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WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

TIMBER FISH
& WILDLIFE

EFFECTIVENESS OF FOREST ROAD AND TIMBER HARVEST BEST MANAGEMENT PRACTICES WITH RESPECT TO SEDIMENT-RELATED WATER QUALITY IMPACTS

Interim Report No. 1

June 1993
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Interim Report No. **1**

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June 1993

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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ABSTRACT

This study to evaluate the effectiveness of certain forest road and timber harvest best management practices (BMPs) is being conducted as a part of the Timber/Fish/Wildlife Cooperative Monitoring, Evaluation and Research Program. The purpose of this first Interim Report is to describe the sampling design for the study, the study sites established to date, survey methodologies employed, and to present our field survey protocols. The project is employing a case study approach to evaluating BMP effectiveness. A total of 75 to 90 examples of typical BMPs, implemented under varying degrees of landscape hazard, will be selected from six of the nine physiographic regions of Washington. General BMP categories targeted in the study include road construction practices, road maintenance practices, and timber harvesting practices. A number of qualitative and quantitative survey techniques are being employed to assess erosion and sediment delivery to streams, aquatic habitat conditions, and biological communities. In most cases, two or more survey techniques are. applied to each BMP example studied. The different survey techniques will provide different kinds of evidence on forest practice effects, leading to a weight-of-evidence approach to determining BMP effectiveness. Thirty-six study sites have been identified so far in the project, at which 79 specific BMP examples are being evaluated. These include 37 harvesting BMPs (tractor/wheeled skidding, Riparian Management Zones, and Riparian Leave Tree- Areas), 38 new road construction BMPs (road drainage design, culvert installation, and construction techniques), and four road maintenance BMPs (active haul road maintenance). Six physiographic regions of the state are represented in the sample.

INTRODUCTION

This study to evaluate the effectiveness of certain forest road and timber harvest best management practices (BMPs) is being conducted by the Department of Ecology as a part of the Timber/Fish/Wildlife (TFW) Cooperative Monitoring, Evaluation, and Research Program (CMBR). The project is sponsored by CMER's Water Quality Steering Committee, and is funded jointly by CMER, Ecology, and the U.S. Environmental Protection Agency.

The Washington Forest Practices Rules and Regulations (Title 222 WAC) contain numerous BMPs intended to minimize the impacts of erosion and sedimentation on water quality. The conceptual efficacy of these BMPs in addressing four categories of erosion processes has been evaluated for the Water Quality Steering Committee by Pentec Environmental, Inc. (Pentec, 1991). Pentec has also recommended methods for conducting quantitative and qualitative evaluations of BMP effectiveness. The four erosion process categories considered by Pentec are: 1) landslides and other rapid mass wasting processes, 2) slumps and earthflows, 3) surface erosion, and 4) channel-bank erosion. The relative extent to which these four processes account for forest practice-related sediment impacts to water quality varies among the different forested regions of Washington and locally within regions, depending on topographic, geologic and climatic conditions. Because of the time scales in which some of these processes occur, this project will primarily be evaluating the effects of surface erosion and channel-bank erosion on water quality. However, landslides and other rapid mass wasting processes may also occur within the 2-3 year timeframe of the project.

The overall test of BMP effectiveness will be the extent to which the BMPs achieve compliance with Washington's surface water quality standards by avoiding sediment-related water quality impacts from forest management activities. These standards prohibit the degradation of aquatic resources in such a manner that it impairs the suitability of water for any aquatic life, wildlife, or human use (i.e., beneficial uses). The standards apply to all types of surface waters.

The water quality standards regulation (Chapter 173-201A WAC) includes both numeric and narrative (i.e., descriptive) criteria that apply to sediment-related impacts. Numeric criteria for turbidity prohibit an increase of 5 NTU, or 10% over background levels, whichever is greater. Narrative criteria that apply to sediment are rather broad, and include general criteria that the water quality must meet, or in the case of Class AA waters, exceed the requirements of characteristic water uses. Other narrative criteria prohibit materials which may adversely affect characteristic uses, cause acute or chronic conditions to aquatic biota, or impair aesthetic values. Other than turbidity, however, there is a lack of clear, numeric criteria for determining when sediment-related impacts violate water quality standards. For the purpose of determining BMP effectiveness, various decision criteria for applying narrative water quality standards to forest practice impacts must be developed.

The project is not intended to specifically address cumulative effects of forest practices. Rather, this study will attempt to isolate the site-specific impacts of individual forest practices. The focus of the project is on testing the effectiveness of standard BMPs based on parameters which indicate the near-field impacts of the activity the BMP is intended to address. The watershed analysis process (Chapter 222-22 WAC) has been established to evaluate the cumulative effects of forest practices in Washington State. We recognize that the watershed analysis process will likely result in customized forest practice prescriptions that go beyond standard BMPs for certain situations. However, there will remain numerous situations where standard BMPs will be used, hence it is necessary to determine the effectiveness of these standard BMPs.

The objectives of the project are to:

1) gather qualitative and quantitative information on BMP effectiveness by monitoring representative examples of selected timber harvesting, road construction, and road maintenance practices;
2) develop and apply decision criteria for determining whether water quality standards are met where forest practice-related sediment impacts are concerned;
3) evaluate and describe the factors influencing BMP effectiveness; and
4) determine whether certain BMPs require modifications in order to achieve water quality standards, and recommend such changes.

The purpose of this Interim Report is to describe the sampling design for the study,, to describe the study sites established to date and survey methodologies employed, and to present .our field survey protocols. This is the first of two interim reports. The second interim report is scheduled for April 1994, with the final project report to be completed in June 1995.

METHODS

We are using a case study approach to evaluating the effectiveness of the targeted BMPs, and are employing a sample stratification scheme to produce a collection of care studies that is representative of statewide BMP implementation. Our goal is to evaluate *typical* BMPs implemented under varying degrees of inherent landscape hazard in different physiographic regions of the state. We expect to have BMP examples within each of these strata, with the distribution among strata determined by the distribution of Forest Practices Applications (FPAs) submitted within the various physiographic regions. We will use. a weight-of-evidence approach that considers results from multiple survey techniques to determine the effectiveness of BMPs implemented in a variety of settings. This will allow us to assess a range of BMP effectiveness and to describe various factors influencing effectiveness.

Overview of Sampling Design

The project study plan calls for the sample, grouped according to general BMP categories, to be stratified according to physiographic regions and relative hazard classes. As called for in the project study plan (Rashin, 1992), experience gained during the pilot phase was used as a "reality check" to refine the scope of the project. The study plan included a map of physiographic regions compiled by Pentec (1991), a landscape hazard classification scheme, and a table listing various high and low priority BMPs to sample. During the pilot phase of the project, we refuted the regional stratification scheme, the hazard classification scheme, and the list of BMPs to sample (Rashin *et* al., 1992).

BMPs Under Consideration

The study plan included a table that lists BMPs grouped according to "Higher Priority" and "Lower Priority." We have decided not to actively pursue examples of the lower priority BMPs, which include site preparation, cable yarding, maintenance of inactive and abandoned roads, slash disposal, and landing location/construction BMPs. Whiie these BMPs are important, we believe it is necessary to focus our sample on the higher priority BMPs. These include new road construction techniques, road drainage design, stream crossings and culvert installation, maintenance of active ("mainline") haul roads, tractor and wheeled skidding, riparian management zones (including stream bank integrity practices), and riparian leave tree areas. The BMPs evaluated in this project are presented in Appendix A, which contains excerpts from the Forest Practice Rules (Title 222 WAC). We acknowledge that some of the lower priority BMPs, particularly maintenance of inactive and abandoned roads, are quite important as sources of sediment that may impact water quality, but it was necessary to narrow our scope in order to more effectively evaluate the higher priority BMPs. With maintenance of inactive roads, compliance with applicable regulations has been shown to be lacking in many cases (TFW Field Implementation Committee, 1991), and it would be difficult to separate impacts due to non-compliance from those associated with proper BMP implementation. For this reason, we are focusing on maintenance of active haul roads, which have a better compliance record. While we will not focus our efforts on the lower priority BMPs, we may obtain some information on their effectiveness where this is reflected in our surveys of other practices. For example, in some cases we will evaluate the effectiveness of Riparian Management Zones or Riparian Leave Tree Areas within units where cable-yarding is used. In evaluating the effectiveness of the stream buffers, we will gather secondary information on the effects of cable-yarding practices.

In order to stratify our sample and focus our efforts in a deliberate way, we are targeting a proportion of the total number of BMP examples to each general BMP category. The priorities for addressing sediment-related water quality impacts, based on our literature review and discussion with field personnel and the WQSC, suggest focusing about 40% of our sample on harvest BMPs, 40% on new road construction, and 20% on active haul road maintenance. Our current expectation is that we will have a total sample sire of 75 to 90 examples of specific BMPs, evaluated at 35 to 40 different study sites. In many cases we will assess more than one specific BMP example at a given forest practice unit or study site.

Reeional Stratification

The map of physiographic regions, shown in Figure 1, is slightly modified from that given in the study plan. We have changed the boundaries between the Northern Rockies (referred to as the Okanogan Highlands in the Pentec map), Eastern Cascades, and Columbia Basin to reflect the ecoregion boundaries given in Omemik and Gallant (1986). We have also revised the boundary between the Willapa Hills and Southern Cascades regions to better reflect similarities in surface geology, soils, and pleistocene glaciation effects.

During the pilot phase of the study we decided to modify the statewide scope of the project. We will not be sampling within three of the nine physiographic regions: Columbia Basin, Blue Mountains, and Puget Lowlands. The Columbia Basin is an obvious choice for exclusion because it has very little commercial forest land. A limited amount of state or privately owned forest land is found in the Blue Mountains region, and we have screened and conducted reconnaissance on potential study sites there. However, we have decided to exclude this region from our sample because interferences from past logging and grazing practices appear to be rather widespread, and it is far from our base of operations. We believe that many of our observations made in other regions of eastern Washington will be applicable to BMP effectiveness in the Blue Mountains region. We have excluded the Puget Lowlands because of the need to further narrow our focus and our perception that land use conversion plans may affect BMP implementation on many of the forest practice operations in this region.

We plan to distribute our sample over the remaining regions according to the approximate proportions of FPAs submitted for these regions. We have used the Forest Practice Program 1991 Calendar Year Report (Department of Natural Resources, 1992) as a guide to this distribution. We made several assumptions about distribution within the DNR regions, since their regional boundaries did not correspond with our physiographic regions. We assumed that the 1991 distribution of Class III and Class III Priority FPAs approximates the distribution of BMPs we seek to sample. Based on the statistics summarized in the report, we plan to distribute our total sample (defined by the number of specific BMP examples we evaluate) as shown in Figure 1.

Hazard Classification

For purposes of sample stratification, we have simplified the landscape hazard classification scheme presented in the study plan. We now identify high, moderate, and low hazard categories based solely on slope gradient. The former scheme incorporated slope form and rain-on-snow hydrology as modifiers to the slope hazard. While we acknowledge that these as well as other factors influence the inherent landscape hazard, we believe that it is most appropriate. to evaluate their influence on a case by case basis. For purposes of distributing our sample across varying degrees of inherent hazard, we will use the unmodified slope hazard classification. We believe that slope gradient is a primary controlling factor, and one that can be objectively defined and determined on-site from easily obtained field measurements. The slope hazard category for each BMP example is based on the steepest hillslope gradient in the vicinity of streams. This is

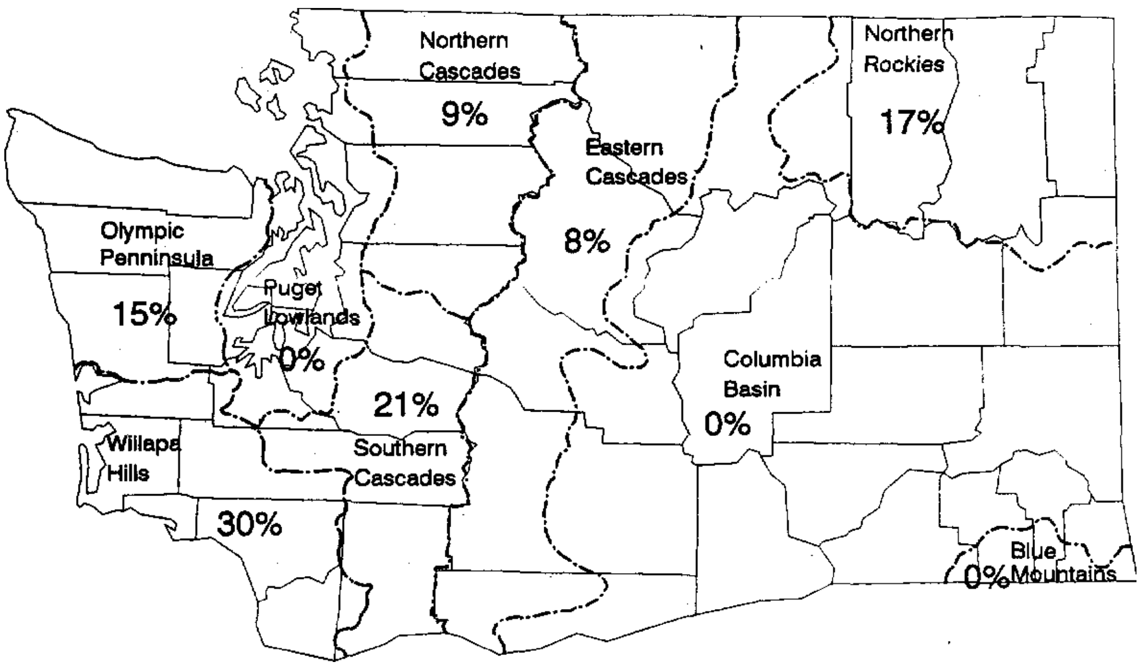

Figure 1: Targeted Sample Distribution by Physiographic Region

because hillslopes are generally steepest near streams (e.g., where roads cross streams), and it is the near-stream areas that are most critical from the standpoint of water quality protection.

While we have simplified the scheme in terms of the factors considered, we have decided to have separate schemes for harvesting and road-related BMPs. We have done this because of a difference in the relative dominance of erosion processes; surface erosion may be a more dominant process for harvest practices such as skidding, whereas mass wasting processes may be more important for mad construction and maintenance. The new scheme is presented below in Table 1.

TABLE 1: SLOPE HAZARD CLASSIFICATION
(For Purposes of Sample Stratification)

BMP Category	LOW	MODERATE	HIGH
Harvesting BMPs	0-19% slope	2040% slope	>40% slope
New Road Construction & Road Maintenance BMPs	0-19% slope	20-50% slope	>50% slope

We believe that our process of screening groups of forest practice units within a region and considering all potential study sites (i.e., practices in the vicinity of streams) will result in a sample that reflects the approximate distribution of targeted BMPs across the three slope hazard classes.

Study Site Selection

Study site selection for the project generally begins by screening Forest Practices Applications (FPAs) submitted to Ecology Regional Offices for road building and ground-based harvesting practices conducted near streams. Potential study sites are also identified through annual review materials and other information provided by forest land owners. We discard any forest practice units that do not include type l-5 waters within or adjacent to the operational boundary, and organize the potential study sites according to physiographic region. We then contact the landowner. Landowners willing to participate in the study are asked a series of questions regarding operation timing, accuracy of water type maps, and access to the sites.

After identifying potential study sites within a physiographic region, a field reconnaissance survey is conducted. Typically, an integral part of the field survey is a meeting with the landowners to facilitate information exchange and logistics. After landowner consultation, a field visit is made to candidate sites to determine their acceptability as study sites. The field reconnaissance protocol is presented in Appendix B.

Acceptance of a candidate site involves four primary criteria:. representativeness, timing, isolation, and control site availability. Representativeness refers to whether the forest practice is a typical example of the BMP that has been implemented in accordance with the Forest Practice Rules. In addition to an evaluation by the research team, compliance with the rules is often evaluated by talking with forest practices foresters or others familiar with compliance issues about our study sites. In some cases, a field visit is made with a person having a forest practices compliance background. Because many of the current rules indicate that acceptability of certain practices is to be "determined by the department" (i.e., based on the juclgement of the DNR Forest Practice Forester), we normally take the stance that if the Forest Practices Application (FPA) was approved and the practice was implemented according to the FPA, the practice is in compliance. In cases where an interdisciplinary team was involved in conditioning the FPA, this is noted in the reconnaissance record.

Timing refers to the date of the actual operation in relation to a major hydrologic event. We generally discard operations which occurred before a high intensity, runoff-producing rain storm, rain-on-snow or other major snowmelt event. For certain BMPs and for in-stream surveys it is important to conduct preliminary surveys before the practice is conducted. This is generally the case with harvest BMPs. On the other hand, for many of the BMPs and survey techniques, it is preferable or necessary to have the practice on the ground before we begin our surveys. For example, when evaluating culvert installations, road cutbank or fillslope erosion, or sediment routing from skid trails, conditions existing in upland areas before the practice are not necessarily relevant to our study, and conditions in stream channels downstream of the practice will not be impacted until a significant hydrologic event occurs. The important information for the study is how the upland features and stream crossings do or do not stabilize over the one- to three-year period following BMP implementation, and whether or not sediment is routed to streams.

The isolation criterion refers to land use patterns and the ability to separate the effects of the BMP from cumulative effects of other forest practices or land use interferences such as grazing and mining. We discard sites which demonstrate substantialimpacts from these other land uses that might interfere with our survey results--a particular concern in eastern Washington. The location and timing of other forest practice activities are considered in deciding whether we can isolate the targeted BMP. An upstream/downstream sampling design, looking primarily at near-field indicators of BMP effectiveness, generally allows us to isolate site specific influences of the practice. Recognizing that most of the state and private forest land base has experienced some historical cumulative effects, we are primarily *concerned* with being able to identify the *net* effect of the BMP examples we study.

The fourth criterion involves the availability of a control site, usually a stream reach immediately upstream from the BMP. This is a requirement if we are planning to do in-stream surveys at the site. Off-site reaches may be used as controls if they are nearby and have similar morphology and flow regime. The procedure for evaluating 'whether treatment and control reaches are similar is detailed in the field reconnaissance protocol in Appendix B. Sites lacking suitable controls are discarded if the BMP evaluation requires in-stream surveys.

Potential study sites satisfying the site selection criteria are accepted. The selection of samples (i.e., BMP examples) is not random in the technical sense because of our site selection criteria. However, it is random in the general sense that when selecting study sites we begin by considering several BMP examples for an area (e.g., a stack of recently approved FPAs), and our screening process eliminates only those which do not meet our criteria. All others are considered as potential sites.

Field Survey Methods

In order to systematically gather qualitative and quantitative information on BMP effectiveness at selected field sites, we have developed and field tested numerous survey methodologies. In developing these survey methods we held focused work sessions to discuss our working assumptions, site and timing conditions required by the survey techniques, the relative sensitivity of the techniques to documenting changes that may occur over the study period, and how results of the surveys will be used in our BMP effectiveness evaluations. Detailed field survey protocols are presented in Appendix B. The protocols include a purpose statement, equipment and materials required, site selection criteria, method summary, assumptions relating specifically to the survey method, specific steps for data collection, a conceptual rating strategy for BMP effectiveness, miscellaneous notes and recommendations for conducting each survey, references, and field forms. In the case of the two protocols for amphibian, and macroinvertebrate bioassessment, less detail is provided since these surveys are primarily conducted cooperatively by other investigators according to published methods.

Each of our survey methods has been identified as qualitative, quantitative, or both in Table 2. Also included in Table 2 are abbreviations for each survey and the general BMP category which may be evaluated by the survey. As outlined in the study plan, it is our intent to overlay quantitative surveys on qualitative surveys for at least 15-20% of the total number of BMP examples evaluated.

