control and road prism stabilization

Activities to minimize the impact of silt and sediment transport on forest resources include erosion control measures (such as grass seeding, vegetation planting, soil bioengineering, and installation of erosion control blankets) and sediment control measures (such as silt fence, catch basins, and check dams). See Chapter 5: Road Construction for examples of surface soil erosion and sediment control techniques, as well as for works shutdown indicators and procedures.

For roads that have been built on fans, ensure that care is taken to minimize erosion and sediment transport during the deactivation works; in particular, avoid any non-essential excavation of the stream channel or banks.

Where the road prism is unstable, consider using partial or full road fill pullback and cut slope buttressing or other measure to suitably address the landslide hazard and risk of damage or loss to values. As well, take measures to remove organic material (stumps, roots, embedded logs, and topsoil) that may reasonably be expected to fail and destabilize the road fill.

Take care in verifying indicators of slope instability. For example, tension cracks or minor slumps in the road surface may indicate a failing road fill, rather than signaling unstable terrain. Consider using a partial pullback of the road fill to stabilize the road prism and protect users of the road and adjacent resources. However, if the slope instability indicators occur outside the road prism (e.g., a small slide) or the instability within the road prism has the potential to affect adjacent resources (e.g., debris from a potential fill slope failure could reach a fish stream), consider the area to be unstable.

7.8 Road Deactivation Techniques

To reduce potential adverse effects on adjacent forest resources, there are a number of common techniques available for water management, road fill pullback, and revegetation. Refer to the Best Management Practices Handbook (BMP): Hillslope Restoration in British Columbia - Chapter 3 (PDF, 7.55 MB) for more details on each technique.

7.8.1 Water Management Techniques

Maintain surface drainage patterns consistent with natural drainage patterns by employing one or more of the following water management techniques:

Cross-ditch across an intact road

The purpose of a cross-ditch is to intercept road surface and ditchline water and convey it across the road onto stable, non-erodible slopes below the road (Figure 7-1).

A cross-ditch is a ditch across a road excavated to a depth equal to, or greater than, the depth of the ditch at the road cut. Cross-ditches generally have a berm on the lower side, and a compacted ditchback.

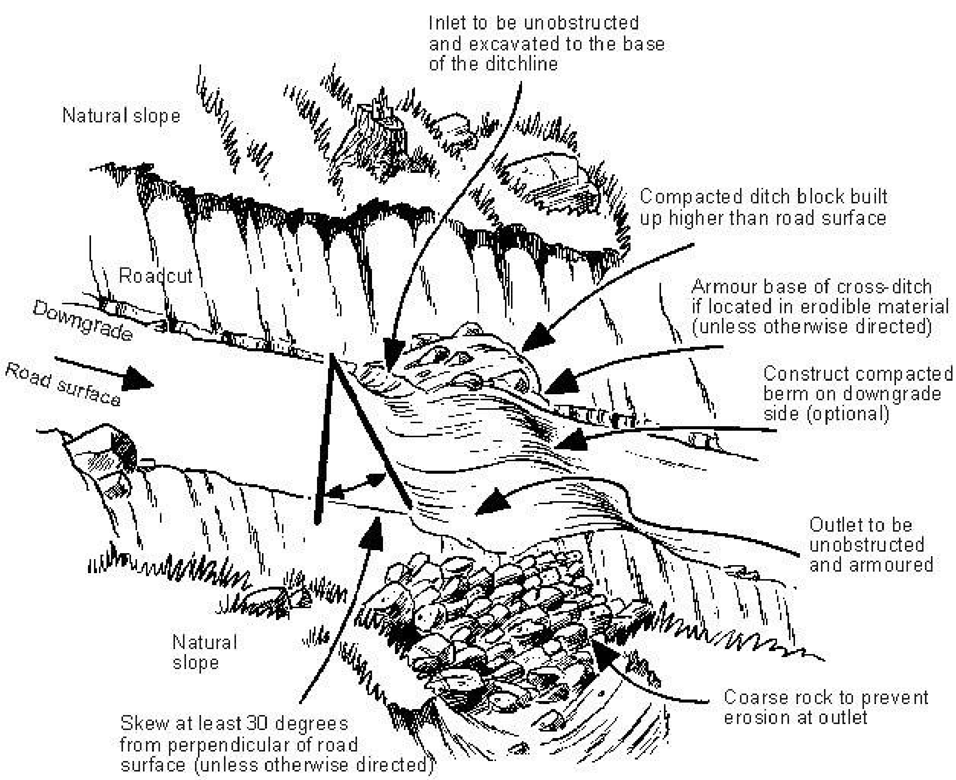
Install a well-compacted ditch block immediately downgrade of the cross-ditch inlet. Ensure that the ditch block is:

- higher than the road surface;
- large enough to divert all expected flows into the cross-ditch; and
- non-erodible and relatively impermeable.

Where ditchwater converges at low points in the road, construct the cross-ditch as a broad gentle swale so that no ditch block or berm is required. If constructed properly, cross-ditches are maintenance free.

Refer to [BMP: Hillslope Restoration in British Columbia - Chapter 3.5.1 (PDF, 7.55 MB)] for further details.

Figure 7-1 Cross-ditch installation across an intact road



Note: Refer to Typical Road Deactivation Prescriptions Drawings in Appendix III

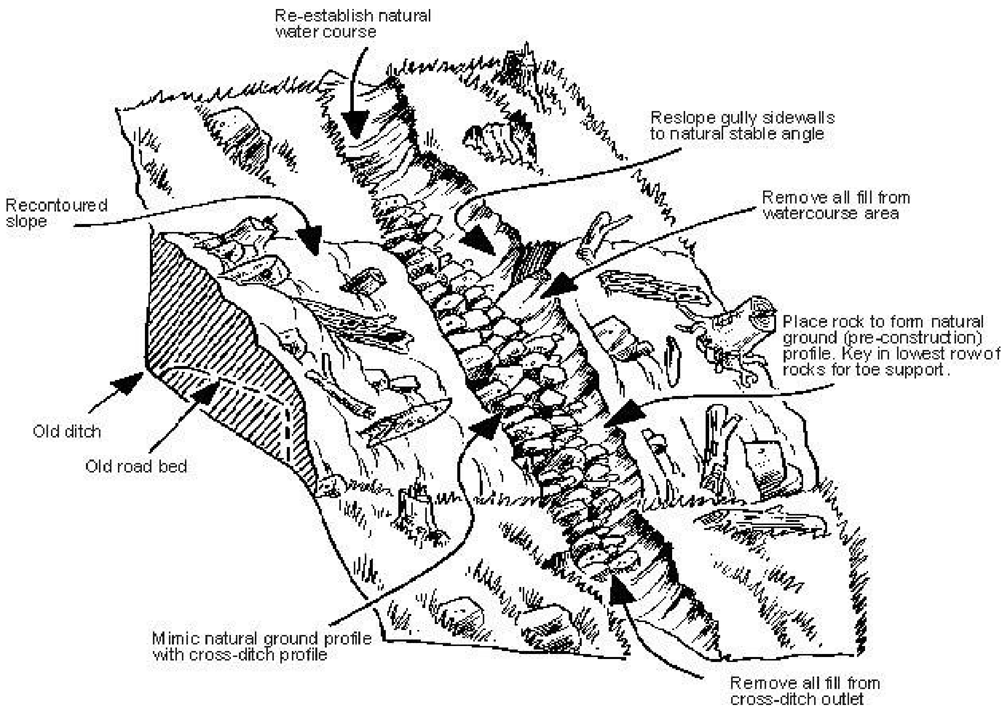
Cross-ditch in full pullback

The purpose of a cross-ditch located within segments of full road fill pullback is to restore the natural drainage paths to pre-construction (historic) locations along the hillslope (Figure 7-2). Since water flow along the surface is not possible in areas of road fill pullback, fewer cross-ditches are needed in pullback than for roads where pullback is not carried out.

A cross-ditch in pullback is a ditch across the old roadbed connecting a natural hillslope drainage path (streams, gully channels, and swales with flow). Excavate cross-ditches in pullback down to natural (undisturbed) non-erodible material.

Refer to [BMP: Hillslope Restoration in British Columbia - Chapter 3.5.2 (PDF, 7.55 MB)] for further details.

