

SUMMARY OF PROVINCIAL WATER QUALITY EFFECTIVENESS EVALUATION RESULTS (2008-2010)

FREP

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INTRODUCTION

This report reviews 3 years of water quality effectiveness evaluation results collected under the Forest and Range Evaluation Program (FREP) (see: <http://www.for.gov.bc.ca/ftp/hfp/external/!publish/frep/indicators/Indicators-WaterQuality-Protocol-2009.pdf>). The procedure assessed potential water quality impacts associated with resource roads and timber harvesting. Where free-range cattle were present, potential fecal contamination was assessed upstream of drinking-water intakes.

METHODOLOGY

The water quality effectiveness evaluation was developed to quantify the potential effect of forest- and range-related disturbances on water quality and how those impacts might be mitigated. The evaluation is designed so that a non-specialist can quickly estimate, within an order of magnitude for a site, all potential factors contributing fine sediment to a water body and to prioritize that estimate into a "Very Low," "Low," "Moderate," "High," or "Very



Carefully designed and installed stream crossings result in low erosion potential.

The purpose of FREP Extension Notes is to provide the results and recommendations of the monitoring and evaluation of British Columbia's natural resource values for those who impact and influence the management of these resources.

FREP Mission: *To be a world leader in resource stewardship monitoring and effectiveness evaluations; providing the science-based information needed for decision making and continuous improvement of British Columbia's forest and range practices, policies and legislation.*

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High” impact class. Potential fecal contamination is flagged by considering a number of indicators.

The water quality effectiveness evaluation has two components in its estimation of potential impact to water quality. Component 1 identifies fine sediment generation from forest harvesting, road construction/maintenance/deactivation activities, and landslides that occur within the cutblock and road prism. Component 2, where relevant, identifies fine sediment and potential fecal contamination generation from range activities.

The following attributes were used to evaluate potential water quality degradation of selected sites.

- the connectivity, or ability to transport generated fine sediments, from the identified surface to a natural drainage, whether a stream, river, or lake;
- the area of exposed soil and active road (or other disturbed) surface drained by overland flow towards a water body. This included road surfaces, ditches, cut banks, slope failures, and any other forestry-related disturbance features; and
- the relative degree to which the identified surfaces may erode and generate sediment.

Following the identification of a potential sediment source and its connectivity to a water body or stream, the disturbed surface area was estimated and its erosion potential calculated. Using these data, the potential amount of fine sediment entering a stream as a result of site disturbances was estimated.

Five classes were developed to rate the outcome of the water quality effectiveness evaluation (Table 1). Based on the general consensus of sedimentologists, hydrologists, district staff, licensees, and water purveyors, these classes reflect the severity of water quality impact that a site may have on a watershed. Sites that rated moderate or higher required the evaluator to identify options for improved management.

The range assessment currently (since 2009) focuses on the potential for fine sediment generation and fecal contamination where free range cattle activities occur upstream of a licensed domestic water intake. By targeting stream crossings for range assessments, the evaluator captures, not only potential fine sediment generation but also potentially impacted range sites. The potential impacts occur where the lack of control structures allow livestock to travel along road right of ways where travel is easier and access to water is most direct.

The range assessment focuses on the potential for fecal contamination rather than fine sediment contribution to drinking water because sediment generated by livestock is much less important for drinking water than the fecal contamination they can generate.

Evaluators use the following riparian site indicators to assess for potential water quality contamination by livestock:

- condition of the plant community,
- condition of the ground surface,
- condition of the stream bank and channel,
- presence of livestock dung, and
- specific range management practices (e.g. p.19 of protocol “livestock drink directly from water source.”).

Table 1. *Thresholds developed to assign water quality impact ratings for selected sites.*

VOLUME OF FINES* GENERATED (M3)	SITE CLASS	SITE DESCRIPTION	TYPICAL SITE	EFFECTIVENESS OF MANAGEMENT
< 0.2	Very Low	Site does not generate significant amounts of sediment. Reflects best management practices.	Most deactivated roads; recent, well-engineered crossings	<p>Very High</p> <p>Very Low</p>
0.2–0.99	Low	Site generating some sediment but would still be within the range considered normal for background levels.	Light to moderate used, well-managed, industrial roads	
1–4.99	Moderate	Site generating measureable levels of fine sedimentation and, under special situations, of interest to watershed managers.	Moderate to heavy used industrial roads under a range of conditions	
5–19.99	High	Site generating unacceptable levels of fine sediment having a significant impact on water quality in a watershed. Remedial action required to reduce water quality impacts.	Heavily used main lines built more than 20 years ago in sensitive location	
> 20	Very High	Site generating very high levels of fine sediment with major consequences for water quality within a watershed. Remedial action critical for protection of water resources.	Slope failure caused by road or harvesting. Poor location and (or) water management	

* ≤ 1 mm in diameter.