Site selection criteria have been described above. At sites which meet our selection criteria, we first conduct preliminary qualitative surveys (e.g., channel condition, photo point surveys, cutbank/fill slope condition, culvert condition, etc.). Then, as time permits, and as required in that particular physiographic region, we conduct preliminary quantitative surveys (e.g., streambank erosion, streambed stability, channel substrate transects, erosion pin networks, etc.). Follow-up site visits are often required in order to complete all planned surveys. For example, sediment routing surveys are conducted after the aerial photography has been flown, and mainline haul road run-off surveys are conducted during run-off events only. A series of follow-up surveys will be conducted from one to three years following the preliminary surveys to evaluate change in erosion and sediment delivery processes over the study period.

Table 2. Survey Techniques Summary

Survey Name	Abbv.	Qualitative	Quantitative	Harvest	Road Const.	Road Maint.
Photo Point Survey	PS	X		X	X	X
Channel Condition Survey	CS	X		X	X	X
Streambank Erosion Survey	SE	X	X	X	X	
Streambed Stability Survey	ST	X	X	X	X	
Channel Substrate Survey	SU	X	X	X	X	
Culvert Condition Survey	CC	X			X	X
Cutbank/Fillslope Survey	CF	X			X	X
Erosion Pin Network	EP		X	X	X	
Road Surface Condition Survey	RS	X	X			X
Runoff Sampling	RO		X	X	X	X
Sediment Routing Survey	SR	X		X		
Amphibian Survey	AM		X	X		
Macroinvertebrate Survey	MI		X	X	X	X

Table 4: Study Site Information, cont.

uthern Cascades	S-01	Road Maintenance	Active Haul Road Maintenance
	S-02	New Road Construction	Road Drainage Design Culvert Installation -- Construction Techniques
	S-03	New Road Construction	Road Drainage Design Construction Techniques Culvert Installation
	s-04	Harvest	RLTA
	s-05	Harvest	RLTA
	S-06	Harvest	Tractor/Wheeled Skidding
	s-07	Harvest	RMZ
	S-08	Harvest	RMZ
	s-09	Harvest	RMZ
istern Cascades	E-01	New Road Construction	Culvert Installation Road Drainage Design
	E-02	New Road Construction	Road Drainage Design Culvert Installation Construction Techniques
	E-04	Harvest	Tractor/Wheeled Skidding
	E-05	Harvest	Tractor/Wheeled Skidding
orthern Rockies	R-01	New Road Construction	Culvert Installation
		Harvest	Tractor/Wheeled Skidding RMZ
	R-02	Harvest	RMZ Tractor/Wheeled Skidding
		New Road Construction	Road Drainage Design Construction Techniques Culvert Installation
	R-03	Harvest	RMZ Tractor/Wheeled Skidding
	R-04	Harvest	RMZ
	R-05	Harvest	RMZ Tractor/Wheeled Skidding
	R-06	Harvest	RMZ Tractor/Wheeled Skidding
	R-07	Harvest	RMZ Tractor/Wheeled Skidding
		New Road Construction	Road Drainage Design Construction Techniques Culvert Installation
	R-08	Harvest	RMZ Tractor/Wheeled Skidding

We have summarized the key hypotheses we are testing in Table 3. The hypotheses are organized by BMP, and survey methods that may be considered for testing each hypothesis are indicated. These hypotheses address BMP effectiveness from the standpoint of what each BMP is designed to accomplish.

Determination of BMP Effectiveness

This project will use a weight-of-evidence approach to determine BMP effectiveness. That is to say that we will generally use a combination of survey techniques to gather evidence of effectiveness for each BMP example we study. The surveys allow us to collect different kinds of information on various water quality related parameters. Some surveys will provide evidence of erosion in upland areas and sediment delivery to streams, while others will provide evidence of changes in aquatic habitats (i.e., stream channels) or biological communities. In addition to collecting different kinds of evidence, the different survey techniques also vary in their sensitivity for detecting changes in sediment dynamics and water quality impacts, with some surveys sensitive only to gross changes and others able to detect more subtle effects.

The weight-of-evidence approach is illustrated in Figure 2. The results of each survey will be evaluated using decision criteria relating survey results to the water quality standards. Survey results will fall into one of three categories: "Yes," the BMP example was effective; "No," the BMP example was not effective; or, in some cases, "Indeterminate," meaning effectiveness could not be determined for this BMP example with the survey technique used. Indeterminate calls may be used where it is found that the survey technique was not appropriate to document the type of change that occurred at a particular site, or where interferences did not allow adequate evaluation of a particular practice. The evidence from the different survey techniques employed will be used collectively to determine effectiveness of that particular BMP example. However, since the survey techniques vary in their sensitivity, all survey results may not be weighted equally in the overall BMP effectiveness call. Such a weight-of-evidence approach to evaluating BMP effectiveness has been recommended in a national effort spear-headed by the U.S. Forest Service (Dissmeyer, 1993), and is consistent with the approach outlined by MacDonald et *al.* (1991) in the Environmental Protection Agency's monitoring guidelines for evaluating the effects of forest practices on streams in the Pacific Northwest.

Tests of BMP effectiveness will be based on narrative and numeric water quality standards issues, especially beneficial use impairment. Effectiveness or ineffectiveness may be reflected in assessments of erosion and sediment delivery to streams, aquatic habitat condition, direct assessment of biota, or a combination of these types of information. For in-stream surveys, determining the effects of the BMP example will be based largely on changes in the magnitude or rate of erosion, sediment deposition, or stream channel destabilization in the treatment (downstream) reach relative to the control (upstream) reach. The effects of delivered sediment (as may be documented by on-slope monitoring techniques) that is transported downstream of the BMP implementation site will also be considered.

Table 3: Hypotheses Framework for Sediment BMP Study

BMP Category	Null Hypotheses to be Tested	Surveys to Test Hypothesis
New Road Construction		
A) Road Drainage Design WAC 222-24-025 (5)-(9)	A) BMP specifications for design of road prism and drainage structures result in adequate drainage relief (i.e. dissipation of runoff volume/energy) such that drainage from new road construction will not cause accelerated bank and channel erosion, mass wasting, or other erosion in stream channels and zero order basins that degrades aquatic habitat or negatively affects other beneficial uses.	-Culvert Condition Survey -Cutbank/Fillslope Survey -Photo Point Survey -Channel Condition Survey -Streambank Erosion Survey -Streambed Stability Survey
B) Culvert Installation and Temporary Stream Crossings WAC 222-24-040 (2)-(4)	B) BMP specifications result in culverts and temporary stream crossings that are adequately designed and stabilized such that there is no continuing erosion with sediment delivery to surface water; accelerated streambank erosion; culvert blowouts or other mass failure at stream crossings that degrades aquatic habitats or negatively affects other beneficial uses.	-Culvert Condition Survey -Photo Point Survey -Channel Condition Survey -Streambank Erosion Survey -Streambed Stability Survey -Channel Substrate Survey
C) Construction Techniques WAC 222-24-030 (2) & (4)-(9)	C) BMP specifications for new road construction result in adequately stabilized cut and fill slopes and properly placed sidecast material such that new road construction sites are not subject to excessive surface erosion and mass wasting that results in sediment delivery to surface water and subsequent degradation of aquatic habitat or other beneficial uses.	-Cutbank/Fillslope Survey -Culvert Condition Survey -Photo Point Survey -Channel Condition Survey -Streambank Erosion Survey -Streambed Stability Survey -Channel Substrate Survey -Erosion Pin Network -Runoff Sampling -Macroinvertebrate Survey

Road Maintenance

D) Active Haul **Roads** WAC **222-24-050** (2) **& (4)**	**D) BMP** specifications for maintenance of active haul roads **result** in roads that are maintained to minimize erosion of road surfaces and keep road subgrades, culverts, and ditches functional so that surface erosion and mass wasting do not result in delivery of **sediment** to surface water and subsequent degradation of aquatic habitats or other beneficial uses.	-Road Surface Condition Survey -Runoff Sampling **-Cutbank/Fillslope** Survey -Channel Condition Survey **-Channel** Substrate Survey **-Macroinvertebrate** Survey

Harvesting

E) Tractor **&** wheeled Skidding WAC **222-30-070 (1)-(5) & (7)-(9)**	**E) BMP** specifications for ground-based yarding systems are adequate to avoid excessive erosion and protect streams, such that erosion and subsequent sediment delivery to streams and destabilization of **streambanks** and channels **does** not degrade aquatic habitats or negatively affect other beneficial uses.	-Sediment Routing Survey -Photo Point Survey -Channel Condition Survey **-Streambank** Erosion Survey **-Streambed** Stability Survey -Channel Substrate Survey -Erosion Pin Network -Runoff Sampling **-Macroinvertebrate** Survey -Amphibian Survey
F) RMZs, Streambank Integrity, & RLTAs WAC **222-30-020 (3)-(5), and WAC 222-30-030**	**F) BMP** specifications for Riparian Management Zones **(RMZs), Streambank** Integrity, and Riparian Leave Tree Areas **(RLTAs)** are adequate to prevent disturbance of stream banks and channels and prevent sediment delivery to streams that degrades aquatic habitats or negatively affects other beneficial uses.	-Sediment Routing Survey -Photo Point Survey -Channel Condition Survey **-Streambank** Erosion Survey **-Streambed** Stability Survey -Channel Substrate Survey **-Macroinvertebrate** Survey -Amphibian Survey -Runoff Sampling

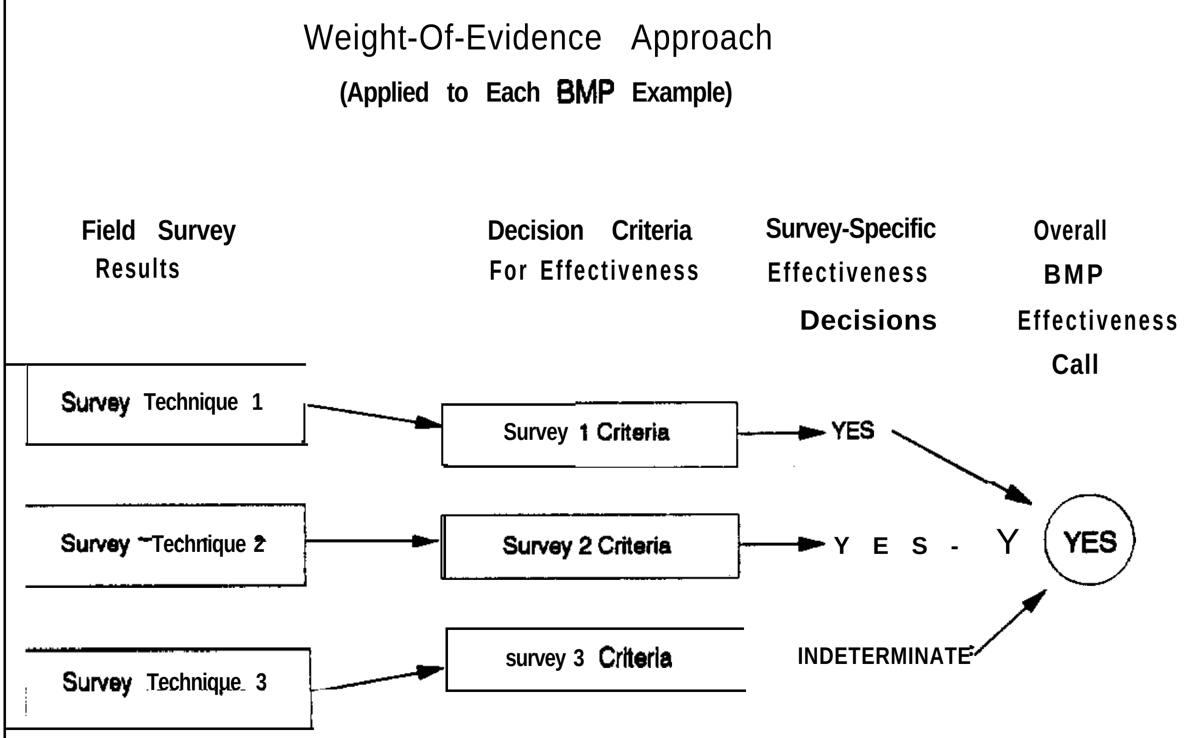

Figure 2: Schematic of Weight-of-Evidence Approach Used to Determine BMP Effectiveness

Several of the BMPs described in the Forest Practices Rules and Regulations apply explicitly to type 1, 2, 3, and in some cases type 4 waters. With such rules, an important aspect of BMP effectiveness that will be considered is the lack of explicit protection provided for type 5, and in some cases, type 4 waters. As discussed in Pentec (1991), first and second order channels (type 5 and 4 waters) comprise over 80% of the cumulative channel length in mountainous watersheds and are significant sites for erosion and sediment production processes. This project will evaluate the effectiveness of targeted BMPs from the standpoint of the protection provided for all water types, not just water types explicitly stated in the language of the rules. This is because the water quality standards apply to all water types.

The survey protocols presented in Appendix B contain conceptual strategies for rating BMP effectiveness. Development of final decision criteria for determining whether water quality standards are achieved, including criteria for interpreting narrative water quality standards, will be a significant part of the analysis effort. Decision criteria which are appropriate for the various surveys will depend upon the range of results obtained and the variability and uncertainty inherent in the final data sets. The effort to develop decision criteria will include literature review and consultation with the Water Quality Steering Committee, the Department of Ecology Water Quality Program, and other experts on water quality standards issues and beneficial uses as related to sediment impacts. We envision the formation of a work group to help formulate decision criteria.

In addition to using multiple survey techniques to evaluate specific examples' of BMP implementation, we will be making effectiveness calls for multiple examples of each BMP category assessed. This will lead to an overall determination of whether the BMP is effective, partially effective, or not effective, and under what situations. Factors associated with BMP effectiveness or ineffectiveness will be described. Based on these factors, recommendations will be developed for enhancing the forest practice rules to prevent sediment-related water quality impacts.

RESULTS

To date we have selected 36 study sites at which we are evaluating 79 examples of specific BMP implementation. Study site locations and physiographic regions are shown in Figure 3. Table 4 summarizes study site information according to physiographic regions and BMPs evaluated. We have categorized BMP examples into three general categories: harvesting, new road construction, and road maintenance. Within these general categories, we have identified "specific BMPs," which are groupings of closely related practices as listed in the Washington Forest Practices Rules and Regulations (Title 222 WAC--see Appendix A). Thus, each study site has one or more specific BMP example to be evaluated, and each specific BMP example may represent one or more individual practices, as listed in the WAC. Once a determination of compliance has been made for a study site, it is assumed that the site is representative of typical BMP implementation.

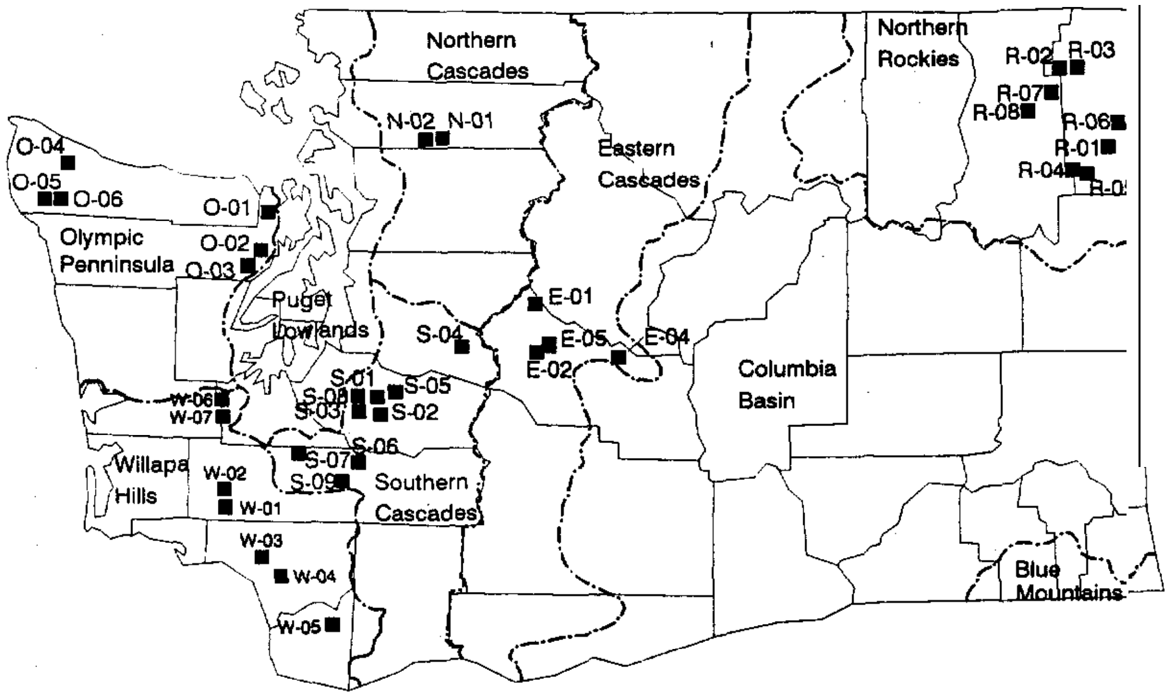

Figure 3: Physiographic Regions and Study Site Locations

Table 4: Study Site Information

Physiographic Region	Site ID #	BMP Category Evaluated	Specific BMP Evaluated
Olympic Peninsula	O-01	Harvest	Tractor/Wheeled Skidding RMZ
	O-02	Harvest	RLTA Tractor/Wheeled Skidding
	O-03	New Road Construction	Road Drainage Design Culvert Installation Construction Techniques
	O-04	Road Maintenance	Active Haul Road Maintenance
	O-05	Harvest	Tractor/Wheeled Skidding
		New Road Construction	Culvert Installation Road Drainage Design
	O-06	Harvest	Tractor/Wheeled Skidding RMZ
Willapa Hills	W-01	Harvest	RMZ Tractor/Wheeled Skidding
		New Road Construction	Culvert Installation Road Drainage Design Construction Techniques
	W-02	Harvest	Tractor/Wheeled Skidding
		New Road Construction	Culvert Installation Construction Techniques Road Drainage Design
	W-03	New Road Construction	/Culvert Installation Road Drainage Design Construction Techniques
	w-04	Road Maintenance	Active Haul Road Maintenance
	w-05	New Road Construction	Culvert Installation Road Drainage Design Construction Techniques
	W-06	Harvest	RMZ
	w-07	Harvest	RMZ
Northern Cascades	N-01	Harvest	Tractor/Wheeled Skidding RLTA
		New Road Construction	Road Drainage Design Construction Techniques Culvert Installation
	N-02	Road Maintenance	/Active Haul Road Maintenance

Table 4: Study Site Information, cont.

uthern Cascades	S-01	Road Maintenance	Active Haul Road Maintenance
	S-02	New Road Construction	Road Drainage Design Culvert Installation -- Construction Techniques
	S-03	New Road Construction	Road Drainage Design Construction Techniques Culvert Installation
	s-04	Harvest	RLTA
	s-05	Harvest	RLTA
	S-06	Harvest	Tractor/Wheeled Skidding
	s-07	Harvest	RMZ
	S-08	Harvest	RMZ
	s-09	Harvest	RMZ
istern Cascades	E-01	New Road Construction	Culvert Installation Road Drainage Design
	E-02	New Road Construction	Road Drainage Design Culvert Installation Construction Techniques
	E-04	Harvest	Tractor/Wheeled Skidding
	E-05	Harvest	Tractor/Wheeled Skidding
ortbern Rockies	R-01	New Road Construction	Culvert Installation
		Harvest	Tractor/Wheeled Skidding RMZ
	R-02	Harvest	RMZ Tractor/Wheeled Skidding
		New Road Construction	Road Drainage Design Construction Techniques Culvert Installation
	R-03	Harvest	RMZ Tractor/Wheeled Skidding
	R-04	Harvest	RMZ
	R-05	Harvest	RMZ Tractor/Wheeled Skidding
	R-06	Harvest	RMZ Tractor/Wheeled Skidding
	R-07	Harvest	RMZ Tractor/Wheeled Skidding
		New Road Construction	Road Drainage Design Construction Techniques Culvert Installation
	R-08	Harvest	RMZ Tractor/Wheeled Skidding

The 79 BMP examples selected to date include 37 harvesting BMPs (tractor/wheeled skidding, Riparian Management Zones, and Riparian Leave Tree Areas), 38 new road construction BMPs (road drainage design, culvert installation, and construction techniques), and four road maintenance BMPs (active haul road maintenance). Six physiographic regions of the state are represented in the sample. Table 5 is a matrix that shows the surveys conducted or planned for each of the study sites and specific BMP examples selected as of the date of this report. Planned surveys are subject to change in cases where they are dependent on weather or timing of forest practices.