Figure 7-2 Cross-ditch installations across full road pullback



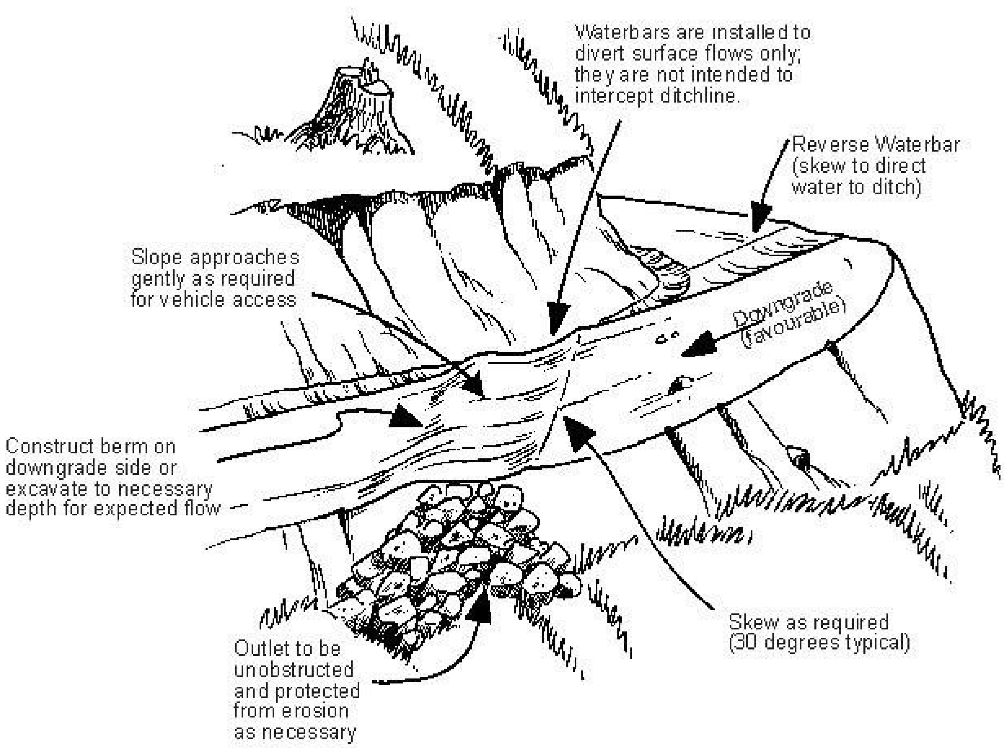
Waterbars

The purpose of a waterbar is to intercept surface water on the road and convey it across the road onto stable slopes below the road. Also, use waterbars to reduce the flow energy along the grade. Reverse waterbars direct flow off the road into the drainage ditch (Figure 7-3).

A waterbar is a shallow ditch across a road, skid trail, or backspar trail to prevent excessive flow down the road surface (or trail). Waterbars are not intended to intercept ditchlines; thus, the base of the waterbar is above the base of the ditch and a ditchblock is not required.

Refer to [BMP: Hillslope Restoration in British Columbia - Chapter 3.5.3 (PDF, 7.55 MB)] for further details.

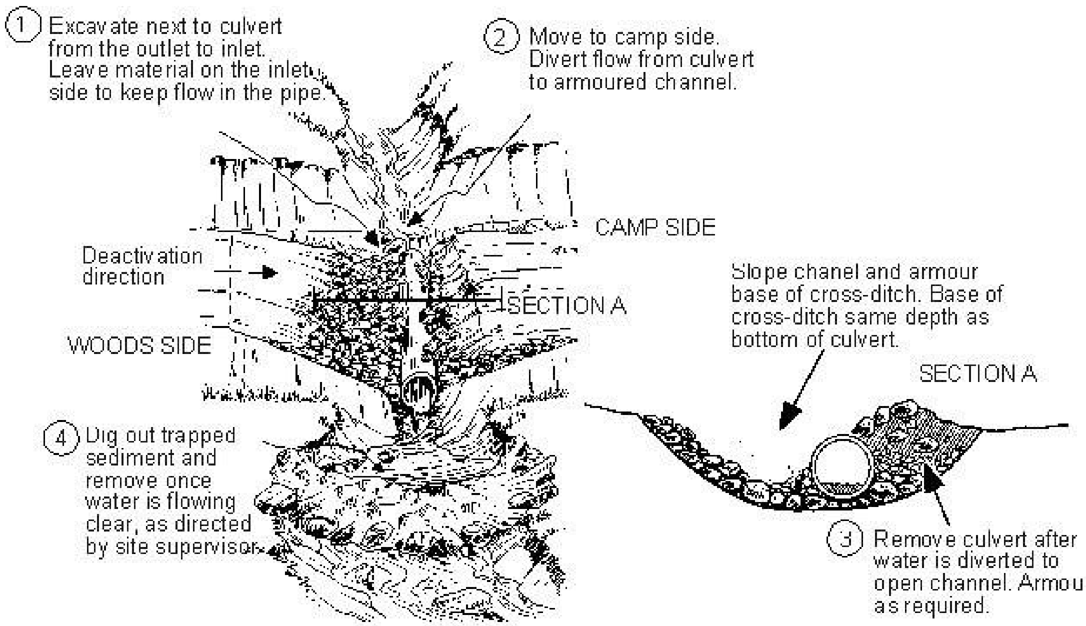
Figure 7-3 Waterbar installation



Stream culvert removal

Remove stream culverts (metal or plastic pipes or log culvert stringers) and reconstruct the channel, to remove the existing culvert while creating the least amount of sedimentation possible and leaving a cross-ditch. Re-establish the natural width and gradient of the stream and armour the streambanks (sides of the cross-ditch) and the base of the channel. The size, depth, and shape of the re- established stream crossing depend on the hillslope and creek/gully contours and expected flows. (Figure 7-4) and (Figure 7-5) show techniques that can be used to remove a pipe or log culvert where running water is present in the channel and the stream is hydraulically connected to fish habitat or community water supplies.

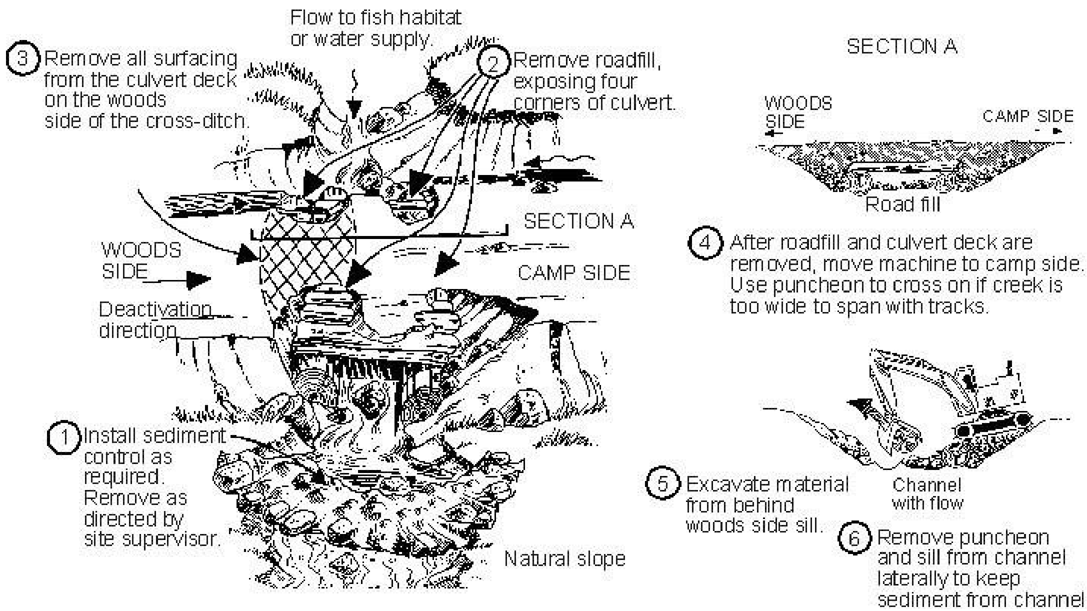
Figure 7-4 Metal or plastic pipe stream culvert removal (non-fish stream)



At challenging sites, explore the range of practical options with fisheries agencies, to ensure that the potential for sedimentation is reduced to acceptable levels.

Refer to BMP: Hillslope Restoration in British Columbia - Chapter 3.5.4 (PDF, 7.55 MB) and Chapter 3.5.5 (PDF, 7.55 MB) for further details.

Figure 7-5 Log stream culvert removal (non-fish stream)



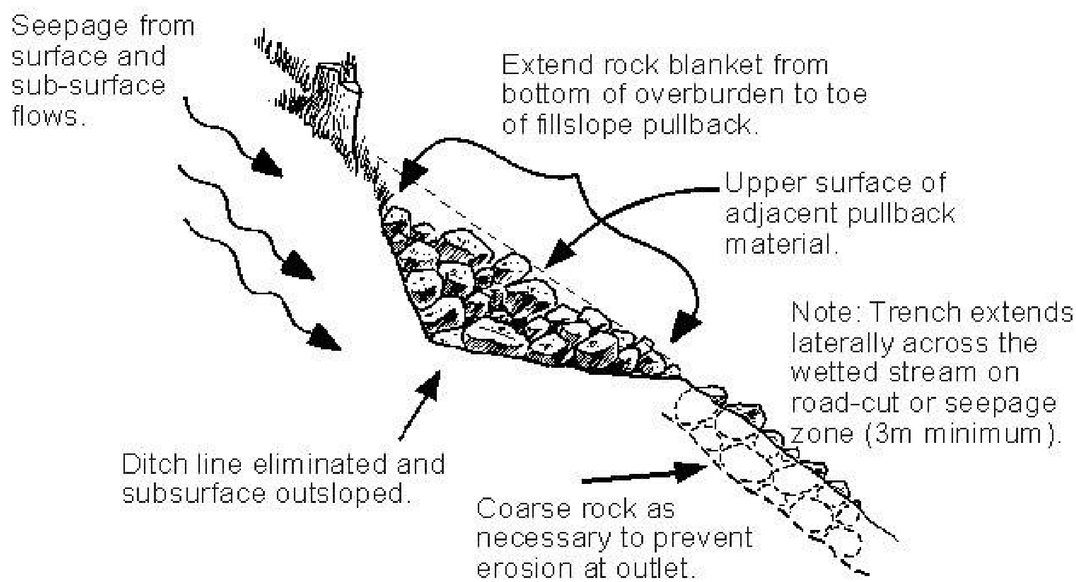
Trench drains

Consider prescribing trench drains in areas of full (heavy) pullback; they are particularly useful where it is necessary to use all the space on the road bench for placement of road fill pullback.