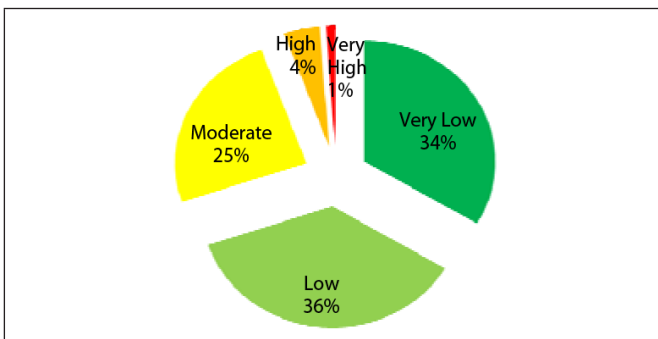
If three of the above categories are identified at a site, the water is considered to have been impacted and a more detailed investigation by a range specialist is recommended.

RESULTS AND DISCUSSION

A total of 517 randomly selected sites generated 2643 water quality assessments from 2008 to 2010. A further 154 sites were assessed using the range component of the evaluation.

Of the 2643 sites evaluated, 34% were classed as having a “Very Low” impact (Figure 1). These sites were not considered to be adversely affecting water quality in any measurable way. Another 36% were classed as having a “Low” impact, which means they were generating some fine sediment but still within normal background levels for the stream. An additional 25% of sites were evaluated as having “Moderate” impact. Depending on the potential risk to in-stream and downstream values such as fish resources or downstream domestic water intakes, this level of impact may be of concern to water resource managers. The vast majority of sites rated as “Moderate” were not considered to be sensitive as no intakes were present downstream, nor were these sites directly connected to fish streams. Another 4% of sites were classed as “High” and 1% “Very High” for potential water quality impact. Substantial water quality impacts had or are occurring on these sites. Three major harvesting-related landslides occurred within the sampled sites and, while rare, had major consequences for water quality and channel morphology. Because the water quality effectiveness evaluation is a routine-level investigation, a further detailed professional assessment of these sites will more accurately estimate sediment generation as well as site remediation recommendations.

Figure 1. Proportion of sites evaluated throughout British Columbia with given water quality impact rating (2008–2010).



FREE-RANGING LIVESTOCK

Evaluation results from the past 3 years focused on the Okanagan-Shuswap, Kamloops, Cascades, Selkirk, 100 Mile House, Quesnel and Cariboo-Chilcotin forest districts. In 2008, 112 range assessments were completed. Approximately 90% of the sites tested positive for potential water quality impacts. In 2009 following a change in

site selection (only monitoring upstream of a domestic water intake), only 28 range assessments were completed of which 38% tested positive for potential water quality impacts. In 2010, 14 range assessments were completed of which 10 or approximately 71% tested positive for potential water quality impacts. All potentially impacted sites were identified to local range specialists with a recommendation for a more detailed assessment.

Potential water quality impacts most frequently occurred due to free range cattle having access to streams via resource roads (lack of control structures) and riparian areas (lack of riparian retention).

RESOURCE ROADS AND OTHER FORESTRY-RELATED ACTIVITIES

The scientific literature identifies resource roads as a major potential source of fine sediment generation that can affect water quality. Provincially, 70% of sites evaluated showed no measurable impact on water quality. Existing road location, design, construction, management, and deactivation have mitigated any potential water quality impact on these sites. Appropriate management at these sites has preserved water quality.

In 25% of the sites, a water quality impact was noted and assigned a “Moderate” rating. The methodology considers a “Moderate” rating as a warning sign. Although immediate action is not required at these sites, there is an indication that practices can be improved, and should be improved where potential consequences warrant. The remaining 5% were rated as having “High” and “Very High” impact to water quality and requiring changes to management to address the root causes of such impacts. For all sites rated “Moderate,” “High,” and “Very High,” evaluators were asked to choose from a list of 24 potential suggestions for improvement that would reduce the level of water quality impact. The 24 suggestions are divided into five categories of activity:

1. road and cutblock location,
2. design of road or cutblock,
3. construction of road/harvesting of cutblock,
4. road management/maintenance, and
5. deactivation.