During the initial phase of the study, we found that the FPA or other information on the proposed practice is often not available for screening very far in advance of the operation. Therefore, at several of our study sites we are having to rely on surveys which may be conducted following BMP implementation, such as the sediment routing survey and surveys evaluating the road prism and culvert installations. However, in more recent study site selection efforts we have been successful at finding sites early enough to evaluate BMPs using additional in-stream surveys.

At many of our study sites we are evaluating the effects of BMPs on small (type 4 and 5) streams. This is partly because it is-often difficult to meet our site selection criteria for isolation and control sites on larger streams, due to cumulative effects. It is also due in large part to the greater number of small streams located in the vicinity of forest practices. A focus on low order streams has been recommended in the U.S. Forest Service national approach to evaluating BMP effectiveness (Dissmeyer, 1993), based on the premise that the possibility of accurately evaluating forestry BMP effectiveness decreases with increasing stream order. However, we believe that with some of our survey techniques and with an upstream/downstream sampling design we can adequately address type 3 and larger streams in our evaluations of Riparian Management Zones and several other BMPs.

FUTURE EFFORTS

Preliminary surveys will be conducted at many of the study sites during the summer through fall period of 1993. The first set of follow-up surveys will be conducted in the late summer and fall of 1993 at those sites where preliminary surveys were conducted in the late summer and fall of 1992. A few additional study sites are needed in the Willapa Hills, Southern Cascades, and Northern Cascades regions. Additional examples of active haul road maintenance BMPs will be selected by late fall of 1993:

The project study plan states that study site selection will be coordinated with cumulative effects watershed analysis (WA) efforts, subject to other. site selection considerations (e.g. the stratification scheme). We had planned to consider incorporating BMP examples from watersheds where WA had been completed with prescription packages approved through the Forest Practice Rules provisions. This would allow an assessment of the effectiveness of the WA decision process for determining where standard BMPs are adequate and/or the effectiveness

*Table 5: Study Site Survey Matrix with Preliminary Surveys Completed and Planned**

Site ID #	Specific BMP Evaluated	Photo Point Network	Channel Condition Survey	Streambank Erosion Survey	Streambed Stability Survey	Channel Substrate Survey	Culvert Condition Survey	Cutbank/ Fillslope Survey	Erosion Pin Network	Road Surface Condition	Runoff Sampling	Sediment Routing Survey	Amphibian Survey	Macro– invertebrat Survey
O–01	Tractor/Wheeled Skidding	C							C			C		
	RMZ											C		
O–02	RLTA	C	C								P	C		
	Tractor/Wheeled Skidding	C	C								P	C		
O–03	Road Drainage Design	C	C				C	P						
	Culvert Installation	C	C				C							
	Construction Techniques	C	C					P						
O–04	Active Haul Road Maintenance		C							P	P			
O–05	Tractor/Wheeled Skidding	C	C	P	P							P		
	Culvert Installation						C							
	Road Drainage Design						C	P						
O–06	Tractor/Wheeled Skidding	C	C	P								P		
	RMZ											P		
W–01	RMZ	C	C			C						P		P
	Tractor/Wheeled Skidding	C	C			C						P		P
	Culvert Installation	P	P	P			P							
	Construction Techniques	P	P	P				P						
	Road Drainage Design	P	P	P			P	P						
W–02	Tractor/Wheeled Skidding	P	P									P		
	Culvert Installation		C				P							
	Construction Techniques		C					P						
	Road Drainage Design		C				P	P						
W–03	Culvert Installation						P							
	Road Drainage Design	P	C	P	P		P	P						
	Construction Techniques	P	C	P	P			P						
W–04	Active Haul Road Maintenance		P							P	P			
W–05	Culvert Installation	P	P				P							
	Road Drainage Design	P	P				P	P						
	Construction Techniques	P	P					P						
W–06	RMZ	C	C									P	C	P
W–07	RMZ	C	C									P	C	P
W–08	Active Haul Road Maintenance		C							P	P			

* C = surveys completed; P = surveys planned.

Table 5: Study Site Survey Matrix with Preliminary Surveys Completed and Planned, cont.

Site ID #	Specific BMP Evaluated	Photo Point Network	Channel Condition Survey	Streambank Erosion Survey	Streambed Stability Survey	Channel Substrate Survey	Culvert Condition Survey	Cutbank/ Fillslope Survey	Erosion Pin Network	Road Surface Condition	Runoff Sampling	Sediment Routing Survey	Amphibian Survey	Macro– invertebrate Survey
N–01	Tractor/Wheeled Skidding											P		
	RLTA											P		
	Road Drainage Design	P	P				P	P						
	Construction Techniques	P	P					P						
	Culvert Installation						P							
N–02	Active Haul Road Maintenance		P							P	P			
S–01	Active Haul Road Maintenance		C							C	C			
S–02	Road Drainage Design						C	C						
	Culvert Installation						C							
	Construction Techniques							C			P			
S–03	Road Drainage Design						C	C						
	Construction Techniques							C						
	Culvert Installation						C							
S–04	RLTA		P									P	C	
S–05	RLTA	P	P									P	C	
S–06	Tractor/Wheeled Skidding	C	C		P							P		P
S–07	RMZ	P	C		P							P	C	
S–08	RMZ	P	C		P							P	C	P
S–09	RMZ	P	C			P						P	C	P
E–01	Culvert Installation	C	C											
	Road Drainage Design	C	C											
E–02	Road Drainage Design	C	C	C			C	P	C					
	Culvert Installation	C	C	C			C							
	Construction Techniques	C	C	C				P						
E–04	Tractor/Wheeled Skidding	C										P		
E–05	Tractor/Wheeled Skidding											P		
R–01	Culvert Installation						P							
	Tractor/Wheeled Skidding	P	P									P		
	RMZ	P	P									P		

- C = surveys completed: P = surveys planned.

Table 5: Study Site Survey Matrix with Preliminary Surveys Completed and Planned, cont.

Site ID #	Specific BMP Evaluated	Photo Point Network	Channel Condition Survey	Streambank Erosion Survey	Streambed Stability Survey	Channel Substrate Survey	Culvert Condition Survey	Cutbank/ Fillslope Survey	Erosion Pin Network	Road Surface Condition	Runoff Sampling	Sediment Routing Survey	Amphibian Survey	Macro-invertebrate Survey
R-02	RMZ	P	C		P							P	C	P
	Tractor/Wheeled Skidding	P	C	P	P							P	C	P
	Road Drainage Design						P	P						
	Construction Techniques							P						
	Culvert Installation						P							
R-03	RMZ	P	P									P	C	P
	Tractor/Wheeled Skidding	P	P									P	C	P
R-04	RMZ	P	C									P	C	
R-05	RMZ	P	C			P						P	C	P
	Tractor/Wheeled Skidding	P	C			P						P	C	P
R-06	Tractor/Wheeled Skidding											P	C	
	RMZ											P	C	
R-07	RMZ	P	C									P	C	P
	Tractor/Wheeled Skidding	P	C	P								P	C	P
	Road Drainage Design					P	P	P						
	Construction Techniques					P		P						
	Culvert Installation					P	P							
R-08	RMZ	P	C									P	C	
	Tractor/Wheeled Skidding	P	C									P	C	

* C = surveys completed; P = surveys planned.

of the customized prescriptions developed through WA. However, it does not appear that the timing of completed prescription packages can accommodate this goal of coordinating our study site selection with WA. Therefore we will focus our efforts on evaluating standard BMPs as they are currently prescribed, including some which may be conditioned via the interdisciplinary team process.

Some of the BMP examples we are evaluating are co-located with the study sites selected for CMER's Wildlife Riparian Management Zone study. BMP examples considered at these sites will include riparian management zones and other harvest BMPs, as well as new road construction BMPs. One major advantage of co-locating study sites with the wildlife study is that many of these sites will have stream amphibian surveys conducted by the wildlife study teams. Another obvious advantage is that the timing of timber harvest activities has already been coordinated to accommodate before and after field surveys. Efforts to co-locate suitable study sites are being coordinated with CMER's Wildlife Steering Committee and the researchers from the University of Washington and Eastern Washington University.

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APPENDIX A: BEST MANAGEMENT PRACTICES EVALUATED
(Excerpted from the Washington Forest Practices Rules and Regulations, Title 222 WAC)

WAC 222-24-025 Road Design.

*(5) ALL ROADS should be outsloped or ditched on the uphill side and appropriate surface drainage shall be provided by the use of adequate cross drains, ditches, drivable dips. relief culverts, water bars, diversion ditches, or other such structures demonstrated to be equally effective.

*(6) CROSS DRAINS, relief culverts, and diversion ditches shall not discharge onto erodible soils, or over fill slopes unless adequate outfall protection is provided.

*(7) INSTALL cross drains, culverts, water bars, drivable dips, or diversion ditches on all forest roads to minimize erosion of the road bed, cut bank, and fill slope, or to reduce sedimentation of Type 1, 2, 3 or 4 Water. Cross drains are required in wetlands to provide for continued hydrologic connectivity. These drainage structures shall be installed at all natural drainages, all low points in the road gradient and spaced no wider than as follows:

Grade	Distance Westside	Distance Eastside
0 to 7%	1,000 ft.	1,500 ft.
8% to 15%	800 ft.	1,000 ft.
over 15%	600 ft.	800 ft.

More frequent culvert spacing or other drainage improvements are required where site specific evidence of peak flows or soil instability makes additional culverts necessary to minimize erosion of the road bed. ditches, cut bank, and fill slope to reduce sedimentation of Type 1, 2, 3 or 4 Waters, or within wetlands or to avoid unreasonable risk to public resources. See Part 5. Table 2 in the forest practices board manual for "Additional culvert spacing recommendations." On request of the applicant. the department may approve less frequent drainage spacing where parent material (e.g. rock. gravel) or topography justify.

*(8) RELIEF CULVERTS installed on forest roads shall meet the following minimum specifications:

(a) Be at least 18 inches in diameter or equivalent in western Washington and 15 inches in diameter or the equivalent in eastern Washington.

(b) Be installed sloping toward the outside edge of the toad at a minimum gradient of 3 percent.

*(9) DITCH DIVERSION. Where roadside ditches slope toward a Type I, 2, 3 Water, or Type A or B Wetland for more than 300 feet and otherwise would discharge into the stream or wetland, divert the dishwater onto the forest floor by relief culvert or other means at the first practical point.

WAC 222-24-030 Road Construction.

*(2) DEBRIS BURIAL.

(a) In permanent road construction, do not bury:

(i) Loose stomps, logs or chunks containing more than 5 cubic feet in the load-bearing portion of the mad, except as puncheon across wetlands or for culvert protection.

(ii) Any significant amount of organic debris within the top 2 feet of the load-bearing portion of the mad. except as puncheon across wetlands or for culvert protection.

(iii) Excessive accumulation of debris or slash in any part of the load-bearing portion of the toad fill, except as puncheon across wetlands or for culvert protection.

(b) In the cases where temporary roads are being constructed across known areas of unstable soils and where possible construction failure would directly impact waters, the requirements in (a). (i), (ii) and (iii) of thii subsection shall apply. A temporary road is a roadway which has been opened for the purpose of the forest practice operation in question. and thereafter will be an inactive or abandoned road.

*(4) STABILIZE SOILS. When soil, exposed by mad construction. appears to be unstable or erodible and is so located that slides. slips, slumps, or sediment may reasonably be expected to enter Type 1, 2, 3 or 4 Water and thereby cause damage to a public resource, then such exposed soil areas shall be seeded with grass, clover, or other ground cover, or be treated by erosion control measures acceptable to the department. Avoid introduction of nonnative plant species, as listed in the board manual. to wetlands and wetland management zones.

*(5) CHANNEL CLEARANCE. Clear stream channel of all debris and slash generated during operations prior to the removal of equipment from the vicinity, or the winter season, whichever is first.

*(6) DRAINAGE.

(a) All required ditches. culverts, cross drains. drainage dips, water bars, and diversion ditches shall be installed concurrently with the construction of the roadway.

(b) Uncompleted mad construction to be left over the winter season or other extended periods Of time shall be drained by outsloping or cross draining. Water ban and/or dispersion ditches may also be used to minimize cmdiig of the construction area and stream siltation. Water movement within w&lands must be maintained.

*(7) MOISTURE CONDITIONS. Construction shall be accompli&d when moisture and soil conditions are not likely to result in excessive erosion and/or soil movement, so as to avoid damage to public resources.

*(8) END HAUL/SIDECASTS. End haul or overhaul construction is required where significant amounts of sidecast material would rest below the 50-year flood level of a Type 1, 2, 3, or 4 Water, within the boundary of a Type A or Type B Wetland or wetland management zones or where the department determines there is a potential for mass soil failure from overloading on unstable slopes or fmm erosion of side cast material causing damage to the public resources.

*(9) WASTE DISPOSAL. When spoil, waste and/or other debris is generated during construction, this material shall be deposited or wasted in suitable areas or locations and be governed by the following:

(a) Spoil or other debris shall be deposited above the SO-year flood level of Type 1, 2, 3, or 4 Waters or in other locations so as to prevent damage to public resources. The material shall be stabilized by erosion control measures as necessary to prevent the material from entering the waters.

(b) All spoils shall be located outside of Type A and Type B Wetlands and their wetland management zones. Spoils shall not be located within the boundaries of forested wetlands without written approval of the department and unless a less environmentally damaging location is unavailable. No spoil area greater than 0.5 acre in size shall be allowed within wetlands.

*(c) Truck roads, skid trails. and tire trails shall be outsloped or cross drained uphill Of landings and the water diverted onto the forest floor away from the toe of any landing fill.

*(d) Landings shall be sloped to minimize accumulation of water on the landing.

*(e) Excavation/sidecast material shall not be where there is hih potential for material to enter Type A or B wetlands or wetland management zones or below the ordinary high-water mark of any stream or the 50-year flood level Of Type 1, 2, 3, or 4 Water.

*(f) All spoils shall be located outside of Type A and Type B Wetlands and their wetland management zones. Spoils shall not be located within the boundaries of forested wetlands without written approval of the department and unless a less environmentally damaging location is unavailable. No spoil area greater than 0.5 acre in size shall be allowed within wetlands.

WAC 222-24-040 Water Crossing Structures.

'(2) CULVERT INSTALLATION: AU permanent culverts installed in forest toads shall be of. size that is adequate to carry the 50-year flood or the road shall be constructed to provide erosion protection from the 50-year flood waters which exceed the water-carrying capacity of the drainage structure. Refer to Part 5 'Recommended culvert sizes" in the forest practices board manual for the size of permanent culverts recommended for use in forest roads. If the department determines that because of unstable slopes the culvert size show, on that table is inadequate to protect public resources, it may require culvcn sizes in accordance with the nomograph (chart) contained in Part 5 of the forest practices board manual or with other generally accepted engineering principles.

(a) No permanent culverts shall be installed that are smaller than:

(i) 24 inches in diameter or the equivalent for anadmmous fish streams or wetlands where anadmmous fish are present.

(ii) 18 inches or the equivalent for resident game fish streams.

(iii) 18 inches or the equivalent for all other water or wetland crossings in western Washington.

(iv) 15 inches or the equivalent for all other water or wetland crossings in eastern Washington.

(b) The alignment and slope of the culvcn shall parallel the natural flow of the stream whenever possible.

(c) When fish life is present, construct the bottom of the culvert at or below the natural stream bed at the inlet and outlet.

(d) Terminate culverts on materials that will not readily erode, such as riprap, the original stream bed (if stable), or other suitable materials.

(e) If water is diverted from its natural channel. return this water to its natural stream bed via culvert. flume, spillway, or the equivalent.

(f) When flumes, downspouts. downfall culverts, etc., are used to protect fill slopes or to return water to its natural courses, the discharge point shall be protected from erosion by: (i) Reducing the velocity of the water, (ii) use of rock spillways. (iii) riprap, (iv) splash plates. or(v) other methods or structures demonstrated to be equally effective.

(g) Stream beds shall be cleared for a distance of 50 feet upstream from the culvert inlet of such slash or debris that reasonably may be expected to plug the culvcn.

(h) The entrance of all culverts should have adequate catch basins and headwalls to minimize the possibility of erosion or fill failure.

*(3) CULVERTS IN ANADROMOUS FISH STREAMS. In addition to the requirements of subsection (2) of this section, in streams used by anadromous fish:

(a) Culverts shall be either open bottomed or have the bottom covered with gravel and installed at least 6 inches below the natural stream bed at the inlet and outlet.

(b) Closed bottom culverts shall not slope more than 1/2 percent; except as provided in (e) of this subsection; open bottom culverts shall not slope more than the natural slope of the stream bed.

(c) Where multiple culverts are used, one culvert shall be at least 6 inches lower than the other(s).

(d) Culverts shall be set to retain normal stream water depth throughout the culvert length. A downstream control may be required to create pooled water back into the culvert and to insure downstream stream bed stability.

(e) Closed bottom culverts. set at existing stream gradients between 1/2 percent and 3 percent slope shall be designed with baffles for water velocity control. or have an approved designed fishway.

(f) The department, after consultation with the departments of fisheries and wildlife, shall impose any necessary limitations on the lime of year in which such culverts may be installed to prevent interference with migration or spawning of anadmmous fish.

(g) Any of the requirements in (a) through (f) of this subsection may be superseded by a hydraulic project approval.

'(4) TEMPORARY WATER CROSSINGS.

(a) Temporary bridges and culverts, adequate to carry the highest anticipated flow in lieu of carrying the 50-year flood, may be used:

(i) In the westside region if installed after June I and removed by September 30 of the same yur.

(ii) In the eastside region if installed after the spring runoff and removed prior to the snow buildup which could feed a heavy runoff.

(iii) At other times, when the department and applicant can agree to specific dates of installation and removal.

(b) Temporary bridges and culverts shall be promptly removed upon completion of use, and the approaches to the crossing shall be water barred and stabilized at the time of the crossing removal.

(c) Temporary wetland crossings shall he abandoned and restored based on a written plan approved by the department prior to construction.

WAC 222-24-050 Road Maintenance.

*(2) ACTIVE ROADS. An active mad is a forest mad being actively used for hauling of logs. pulpwood, chips, or other major forest products or rock and other mad building materials. To the extent necessary to prevent damage to public resources, the following maintenance shall be conducted on such roads:

(a) Culverts and ditches shall be kept functional.

(b) Road surface shall be maintained as necessary to minimize erosion of the surface and the subgrade.

(c) During and on completion of operations. mad surface shall be crowned, outsloped, or water barred and berms removed from the outside edge except those intentionally constructed for protection of fills.

*(4) ADDITIONAL CULVERTS/MAINTENANCE. If the department determines based on physical evidence that the above maintenance has been or will be inadequate to protect public resources and that additional measures will provide adequate protection it shall require the landowner or operator to either elect to:

(a) Install additional or larger culverts or other drainage improvements as deemed necessary by the department; or

(b) Agree to an additional mad maintenance program. Such improvements in drainage or maintenance may be required only after a field inspection and opportunity for an informal conference.

WAC 222-30-020 Harvest Unit Planning and Design.