A trench drain is a cross-ditch in road fill pullback that is filled with coarse rock to carry water from seepage areas on the road and/or small surface flows. The purpose of a trench drain is to allow both surface and seepage flow to pass across road fill pullback (Figure 7-6).

Refer to BMP: Hillslope Restoration in British Columbia - Chapter 3.5.6 (PDF, 7.55 MB) for details.

Figure 7-6 Trench drain



Blanket drains

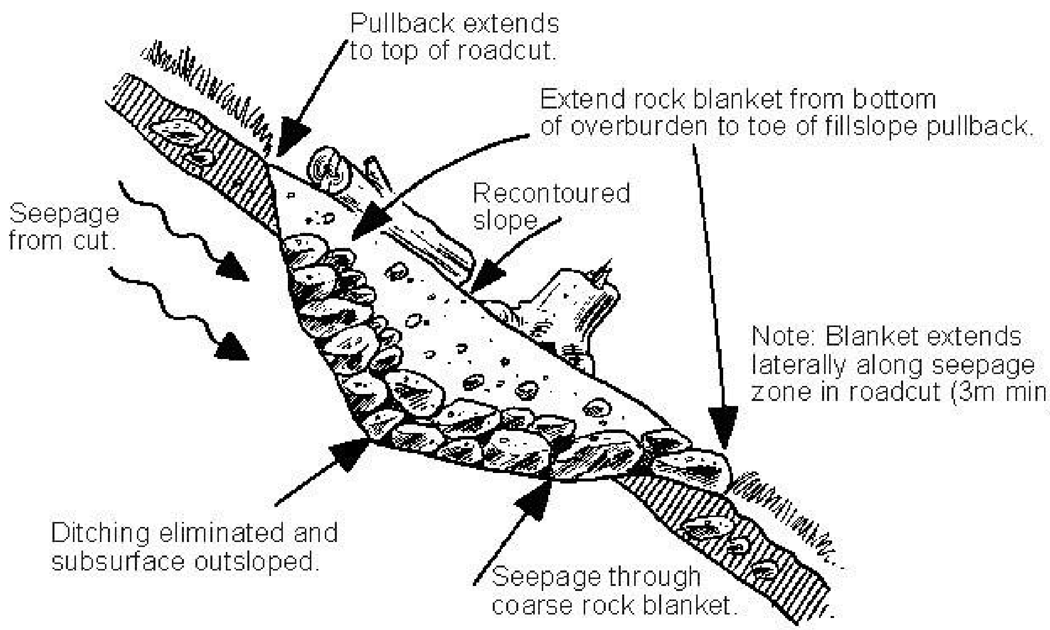
The purpose of a blanket drain is to disperse point seepage or subsurface flow under the road fill pullback. Blanket drains disperse flow rather than concentrate the flow at one hillslope locations and are not intended to convey surface flows or replace open cross-ditches in areas of substantial flow.

A blanket drain consists of a layer of cobbles or shot rock placed against the seepage zone in the road cut. The blanket extends down the cutslope and across the decompacted road surface to the ground surface. Road fill is placed on top of the road cut to the bottom of the blanket. The blanket of shot rock does not extend to the top of the road cut, but only to the top of the seepage zone.

A blanket drain has a wider "footprint" in plan than a trench drain: it commonly extends a greater lateral distance along the road, providing increased flow capacity (Figure 7-7).

Refer to BMP: Hillslope Restoration in British Columbia - Chapter 3.5.7 (PDF, 7.55 MB) for further details.

Figure 7-7 Blanket drain



French drains

The purpose of a French drain is to divert flow along the base of a cut slope and discharge it into a stable location, such as a creek or gully. Use French drains where road fill pullback or bank sloughing may block the ditch and cause water management problems. These drains also provide some degree of water management if the road cannot be decompacted to below ditchline depth. The rock-filled French drain extends down the ditchline until it intersects, and is hydraulically connected with, a cross-ditch or gully.

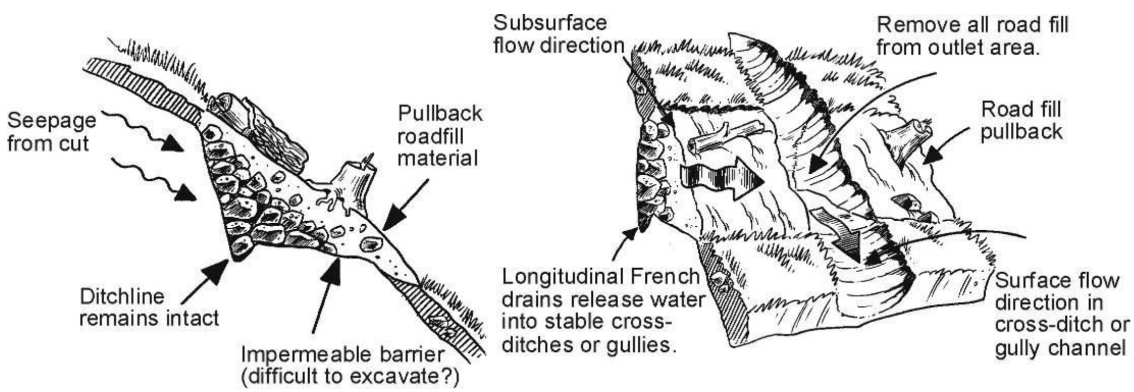
Consider using a French drain where a cross-ditch is impractical, specifically:

- where the seepage zone is extensive in length;
- the retrieved road fill will be impermeable when placed against the road cut; and
- the stability of the road fill material may be compromised if it becomes saturated.

Normally, use French drains in conjunction with road fill pullback (Figure 7-8).

Refer to [BMP: Hillslope Restoration in British Columbia - Chapter 3.5.8 (PDF, 7.55 MB)] for further details.

Figure 7-8 French drain



Fords and armoured swales

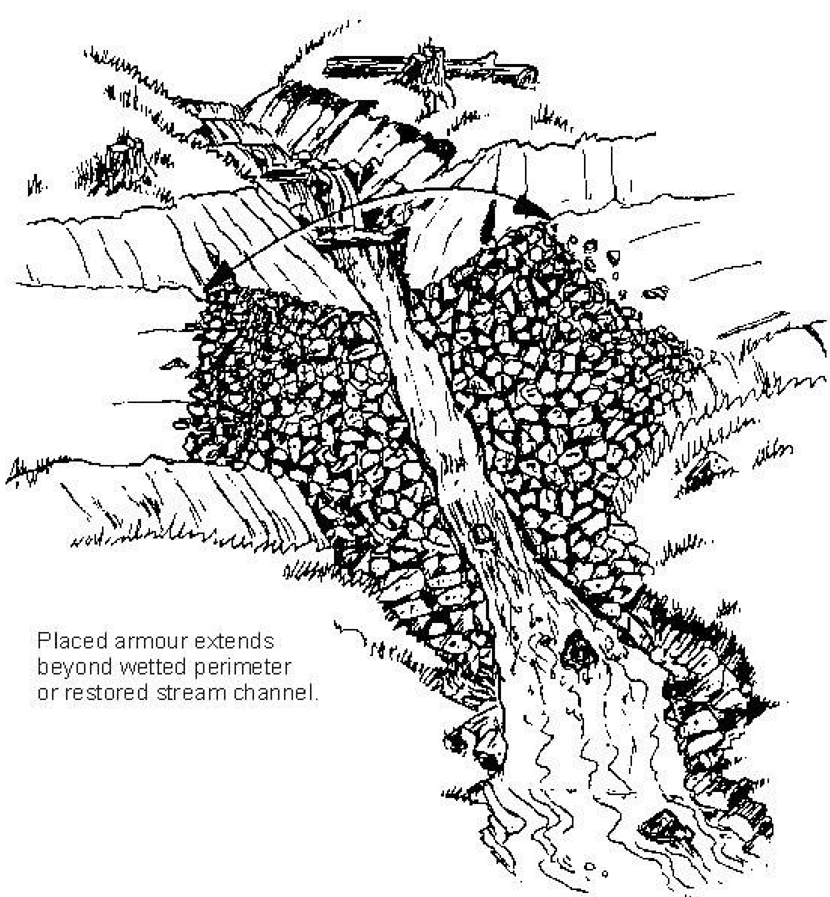
Fords and armoured swales provide erosion-resistant and storm-proof wet crossings for motor vehicles. A ford is used to cross a stream, whereas an armoured swale is constructed where a cross-ditch would normally be used.