Some problem sites have immediate and obvious solutions that can be dealt with through normal road maintenance; others would require capital investment including possible road decommissioning or relocation.

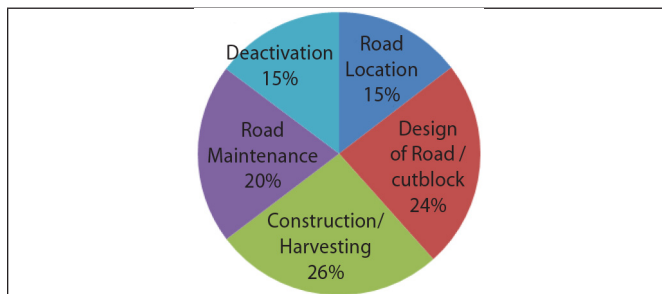
On sites where “Moderate,” “High,” or “Very High” water impacts were noted, all suggestions for improvement were compiled to summarize shortcomings in resource road management throughout British Columbia. Some sites

received two or more suggestions on specific conditions that resulted in accelerated fine sediment generation, for a total of 1172 specific suggestions to reduce fine sediment generation.

OBSERVATIONS ON SEDIMENT MANAGEMENT OF RESOURCE ROADS AND OTHER FORESTRY-RELATED ACTIVITIES

Problems associated with impacted sites (“Moderate” rating or higher) were divided among five areas of concern from initial planning of road location to road deactivation (Figure 2). These categories suggest that improvements can be made at all stages of a road’s life.

Figure 2. Forest management activity and recommendations for improvement based on 1172 observations.



1. ROAD LOCATION

Concerns about road location were noted in 171 instances, with most of those problems related to roads paralleling streams, difficult stream crossing sites, and road alignments on steep and unstable slopes. Most of these sites were associated with road alignments built more than 20 years previously when water quality standards were not as stringent as they are today. Road managers inheriting such roads are limited in options for reducing fine sediment impacts, other than changing road location. The high frequency with which a difficult location is recognized as a problem impacting water quality emphasizes the ongoing need for vigilance in the layout of future roads and cutblocks near water bodies and/or along unstable slopes. Such sites can continue to produce substantial fine sediment loads as long as the road continues to be used.

2. DESIGN OF ROAD/CUTBLOCK

Problems with road and cutblock design were noted at 279 sites. Increasing the number and improving the placement of culverts was mentioned 183 times by evaluators, the single most frequent recommendation associated with road design and reducing fine sediment generation on forest roads. On older roads, inside road ditches often flowed directly into the stream, transporting all road surface, ditch, and cut bank sediment to the stream. The methodology provides a simple technique

to determine exactly where the inside road ditch should be diverted via a ditchblock and culvert to minimize ditch-transported sediment from flowing directly into a stream while maximizing the forest floor buffer to absorb and filter storm water. Avoiding deep ditches along roads adjacent to streams was mentioned 44 times, again mostly on older roads where road subgrade was dug directly from excavated ditches. The deeper the ditch, the fewer the options for safely removing road surface drainage and allowing it to be reabsorbed onto the forest floor before it reaches a stream. Raising bridge decks above the road grade was mentioned 33 times as a solution for reducing higher sediment generation. Where bridge decks are positioned below road grade, sediment transported along even slightly rutted roads has no other option but to flow onto the bridge and thence into the stream. Evaluators reported that new bridge construction invariably had decks positioned above grade. Problem bridges are usually old. Building narrower roads was mentioned 17 times. The larger the road surface, the greater the amount of potential sediment generation. Although windthrow was often associated with riparian leave strips, the volume of sediment generated remained in the “Very Low” and “Low” Water Quality Impact Class for the sites evaluated.

3. CONSTRUCTION OF ROAD AND HARVESTING

Problems with the construction of road and harvesting of cutblocks were mentioned 308 times (the largest category associated with any forestry-related activity). The most frequent recommendation was the need to armour and/or reseed bare ground as soon as possible after construction (195 sites). Depending on the amount of coarse rock in a native soil, most disturbed soils eventually “self-armour” as the fines are selectively removed by erosion. Road construction in stone-free silty soils are problematic because they depend only on revegetation for protection. On cut banks, such soils were found to resist revegetation because of pervasive needle ice formation and its destruction of surface vegetation. Sensitive soil requires special consideration when roads are being built and other means of sediment management considered (such as interception of any generated storm flow and diversion before reaching stream) in road design. Using better road subgrade and capping material was mentioned 45 times and using coarse rock armouring at culvert outfalls, 32 times. Fulfilling such recommendations depends on the presence of nearby gravel pits and quarries. Long haul distances in some districts mean that licensees must sometimes choose other methods of addressing sediment problems. While the road construction phase generates the highest levels of fine sediment, it is apparent that immediately addressing connectivity on those sites can dramatically lessen the water quality impact while those sites are “hardening up.”