*(3) WESTERN WASHINGTON RIPARIAN MANAGEMENT ZONES. These zones shall be measured horizontally from the ordinary high-water mark of Type 1, 2 or 3 Water and extend to the line where vegetation changes from wetland to upland plant community. or to the line required to leave sufficient shade as rewired by WAC 222-30-040. whichever is greater, but shall not be less than 25 feet in width nor more than the maximum widths described in (c) of this subsection, provided that the riparian management zone width shall be expanded as necessary to include wetlands or ponds adjacent to the stream. When the riparian management zone overlaps a Type A or B Wetland or a Wetland Management Zone, the requirement whiih best protects public resources shall apply.

(a) Harvest units shall be designed so that felling, bucking. yarding or skidding, and reforestation can be accomplished in accordance with these regulations. including those regulations relating to stream bank integrity and shade requirements to maintain stream temperature. Where the need for additional actions or restrictions adjacent to waters not covered by the following become evident. WAC 222-12-050 and 222-12-060 may apply.

(b) When requested in writing by the applicant. the department shall assist in preparation of an alternate plan for the riparian management zone.

(c) Within the riparian management zone, there shall be trees left for wildlife and fisheries habitat as provided for in the chart below. Fifty percent or more of the trees shall be live and undamaged on completion of the harvest. The leave trees shall be randomly distributed when feasible; some clumping is allowed to accommodate operational considerations. The number. size, species and ratio of leave trees, deciduous to conifer, is specified by the bed material and avenge width of the water type within the harvest unit. Trees left according to (d) of this subsection may be included in the number of rquircd leave trees in this subsection.'

WATER TYPE/ AVERAGE WIDTH	RMZ MAXIMUM WIDTH	RATIO OF CONIFER TO DECIDUOUS/ MINIMUM SIZE LEAVE TREES	# TREES/1000 FT. EACH SIDE: GRAVEL/ COBBLE <10" DIAMETER	# TREES/1000 FT. EACH SIDE: BOULDER/ BEDROCK
1 & 2 Water 75' & over	100'	represen-tative of stand	50 trees	25 trees
1 6 2 water under 75'	75'	represen-tative of stand	100 tree*	50 trees
3 Water 5' a over	50'	2 to 1/ 12" or next largest available	75 trees	25 trees
3 Water less than 5'	25'	1 to I/ 6" or next largest available	25 trees	25 trees

'Or next largest available" requires that the next largest trees to those specified in the rule be left standing when those available are smaller than the sizes specified. Ponds or lakes which are Type 1, 2 or 3 Waters shall have the same leave tree requirements as boulder/bedrock streams.

(d) Far wildlife habitat within the riparian management zone, leave an average of 5 undisturbed and uncut wildlife trees per acre at the ratio of 1 deciduous tree to l conifer tree equal in size to the largest existing trees of those species within the zone. Where the 1 to I ratio is no, possible, then substitute either species present. Forty percent or more of the leave trees shall bc live and undamaged an completion of harvest. Wildlife trees shall be left in clumps whenever possible.

(e) When 10 percent or more of the harvest unit lies within any combination of a riparian management zone of Type I , 2 or 3 Waters or a wetland management zone and the harvest unit is a clearcutting of 30 acres or less, leave not less than 50 percent of the trees required in (c) of this subsection.

*(4) EASTERN WASHINGTON RIPARIAN MANAGEMENT ZONES. These zones shall be measured horizontally from the ordinary high-water mark of Type 1, 2 or 3 Waters and extend to the line where vegetation changes from wetland to upland plant community, or to the line required to leave sufficient shade as required by WAC 222-30-040, whichever is greater, but shall not be less than the minimum width nor more than the maximum widths described in (c) of this

subsection. provided that the riparian management zone width shall be expanded as necessary to include wetlands or ponds adjacent to the stream. When the riparian management zone overlaps a Type A or B Wetland or a Wetland Management Zone. the requirement which best protects public resources shall apply.

(a) Harvest units shall be designed so that felling, bucking, yarding or skidding, and reforestation can be accomplished in accordance with these regulations. including those regulations relating to stream bank integrity and shade requirements to maintain stream temperature. Where the need for additional actions or restrictions adjacent to waters not covered by the following become evident. WAC 222-12-050 and 222-12-060 may apply.

(b) When requested in writing by the applicant. the department shall assist in preparation of an alternate plan for the riparian management zone.

(c) Within the riparian management zone, there shall be trees left for wildlife and fisheries habitat as provided for below. Fifty percent or more of the trees shall be live and undamaged on completion of the harvest. The leave trees shall be randomly distributed where feasible; some clumping is allowed to accommodate operational considerations.

(i) The width of the riparian management zone shall be based on the adjacent harvest type as defined in WAC 222-16- 010(33) Partial cutting. When the adjacent unit harvest type is:

Partial cutting - The riparian management zone width shall be a minimum of 30 feet to a maximum of 50 feet on each side of the stream.

Other harvest types - The riparian management zone shall average 50 feet in width on each side of the stream with a minimum width of 30 fat and a maximum of 300 feet on each side of the stream.

(ii) Leave tree requirements within the riparian management zones of Type 1, 2 or 3 Waters:

(A) Leave all trees 12 inches or less in diameter breast height (dbh); and

(B) Leave all wildlife reserve trees within the riparian management zone where operations in the vicinity do not violate the state safety regulations (chapter 296-54 WAC and Chapter 49.17 RCW administered by department of labor and industries. safety division): and

(C) Leave 16 live conifer trees/ acre between 12 inches dbh and 20 inches dbh distributed by size. as representative of the stand; and

(D) Leave 3 live conifer trees/acre 20 inches dbh or larger and the 2 largest live deciduous trees/acre 16 inches dbh or larger. Where these deciduous trees do not exist, and where 2 wildlife reserve trees/acre 20 inches or Larger do not exist, substitute 2 live conifer trees/acre 20 inches dbh or larger. If live conifer trees of 20 inches dbh or larger do not exist within the riparian management zone, then substitute the 5 largest live conifer trees/acre; and

(E) Leave 3 live deciduous trees/acre between 12 inches and 16 inches dbh where they exist.

(iii) Minimum leave tree requirements per acre for Type 1, 2 and 3 Waters. Trees left for (c)(ii) of this subsection shall be included in the minimum counts.

(A) On streams with a boulder/bedrock bed, the minimum leave tree requirements shall be 75 trees/acre 4 inches dbh or larger.

(B) On streams with a gravel/cobble (less than 10 inches diameter) bed, the minimum leave tree requirement shall be 135 trees/acre 4 inches dbh or larger.

(C) On laker or ponds the minimum leave tree requirement shall be 75 trees/acre 4 inches dbh or larger.

Note: (See the Forest Practices Board Manual for assistance in calculating trees/acre and average RMZ widths.)

(d) When 10 percent or more of the harvest unit lies within any combination of a riparian management zone of Type 1, 2 or 3 Waters or wetland management zone and either the harvest unit is a clearcutting of 30 acres or less or the harvest unit is a partial cutting of 80 acres or less, leave not less than 50 percent of the trees required in (c) of this subsection. (See WAC 222-16-010(33) Partial cutting.)

*(5) RIPARIAN LEAVE TREE AREAS. The department will require trees to be left along Type 4 Water where such practices are necessary to protect public resources. Where such practices are necessary leave at least 25 conifer or deciduous trees, 6 inches in diameter or larger, on each side of every 1000 feet of stream length within IS feet of the stream. The leave trees may be arranged to accommodate the operation.

WAC 222-30-030 Stream Bank Integrity.

*In the riparian management zone along all Type 1, 2 and 3 Waters, the operator shall:

(1) AVOID DISTURBING BRUSH and similar understory vegetation;

(2) AVOID DISTURBING STUMPS and root systems and any logs embedded in the bank;

(3) LEAVE HIGH STUMPS where necessary to prevent felled and bucked timber from entering the water;

(4) Leave trees which display large root systems embedded in the bank.

[Statutory Authority: RCW 76.09.040. 87-23-036 (Order 535), §222-30-030, filed 1 1/16/87, effective 1/1/88; Order 263. §222-30-030, filed 6/16/76.]

WAC 222-30-070 Tractor and Wheeled Skidding Systems.

'(1) TYPED WATERS AND WETLANDS.

(a) Tractor and wheeled skidders shall not be used in Type 1, 2 or 3 Waler, except with approval by the department and with a hydraulic project approval of the departments of fisheries or wildlife.

(b) In order to maintain wetland water movement and water quality, and to prevent soil compaction, tractor or wheeled skidders shall not be used in Type A or B Wetlands without prior written approval of the department.

(c) Within all wetlands. tractors and wheeled skidder systems shall be limited to low impact harvest systems. Ground based logging systems operating in wetlands shall only be allowed within wetlands during periods of low soil moisture or frozen soil conditions.

(d) Skidding across any flowing Type 4 Water shall be minimized and when done, temporary stream crossings shall be used, if necessary. to maintain stream bed integrity.

(e) Whenever skidding in or across any type water, the direction of log movement between stream banks shall be as close to right angles to the stream channel as is practical.

'(2) RIPARIAN MANAGEMENT ZONE.

(a) Logging will be permitted within the zone. However, any use of tractors, wheeled skidders, or other yarding machines within the zone must be as described in an approved forest practices application or otherwise approved in writing by the department.

(b) Where skidding in or through the riparian management zone is necessary, the number of skidding routes through the zone shall be minimized.

(c) Logs shall bc skidded so as to minimize damage to leave trees and vegetation in the riparian management zone, to the extent practical and consistent with good safety practicer.

*(3) WETLANDS MANAGEMENT ZONES.

(a) Logging will be permitted within wetland management zones.

(b) Where feasible logs shall be skidded at least with one end suspended from the ground so as to minimize soil disturbance and damage to leave trees and vegetation in the wetland management zone.

(c) Tractors, wheeled skidders, or other ground based harvesting systems shall not be used within the minimum WMZ width without written approval of the department.

*(4) DEADFALLS. Logs firmly embedded in the bed or bank of Type 1. 2, 3 or 4 Waters shall not be removed or unnecessarily disturbed without hydraulic project approval of the departments of fisheries or wildlife.

*(5) MOISTURE CONDITIONS. Tractor and wheeled skidders shall nor be used on exposed erodible soils or hydric (wetland) soils when soil moisture content is so high that unreasonable soil compaction, roil disturbance, or wetland, stream, lake or pond siltation would result.

(6) PROTECTION OF RESIDUAL TIMBER. Reasonable care shall be taken to minimize damage from skidding to the stems and root systems of residual limber and to young reproduction.

*(7) SKID TRAIL CONSTRUCTION.

(a) Skid trails shall be kept to the minimum feasible width.

(b) Reasonable care shall be taken to minimize the amount of sidecast required and shall only be permitted above the 50-year flood level.

(c) Skid trails shall be outsloped where practical. but be insloped where necessary to prevent log, from sliding or rolling downhill off the skid trail.

*(8) SKID TRAIL MAINTENANCE. Upon completion of use and termination of seasonal use, skid trails on slopes in exposed soils shall be water barred where necessary to prevent soil erosion.

*(9) SLOPE RESTRICTIONS. Tractor and wheeled skidders shall not be used on slopes where in the opinion of the department this method of operation would cause unnecessary or material damage to a public resource.

Appendix B: Field Survey Protocols

1. Field Reconnaissance Survey
2. Photo Point Survey
3. Channel Condition Survey
4. Streambank Erosion Survey
5. Streambed Stability Survey
6. Channel Substrate Survey
7. Culvert Condition Survey
8. Cutbank/Fillslope Survey
9. Erosion Pin Survey
10. Road Surface Condition
11. Runoff Sampling
12. Sediment Routing Survey
13. Amphibian Survey
14. Macroinvertebrate Survey

Field Reconnaissance Survey

Purpose:

The purpose of the field reconnaissance is to document preliminary information on a potential study site in order to apply standardized, objective criteria during study site selection. A second purpose is to collect field reconnaissance information to assist in evaluating **BMP** effectiveness during follow up surveys. The third purpose is to summarize logistics information for future work, including landowner contacts, legal descriptions, etc. A fourth purpose is to apply a standardized methodology for ranking study sites into "Slope Hazard' categories. The fifth purpose of the field reconnaissance survey is to identify surveys which are both feasible and necessary for adequate **BMP** evaluation.

Information gathered during field reconnaissance will be used to provide the information framework necessary for investigation, analysis, and meaningful interpretation of data.

Materials:

Forest Practices Application (FPA)
Area Road Map or Gazetteer
USGS 7.5 minute quadrangle maps (if available)
orthophoto maps of the relevant township or 1\4 township (if available)
aerial photos (1:12,000 scale)
soils maps and/or geologic maps (identify source)
State DNR rain-on-snow zone maps
water type maps
clinometer
compass
wide angle, 35 mm. camera
200 or 400 ASA print film
100 meter fiberglass measuring tape
field reconnaissance survey forms
channel condition survey form
lead pencils

Site Selection Criteria

Following FPA review, candidate study sites are selected for the field reconnaissance survey. The three primary criteria we used to select sites for reconnaissance are 1.) the presence of any type I-V waters of the state 2.) the timing of the forest practice and whether it is possible to conduct preliminary surveys before a significant hydrologic event, and 3.) whether there is a reasonable possibility of isolating the effects of the BMP from the cumulative effects of past land use activities including, but not limited to, forest practices, grazing, and mining.

Method Summary:
After initial screening, field visits are conducted at potential study sites in order to ground truth the site conditions. Information gathered at the' site, including logistics, slope hazard class, an assessment of compliance with BMPs, availability of suitable control sites, and survey potential are used to assess the suitability of study sites.

Assumptions:
Study sites are selected without bias, other than site selection criteria, because all FPAs obtained for review are screened for the same criteria.

Survey Methods:
1. Following initial screening of FPAs for potential study sites, landowners are contacted, informed about the objective of the project, and, if cooperative, asked a series of standardized questions regarding the accuracy of water types identified on the FPA, the timing of the operation, access and logistics details. A written record of the telephone conversation is filed. Very often we coordinate a meeting with the landowner at this point to discuss the project and the potential study site(s).

2. Maps and aerial photos of the study site are now obtained and the information recorded on the field reconnaissance form.

3.. Upon arrival at the potential study site we locate and confirm the water types. If a suitable type I-V stream is present, we then investigate land use interferences and discuss whether these impacts are so great as to preclude using the site. Impacts from past land uses vary on a continuum across the landscape and we often spend some time discussing the suitability of particular sites for this reason. Unlike slope angles which can be measured and soils which can be classified for various characteristics, the impacts of past activities are not quantifiable, making this portion of the survey difficult and subject to best professional judgement.

4. If the waters are accurately typed and are located withii or adjacent to the BMP affected area and any interferences from past and current land uses are acceptable, we then evaluate the availability of a reference/control stream reach. A reference area would be one outside the forest practices unit boundary with similar physical characteristics as that reach of stream potentially affected by the BMP. Ideally, gradient, and overall channel morphology would be similar between the two reaches in order to more readily compare changes between them. In most cases we look for a control reach immediately upstream of the treatment reach. Treatment and control reaches are considered similar, if, using the channel condition survey, it is determined they: 1) have the same channel morphology class, 2) have the same peak flow response category, and 3) the relative percent difference of the reach gradients, (RPD) does not exceed 50 %, where the RPD is the range of the reach gradients expressed as a percent of the mean gradient.

5. If the criteria identified above are met, the study site is accepted. The study site is rejected if one or more of the criteria are not met.

6. The surveys which may be conducted in order to evaluate the effectiveness of the BMP are noted on the field form before leaving the site.

7.) Slope measurements are taken which are used to determine the Slope Hazard category from the sample stratification scheme. The Slope Hazard category is determined separately for road and harvest BMPs, according to the following protocols.

For Road BMPs: Slope Hazard Categories are determined by measuring the sideslope with a clinometer, above and below the road at all type l-5 stream crossings within the study segment. Measurements are taken directly along the fall line from the top of upper streambanks (i.e. extreme high water mark) for a slope distance of 30-60 meters or to the first significant slope break. Slope measurements are taken and recorded in %. All measurements taken at stream/drainage crossings of the road are averaged to determine average slope for the site. Average and maximum slopes are recorded on the field form. The maximum side slope gradient at the stream crossing(s) which are the focus of planned surveys is used to determine the Slope Hazard Category for sample stratification.

For Harvest BMPs: Slope Hazard Categories are determined by measuring the sideslope with a clinometer, within the stream valley along the treatment reach (i.e. the reach within the harvest unit.) Measurements are taken directly along the fall line from the top of upper streambanks (i.e. extreme high water mark) for a slope distance of 30-60 meters or to the first significant slope break. Slope measurements are taken at the top, middle, and bottom of the study reach. Study reaches are 20-25 times the average active channel width. If the harvesting practice will be on both sides of the stream, then slope measurements are taken on both sides. All measurements taken are averaged to determine average slope. The average and maximum slope are recorded on the field form. The maximum side slope gradient, in %, within the stream valley of the treatment reach is used to determine the Slope Hazard Category for sample stratification.

Miscellaneous Notes and Recommendations:

Always attempt to complete the field reconnaissance form before leaving the site. While best obtained in the field, hi slope gradients can be calculated from topographic maps.

FIELD RECONNAISSANCE FORM

Note: Attach Unit Maps and Photos

Accept Study Site: (Y or N)

DATE:________________ SURVEYORS:________________

Section ________ Township ________ Range ________ Site Id # ________

FPA # ________ Landowner ________ Unit Name ________

LandownerOffice/Address________________

LandownerContact/Phone#________________

AccessNotes(keys, driving directions)________________

Physiographic Region________________ Ecology Region ________

BMPs Proposed ________________

BMPs Completed (Yes or No) Date of Completion ________________

Comments on Compliance: Meets Minimum BMPs (Y or N) ________________

Hydrologic Events Since Completion ________________

Watershed Analysis (yes or no) Id Teams (yes or no)

% of Sideslopes Adjacent to Streams ________________

Average Slope (%) ________ Maximum Slope @ Study Reach ________

Slope Form (Planar, Convergent, Divergent) ________________

Slope Hazard Category (Based on Max. Slope) Road BMPs: L M H Harvest BMPs: L M H

Geology\Parent Material ________________

Soils ________________

Sources for Geology/Soils ________________

Water Types ________ Stream Orders ________ Flow Regime (High, Base, Dry)

Study Site Interferences (Other Land Uses, Ability to Isolate BMP, Prospects for Control Sites)

Similarity of Control and Treatment Reaches for In-stream Surveys:

Treatment: Morphology ________ Response Category ________ Gradient ________

Control: Morphology ________ Response Category ________ Gradient ________ RPD: ________

Comments________________

SURVEY LIST:

(PS) Photo Point Network, (CC) Culvert Condition, (CF) Cutbank/Fillslope,

(SR) Sediment Routing, (SU) Channel Substrate Transects, (ST) Streambed Stability, (CS) Qualitative Channel Condition,

(SE) Streambank Erosion, (RS) Road Surface Condition, (RO) Runoff Sampling, (EP) Erosion Pin Network, (MI) Macroinvertebrates

(AM) Amphibians

BMP LIST:

New Road Construction: A.) Road Drainage Design, B.) Culvert Inst. and Temp. Stream Xings, C.) Construction Techniques

Road Maintainance: D.) Active Haul Roads

Harvesting: E.) Tractor & Wheeled Skidding, F.) RMZs & RLTAs

BMP EVALUATIONS

Specific BMP ____________________

Surveys to Evaluate BMP ____________________

____

Specific BMP ____________________

Surveys to Evaluate BMP ____________________

____

Specific BMP ____________________

Surveys to Evaluate BMP ____________________

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Specific BMP ____________________

Surveys to Evaluate BMP ____________________

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Specific BMP ____________________

Surveys to Evaluate BMP ____________________

____

NOTES ____________________

____

Photo Point Survey
for
Stream Channels and Skid Trails

Purpose:
To establish photo points that visually document stream, skid trail, and related features subject to change after a Best Management Practice is implemented. To record point lines along stream channels and skid trails in a way that allows the same photo points to be used over time.