Fords

A ford is a dip in a road, constructed to cross a perennial or ephemeral stream, normally designed, and built as a permanent feature (Figure 7-9). Fords are a suitable road deactivation option where vehicle access is to be maintained. Fords are restricted to non-fish streams unless otherwise approved by the fisheries agencies. For deactivation, consider protecting the running surface of the ford using rock armour where the natural stream bottom will not support the intended vehicle loads.

Refer to [BMP: Hillslope Restoration in British Columbia - Chapter 3.5.9 (PDF, 7.55 MB)] for further details.

Figure 7-9 Example of a ford installed on a non-fish bearing stream

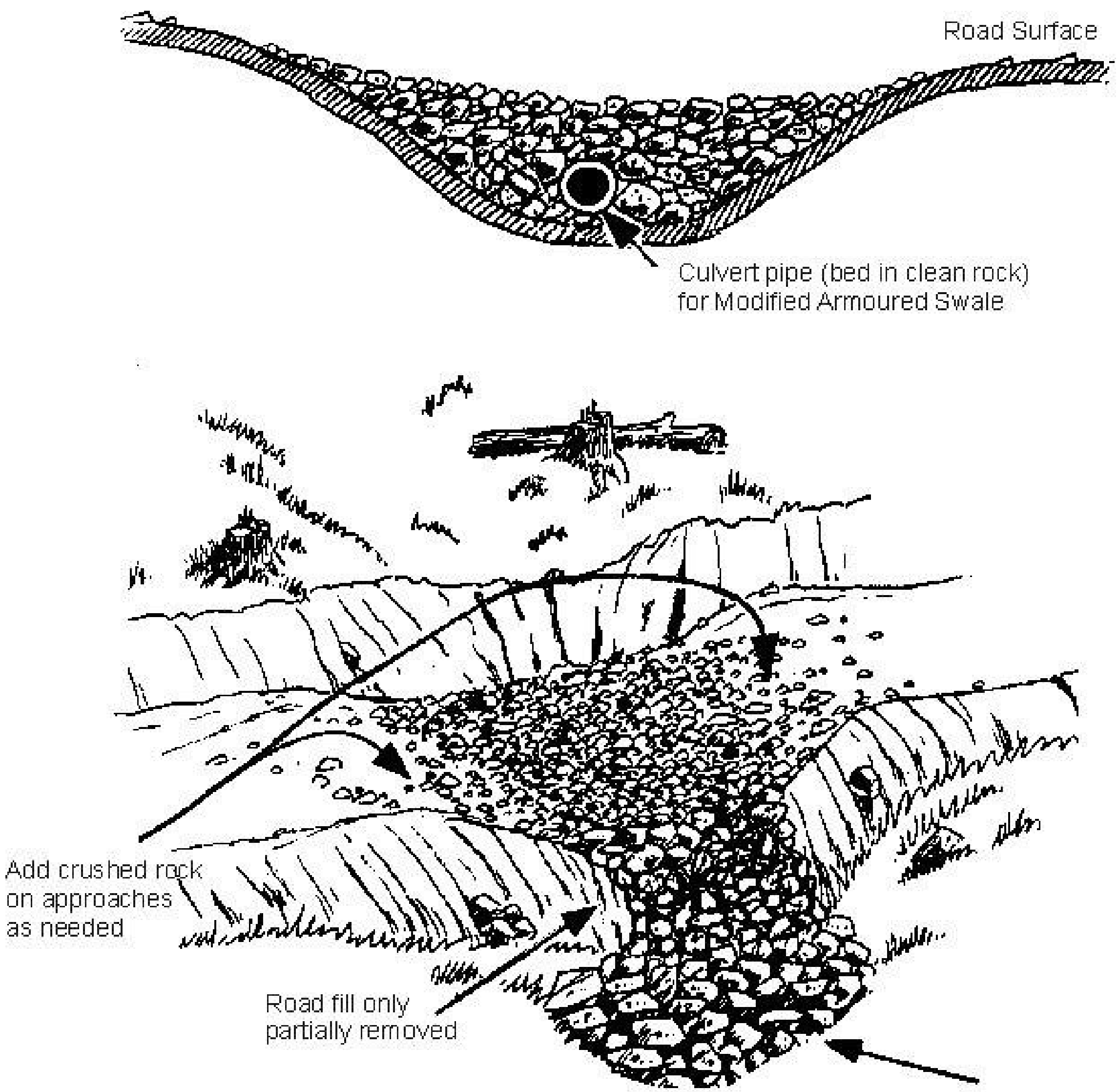


Armoured Swales

An armoured swale is a dip in the road grade, installed to convey road surface runoff, ditchwater, or cutbank seepage across a road during works such as road deactivation, where it is critical to minimize sedimentation while short-term vehicle access is required (Figure 7-10).

Refer to BMP: Hillslope Restoration in British Columbia - Chapter 3.5.9 (PDF, 7.55 MB) for further details.

Figure 7-10 Example of an armoured swale



Insloping / outsloping road surface

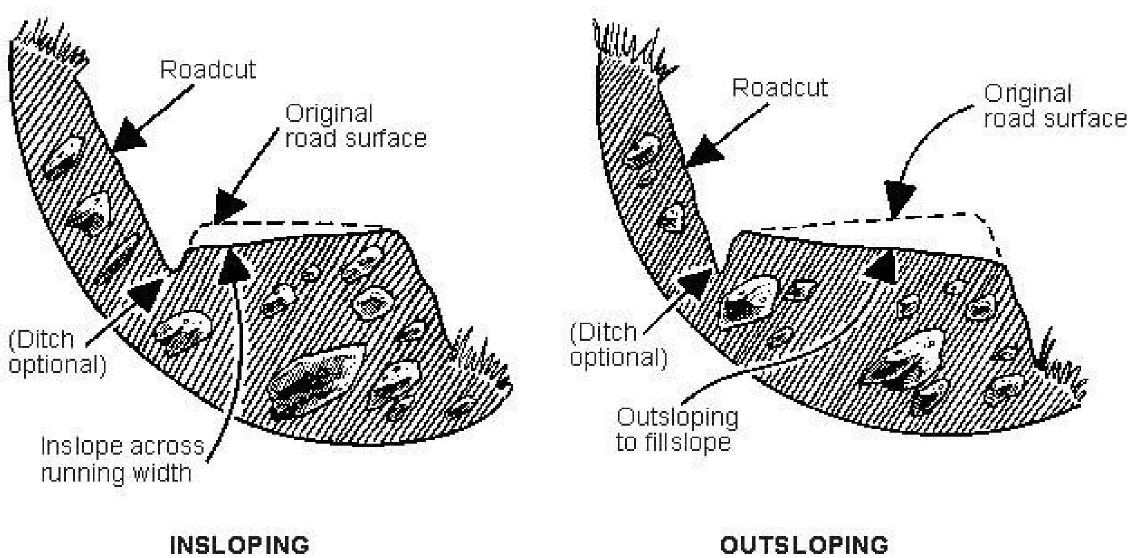
The purpose of insloping or outsloping the road surface is to control water without using ditches or cross-ditches (Figure 7-11).

Insloping is the sloping (reshaping) of the road surface to direct road surface water toward the road cut and away from unstable or erodible road fill materials. Outsloping is the sloping (reshaping) of the road surface to direct water across the road and onto the road fill in a dispersed fashion.

This technique is more effective on roads where there is no vehicle traffic. However, where deactivated roads receive vehicle traffic, the insloping or outsloping will disappear with road use.

Refer to BMP: Hillslope Restoration in British Columbia - Chapter 3.5.10 (PDF, 7.55 MB) for further details.

Figure 7-11 Insloping and outsloping the road surface

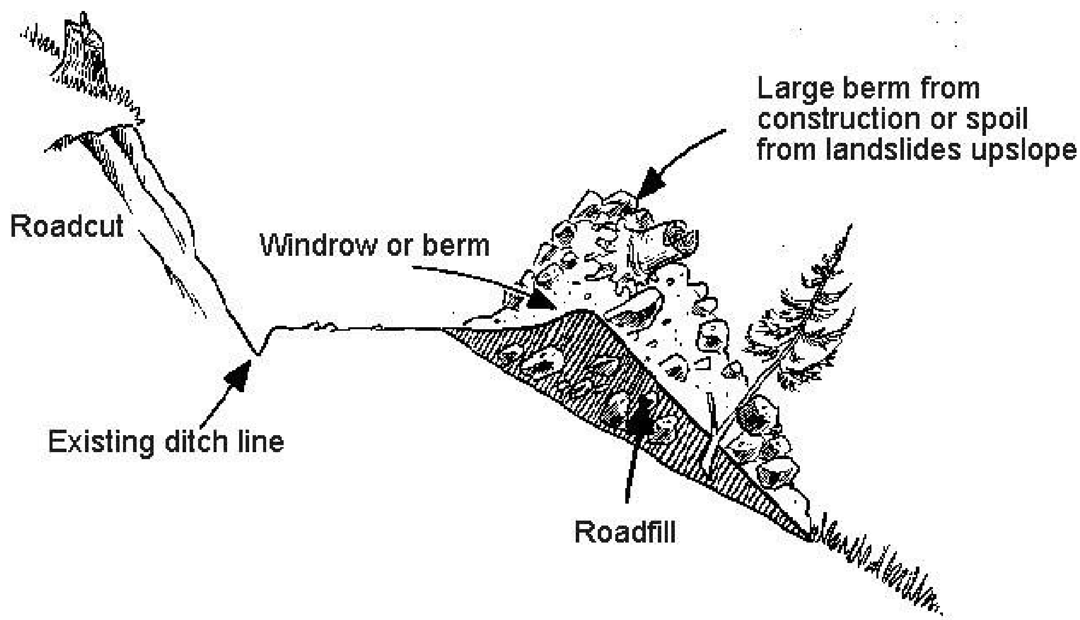


Windrow or roadside spoil pile pullback

The purpose of windrow or roadside spoil pile pullback is to restore natural hillslope drainage paths where road maintenance activities have left a continuous soil berm on the edge of the road. Pull back larger berms to reduce the weight on the outside edge of the road, or to meet silviculture objectives (Figure 7-12).