4. ROAD MAINTENANCE

Improving road maintenance to reduce water quality impact was mentioned 241 times – 199 in association with grading operations (managing road crowns and grader berms). In many cases, simply breaking a berm to allow water to leave a road before it reached the stream could dramatically reduce water quality impacts. Where road subgrade permits crowning, maintenance of the crowned profile permits at least the outside half of road drainage to flow safely onto the forest floor. Problems associated with road maintenance are mostly addressed in day-to-day decision making by road workers.

5. ROAD DEACTIVATION

Road deactivation was mentioned 173 times (restricted to roads no longer in active use). The recommendations were primarily associated with placing and designing cross-ditches and waterbars, and locating spoil areas. Possible quad and dirt bike activity was recorded as the primary reason for the breakdown of functioning cross-ditches and waterbars, and in some cases rutting of roads. The evaluation methodology provides a simple, direct means to choose specific locations for ditchblocks, cross-ditches, and waterbars to address sediment and erosion control.

Although the water quality evaluation procedure estimates a potential volume of sediment likely to erode from a road surface annually, the procedure does not assess who is responsible for generating that volume of sediment. The roads assessed by this procedure were originally constructed to access timber. However, since their construction, many are now used for various non-forestry resource activities such as mining, agriculture, range, recreation, oil, and gas. All of these activities can be potentially responsible for some or all of the fine sediment generated by the road. Consequently, the attribution of a volume of sediment generated by any particular road segment to any resource activity is beyond the scope of the water quality effectiveness evaluation procedure.

CONCLUSIONS

All aspects of road management (and to a lesser degree, cutblock management), from their initial location through to eventual deactivation, play a crucial role in helping to minimize water quality impacts. The conditions most associated with water impacts at sites repeatedly emphasized the importance of artificial drainage management and ensuring that disturbed sites are either quickly revegetated or armoured (Figure 3). These concerns are directly manageable by road and site supervisors. In all five activities of concern discussed above, training workers about the impact of their activities on potential

water quality impacts can dramatically improve licensee's performance. The most commonly recognized specific concerns/recommendations identified were:

1. minimizing soil disturbance during construction of road/harvesting cutblock;
2. increasing the number of culverts during the design of road/cutblock;
3. using cross-ditches, kick-outs, etc. during deactivation;
4. seeking alternate road alignment in the location of roads;
5. removing road berms; and
6. using good quality materials and road crown in road/cutblock management/maintenance.



Figure 3. This resource road approaching a stream crossing has incorporated many attributes required to minimize water quality impacts. The cut banks and fill slope are well vegetated, a culvert and ditchblock are strategically located to remove inside ditch water and allow sufficient forest floor to reabsorb the water, a swale is located before the bridge, and the bridge deck itself (from which the photo was taken) built above road grade.

The potential for range impacts was noted at between 38 to 90% of the sites evaluated, depending on year of sampling. In other words, a drinking water intake where livestock were noted upstream had a good chance of being impacted by fecal contamination. These potential impacts most frequently occurred where livestock had direct access to the stream.

However, many problem situations influencing water quality fall outside the direct responsibility and/or authority of road managers. A major resource road issue has arisen where the primary users of the road are not the road

permit holder. Mining and oil exploration were dominant users of certain resource roads still under forest licensee permitting. Recreationists were found to use certain roads heavily, sometimes substantially, increasing the water quality impact. In particular, constructing informal stream crossings, building trails, and removing barricades from deactivated roads were commonly reported, which led to greater sedimentation. Newly opened forest roads have very low direct inputs on sediment generation; however, where livestock are present, there is an increased risk of fecal contamination of domestic water sources. Community Forest Committees throughout the province struggle with fine tuning and then administering access management plans to address such issues. Revisiting policies dealing with management of resource roads in British Columbia would be welcomed.

Other resource managers have applied the methodology used here to evaluate the water quality impact of sites. Community Watershed Managers have found the methodology helps set priorities for road maintenance budgets. Licensees have given their road management staff (including foremen, surveyors, engineers, excavator, and grader operators) training in use of the methodology to fine tune their day-to-day operations. The Forest Practices Board has also used the methodology to evaluate compliance with regulations under the *Forest and Range Act*.

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