Materials:
camera with date-back feature
200 or 400 ASA print film
100 meter measuring tape
compass
survey rod
bright pink meter stick, for scale
bright pink half meter stick, for scale
survey flags
write-in-the-rain field book
photo point survey field forms
sharpie or grease pencil
lead pencils

Site Selection Criteria:
Sites for stream channel photo points are selected where new road construction and/or harvest activities are conducted near streams and where a control reach is available either upstream or nearby a treatment reach. Sites for skid trail photo points are selected where a survey is able to be conducted after BMP implementation and prior to impacts from a high intensity rainfall/runoff event.

Method Summary:
Oblique angle photographs are taken of stream channels, skid trails, or road surface features Initial photos of stream channels are taken prior to any instream impacts from the implemented BMP. Initial photos of skid trails are taken as soon as practical after BMP implementation. Photos are taken along a point line established so that subsequent surveys are able to be conducted using the same viewpoints. Erosion, sediment storage, and other features are noted to show how the skid trial or channel changes over the project study period. Streambanks, sediment wedges, boulder clusters, and woody debris are some of the stream features photographed during this survey. Skid trail surfaces, water bars, vegetative covering, and design are some of the skid trail features photographed during this survey. Additional photo point surveys are conducted one to three years later, depending on the site and project considerations.

Assumptions:

Gross changes in stream features, substantial amounts of surface erosion and sediment delivery from skid trails to surface water are able to be documented by sequential photo surveys over the project study period.

The magnitude, rate, and type of change in channel conditions in control reaches, immediately upstream of implemented BMPs, represent baseline conditions against which changes in downstream treatment reaches can be compared. Certain differences may be attributed to the effects of the implemented forest practice.

Any delivery of sediment originating from a skid trail to surface water is an increase over background levels.

While small, steep streams may ultimately function as sediment transport reaches **over** geomorphologically relevant time scales. they function as sediment storage reaches and aquatic life habitat the majority of the time.

Stability of stream banks. channels, and sediment storage elements such as large woody debris is essential for maintaining beneficial uses.

At channel crossings and direct entry ditchlines along skid trials the sediment delivery ratio is 100%. At cross drains located within 60 meters of surface water the probability of sediment delivery is less than 100% (Burroughs and King, 1989).

Survey Method:

1. Identify the survey location on unit map. Use sketch if necessary to **ensure** relocation of survey.

2. Complete the following required survey site information on the first page of the field notebook:

Study Site ID (e.g. E02)
Survey ID (e.g. P01)
Brief Description of Features Surveyed, BMP studied, and Location of Unit
Date
Time
Film Type
Film Speed
Camera Used
Weather
Permanent Point Description

3. Select a permanent point near the start of the photo point network. Examples **include:** culverts, large stumps, large rocks that arc unlikely to move, etc. Describe the features of the permanent point for future reference in the notebook. Use sketch if necessary. A photo may be taken from the permanent point. Make sure date-back feature on camera is turned on

and set for the month/date/year mode. Record the object photographed, azimuth and distance from the permanent point in the notebook. Flag the permanent point and label it PP (for "permanent point") with the survey number.

4. Select a feature to be photographed. Measure the distance, percent slope, and azimuth from the permanent point to this first selected point. Note: for skid trail photo surveys place photo points a maximum of 15 meters apart. Place a flag on or near the location where the photographer stands and label it PO1 (photo point 1). If it is not possible to place a flag where the photographer would stand to take a picture, record the location in relation to the photo point (i.e. "standing 1 meter towards the stream channel"). Include the survey number on all flags. Take a picture of one or more features and record the following information in the notebook:

Stream Photo Surveys

Information is to be recorded on facing pages. On the left page record: from point #, to point #, distance, azimuth, and percent slope. On the right page record for each photo taken: frame #, telephoto (y/n), stereo pair (y/n), and feature description. Describe the photo technique (crouching, bent over, etc.), and note location of the viewpoint relative to the flag placement, and the subject photographed. These original notes are to be referred to on subsequent surveys.

Skid Trail Photo Surveys

Information is to be recorded on facing pages. On the left page record: from point #, to point #, distance, azimuth, and percent slope. On the right page record for each photo taken: frame #, telephoto (y/n), stereo pair (y/n), percent vegetative covering on the skid trail surface, evidence of erosion (gullies, rills, tension cracks, sediment wedges, etc.), evidence of storage and erosion prevention (water bars, hill slope benches), and skid trial design description (inslope, outslope, flat, crowned). Also, place the points so that water bars are able to be photographed and the distances between water bars is documented. Describe the photo technique (crouching, bent over, etc.), and note location of the viewpoint relative to the flag placement, and the subject photographed. These original notes are to be referred to on subsequent surveys.

5. Select the next feature to be photographed. Measure the distance, percent slope, and azimuth from the previous point to this next selected point. Place and flag, take one or more photos, and record information in the field notebook as in step 4.

6. Continue moving along the point line being established until the survey is finished. For photo surveys in streams, the reach length to be surveyed equals roughly 25 times the active channel width. Label the final point as "Px, last point" in the notebook.

7. Option: Create a photo mosaic using low altitude photos. Photos are taken by suspending a camera 6 meters above the stream features viewing straight down. Photo points are spaced every 3 to 4 meters to create a connected photo mosaic.

8. Subsequent photo point surveys are conducted one to three years after BMP implementation, depending on site and project considerations. Subsequent surveys are used to determine changes in features that have occurred over the study period. Where possible, subsequent surveys are conducted during the same season and under similar flow conditions as the previous surveys.

Miiellaneous Notes and Recommendations:

General Photography Notes:

Capture the entire scale (one meter or one-half meter) when taking all photographs.

Make sure the wide view of the scale is facing the camera.

Keep in mind that the final prints do not show the entire area inside the camera's viewfinder, shoot conservatively.

Never take the original photo survey field notes into the field. Take copies from the site file only.

Do not take a series of photos of the same feature that will need to be pasted together later. Try to capture the entire feature in one photo.

Streambank Features Photo Notes:

Shoot from center of stream channel, upstream, adjacent, or downstream of streambank. Place the scale either vertically on high banks, horizontally on long, low banks.

Sediment Wedge Features Photo Notes:

Take the photos while looking downstream. Stand above or on top of the stored sediment and shoot down. Place the scale horizontal to the photo direction on top of the substrate.

Sediment Wedge Obstruction Photo Notes:

Take the photos while looking upstream. Place the scale vertically against the storage mechanism to give a sense of the feature's height.

Stream Channel Morphology Features Photo Notes:

Take photos looking both downstream and back upstream as the network is built. Try to capture the channel cross section features. Place the scale horizontally across the stream bottom.

Skid Trail Features Photo Notes:

When taking photos of water bars, place the scale vertically on the water bar, leaning back along the slope distance. When taking photos of skid trail surfaces, place the scale horizontally across the width of the skid trail, tilted so that the wide part of the scale is facing the camera.

Skid Trail Cutbank Features Photo Notes:
Lean the scale vertically, along the slope distance of the cutbank, with the wide part of the scale facing the camera.

Conceptual Rating Strategy:

Determination of BMP effectiveness using the stream photo survey considers the relative magnitude and rate of change in streambank erosion, sediment deposits, and storage elements in the treatment reach relative to that of the control reach based on photo interpretation and best professional judgement. The BMP is considered effective if there is no evidence of an increase in bank erosion, sediment deposition, or destabilization of channel features such as large woody debris.

Determination of BMP effectiveness using the skid trail photo surveys considers evidence of continuing erosion with sediment delivery to a stream. The BMP is considered effective if there is no evidence of continuing erosion with sediment delivery to a stream.

Final decision criteria for determining whether water quality standards are achieved will be developed through a process that includes literature review and consultation with the TFW Water Quality Steering Committee, the Department of Ecology Water Quality Program, and other experts on water quality standards issues and beneficial uses as related to sediment impacts.

References:

Burroughs, E.R. Jr., J.G. King. 1989. Reduction of soil erosion of forest roads. USDA Forest Service General Technical Report INT-264. p. 2 1.

Stream Photo Point Network

Study Site # ________________ **Date** ________________

Site Name ________________ **Time** ________________

Survey ID # ________________ **Surveyors** ________________

Film Type __________

Film Speed _________

Camera Used: __________

Weather ____________

Permanent Point Description:

From:	To:	Distance:	Azimuth :	Slope:

Frame #	T	S	Description - Direction of Photo - Notes

Skid Trail Photo Point Network

Study site #________________ Date _______________

Site Name ________________ Time _______________

Survey ID # ________________ Surveyors _______________

Film Type __________

Film Speed __________

Camera Used: __________

Weather __________

Permanent Point Description:

From:	To:	Distance:	Azimuth:	Slope:

Frame	#	T	S	% Veg Cover	Erosion Evidence (cut/fill, etc.)	Trail Design Notes

Channel Condition Survey

Purpose:
To qualitatively document stream channel characteristics and conditions of certain channel features within control and treatment reaches, before and/or after a harvest, road construction, or haul road maintenance Best Management Practice (BMP) is implemented. Also, to evaluate the similarity between control and treatment stream reaches at a candidate study site during field reconnaissance.

Materials:
100 and 30 meter fiberglass tape
metric carpenter's tape
survey flags
channel condition field forms and clipboard
lead pencils
clinometer
substrate viewer

Site Selection Criteria:
Channel condition surveys are conducted at sites where new road construction, harvest, and/or haul road maintenance BMPs are implemented near streams, and where a control reach is located upstream of or nearby the treatment reach.

Method Summary:
Initial assessments of the control reach and downstream treatment reaches are conducted prior to any in-stream impacts from the implemented BMP for harvest practices, and after road construction but prior to a major hydrologic event (e.g. winter storms or snowmelt) for road construction practices. The study reach is generally 25 times the average active channel width in length. The reach is walked and the conditions of the channel bed and banks are observed. Gradient over the reach length is measured using a clinometer. After walking the reach one or more times, a channel condition form is completed. Additional channel surveys are conducted one to three years later, depending on site and project considerations.

Assumptions:
Gross changes in stream channel conditions, including streambank stability, in-channel sediment storage, and substrate composition, can be documented by sequential qualitative surveys of channel features over the project study period.

The magnitude, rate, and type of change in channel conditions in the control reach immediately upstream of BMPs represents the baseline conditions against which changes in the downstream reach can be compared, and certain differences may be attributed to the effects of the forest practice.

While small, steep streams may function as sediment transport reaches over geomorphologically relevant time scales, they function as sediment storage reaches and aquatic life habitat the majority of the time.

Stability of stream banks, channels, and sediment storage elements such as large woody debris is essential for maintaining beneficial uses.

Survey Method:

1. Identify the survey location on unit map. Use sketch if necessary to ensure relocation of survey.

2. Measure a minimum of three representative average active channel widths on the control reach and multiply by 25 to obtain reach length; minimum length is 20 channel widths for longer reaches. In some cases, the study reach may be longer than 25 channel widths. Note the reach length on the channel condition form.

3. Walk the control reach for the entire length one or more times and observe conditions of the channel bed, banks, and other items listed on the channel condition form. Take gradient shots between two people throughout the reach using a clinometer, measure the distance of the shot with fiberglass tape, and note in the field book. Gradient for the reach is calculated as a weighted-average of shots taken along the reach (weighted by the distance of each shot). Active channel and valley bottom width are generally measured at each stopping point while walking the reach for gradient measurements. Valley wall slope is measured occasionally while walking the reach.

4. Set a flag or tie a ribbon at the beginning and end of the reach. If the channel conditions such as confinement, stream gradient, or dominant channel bed or bank material change significantly, a new reach is described.

5. Complete the channel condition assessment of the control reach by circling or filling in the field form. The channel condition field form has been adapted from the methodology developed by Metzler (1992). The channel morphology classification used was developed by Montgomery and Buffington (1993) as part of the TFW CMER Program.

6. Conduct a channel condition assessment of the treatment reach as described for the control reach above, steps 2-5.

7. Subsequent channel condition assessments are conducted one to three years after the BMP has been implemented (depending on site and project considerations), and are used to determine changes in channel features that have occurred over the study period in control and treatment reaches. Where possible, subsequent surveys are conducted during the same season and at similar flow regimes as the initial survey.

Miscellaneous Notes and Recommendations:

It is helpful to take notes in the field book while measuring gradient, width, etc., indicating channel conditions within each segment of the study reach. Take notes on bank condition, substrate composition, pool condition, armoring, fresh deposits, etc. to use in tilling out the form after walking the reach.

Conceptual Rating Strategy:

Determination of BMP effectiveness related to instream impacts considers the rate and magnitude of change in streambank destabilization, sediment deposits and channel substrates, and sediment storage elements in the study reach relative to changes in the control reach.

The BMP is considered effective if there is no evidence of an increase in bank erosion, sediment deposition or destabilization of channel control elements such as large woody debris

Final decision criteria for determining whether water quality standards are achieved will be developed through a process that includes literature review and consultation with the TFW Water Quality Steering Committee, the Department of Ecology Water Quality Program, and other experts on water quality standards issues and beneficial uses as related to sediment impacts.

References:

Metzler, J. 1992. Stream Channel Conditions Assessment. A Methodology to Evaluate Channel Damage Related to Increased Peak Flows. Jones and Stokes Associates. Bellevue, Washington.

Montgomery, D.R. and J.M. Buffington. 1993. Channel Classification. Prediction of Channel Response, and Assessment of Channel Condition. Department of Geological Sciences and Quaternary Research Center, University of Washington. Seattle, Washington.

CHANNEL CONDITION SURVEY
ECOLOGY SEDIMENT BMP STUDY

Study Site ID #: ____ Study Site Name: ________________________ Reach # (@ site): ____ Channel Cond. Survey #: CS-____

DNR Water Type: ___ Stream Order: ___ Ave. Active Channel Width:_____ m Ave. Wetted Width: ______ m Reach length: ______ m

Date: ______________________ Flow today is (relative to HWM): High Moderate Low Dry Q meas:______ cfs/l-s
Surveyors:

Walk the study reach and observe the conditions of the channel bed and banks. Length of the study reach should be 20-25 active channel widths. If conditions such as confinement of the channel, stream gradient, or dominant channel bed or bank material change significantly, then a new reach should be described. After walking the reach, fill in the blanks and circle the letter responses to describe conditions within the channel. If none of the descriptions fit, do not circle any responses, but supply comments to describe the condition. If applicable, more than one response can be circled for an item.

Survey Description:
Preliminary Survey: Y / N BEFORE / AFTER Forest Practice Operation CONTROL or TREATMENT Reach

Approx. Date of Forest Practice Operation __________

Reach Location:

I FACTORS AFFECTING CHANNEL RESPONSE

A. Channel Morphology Classification (from Montgomery & Buffington, 1993):
a. BEDROCK c. CASCADE e. PLANE-BED g. REGIME
b. COLLUVIAL d. STEP-POOL f. POOL-RIFFLE h. BRAIDED

B. Landscape Position of Reach:
a. Bench b. Uninterrupted Sideslope c. Main Valley Floor d. Other:______________________

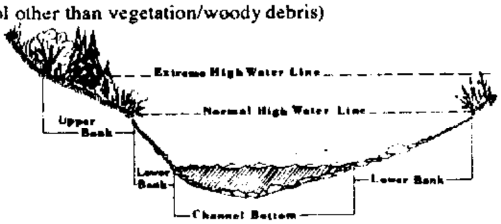
C. Channel Constraint
- Average active channel width = __________ meters
- Average valley bottom width = __________ meters VBW/ACW = _______

- Valley Form: a. V-shaped b. U-shaped (narrow alluviated) c. Wide alluviated d. Flat (very wide or no valley walls)

D. Channel Bed/Bank Parent Material
Source of material: a. alluvium b. glacial till c. colluvium d. hard bedrock e. soft bedrock f. lacustrine g. unknown
other ____________________

E. Primary Controls on Stream Banks
a. Bedrock Control b. Boulder Control c. Erodable Soil Banks (no control other than vegetation/woody debris)

F. Stream Energy
Average channel gradient of reach = _____ %
Is the profile "stairstepped"? Yes No
If yes, what forms the steps? Bedrock Boulders Woody debris
Do the steps appear stable? Yes No



From flow chart, peak flow response category is:
Type A: unconstrained
Type B: slightly constrained, unconsolidated bottom
Type C: laterally constrained, unconsolidated bottom
Type D: constrained, bedrock/large boulder
Type E: boulder/bedrock stairstep
Type F: woody debris stairstep

II. CONDITION OF CHANNEL BANKS

A. Channel Capacity

1. Response Category Type A or B (channels with floodplains):
   a. active channel carries average annual flood, larger events spread across floodplain
   b. active channel has downcut or widened, so peak flows rarely spread over the floodplain
   c. active channel has downcut and/or widened to the extent that peak flows never spread over the floodplain; an inner terrace has developed within the "blownout" channel area, marking a new active channel
   d. a major flood has passed through and caused obvious damage in this channel

2. Response Category Type C, D, E, F (channels without floodplains)
   a. active channel appears adequate to carry average annual flood; streamside vegetation comes down to active channel margin
   b. active channel area shows signs of enlargement, raw banks indicate some widening or downcutting; there is a flood-disturbed area that is greater than the active channel width
   c. channel appears "blownout"; active channel area is much smaller than the flood-disturbed area within the valley bottom
   d. a debris flow or flood has obviously come down this channel and caused damage

B. Degree of Existing Bank Erosion

1. Percent of reach length with Bedrock/Boulder (i.e. non-erodable) Banks
   a. 1-25% c. 51-75%
   b. 26-50% d. > 75%

2. Percent of reach length with Eroding Banks:
   a. 1-25% c. 51-75%
   b. 26-50% d. > 75%

3. Location of bank erosion:
   a. nowhere in reach
   b. in expected places, such as outside of bends and constrictions
   c. in unusual places, such as straight stretches and inside of bends
   d. upper banks

4. Apparent cause of erosion (based on visual evidence):
   a. flowing water c. heavy equipment e. large animals (elk, cattle, etc.)
   b. windthrow d. tree falling/yarding f. other: ______________

5. Angle of banks exposed by erosion:

   a. vertical: |_| b. angled back: _/ c. undercut:/__\

6. Angle of unexposed banks:

   a. vertical: |_| b. angled back: _/ c. undercut:/__\

7. Upper Bank Condition:
   Has the stream undercut the upper banks? Yes No
   If yes, has this resulted in mass wasting? Yes No
   Is there evidence of a high rate of soil creep? Yes No

C. Degree of Bank Protection

1. Predominant type of vegetation along the banks: (circle more than one if mixed)
   a. mature coniferous trees
   b. mature hardwood trees
   c. immature conifers 6-18 meters tall
   d. immature conifers 2-6 meters tall
   e. recent clearcut, trees <2 meters tall
   f. immature hardwood trees
   g. shrubs
   h. grass

2. Vegetation density:
   a. banks are well protected by a deep, dense root network, which is inferred from the dense, mature (well-established) forest
   b. banks are fairly well protected by deep roots with several open areas
   c. banks are protected by a dense but shallow root network, inferred from the dense, young trees or shrubs
   d. banks are poorly protected by a shallow root network with numerous openings
   e. banks receive little or no protection from roots

D. Resistance of Lower Bank Material

1. Bank cohesion (kick the bank!)
   a. resistant bedrock
   b. erodible bedrock
   c. cohesive silt/clay resistant to erosion
   d. cemented matrix of fine material containing rock particles
   e. cohesive but erodible silt/clay
   f. noncohesive assortment of mostly cobble and larger sizes
   g. noncohesive assortment of mostly cobble to gravel-size rocks
   h. noncohesive assortment of mostly gravel-size rocks
   i. noncohesive assortment of mostly fine material