Refer to BMP: Hillslope Restoration in British Columbia - Chapter 3.5.11 (PDF, 7.55 MB) for further details.

Figure 7-12 Grader windrow and spoil pile berm (site conditions before fill pullback)



7.8.2 Road Fill Pullback Techniques

Where there is potential for unstable road cut or fill slopes to develop during periods of inattention, consider using road fill pullback. This removes marginally stable sidecast fill that has a high risk of failure, and effectively adds a weighting berm to the toe of the road cut.

Full road fill pullback

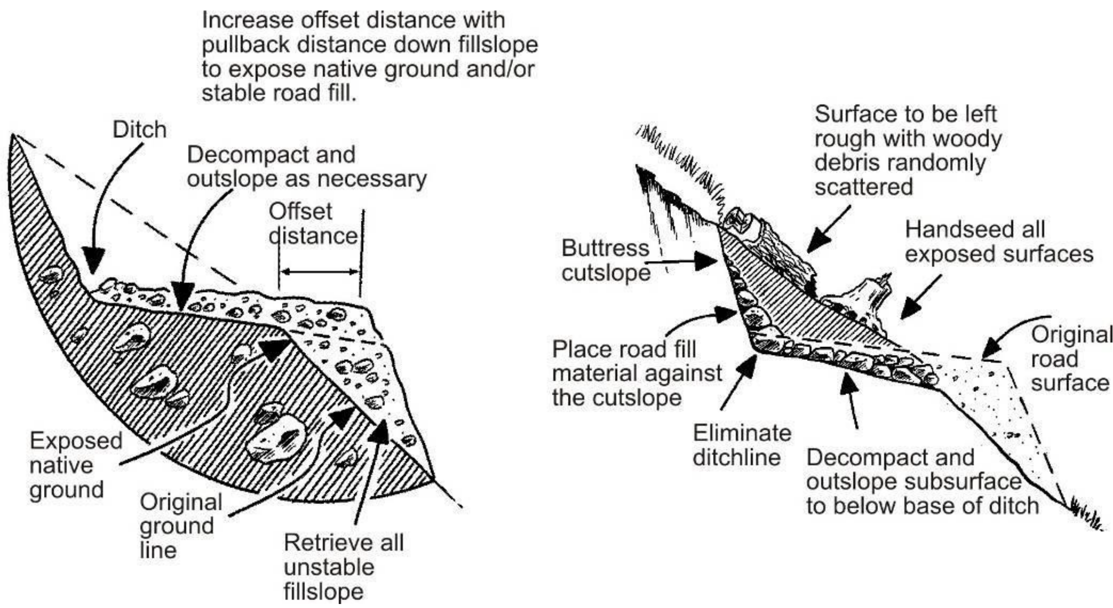
The purpose of full road fill pullback is to retrieve all potentially unstable sidecast material and place it tight against the road cut, thereby reducing the landslide hazard to the greatest extent possible. Usually no access – or only limited access for foot or all-terrain vehicle traffic – is possible after full road fill pullback (Figure 7-13).

Full road pullback is the deconstruction (also known as “re-contouring” or “de-building”) of the road subgrade to restore the original hillslope profile and contours.

Decompaction may also be necessary. This involves breaking up road fill materials to a depth equal to, or greater than, the depth of the ditch, and removing this material to outslope the surface before pullback material is placed over top.

Refer to BMP: Hillslope Restoration in British Columbia - Chapter 3.5.14 (PDF, 7.55 MB) for further details.

Figure 7-13 Example of full road fill pullback



Partial road fill pullback

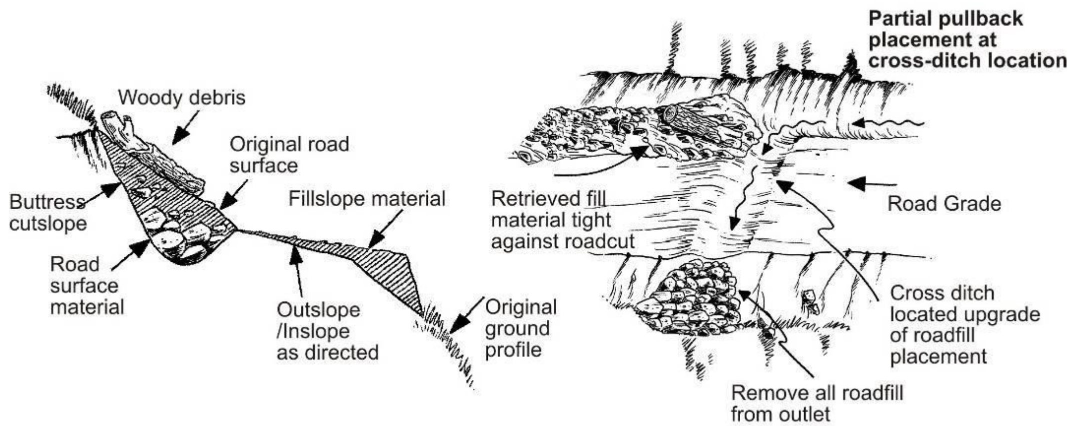
Partial road pullback may be appropriate to maintain motor vehicle access if the road is open to traffic or if road access is needed in the future. Full road fill pullback may be required at some future date to provide long-term stability of the road prism.

Partial road pullback (Figure 7-14) retrieves the currently or imminently unstable portions of the road fill and leaves those portions with no evidence of immediate instability intact. Retrieved road fill is placed tightly to the road cut with organic soil and woody debris on top to promote revegetation.

Refer to [BMP: Hillslope Restoration in British Columbia - Chapter 3.5.13 (PDF, 7.55 MB)] for further details.

Endhaul the pullback material when the unstable volumes of road fill exceed the available room in the ditchline. This is the process of removing excess road fill and placing it in an approved waste area. Refer to [BMP: Hillslope Restoration in British Columbia - Chapter 3.6.1 (PDF, 7.55 MB)] for further details.

Figure 7-14 Partial road fill pullback



Gully restoration

Gully restoration is carried out during full road fill pullback to decrease the landslide hazard along the road approaches on the side walls of the gully.

Gully restoration involves pulling back all the fill material out of a gully channel. The size, depth, and shape of the pullback should mimic the natural ground profiles and contours of the gully system above and below the road. Armouring the gully channel and endhauling are often used together. Consider using similar techniques for entrenched creeks. Refer to the Gully Assessment Procedure Guidebook (PDF, 1.83 MB) for detailed technical information on the deactivation of road crossings of gully systems.

Refer to BMP: Hillslope Restoration in British Columbia - Chapter 3.6.1 (PDF, 7.55 MB) for further details.

7.8.3 Revegetation Techniques

To control surface soil erosion and sediment transport, seed or plant, in the first growing season after deactivation, all exposed soils that will support vegetation.

Establish vegetation by the end of the second growing season. Consider prolonging this time period or varying the process for revegetation if it seems apparent that the change will adequately manage and conserve the forest resources. Consider natural revegetation as an appropriate option if it can be suitably established within two growing periods. Revegetation is considered to be successful when there is uniform coverage on the ground. Spotty or clumpy patches of vegetation are not considered adequate.

Consider the following in assessing the adequacy of revegetation efforts:

- the mixture of the grass seed used;
- the time and rate at which the seed was applied;
- the appropriateness of the fertilizer and mulch used; and
- the number of attempts made to establish the vegetation.

Refer to BMP: Hillslope Restoration in British Columbia - Chapter 3.8 (PDF, 7.55 MB) for further details.

Grass and legume seeding

Seeding is the most common and usually the most cost-effective means of treating deactivated roads to prevent erosion.

For further details, refer to Chapter 5: Soil Erosion & Sediment Control and BMP: Hillslope Restoration in British Columbia - Chapter 3.8.1 (PDF, 7.55 MB).

Scarification

To grow trees for soil erosion control purposes in areas that are not part of the net area to be reforested (but where trees can be reasonably expected to grow), it may be necessary to supplement grass seeding by scarifying the road surface, re-using local topsoil, or employing other similar measures.

Note: Scarification is for reforestation purposes, whereas decompaction during fill pullback activities is for deactivation/water control purposes.

Scarification (also known as "silvicultural fluffing") is designed to enhance revegetation. It involves breaking up the road surface to a minimum depth equal to about twice the length of the teeth on an excavator bucket (about 400mm, or 16-20 inches).

Refer to BMP: Hillslope Restoration in British Columbia - Chapter 3.5.12 (PDF, 7.55 MB) for further details.

Woody species establishment

In addition to grass seeding of all deactivated roads where necessary, consider the localized re-use of topsoil to grow trees for soil erosion control purposes.

Consider planting pioneering species such as alder, willow, and, in some cases, lodgepole pine and Douglas-fir on areas of full road fill pullback or on areas that have been scarified. These species are important early colonizers of disturbed sites and prepare the site for later succession forest species such as spruce, cedar, and hemlock. Before any planting activities on a permanently deactivated road are undertaken, consult with the professional forester responsible for silviculture activities in the area to ensure that such planting is consistent with silviculture prescriptions prepared for the area.

Use topsoil and tree planting to achieve revegetation (outside the net area to be reforested) on a permanently deactivated road simply for controlling soil erosion. There is no requirement to reforest all permanently deactivated roads, even where such reforesting is feasible. The choice to reforest rests with the person required to deactivate the road.

Refer to BMP: Hillslope Restoration in British Columbia - Chapter 3.8.2 (PDF, 7.55 MB) for further details.

Soil bioengineering

Consider using soil bioengineering systems if the objective is to:

- drain excess moisture that may be creating slope instability (e.g., live pole drains, live silt fences, live bank protection, live gully breaks, and live staking);
- reduce slope angles relative to the growth of vegetation and prevent raveling of fill slopes (e.g., wattle fences, modified brush layers, brush layers in a cut); or
- control erosion along watercourses (e.g., live gravel bar staking, and live shade).

Soil bioengineering is a term that describes the use of living plant materials to build drains, slope breaks, low slope support walls and other similar living systems for water management and soil erosion control on steep slopes. It may also be an effective technique for riparian restoration.

Refer to BMP: Hillslope Restoration in British Columbia - Chapter 6 (PDF, 7.55 MB) for further details.

Control of noxious weeds

During deactivation assessment, consider the presence of knapweed and other noxious weeds that are found along many old logging roads. Consult with a forester, agrologist, or biologist to minimize the likelihood of spreading these problem weeds through machine travel or seed disturbance, if scheduling deactivation work outside the seed maturity time is not possible.

7.9 Resources & Suggestions for Further Reading

BC Ministry of Forests Forest Practices Code of British Columbia . 1997. . Soil rehabilitation guidebook

1999. Mapping and assessing terrain stability guidebook. Victoria, BC.

2001. Gully assessment procedure guidebook (PDF, 1.83 MB). Victoria, BC.

2002. Fish-stream crossing guidebook (PDF, 4.3MB). Victoria, BC.

BC Ministry of Forests and Range. 2004. Effectiveness evaluation of road deactivation techniques on the west coast of Vancouver Island (PDF, 2.31 MB). Victoria, BC. For. Res. Ext. Note: EN-020.

Grainger, Bill. 2004. Terrain stability field assessments in “Gentle over Steep” terrain of the southern interior of British Columbia (PDF). Grainger and Associates Consulting Ltd. Salmon Arm, BC.

Wise, M.P., G.D. Moore, and D.F. VanDine (editors). 2004. Landslide risk case studies in forest development planning and operations. BC Min. For., Res. Br., Victoria, B.C. Land Manage. Handb. No. 56.

Vanbuskirk, C.D., R.J. Neden, J.W. Schwab, and F.R. Smith. 2005. Road and terrain attributes of road fill landslides in the Kalum Forest District. BC Min. For. and Range, Res. Br., Victoria, BC. Tech. Rep. 024.

Additional website resources:

- Engineers & Geoscientists British Columbia: Division Resources
- Region Research Sections listed for the BC Ministry of Forests

8 Professional Responsibilities & Considerations

This chapter describes the Ministry's mandatory procedures, best practices and applications of professional responsibility of members of the FPBC and EGBC with respect to forest service roads. It is intended to provide enough detail on the processes and expected mandatory procedures, while ensuring that the road meets the regulatory requirements related to safety and protection of other resources.

Note that EGBC Registrants are required under their Regulatory Body's by-laws to authenticate all professional documents they prepare, and FPBC Registrants may use their seal at their discretion.

Consistent with the joint guidelines prepared by the regulatory bodies:

- Guidelines for Professional Services in the Forest Sector - Forest Roads (the Guideline), 2012; and
- Guidelines for Professional Services in the Forest Sector - Crossings, 2021.

road activities will be carried out under the professional direction of a Coordinating Member (CM). Structures that form part of a road will be overseen by a Coordinating Registered Professional (CRP) or a Professional of Record (POR) depending upon the scope of the project and any necessary division of responsibilities.

Note that professional oversight for a forest road project may include responsibility for one or more of the following activities:

- road layout;
- road survey;
- road design
- preparation of a road plan;
- design and fabrication of a structure (bridge, major culvert, retaining structure);
- construction of a road or structure;
- inspection and maintenance of an existing road; and
- road deactivation.

As such, this manual will refer to the scope of works as a project, whether the works encompasses several activities or not. For example, for an existing road that requires inspections and maintenance, and eventually deactivation, the project related to professional responsibilities may be limited to the activity taking place at that time. As well, where a project may cover several activities, but the responsibilities may be shifted from one agency to another, or from one professional to another, each project will be necessarily limited to only those activities within the umbrella of each organization or professional.

Note that while the most common situation is where there is only one CM/CRP responsible for several phases of a project, circumstances such as:

- staff changes in the local office;
- shifts in priorities by management; and
- the range of expertise provided by a CM

may dictate the need for one or more additional CM/CRP's for different job phases. However, there must be a clear division of responsibilities and understanding of each CM/CRP as to their scope of work and their individual professional responsibilities, as well as assurance that there is continuity in the professional oversight for the project. Accordingly, for those projects that have been carried out since the implementation of the Guidelines for either forest roads or crossings, the responsibilities of a CM include reviewing any existing Assurance documents and confirming their project coverage and scope.

For some of its new road access, BCTS may elect to lay out, survey and design, and prepare a road plan for a road, then shift the responsibility for construction to a TSL licensee, subject to the road becoming a forest service road at some point after construction. As such, a professional engaged by the licensee should undertake CM responsibilities for the road works after the transfer of responsibilities. The scope of that CM's responsibilities may include:

- road layout;
- road survey;
- road design;
- preparation/amendment of the road plan;
- road construction; and
- preparing construction and inspection records, including Assurance Statement documents.

These responsibilities may be limited only to road construction, but if the licensee elects to relocate and redesign the road, there should be professional coverage on behalf of the licensee for those activities as well.

When issuing a Timber Sale License, if it is proposed to declare an RP as an FSR subsequent to a timber sales licensee's activities, include the following in a cover letter:

> *Please note FPPR Section 77 regarding preparing, retaining and providing records to the timber sales manager (TSM). It is proposed to declare the RP an FSR upon completion of your activities. If the RP is declared an FSR, the TSM will request construction and inspection records [as identified in FPPR Section 77(1)] as provided for in FPPR Section 77(3).*

Where a bridge or major culvert project will be constructed by a timber sale licensee where upon closure of the of the timber sale licence, if the road is declared a FSR, the Ministry (BCTS TSM) will make a formal request to the timber sale licensee for the bridge and major culvert construction and inspection records (per FPPR Section 77(1) & 77(3).

Once the road becomes a forest service road subsequent to construction, the further professional responsibilities must be provided on behalf of the Ministry, such responsibilities to include review of those construction and inspection records and confirmation of their project coverage and scope.

Generally, the professionals that are impacted by this chapter include the CM/CRP/POR and those Members that undertake the preparation of parts of the road or crossing project, as well as their interaction with Specialists and Road Personnel during the life of the project. The CM/CRP/POR is responsible for considering the composition and interaction of all the road components, as well as their relationships and impact on the users, the road itself and other resources. A key concept is continuity of professional oversight and output reviews. The CM/CRP/POR is charged with retaining a close familiarity with the progress of the project, and with coordinating the various Member and Specialist inputs into the road project and, as such, carries overall professional responsibility for the delivery of the project.

The CM/CRP/POR may be the only professional involved in a road project, or may be managing a team of professionals. A team consists of a CM/CRP/POR who is qualified to oversee and take responsibility for professional practice associated with the forest road activities plus other Members and/or Specialists who are required depending on the size and complexity of the project.

The CM/CRP/POR may need to draw upon other Members and Specialists for their expertise to assist with the development of some or all of a project, and for those situations, the CM/CRP/POR must establish a standard of care by:

- identifying professional tasks;
- identifying considerations that need to be addressed; and
- identifying outputs in the form of deliverables.

As the guidelines reflect, members need to exercise professional judgment when providing professional services associated with the design, construction, maintenance and deactivation of forest roads and crossings, and as such, the applications can vary depending on the circumstances.

There is a need for members to utilize a quality management plan to ensure that the work completed is technically correct and complies with applicable codes, standards and regulatory requirements. The objective of this plan is for the professional to exercise due diligence by ensuring suitable applications of knowledge, completeness and correctness, and professional care. This may be accomplished through:

- use of qualified specialists;
- documentation of supporting rationale for the professional's work;
- retention of project documentation; and
- where the Member so determines, an independent peer review of work that is especially complex or that may particularly impact user safety.