E. Flow Deflection into Banks (focus on thalweg)
   a. little or no deflection of flows into banks
   b. a few areas where flow is deflected into the banks by logs, boulders, or the channel meander pattern
   c. numerous areas where flow is deflected into channel banks by logs, boulders, or the channel pattern

III. CONDITION OF CHANNEL BOTTOM

A. Deposition

1. Extent of bottom affected by fresh deposits (i.e. loose, unarmored, unvegetated masses of sediment without algal staining). *Look closely for signs of vegetation establishing itself; consider **all** size classes **in active channel area**, **not** just wetted area:*
   - a. very few fresh deposits (< 10%)
   - b. 10-25% of bottom area with fresh deposits, a few isolated pockets behind storage elements (e.g. boulders, woody debris) or small point bars
   - c. 25-50% *of bottom area with fresh deposits (i.e. several small point bars, many pockets behind boulders or woody debris.*
   - d. 50-75% of bottom covered with fresh deposits, such as large mid-channel or point bars; deposits common in pools; many moderate to large sediment wedges.
   - e. >75% of bottom covered with fresh deposits

2. Size of dominant material in fresh deposits:
   - a. most particles cobble-size and larger
   - b. most particles are gravel to cobble-size
   - c. particles are mostly gravel with some finer material
   - d. particles are mostly fines (< 6mm--fine gravel, sand and smaller sizes)

3. Pool Types:
   - a. No pools in reach (generally a Cascade or Plane-Bed morphology reach)
   - b. Pool types in reach: i. Plunge Pools ii. Scour Pools iii. Dammed Pools

4. Deposition in Pools:
   - a. Pool substrate mostly gravel and/or cobble (< 25% surface fines)
   - b. Moderate amount of fines in pools (25-75% of surface area) Depth of Fines in pools: < 5 cm
   - c. Pool substrate mostly fines (> 75% of surface area)
   - d. *Depth of fines in pools: i. < 5 cm ii. 5-10 cm iii. >10 cm*

5. Percent of bottom area within depositional zones <u>other than pools</u> (riffles, bars, sediment wedges) covered by fines (<6mm):
   - a. 0-25% c. 51-75%
   - b. 26-50% d. >75%

6. Sediment Storage Elements (associated w/ sediment wedges)
   - a. Type of sediment storage elements: i. LWD ii. Boulders iii. Other (explain):____________________
   - b. Do storage elements appear stable, as evidenced by moss, staining, vegetation, etc.? i. Yes ii. No
   - c. Do storage elements appear to have been destabilized?
     i. No ii. A few destabilized elements iii. many or most elements destabilized

B. Evidence of Recent Bed Mobility

- a. in all but channel thalweg, rocks are "dull"; bed materials show definite staining, algae growth, or have clinging vegetation; bed materials are never or only rarely mobile
- b. throughout the channel, there is a mix of "bright" and "dull" rocks; staining or algae growth or clinging vegetation is evident in some places
- c. mostly "bright" rocks; some staining or algae growth or clinging vegetation is evident in sheltered backwater areas
- d. nearly all "bright" rocks; there is no evidence of staining, algae growth, or clinging vegetation; majority of bed materials appear to be quite mobile during high flows

C. Armoring (pick up some rocks and look at subsurface particles)

- a. Within the wetted channel (or bottom of streambed), are surface particles distinctly larger than subsurface particles?
  Yes No
- b. On bars, are surface particles distinctly larger than subsurface particles?
  Yes No

D. Particle Packing (kick the bottom!)

- a. larger particles are surrounded by smaller or overlapping ones, creating a tightly packed substrate resistant to scour
- b. some overlap and particle packing, larger rocks can be moved with your foot but smaller particles create a tightly packed matrix resistant to erosion
- c. larger particles are surrounded by a loose matrix of smaller particles
- d. bottom is very loose, most particles can be moved with your foot

E. Dominant Particle Sizes:

- a. bedrock
- b. large boulders
- c. small boulders
- d. cobble
- e. gravel
- f. fines (fine gravel, sand, silt)

Subdominant Particle Sizes:

- a. bedrock
- b. large boulders
- c. small boulders
- d. cobble
- e. gravel
- f. fines (fine gravel, sand, silt)

Particle Size Classes:

Large Boulder:	>512 mm
Small Boulder:	256-512 mm
Cobble:	64-256 mm
Gravel:	6-64 mm
Fine Gravel:	2-6 mm
Sand & smaller:	<2 mm

F. Angularity

a. substrate consists mostly of flat or angular rocks resistant to rolling
b. substrate consists mostly of subangular rocks, some flat or rounded rocks present
c. substrate consists mostly of rounded rocks that have little resistance to rolling

IV. WOODY DEBRIS

A. *Location of Woody Debris*

a. individual logs within or adjacent to the wetted channel area
b. clumps or jams within or adjacent to the wetted channel area
c. clumps or jams along the outer margin of the active channel area
d. individual logs along the outer margin of the active channel area
e. most of the logs have been deposited above and outside of the active channel area
f. a debris jam blocks the channel
g. numerous debris jams block the channel
h. numerous logs have been deposited within this reach from upstream
i. there are no logs in or adjacent to the channel

B. Size/Origin of Woody Debris

a. Predominantly large (>25 cm) & Natural
b. Predominantly small (<25 cm) & Natural
c. Predominantly large (>25 cm) Logging Slash
d. Predominantly small (<25 cm) Logging Slash

V. OTHER CHARACTERISTICS

A. Culverts and Bridges

Describe culverts or bridges within or near the study reach (size, condition, armoring, capability for handling flood flows and debris)

C. Known History of Flooding or Debris Flows

Note date, magnitude of flood event, probable cause, source of information

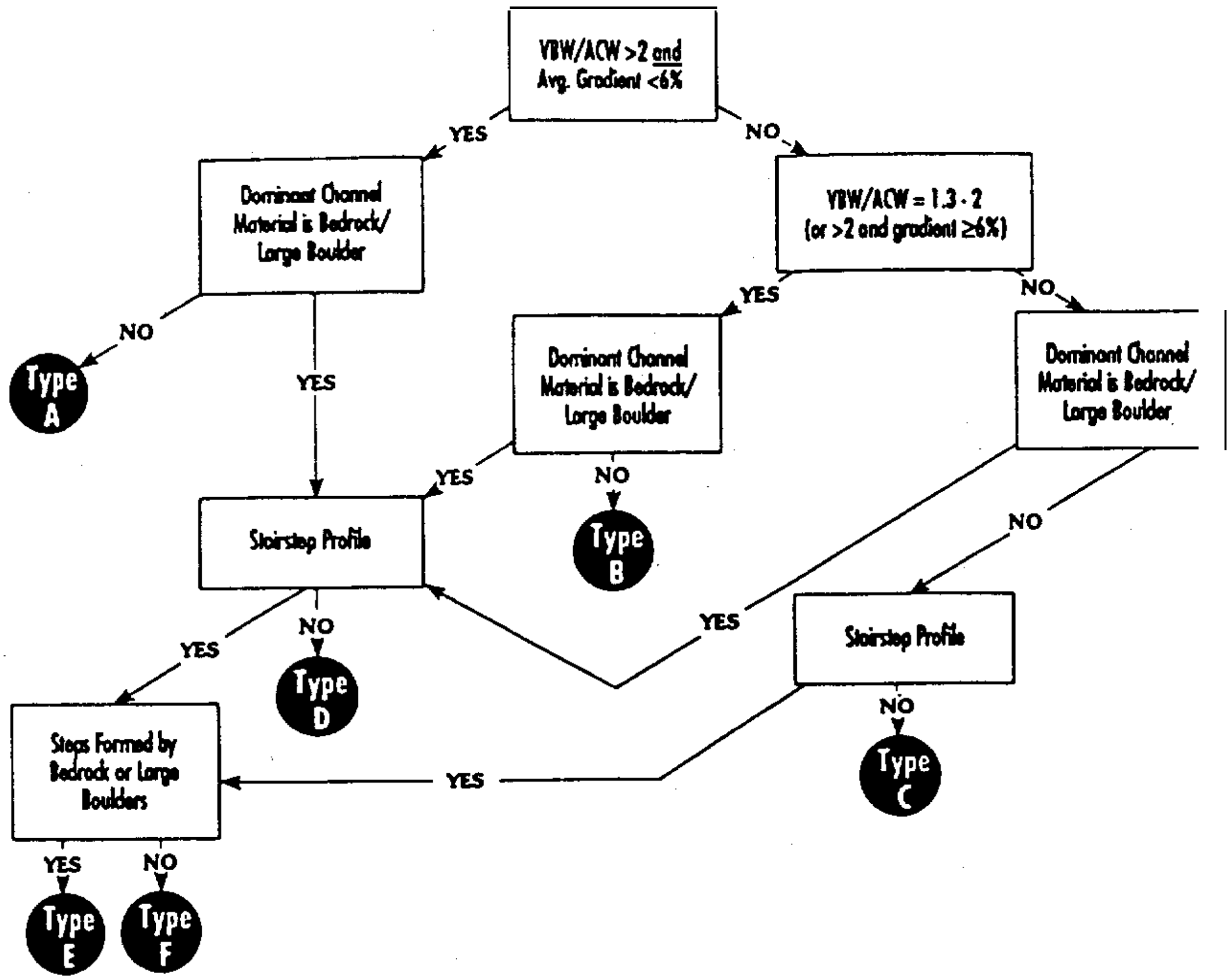
D. Other Observations

	REGIME	POOL-RIFFLE	PLANE BED	STEP-POOL	CASCADE	BEDROCK	COLLUVIAL
Typical bed material	sand	gravel	gravel/cobble	cobble/boulder	boulder	-	colluvium
Bedforms	multi-layered	laterally oscillatory	none	vertically oscillatory	none	discontinuous alluvium	
Reach Type	Response	Response	Response	Transport	Transport	Transport	Source
Dominant Roughness Elements	sinuosity, large scale edies and turbulence, bedforms (dunes, ripples)	bedforms (bars, pools, riffles), grains, LWD, sinuosity, local turbulence	grains, local turbulence	bedforms (steps, pools) causing hydraulic jumps & turbulence, grains, LWD	grains, hydraulic jumps, and local turbulence	structure controlled steps & obstructions	grains, LWD
Dominant Sediment Sources	fluvial/ bank failure/ inactive channel	fluvial/ bank failure/ inactive channel/ debris flows/	fluvial/bank failure/ debris flows	fluvial/ hillslope/ debris flows	fluvial/ hillslope/ debris flows	fluvial/hillslope debris flows	hillslope/ debris flows
Sediment Storage Elements	overbank bedforms inactive channel	overbank bedforms inactive channel	overbank inactive channel	bedforms, pool-filling sediment	Lee & stoss sides of flow obstructions	-	bed
Typical Slope (m/m)	S < .001	.001 < S < .01	.01 < S < .03	.03 < S < .08	S > .08	-	-
Typical Confinement	unconfined	unconfined	unconfined	confined	confined	confined	confined
Pool Spacing (channel widths)	5 to 7	5 to 7	none	1 to 4	none	variable where present	-

Figure 17 General reach-level channel type characteristics.

SOURCE: Montgomery and Buffington, 1993

Flow Chart for Determining
Response Category Type



Type A:	Unconstrained	Increased width and meander wavelength through bank cutting; may also downcut
Type B:	Slightly constrained, unconsolidated bottom	Increased width through bank cutting; this may result in undercutting of the upper banks and accelerated mass wasting; may also enlarge by downcutting
Type C:	Laterally constrained, unconsolidated bottom	Most likely to downcut; may also increase width through bank cutting, which could trigger accelerated mass wasting of upper banks
Type D:	Constrained, bedrock/large boulder bottom and banks	Cannot enlarge through downcutting, may widen slightly where banks can erode; will transmit water, sediment, and debris to lower reaches
Type E:	Boulder/bedrock stairstep	High stream energy will transport water, sediment, and debris to lower reaches; if upper banks are not bedrock, may widen slightly and accelerate mass wasting
Type F:	Woody debris stairstep	If "steps" are stable, will respond as Type E, or may trigger debris flow/dam break flood if debris recruitment is high and "steps" fail

SOURCE: Metzler, 1992

Streambank Erosion Survey

Purpose:

To document the number, type, and extent of streambank erosion features in treatment and control reaches, and take measurements of the physical dimensions (exposed surface area, length, height) in order to evaluate the rate of change in the number and extent of such features.

Materials:

field notes for photo-point survey of the study reach (to generate "P-line" map of study reach)
rite-in-rain graph paper for *making* sketch
metric carpenters tape
field notebook
streambank erosion survey field forms
pencils
30 & 100 meter fiberglass tapes
35 mm camera with telephoto and date-back features
400 ASA print film
random number generator

Site Selection:

Study reaches are selected at ground-based harvest or road construction sites, where a control stream reach can be located upstream of or nearby the treatment reach, and where preliminary streambank erosion surveys may be conducted prior to any impacts from the BMP example (except for localized disturbance in the case of road crossings).

Method Summary:

Surface area measurements of eroding banks along stream reaches are obtained at selected BMP study sites. Measurements include bank length, height, and percent exposed surface. Preliminary surveys are conducted prior to BMP-related impacts on streambanks within the treatment reach, other than localized disturbance at road crossings (e.g. prior to a major hydrologic event that follows BMP implementation). Additional surface area measurements of eroding banks along the same stream reaches are obtained one to three years later, depending on site and project considerations.

Assumptions:

Changes in the magnitude and rate of streambank erosion may be detected by sequential measurements of eroding (i.e. bare) streambanks within a particular reach.

Streambank erosion is a natural process that can be accelerated by certain forest practices which directly or indirectly (i.e. through changes in hydrologic regimes) disturb streambanks.

Accelerated streambank erosion can destabilize and degrade aquatic habitat.

The magnitude and rate of change in streambank erosion observed in the control reach located immediately upstream of the BMP represents baseline conditions against which changes in the treatment reach can be compared, and certain differences in erosion may be attributed to the effects of the forest practice.

Survey Method:

1. Within each of the study reaches, streambank erosion features are identified during the establishment of a photo-point network in the stream channel. Study reaches are approximately 25 channel widths in length. The photo-point network is used to establish the P-line from which the channel centerline is mapped. After the plan view centerline sketch is made, a 100 meter tape is laid along the centerline and the locations of eroding banks are noted on the sketch along with the approximate outline of the streambank perimeter. On this sketch, centerline length is to scale, but width is not drawn to scale.

2. Measure the total streambank length on each side of the stream by running a fiberglass tape along the top edge of the bank from the top of the reach to the bottom, and record on front page of field form.

3. Each eroding bank feature within the reach is numbered from upstream to downstream. Eroding banks are numbered sequentially, in the order encountered, as B1, B2, etc, with the number noted on the sketch. Indicate the approximate length of the streambank on the sketch next to the bank number. The location of the beginning and ending points of the bank feature, in meters from the top of the reach, is also noted on the sketch as well as the field notes form. It is not necessary to draw the streambank features to scale.

4. If there are less than 10 eroding streambanks within the reach, sample each feature. If there are more than 10 eroding streambanks, randomly choose at least 10 streambanks to sample, or sample all eroding banks in the reach.

5. Beginning with B1, measure the physical dimensions of each feature sampled and record on the Eroding Streambank Form:
   a. Measure the length of the bare or partially bare bank by running a tape along fhe top edge of the bank.
   b. Measure the height of the eroding streambank at 25, 50, and 75% intervals along the total length. Height is the cumulative height of exposed bank face, excluding areas of moss or other vegetative cover. Measure height as slope length from the top edge to the streambed (generally the edge of active channel), curving the tape underneath any overhang in order to measure the entire exposed surface.
   c. Visually estimate the % of total bank surface area that is exposed soil (i.e. not covered by vegetation, moss or boulders) as 0-25%, 26-50%, 51-75%, or 75-100%.
   d. Indicate bank shape (angled in, angled out, or straight) on the field form.
   e. Other comments about a bank may be noted in the comment column of the form.

6. Take one or more photograph of the eroding streambank from the center of the channel; note frame number(s) in field notes.

7. Continue down the stream channel in this fashion until the end of the study reach or until at least 10 banks have been surveyed. Be sure to note the total length of the reach surveyed.

8. In subsequent surveys conducted from one to three years following BMP implementation, the same numbered bank features are resurveyed. Any new features not present in previous surveys are noted on an updated sketch, and these new features are also surveyed.

Miscellaneous Notes and Recommendations:
Eroding banks are defined as stream banks with exposed soil (mineral and organic) that can be influenced by flowing water (either through scour or undercutting/mass wasting) during moderate and/or high flow events. Eroding banks are influenced such that moss and other hydrophilic plants have been scraped *or* scoured off *or* are unable to grow and/or grass and roots from above the active channel are scoured away. Bank cover may have been removed either by flowing water or other physical disturbance. (Note: exposed soil along an eroding bank should be able to be seen without lifting grass or root mats for viewing; undercut banks without associated upper bank failure must be tall enough to be viewed without lifting grass and/or root mats originating from above the active channel.)

Conceptual Rating Strategy:
Determination of BMP effectiveness considers the magnitude and rate of change in streambank erosion in the treatment reach relative to that in the control reach. The BMP is considered effective if there is no evidence of an increase in the rate or magnitude of streambank erosion associated with the forest practice.

Final decision criteria for determining whether water quality standards are achieved will be developed through a process that includes literature review and consultation with the TFW Water Quality Steering Committee, the Department of Ecology Water Quality Program, and other experts on water quality standards issues and beneficial uses as related to sediment impacts.

Stream Bank Erosion Survey Field Form

Study Site ID # ______________________________

Study Site Name ______________________________

Stream ID ______________________________

Surveyors ______________________________

Date ______________ Reach # ______________

Survey I: SE- ______________ Resurvey: Yes NO

Map Updated: Yes NO

Total # Eroding Banks in Reach ______________

Total # Sampled ______________

Total Reach Centerline Length (m) ______________

	Left Side (LDS)	Right Side (LDS)
Total Length of Banks (m)		
Total Length of Eroding Banks (m)		

Comments:

Bank #	ength fron p of Reac (meters)	Bank Length meters	Height 1	2	3		Shape /_\ _/ |_|	Frame #:	mme

No 352

Streambed Stability Survey

Purpose:

To quantitatively and qualitatively assess the size, volume, and stability of sediment deposits and associated storage structures within the treatment and control reaches.

Materials:

hand compass
metric carpenter's tape
7 meter telescoping level rod
Abney hand level
30 and 100 meter fiberglass tape
rite-in-the-rain graph paper (5 squares to the cm.)
streambed stability field forms
field book
5/8 " re-bar stakes
random number generator
pencils
survey flagging
cross section kit (tension clamps, etc.)

Site Selection Criteria:

Study reaches are selected at ground-based harvest, road construction sites, or sites where RMZs or RLTAs are left as a water quality protection measure. These reaches are located where the effects of the BMP being evaluated can be reasonably isolated from other land use interferences and the cumulative effects of past forest practices. Control reaches are generally located immediately upstream of the study reach.

Method Summary:

Treatment and control reaches are mapped using a rod and tape method. Storage structures and sediment wedges are mapped and measured throughout the reach. Seasonal or annual surveys are conducted to measure and/or monitor the number, size, volume, and stability of these stream features. Sequential surveys are conducted for 1-3 years following BMP implementation to document the relative magnitude of change between the control and treatment reaches in volume of sediment stored and the number and stability of the storage structures associated with the sediment deposits.

Within our project we have adopted sampling methods for depositional areas and associated storage structures that are stream gradient dependent. Megahan (1982) demonstrated that obstructions--(primarily large woody debris), within steep, headwater streams play a vital role in long-term sediment routing through forested drainage basins. Based on sediment transport mechanics, we have decided to sample reaches with steeper gradients differently than those with more gentle gradients. This methodology describes the survey we will use in streams with gradients greater than 5 %.

Assumptions:

Changes in the size, volume, number, and stability of sediment deposits can be measured by sequential surveys of stream features.

The magnitude, rate, and type of change in channel conditions in the control reach immediately upstream of BMPs represents the baseline conditions against which changes in the downstream reach can be compared.

While small, steep streams may function as sediment transport reaches over geomorphologically relevant time scales, they act as sediment storage reaches and aquatic life habitat the majority of time.

Stability of stream banks, channels, and sediment storage elements such as large woody debris is essential for maintaining beneficial uses.

Logging activities which significantly change the number, volume, integrity, or stability of sediment storage structures impact the habitat quality and beneficial uses of the stream.

Survey Method:

1. Within each of the study reaches, areas of sediment deposition, large woody debris (LWD), stream banks, and other notable features are mapped by using a modified version of the rod and tape mapping technique described in detail by Platts et. al. (1987). A metric fiberglass tape is stretched down the stream channel beginning at the top of the reach. The length and bearing to the first turning point is noted. The tape is secured with rebar stakes. A survey rod is held perpendicular to the tape and the distance of significant features noted. Measurement intervals are spaced along the tape as needed to sketch important features. Stream gradient between the ends of the tape is measured using an Abney hand level and survey rod. The map of the study reach is scaled using graph paper. Study reaches are 20-25 average channel widths in length.

2. After the sketch is made, each sediment wedge is numbered. The depositional units to be sampled are selected by random numbers. A maximum of 10 units are sampled in each reach. All units are sampled if there are less than 10 within a reach.

3. Selected units are measured for volume using a metric carpenter's tape, a level rod, and an Abney hand level. For volume measurements, the height of the sediment wedge is defined as the difference between a level rod reading taken on the bed at the downstream side of the obstruction and a rod reading taken on the sediment deposit immediately upstream from the obstruction. The width of the wedge is calculated by averaging three readings taken at 25, 50, and 75 % of the total length. The length is the longest axis of the wedge. The type of retention structure is noted, such as, Large Woody Debris (LWD), boulder, rootwad, or a

combination of the above.

4. Subsequent surveys are made as described in steps 1, 2, and 3 using an updated sketch map. A copy of the original sketch map is used for the updated map template. New or substantially modified sediment deposits and storage elements are resurveyed and added to the sketch map and highlighted as new or modified features. Features which are no longer present are highlighted on the copy of the original sketch map. Following the procedures *outlined in* 2. above, the same numbered features that *were* initially measured are re-surveyed. Any new sediment deposits that have been added to the sketch map are also numbered and surveyed. Cross-sections are resurveyed. Follow-up surveys are conducted annually at similar flow regimes, though they may be done more frequently following major hydrologic events.

Conceptual Rating Strategy:

Determination of BMP effectiveness considers the magnitude and rate of change in sediment deposits and storage elements in the treatment reach relative to that of the control reach.

The BMP is considered effective if there is no evidence of an increase in sediment deposition or stream channel destabilization, as reflected in the rate of change in sediment storage elements and sediment deposits.

Final decision criteria for determining whether water quality standards are achieved will be developed through a process that includes literature review and consultation with the TFW Water Quality Steering Committee, the Department of Ecology Water Quality Program, and other experts on water quality standards issues and beneficial uses as related to sediment impacts.

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Streambed Stability Survey

Site ID # ______________________

Site Name ______________________

Date ______________ Surveyors ______________

Survey # ______________ Flow ______________

Weather ______________ Reach # ______________

Comments:

Sediment Deposit #	Deposit Length	Deposit Width				Deposit Height		
		5%	50%	75%	Ave.	op Elev.	Base Elev.	Ht. Top-Base

No. 352

Channel Substrate Transects

Purpose:

To quantitatively and qualitatively evaluate the accumulation of surface fines, particle size distribution, the extent and stability of sediment deposits, and tilling of pools with fine sediment within the studied stream reaches.

Materials:

interconnected series of 30 cm. diameter hoops
metric carpenter's tape
particle size class samples encased in resin or a metric ruler
7 m. telescoping level rod
Abney hand level
rite-in-the-rain field forms
pencils
hinged plexiglass scale
random number generator
30 and 100 m. fiberglass tape
rite-in-the-rain graph paper (5 squares to the cm.)
hand compass
5/8 inch re-bar stakes
cross-section kit (tension clamps, etc.)

Site Selection Criteria:

Study reaches are selected at ground-based harvest, road construction sites, or sites where RMZs or RLTAs are left as a water quality protection measure. These reaches are located where the effects of the BMP can be isolated from other land use interferences and the cumulative effects of past forest practices. A control reach must be available; generally this reach will be immediately upstream of the treatment reach.

Method Summary:

Detailed sketch maps of study reaches are made using the rod and tape technique. Established transects within control and treatment reaches are seasonally or annually surveyed for relative changes in surface substrate composition, particle size distribution, cobble embeddedness-interstitial space index, residual pool depth, and cross section profiles. The preliminary survey is conducted prior to or immediately following BMP implementation. Sequential surveys are conducted 1-3 years following BMP implementation to document changes in sediment deposits, sediment storage structures, and channel stability.

Within our project we have adopted sampling methods for depositional areas and associated storage structures that are stream gradient dependent. Based on sediment transport mechanics, we have decided to sample reaches with steeper gradients differently than those with more gentle gradients. The channel substrate transects methodology will be used in streams with an average gradient of 8 %.

Assumptions:

Changes in substrate composition within depositional areas of stream channels can be measured by sequential surveys of these depositional areas.

The filling of pools with fine sediment can be measured by sequential residual pool depth surveys.

The magnitude, rate, and type of changes in channel substrate observed in control reaches immediately upstream of BMPs represent baseline conditions against which changes in the downstream reach can be compared.

Activities which result in the filling of interstitial spaces with fine or coarse sediment impact the habitat quality and beneficial uses of the stream.

Survey Method:

1.) Within each of the study reaches, areas of sediment deposition, large woody debris (LWD), stream banks, and other notable features are mapped by using a modified version of the rod and tape mapping technique described in detail by Platts et. al. (1987). A metric fiberglass tape is stretched down the stream channel beginning at the top of the reach. The length and bearing to the first turning point is noted. The tape is secured with rebar stakes. A survey rod is held perpendicular to the tape and the distance of significant features such as stream banks, LWD, pools, bars, and sediment deposition areas noted. Measurement intervals are spaced along the tape as needed to sketch important features. Stream gradient between the ends of the tape is measured using an Abney hand level and survey rod. The map of the study reach is scaled using graph paper.

2.) After the sketch is made, depositional areas are numbered. For purposes of this survey, depositional areas include low-gradient riffles, gravel bars, and sediment wedges. Pools are also identified and numbered on the sketch. The depositional areas and pools to be sampled are selected by random numbers. A maximum of 10 depositional units and IO pools are sampled in each reach. All depositional units and/or pools are sampled if there are less than 10 within a reach. If there are less than 10 depositional units within a study reach, distribute 10 transects among the depositional units present.

3.) Transects are established at the midpoint of each depositional unit. For depositional units greater than 5 meters in length, at least two transects are established at 25 and 75 % of the total length. If more than two transects are placed within a depositional unit (e.g. a long, low-gradient riffle), they are evenly spaced between the upper and lower ends of the depositional unit. A series of 30 cm. diameter hoops is placed starting at the left bank, ordinary high water mark (lbohwm) facing downstream and numbered l-n depending on how many hoops are required to reach the right bank (rbohwm). At each transect, the following information is recorded on the field form:

i.) Dominant and sub-dominant particle size classes are visually classified within each hoop using the particle size classification described in Table 1.

Table 1. Particle size classes.

CLASS NAME	CLASS SIZE (mm.)
sand & smaller	< 2.0
tine gravel	2.0-6.0
gravel	6.0-64.0
cobble	64.0-256.0
small boulder	256.0-512.0
large boulder	>512.0

ii.) The percent surface fines--less than 6.0 mm., within each hoop are visually estimated to the nearest 10 %, i.e., O-10, 11-20, etc., and recorded on the field form.

iii.) For each transect, a random number is generated on a hand held calculator or by rolling dice to select a hoop for a cobble embeddedness sample. The hoop number sampled is recorded and the percent embedded is determined for all particles between 6.4 and 25.6 cm. median axis diameter. With the thumb and forefinger defining the plane of embeddedness, the total depth and embedded depth (see Figure I) are measured using a plexiglass scale. The percent embedded is recorded on the field form and particle set aside. Cobbles are replaced after the sampling is complete. The number of free matrix particles (% embeddedness equals zero) are countedand their total depth measured. The percent free matrix particles (as a proportion of the total number of particles in the measured size range) is calculated. If a consistent relationship is established between % free matrix and % embeddedness, then future surveys may only measure % free matrix and use this as a surrogate for % embeddedness as suggested in MacDonald et al (1992).

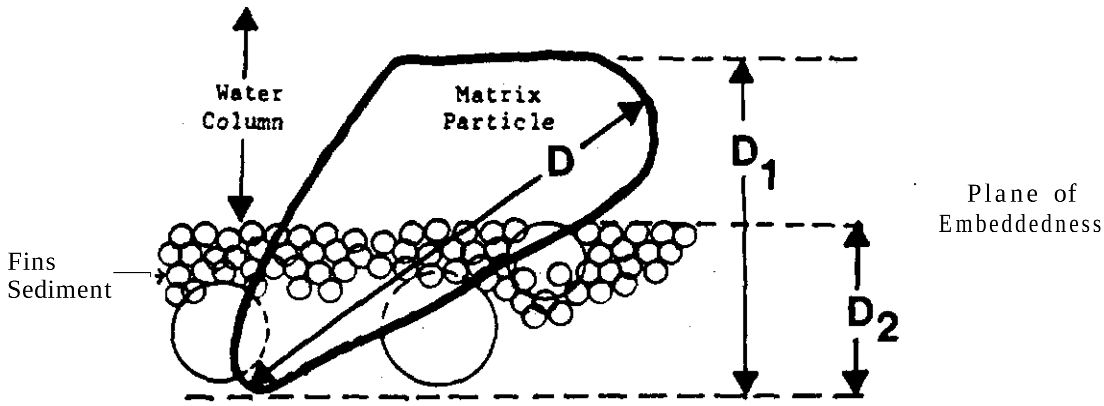
Three options we are reviewing for data analysis are briefly outlined below. These options are described in more detail in Burton and Harvey (1990). Cobble embeddedness data gathered through our method can be applied to all three options.

1. The formula described in figure 1 for measuring percent embeddedness.

2. Weighted embeddedness is an. analysis method used for hoops with > 10 % of the surface substrate covered by fines. For the purposes of this study, fines are defined as being less than 6.0 mm.

Weighted Embeddedness (WE) = Proportion of Surface Fines x 100 + (I Proportion of Surface Fines) x percent embeddedness (see figure 2). Measured embeddedness is equal to percent embeddedness from Figure 1.

Figure 1. Measurement to determine particle embeddedness for cobble and random **hoop** techniques (from Torquemada and Platts, 1988).



Percent embeddedness for each rock $= \left(\frac{D_2}{D_1}\right) \times 100.$

Mean embeddedness . **Sum of** all individual percentages divided by number of rocks.

3. The third analysis method, interstitial space index (ISI), more accurately reflects the amount of interstitial space available for **use by** aquatic organisms.

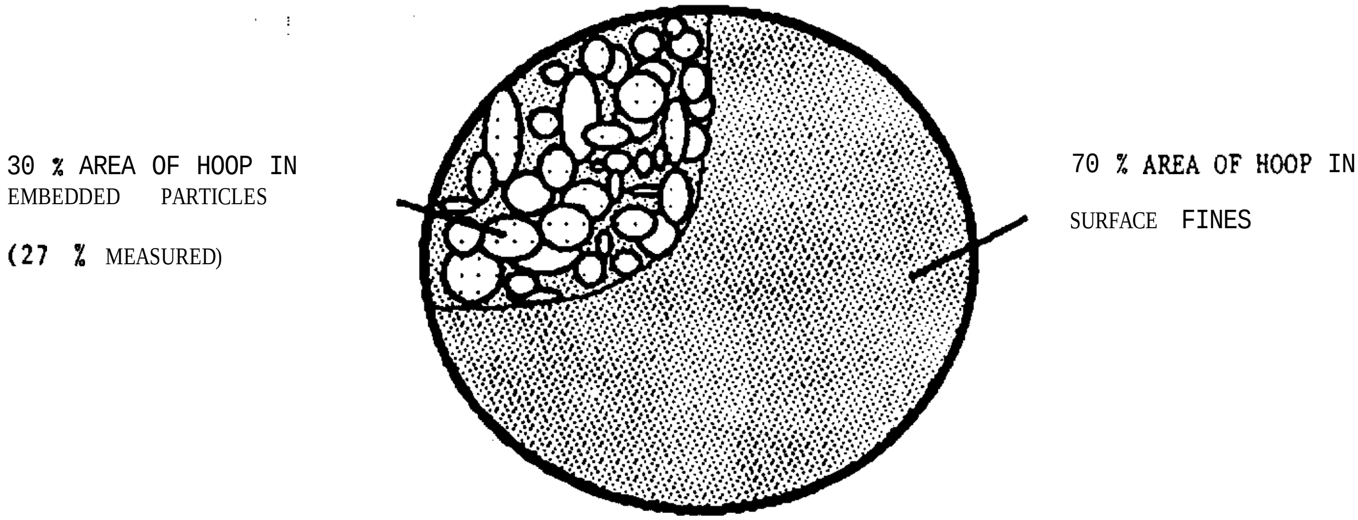
$$ISI = \sum (D1 \cdot D2) / \text{Hoop Area (meters)}$$

Where D1 and D2 are as shown from figure 1

iv.) Lastly, a pebble **count** is conducted. At each transect, 10 particles are randomly selected by moving along the transect line and, without looking, picking'up the particle first touched by the index finger. The particles are measured along the median axis using a metric ruler and the information recorded. A total of at least 100 particles are measured for each reach. From this pebble count data, the dominant and sub-dominant particle size for the overall reach is calculated.

4.) Sediment deposition is monitored in a maximum of 10 pools per reach by measuring residual pool depth. Residual pool depth is defined as the depth of water remaining within the pool if flow were reduced to zero.. Residual pool depth is measured **by** taking the depth of the pool at it's deepest point and subtracting the depth of water at the riffle crest. The riffle crest is that area of the stream where the pool "empties" downstream. Figure 3., taken from Lisle (1987), depicts residual pool depth **measurements from a longitudinal profile.**

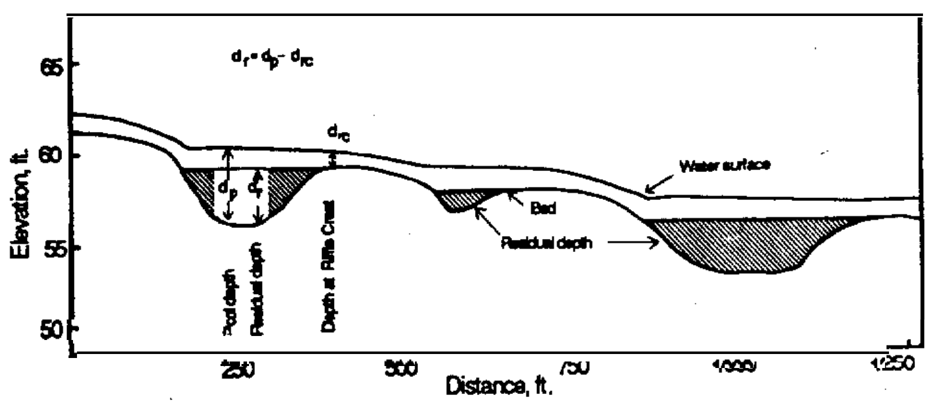
Figure 2. Weighted Embeddedness Calculation (from Torquemada and Platts, 1988).



WEIGHTED EMBEDDEDNESS = (PROPORTION OF SURFACE FINES) * 100 +
(1 - PROPORTION OF SURFACE FINES) * MEASURED EMBEDDEDNESS

EXAMPLE: (.70 * 100) + (.30 * 27) = 78 %.

Figure 3. Longitudinal Profile Showing Residual Pool Depths (from Lisle, 1987).



5.) Selected cross-section profiles are surveyed to document the change in relative bed elevations and channel form. The cross section locations are marked with permanent re-bar stakes driven into the stream bank Cross section profiles are surveyed by securing a 30 meter fiberglass tape at consistent tension across the stream to each permanent stake. The height from the tape to the feature is measured using a metric surveyor's rod. Alternatively, differential leveling may be performed using an Abney level and survey rod. In this case, a permanent benchmark is established at the cross-section location for elevation control.

6.) For resurvey of embeddedness, the hoop is located 0.5 meters immediately upstream of the hoop that was originally sampled. Subsequent transect surveys are conducted using the same techniques described above. A copy of the original sketch map is used to update changes in sediment deposition, including new features. Original transects are resurveyed annually at similar flow regimes, though they may be done more frequently following major hydrologic events.

Conceptual Rating Strategy:

BMP effectiveness is evaluated in terms of the magnitude, rate, and type of change documented in depositional areas of the treatment reach **relative to changes** in the control reach.

The BMP is considered effective if there is no evidence of an increase in deposition of fine sediment, loss of interstitial space habitat, or pool infilling.

Final decision criteria for determining whether water quality standards are achieved will be developed through a process that includes literature review and consultation with the TFW Water Quality Steering Committee, the Department of Ecology Water Quality Program, and other experts on water quality standards issues and beneficial uses as related to sediment impacts.

References:

Burton, T.A. and G.W. Edwards. 1990. Estimating Intergravel Salmonid Living Space Using the Cobble Embeddedness Sampling Procedure. Idaho Department of Health and Welfare, Division of Environmental Quality, Water Quality Bureau, Boise, ID. Water Quality Monitoring Protocols--Report No. 2.

Lisle, T.E. 1987. Usine "Residual Depths" to Monitor Pool Depths Independentlv of Discharge. U.S. Dept. of Agriculture, U.S. Forest Service, Pacific Southwest Forest and Range Experiment Station, Research Note PSW-394.

MacDonald, L.H., A.W. Smart, R.C. Wissmar, 1991. Monitorine Guidelines to Evaluate Effects of Forestrv Activities on Streams in the Pacific Northwest and Alaska. U.S. Environmental Protection Agency, Region 10, Seattle, WA;

Platts, W.S., C. Armour, G.D. Booth, M. Bryant, J.L. Bufford, P. Cuplin, S. Jensen, G.W. Lienkaemper, G.W. Minshall, S.B. Monsen, R.L. Nelson, J.R. Sedell, and J.S. Tuhy. 1987. Methods for Evaluating Riparian Habitats With Applications to Management. U.S. Department of Agriculture, U.S. Forest Service, Intermountain Research Station, General Technical Report INT-221.

Torquemada, R.J., W.S. Platts. 1988. "A Comparison of Sediment Monitoring Techniques of Potential Use in Sediment/Fish Population Relationships." In Idaho Habitat Evaluation for Off-site Mitigation Record. Annual Report 1987. Idaho Department of Fish and Game, and Bonneville Power Administration. Boise. Idaho.

DOMINANT/SUB-DOMINANT AND % FINES FIELD FORM

Site Id # ____________ Site Name ____________ Reach Number ____________

Transect # ____________ Distance of Transect from Top of Reach (meters) ____________

____________ ____________

____________ ____________

____________ ____________

Survey # ____________ Weather ____________ Flow ____________

HOOP #

TRANSECT #		TRANSECT #		TRANSECT #		TRANSECT #	
% Fines	Domin. / Sub-dom.	% Fines	Domin. / Sub-dom.	% Fines	Domin. / Sub-dom.	% Fines	Domin. / Sub-dom.