Skills and knowledge of Members and CM/CRP/POR's should be consistent with the guidelines, as well as those found in the Ministry's Engineering Equipment & Services (EES) system.

Policy

The planning, layout and design, construction, maintenance, and deactivation of a Forest Service Road or crossing on the road must be carried out or coordinated by a CM/CRP/POR who will be professionally responsible for the road outcomes.

8.1 Mandatory Procedures & Best Practices

Last Update: December 21, 2021

Professional practices related to Forest Service Roads must adhere to the Engineers and Geoscientists Act, R.S.B.C. 1996 c. 116 as amended, and the Foresters Act, R.S.B.C. 2003 c. 19. As well, the professional responsibilities and practices are intended to be consistent with the bylaws of the regulatory bodies and with the

- Guidelines for Professional Services in the Forest Sector - Forest Roads (the Guideline), 2012; and
- Guidelines for Professional Services in the Forest Sector - Crossings, 2021.

Table 8-1 Professional Services

Results to be achieved on a Forest Service Road project: CM/CRP/POR's and Members who carry out professional work are qualified members of FPBC who is authorized to practice professional forestry, or professional engineers, professional geoscientists, including limited licensees, licensed to practice by EGBC; overall professional responsibility for a project is clearly assigned, understood and continuous; the responsible professional must sign (and seal as appropriate) the output documents for the project, including the pertinent Assurance Statements;	
M1	The CM/CRP/POR and Members must possess the necessary skills and knowledge to carry out their professional responsibilities; (see skills)
M2	The CM/CRP/POR must sign off the pertinent Assurance Statements identifying him/her as the person with overall professional responsibility for the project; (see Chapter 8 for roads; see Chapter 4 for structures)
M3	where the CM/CRP/POR or Member is a professional engineer or professional geoscientist, the Member must seal all professional documents that he/she has prepared; (see use of seal)
M4	Where a bridge or major culvert project will be constructed by a timber sale licensee where upon closure of the of the timber sale licence, if the road is declared a FSR, the Ministry (BCTS TSM) will make a formal request to the timber sale

	licensee for the bridge and major culvert construction and inspection records (per FPPR Section 77(1) & 77(3).
B1	There should be only one CM/CRP for a project, unless this becomes impracticable; in the event of multiple CM/CRP's, the division of responsibilities and continuity of oversight are critical components that need to be addressed by the subsequent CM/CRP; (see coordinating)
B2	Each project should have, for its professional work, an appropriate quality management plan, determined and overseen by the CM/CRP/POR; (see quality management)
B3	The CM/CRP/POR may adopt design and operational standards contained in this Manual, but is responsible for determining the applicability of the these standards and modifying them as appropriate to address specific project requirements; (see judgement)
B4	Where the Member or CM/CRP/POR is a forest professional, he/she should seal professional documents he/she has prepared; (see use of seal)
B5	When issuing a Timber Sale License, if it is proposed to declare an RP as an FSR subsequent to a timber sales licensee's activities, include the following in a cover letter: Please note FPPR Section 77 regarding preparing, retaining and providing records to the timber sales manager (TSM). It is proposed to declare the RP an FSR upon completion of your activities. If the RP is declared an FSR, the TSM will request construction and inspection records [as identified in FPPR Section 77(1)] as provided for in FPPR Section 77(3).

9 Forest Resource Road and Crossing Erosion and Sediment Management

Forest resource roads and crossings are sources of sediment. This chapter provides general guidance for considerations for forest resource road erosion and sediment management for those involved with Forest Service Roads.

Roads and associated crossings should be located, designed, constructed, inspected, maintained, and deactivated recognizing that they are sources of sediment that can detrimentally impact upon other forest resources such as water quality, fish streams and fish habitat.

Consideration for management of sediment should be made through the life-cycle phases of forest resource roads and crossings. Each phase impacts sediment development and mobilization. It is more effective and efficient to integrate sediment management in road activities than to deal with it in a reactive manner. Plan all activities to minimize the potential for sediment development and movement.

Some factors to consider in all road and crossing phases for sediment development and management:

Soil type

- Fine texture, non-cohesive soils are more erodible and mobile than coarse soils

Exposure

- Minimize exposed soil area and exposure time
- Minimize exposure to wind, rain and runoff
- Maintain natural drainage patterns and dispersion to avoid accumulation and redirection of runoff onto exposed soils

Disturbance

- Minimize soil disturbance to minimize sediment generation
- Machine methods to minimize disturbance
- Re-vegetation disturbed slopes as early as possible to limit sediment generation and transport
- Rough surfaces generally limit sediment generation and transport more than smooth

Proximity

- Avoid high erosion potential soils and sites
- Avoid sediment mobilization and delivery to sensitive sites (eg water courses)
- Avoid activities in close proximity to watercourses and sensitive sites

Connectivity

- Connectivity of sediment sources to water courses via run off, ditches, culvert discharges, etc.

9.1 Road and Crossing Life Cycle Phases and Sediment

The following provides considerations for sediment management for the life cycle phases of forest resource roads and crossings. Implementation of suggested practices will depend on site specific situations.

9.1.1 Planning, location and design

Plan and design forest road locations and geometry to minimize sediment development and exposure and to avoid direct delivery of sediment from roads into watercourses or sensitive habitat areas. Plan and design runoff drainage systems to filter through stable forested, vegetated areas and not directly into water courses. Locate roads and crossings to avoid sensitive slopes and soils, to minimize cut and fill exposed soil slope areas. Locate roads away from water courses and that have vegetation buffers. Identify riparian areas and incorporate measures in design to minimize opportunities for sediment generation and mobilization. Locate borrow/waste sites to minimize sediment delivery to watercourses and to avoid disturbing sensitive slopes and soils.

Design and construct the forest road prism with appropriate subgrade and surfacing materials that meet the expected design life, loading, seasonality, and traffic volume and with consideration for sediment management.

Consider the subgrade and surfacing materials when planning and constructing the forest road prism. Along with the expected design life, loading, seasonality, and traffic volume, consideration should also be given to sediment management. Consider integration of rolling grades, dips and swales, into designs to limit long sections of road surface that will accumulate and redirect water drain water from the road surface. Where such features are implemented in the field, document and consider marking them such that maintainers are aware of the features and do not compromise them.

Management of road drainage is key to minimizing erosion and sediment development. Design roads with adequate drainage to maintain natural drainage patterns and natural dispersion of runoff. Avoid accumulating and concentrating flows which will have greater erosive capacity. Design stream crossings such that runoff drains away from the water course, and they are not at low vertical road points which results in runoff with sediment discharging directly into the stream. Design for road runoff and ditches to not be connected and directly discharge into streams.

9.1.2 Construction

Plan and implement construction practices that minimize soils movement, exposure of disturbed soils, time frame for disturbed soil exposure, and generation of mobilized sediment. Avoid construction works during wet weather. Install temporary erosion control measures to limit transport of sediment to water courses and sensitive habitat. Maintain existing surface vegetation where possible. Protect exposed soils with erosion control measures and establish vegetation as early as possible. Around spoil sites and new crossings use erosion control blankets or straw to reduce the impact of rain drops and aid in the establishment of vegetation. Avoid equipment stream crossings within wetted perimeters and where required provide measures for clean equipment crossings. Install drainage structures concurrent with subgrade construction.

Shape road surfaces to shed water – crown, inslope or outslope the road surface as may be suitable and appropriate to the site conditions.

Remove or breach roadside berms which would retain and accumulate water on the road surface unless the berm has been constructed for a specific purpose.

Install mechanical methods to reduce the velocity of the water in the ditches (ie. sumps or sediment ponds) to encourage sediment settlement and capture.

9.1.3 Inspection

Identification of erosion and sediment potential for delivery to water courses or sensitive habitats is a key focus of road inspections. Even with careful planning and design, things can change particularly from upslope activities. Planned routine road condition inspections is intended to identify problems and address them with maintenance, such that they are appropriate managed to minimize impacts.

Procedures can be implemented where observations by other forest resource practitioners of problems on roads, including sediment getting into streams, lakes and wetlands are reported to those responsible for maintenance.

Careful examination of the drainage of the road, culverts, ditches and crossings should be undertaken as surface runoff can severely impact erosion and sediment development. Opportunities for runoff accumulation, concentration and diversion should be identified for remediation. Road runoff drainage and dispersion should be consistent with natural drainage patterns. The road surface should shed water and not transport it any appreciable distance. Any grader berms or windrows will retain, accumulate, and concentrate surface runoff and should be identified for addressing unless they have been established for an intended purpose such as retaining runoff from discharging onto sensitive sites.

Consider utilizing the Forest & Range Evaluation Program (FREP) Water Quality Monitoring, Water Quality Effectiveness Evaluation Protocol, which provides an estimation of volume of fine sediment generation and its potential impact on nearby water quality and fish habitat. The evaluation assesses a site's connectivity to nearby water sources, the contributing factors for fine sediment generation, and allows for the prioritization of sites from Very Low to Very High potential impact to water quality. The evaluation also provides remediation options to reduce fine sediment generation.

Plugged or non-functional culverts, ditch blocks, erosion sites that disrupt the functionality of the road drainage system and are sources of sediment should be identified for remediation.

At crossings, inspect for road runoff being directed to the crossing and opportunities to redirect and disperse through the forest floor. Examine potential for sediment generation and mitigation opportunities within the stream channel.

Road sections or appurtenances where runoff drainage carries sediment directly into water courses should be identified for remediation.

Unstable and exposed cut or fill slopes contributing to sediment development and delivery to water courses or sensitive sites should be identified for revegetation and or remediation.

9.1.4 Maintenance

Maintenance to address sediment delivery or potential sediment delivery to water courses can be determined during and after identification of problems from road inspection.

As discussed previously, road runoff and drainage management are key means to address sediment development and delivery to watercourses or sensitive habitat. Maintaining natural drainage patterns and dispersion of runoff from roads, road surfaces and crossings is key.

Training of grader operators and other maintenance personnel on sediment potential and impacts, the influence of their activities, the importance of road drainage and sediment control techniques and practices, will greatly influence outcomes.

Maintenance methods for managing surface water runoff include:

- Grading to crown, outslope or inslope such that road surfaces shed water effectively; ensure that runoff is not discharged onto sensitive slopes or areas
- Remove or breach grader berms which serve to retain and accumulate water on road surfaces
- Adequate and clear road ditches to runoff to suitable points of discharge that provide opportunity for sediment settlement and dispersion, not directly into water courses
- Adequate cross drainage in the form of cross drain culverts and road surface treatments (such as waterbars, cross ditches, vertical road swales) to maintain natural drainage patterns and dispersal of flow, designed to carry water from one side of the road to the other and/or have runoff flow off the road surface
- Functional clear cross drain and streamflow culverts, suitably armoured to minimize erosion; culverts with functional ditch blocks to redirect water from ditches into culverts
- Vegetation of exposed soil cut and fill slopes

9.1.5 Deactivation

Care and consideration for sediment development and potential for delivery to watercourses and sensitive sites during deactivation of roads and stream crossing activities must be taken. Plan and implement deactivation practices that minimize soils movement, exposed disturbed soils, time frame for soils exposed exposure and generation of mobilized sediment. Particular attention to management of surface flows and runoff is required considering post deactivation work access and implications. Maintain and re-establish natural drainage patterns as much as possible. Revegetate disturbed soils as soon as practicable post disturbance.

9.2 Resources

More in-depth information relating to resource road erosion and sediment management can be found in the following resources:

- Erosion and sediment control practices for forest roads and stream crossing, a practical operations guide - Clayton Gillies, FPInnovations
- Addressing road surface erosion, protecting watercourse crossings - Clayton Gillies, FPInnovations

10 Adaptation for Climate Change and Weather Extremes

10.1 Resilient Infrastructure Engineering Design

Climate change impacts can result in significant damage to resource road infrastructure which is disruptive to access and costly to repair. Although storms are a normal occurrence, climate change has caused storm events to happen more frequently and with increased intensity. Storm flood damages, that appear to be occurring frequently, on public and resource roads are illustrative examples. These more frequent and more intense storm events are impacting communities across the province and are causing damage to infrastructure, property, resources and ecosystems. Current climate projections predict that this situation will persist and potentially worsen in the decades to come.

Given the potential for climate change to impact Forest Service Road (FSR) infrastructure in BC, it is prudent and necessary to develop policies and guidance for incorporating climate adaptation into engineering designs and activities. Preparing for future conditions, including those potentially influenced by climate change, when considering the design, construction, operation, and maintenance of infrastructure is critical to protecting the integrity of the FSR system and the investment of taxpayer dollars.

The guidance in this chapter is intended to assist Forest Professional and Engineer practitioners in meeting their professional obligations to consider and mitigate the potential impacts of climate change on resource roads and infrastructure.

The design life of FSR infrastructure is frequently long, and maintenance may be required for many decades. As an integral part of our provincial transportation infrastructure, FSR's are already exposed to a range of stressors such as deterioration due to aging, land-use changes, population growth and environmental impacts; many of which are directly influenced by climate. An objective is to design roads, crossings and drainage structures on FSR's to be climate resilient for their intended service life, withstand deterioration over time and potential site impacts such as: floods, wildfires, landslides, geologic subsidence, earthquakes, rock falls, avalanches, snow loading, wind loading, debris passage, debris flows/debris floods, ice forces, extreme temperature variations, and storms of various intensities, etc. While existing transportation infrastructure has been designed to handle a broad range of impacts based on historic climate, preparing for changes in average climate conditions, weather extremes and other climate related events is also essential. This preparation is critical for protecting transportation infrastructure as well as current and future investment.

Climate change adaptation is the practice of implementing actions to address projected climate changes and impacts. Professional regulatory bodies such as Engineers and Geoscientists BC (EGBC) and the Forest Professionals BC (FPBC), expect that their members consider the potential impacts of climate change and to include climate change adaptations in their work. The BC Professional Governance Act strengthens the requirement for members of these associations to complete professional and defendable work.

Many infrastructure parameters, such as location, type, traffic volume, and design life will determine the climate change and extreme weather event analysis required. The level of effort for consideration should be commensurate with the level of risk. For example, design of a small temporary portable bridge may only require a summary analysis, while a high use critical access long span, high industry and public use, permanent bridge will require a more rigorous analysis.

There are currently many climate change adaptation tools available to transportation infrastructure designers and some Climate Adaptation and Vulnerability Analysis Resources are provided below. Utilizing these tools along with local knowledge and professional judgement to adjust designs to a projected future condition that will result in more resilient infrastructure and more efficient use of resources is the challenge and responsibility of all resource professionals.

In general, for FSR engineering design projects, the following should be considered for each project by the designer:

- Reasonable consideration of impacts of changes in climate conditions, weather extremes and future climate-related events that could impact the project (including new, rehabilitation and maintenance projects)
- Assessment of infrastructure and climate vulnerability and risk for the design life of components, indicating relevant information Design that incorporates information, analysis and projections of the impact of future climate change and weather extremes
- Development of practical and affordable project design criteria which takes adaptation to climate change into account and addresses identified vulnerability and risks, and
- Documentation on the project file that summarizes engineering design parameter evaluation and modification for adaptation to climate change.

The following steps provide guidance for infrastructure designers to consider the impacts of climate change.

1. Evaluate vulnerability of project (At the concepts stage):
    - Identify planned lifespan of infrastructure
    - Based on infrastructure lifespan, identify a timescale into the future to analyze
    - Use risk assessment methods and climate information from available sources, consider available local and indigenous knowledge as may be appropriate and available
    - identify the design components at risk from the impacts of future climate change and weather extremes over the extended project design life
    - summarize changes in temperature, precipitation, and other climatic variables over the expected project design life

- Record projected changes in temperature, precipitation and other climate factors from initial analysis and anything significant from sensitivity analysis
- Assess how projected climate changes could impact infrastructure or site in question: usage types and frequency; increase in clear flow discharge; freeze/ thaw; rain on snow event; erosion; probability of debris flow or landslide, (identify what 'failure' would look like at this site)
- identify the risks to the project design components from these projected climate changes and summarize the risks (suggested Climate Change Design Criteria Sheet for Climate Resilience)
- Consider if/ how probability of above events is increased due to projected climate change impacts; ie: probability of failure

2. Evaluate consequence of project 'failure'
    - Identify resources at risk from failure
    - Use vulnerabilities, probability of failure and consequence of failure to identify the impact of climate change factors on risk of project.

3. Identify changes or adaptations that can be made to project design to reduce identified risk.
    - The project designer will develop adaptation design strategies to address climate change risks for the project
    - Based on evaluation of future climate change effects and impacts, the project designer will develop a project-appropriate set of design criteria for event preparedness and resiliency
    - Implement the developed design criteria into the project
    - Engineering design parameter evaluation and modification for adaptation to climate change should be summarized and listed (suggested Climate Change Design Criteria Sheet for Climate Resilience)
    - Document above analysis to show that potential impacts of climate change were considered in a professional and defendable manner.
        - Sample documentation approach provided in Appendix 4-1.

10.2 Climate Adaptation and Vulnerability Analysis Resources

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- **BCFOR Climate change adaptation for resource roads**
- **BCMoTI Climate Adaptation site**
    - **Technical Circular: T04-19 Resilient Infrastructure Engineering Design - Adaptation to the Impacts of Climate Change and Weather Extremes**

- Canadian Centre for Climate Services
- Climate Data for a Resilient Canada
- EGBC - Climate Change Information Portal
- Pacific Climate Impacts Consortium (PCIC)
    - Analysis Tools – Climate Explorer, Plan2Adapt etc
- Pacific Institute for Climate Solutions (PICS)
    - PICS Research
- Public Infrastructure Engineering Vulnerability Committee (PIEVC)
- IDF_CC Tool (Western University Ontario)
- Intergovernmental Panel on Climate Change **(IPCC)** - United Nations body for assessing the science related to climate change
- Federal Highway Administration – Climate Adaptation **(USA)**
    - Tools, Climate Change Adaptation
- AASHTO – Transportation and Climate Change Resource Center **(USA)**