"FINES" ARL LESS THAN 6.0 mm.

CLASS NAME	CLASS SIZE (mm.)
sand & smaller	< 2.0
fine gravel	2.0-6.0
gravel	6.0-64.0
cobble	64.0-256.0
small boulder	256.0-512.0
large boulder	>512.0

PEBBLE COUNT FIELD FORM

Site Id # ____________ Site Name ____________ Reach Number ____________

surveyors ______________________________ Date ____________

Transect # ____________ survey # ____________ Weather ____________ Flow ____________

Comments ____

____

____

____

CLASS NAME	CLASS SIZE (mm.)	PARTICLE COUNT	TOTAL # PARTICLES	% TOTAL	is CUMULATIVE
Sand & Smaller	Less Than 2.0				
Fine Gravel	2.0 - 6.0				
Gravel	6.0 - 64.0				
Cobble	64.0 - 256.0				
Small Boulder	256.0 - 512.0				
Large Boulder	Greater Than 512.0				

COBBLE EMBEDDEDNESS FIELD FORM

Site Name ______________________ Site Id # ________ - ________ - ________

Date ______________________ surveyors ________ - ________ - ________

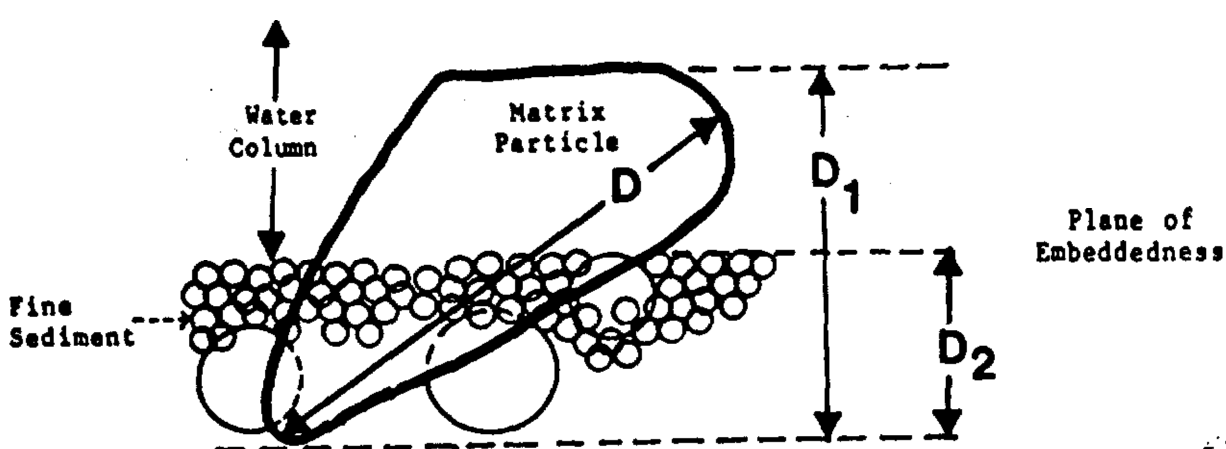
Reach Id # ______________________ Transect # ____________ Total # Cobbles Measured

Hoop # ______________________ Cobbles To Be Measured Are Between 6.4 and 25.6 cms.

comments ____

Survey # ____________ Weather ______________________ Flow ______________________

Cobble #	d (cms.)	d1 (cms.)	d2 (cms.)	Cobble #	d (cms.)	d1 (cms.)	d2 (cms.)



RESIDUAL POOL DEPTH FIELD FORM

Site Id # ______________ Site Name ______________ Reach # ______________

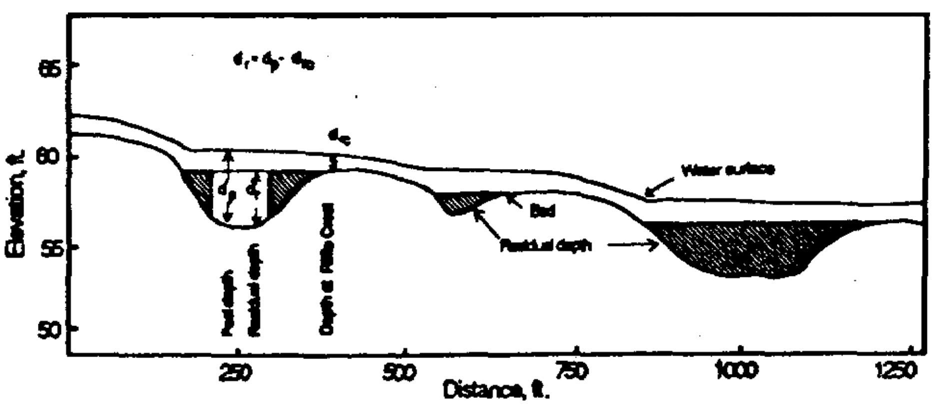
Date ____________________ Surveyors ____

comments ____

____

survey # ______________ Weather ______________________ Flow ______________

POOL NUMBER	MAX. POOL DEPTH (meters)	DEPTH AT RIFFLE CREST (meters)	RESIDUAL POOL DEPTH (meters)



CHANNEL CROSS SECTIONS FIELD FORM

Site Id # ____________ Site Name ____________ Reach # ____________

Transect/Cross Section # ________ Distance to Transect from Top of Reach (meters) ________

Length Between Rebar Stakes (meters) ________ Surveyors ____________

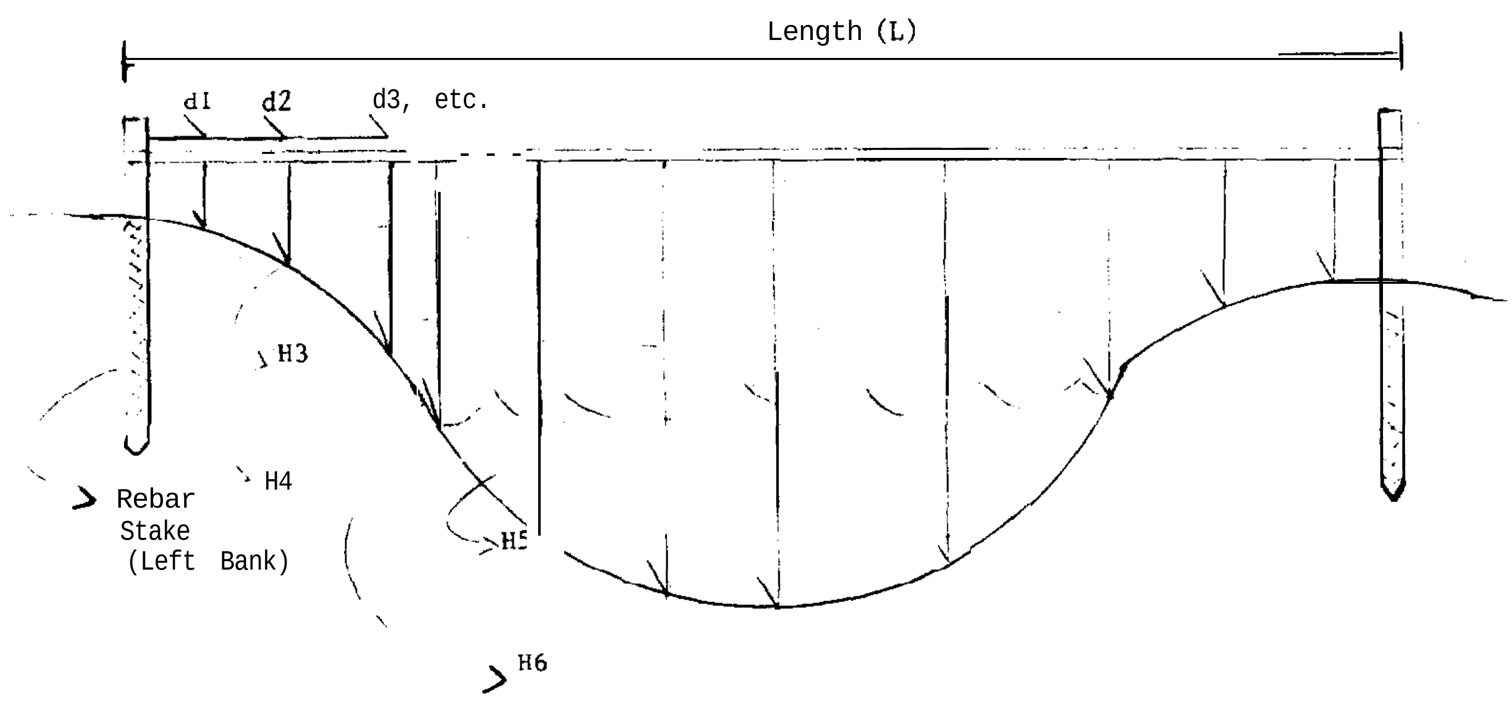
Comments (Notes to Locate Stakes) ______________________________

____

____

Survey # ________ Weather ____________ Flow ____________

Distance (d) On Tape (Measured from Left to Right Bank Facing DS.)											
Height (H) from Tape to Feature. (meters)											
Distance (d) On Tape (Measured from Left to Right Bank Facing DS.)											
Height (H) from Tape to Feature. (meters)											



Qualitative Culvert Condition Survey

Purpose:
To evaluate the integrity of newly installed culverts, particularly outflow and inflow of selected culverts during the first year to two years after installation, to assess the overall stability of stream crossings, and to document the water bar and culvert spacing for the road gradient *at* that site.

Materials:
camera with date-back feature
200 or 400 ASA print film
100 meter fiberglass tape
bright pink meter stick
bright pink half-meter stick
clinometer
compass
culvert condition field forms
field book
lead pencils
copies of previous field notes

Site Selection Criteria:
Sites selected for culvert condition monitoring are those sites with newly installed culverts that meet BMP standards.

Method Summary:
Initial evaluation of the culverts is conducted as soon as practical after installation and prior to a high intensity rainfall or runoff event. Newly installed culverts are monitored for effectiveness of armoring, overall stability, and erosion at culvert sites, using photo point networks. The survey includes documentation of culvert skew, culvert spacing, and road gradient. Subsequent surveys are conducted one to three years after the preliminary survey depending on site and project considerations.

Assumptions:
Substantial amounts of erosion and sediment delivery from culverts that fail or do not stabilize adequately can be detected by sequential surveys which visually document culvert conditions.

Any delivery of sediment to surface water at culvert installations is an increase over background levels.

Noticeable headward migration of a channel head directly down slope of a culvert outflow following road construction is an acceleration of the natural rate of channel head migration and an acceleration of sediment delivery to surface water from the road construction site.

At channel crossings and direct entry ditchlines along roads the sediment delivery ratio is 100%. At cross drains located within 60 meters of surface water the probability of sediment delivery is less than 100% (Burroughs and King, 1989).

Most road construction sediment from surface erosion is produced within the first three years of the life of the road. Also, this erosion may continue at a reduced rate for long periods, especially if exposed soil is adjacent to channel crossings, ditches, and cross drains within the contributing segment to surface water (Burroughs and King, 1989).

Armoring of culvert inflows and outflows reduces surface erosion at stream crossings and cross drains by covering exposed soils and thereby reducing the erosive effects of flowing water and rain-drop impacts.

Survey Method:

1. Identify the culvert condition survey location on unit map and draw a sketch if necessary to ensure relocation of survey. Surveys will always be conducted downhill or as otherwise noted on the unit map. Right and left are always read with the surveyors back to the start of the survey. Identify the first culvert evaluated on the site map and note location on field form.

2. Complete the following survey site information on the cover page of the culvert condition field form:
Study Site ID (e.g. 003)
Survey ID (e.g. CC01)
Brief Description of Road, Hillslope Features, and Location of Road
Date
Time
Surveyors
Film Type
Film Speed
Camera Used
Weather

3. Identify the first culvert evaluated on the site map and note the location on the field form. Number this culvert Cl. Measure the distance, percent slope, and azimuth from the first culvert to the next one along the new road and number this culvert C2. If it is not possible to see the next culvert or it is farther than 100 meters, measure the distance, percent slope, and azimuth to a point in between and label it P2.

4. Photograph the outflow, inflow, ditchline, upslope, and downslope features at Cl. Make sure date-back feature on camera is turned on and is set for the time of day mode.

5. Record the following information for the survey on the left page: from culvert #, to culvert #, distance, percent slope, azimuth, and culvert skew. Distances, slopes, and photos are taken from the culvert labeled "from". On the right page record: frame #, % plugged, armoring effectiveness, extent of erosion, and feature description. Armoring effectiveness: rating categories are poor, fair, and good. Erosion rating categories are none, slight, moderate, and high. Describe the photographed feature as an inflow, outflow, fill, or ditch line portion of the culvert placement.

6. Note whether there is a distinct channel or a channel head below each culvert outflow. Measure the width of the channel and the distance from the channel head to the culvert outflow. Set stakes on either side of the located channel heads below the new road for future reference.

7. Select the next culvert along the road. Take photos and record the location and culvert condition information as in steps 3, 4, 5, and 6. Continue moving, along the road until the last culvert to be surveyed is reached. Record the location of the last culvert in the notebook.

8. Additional surveys are conducted one to three years after the preliminary survey depending on site and project considerations. Subsequent surveys are conducted with review of the initial survey notes. Original field notes taken during the initial survey are copied and left in the project files.

Misc. Notes and Recommendations:
The following ratings are applied to at culvert:

Extent of Erosion:

None = no evidence of erosion

Slight = a few rills, etc.; <25% of the exposed soil surface is affected

Moderate = rills and small gullies (< 10 cm wide), small amount of slumping or undercutting; 25-50% of the exposed soil surface is affected

Severe = rills and small to large gullies (10 cm+ wide), areas of slumping or undercutting; >50% of the exposed soil surface is affected

Armoring:

Poor = little armoring, important locations not armored (e.g. where water flow is directed), and/or rocks used are too soft or too small.

Fair = adequate location of rock, but little extra protection beyond immediate culvert area; water may be diverted into unprotected places

Good = all important locations are armored

General Photography Notes:

The photo frame seen through the lens shows more than is cut from the negatives. Shoot conservatively to capture as much of the feature as possible in the finished photo.

Try to show the entire till area, including the road surface at the top of the photo. Step back to capture these features or take two pictures, one vertical and one horizontal. Avoid taking pictures in such a way that cut and pasting will need to be done at the office.

Place a scale at each feature to be photographed. Make sure to capture the entire length of the scale. Use either the half meter or the meter stick (bright pink) as needed.

Suggested scale placement is horizontal for the culvert inflow/outflow armoring, vertical for fill areas, and length wise down the ditch lines.

Conceptual Rating Strategy:
Determination of BMP effectiveness using the culvert condition survey considers evidence of continuing erosion with sediment delivery to surface water, mass failure associated with the culvert installation, and upslope migration of channel heads downslope of culvert outflows.

The BMP is considered effective if there is no evidence of continuing erosion with sediment delivery to a stream, mass failure associated with the culvert installation, and upslope migration of channel heads downslope of culvert outflows.

Final decision criteria for determining whether water quality standards are achieved will be developed through a process that includes literature review and consultation wither the TFW Water Quality Steering Committee, the Department of Ecology Water Quality Program, and other experts on water quality standards issues and beneficial uses as related to sediment impacts.

References:

Burroughs, E.R. Jr., and J.G. King. 1989. Reduction of soil erosion on forest roads. USDA Forest Service General Technical Report INT-264. p. 21.

Culvert Condition Survey

Study ID #:__________________________ Date: _______________

Study Site Name:________________________ Time:______________

Survey #:__________________ Surveyors: ______________

Camera Used:

Film Type:

Film Speed:

Weather:

Starting & Ending Culvert #'s/Descriptions:

Road, Hillslope, etc.-Descriptive Notes:

M&hod Notes:

From:	To	Distance	Slope:	Azimuth	Culvert Skew	Frame #		Armoring ffectivenes	Extent of Erosion	Feature Description

Cutbank/Fillslope Survey

Purpose:
To evaluate the effectiveness of road drainage design BMPs and new road construction BMPs from the standpoint of road cutbank and tillslope stabilization, ditch function, and sediment delivery to streams.

Materials:
camera with date-back feature
200 or 400 ASA print film
100 meter measuring tape
compass
clinometer
metric survey rod
bright pink meter stick, for scale
survey flags
write-in-the-rain field book
cutbank/fillslope field forms
sharpie or grease pencil
lead pencils

Site Selection Criteria:
Sites are selected where new road construction is conducted near streams and where road segments drain directly to a stream crossing.

Method Summary:
Oblique angle photographs are taken of road prism features on newly constructed roads. Initial photos and reconnaissance of new roads arc conducted after the road has been constructed and prior to a high intensity rainfall or runoff event. A point line is established which runs along the base of the cutbank slope on the inside edge of the road. The cutbank, road surface, and ditch line is photographed from this perspective. The fillslope is photographed by walking directly across the road from the established point line. Erosion and storage features are noted to show how the road prism stabilizes over the project study period. The percent slope of the hill slope adjacent to the road prism is measured using a clinometer. Vegetative cover on slopes, cutbank slumps, tillslope overburden, extent of road surface rutting, and ditch line filling and clean out are some of the 'features to be photographed during this survey. Additional qualitative road surveys are conducted one to three years later, depending on the site and project considerations.

Assumptions:
Substantial amounts of erosion and sediment delivery from newly constructed roads that do not stabilize adequately can be detected by sequential surveys which visually document road prism conditions.

Any delivery of sediment to surface water at new road construction sites is an increase over background levels.

At channel crossings and direct entry ditchlines along roads the sediment delivery ratio is 100%. At cross drains located within 60 meters of surface water the probability of sediment delivery is less than 100% (Burroughs and King, 1989).

Most road construction related sediment from surface erosion is produced within the first three years of the life of the road. Also, this erosion may continue at a reduced rate for long periods after, especially if exposed soil is adjacent to channel crossings, ditches, and cross drains within the contributing segment to surface water (Burroughs and King, 1989).

Survey Method:
1. Complete the required survey site information on the first page of the field notebook. On the first page of each cutbank/fillslope survey the following site information specific to the survey is to be recorded:

Study Site ID (e.g. E02)
Survey ID (e.g. CF01)
Brief Description of Features Surveyed, BMP studied, and Location of Unit
Date
Time
Film Type
Film Speed
Camera Used
Weather
Permanent Point Description

2. Identify the stream crossing of interest and determine the extent of the road segment draining to that crossing. Identify the survey location on unit map. Use sketch if necessary to ensure relocation of survey.

3. Select a permanent point near the start of the photo point network. Examples include: culverts, large stumps, large rocks that are unlikely to move, etc. Describe the features of the permanent point for future reference in the notebook. Use sketch if necessary. A photo may be taken from the permanent point. Make sure date-back feature on camera is turned on and set for the month/date/year mode. Record the object photographed, azimuth and distance from the permanent point in the notebook. Flag the permanent point and label it PP (for "permanent, point") with the survey number.

4. Measure the percent slope of the hill slope adjacent to the road prism at each point by taking clinometer readings above and below the road.

5. Construct a p-line along the inside of the road prism at the slope break into the ditch line. Photograph the cutbank, road surface, and ditch line from this perspective then walk directly across the road and photograph the fillslope. Descend down the fillslope as far as necessary to obtain the best perspective. Record each photo with subject and viewpoint notes.

6. Select the next viewpoint along the inside of the road. Measure the distance, percent slope, and azimuth from the permanent point to this first selected point. Place the flag above the cutbank in organic soil wherever possible (otherwise place the flag near the location where the photographer stands) and label it PO1 (photo point 1). Include the survey number on all flags. Take a picture of one or more features and record the feature description, azimuth, percent slope, and distance from PO1 to PO2 in the notebook.

7. Note the following road condition factors on the field form: % exposed soil covering the cutbank and tillslope; evidence of erosion features (surface, tension cracks, slumps, rills, gullies); evidence of storage features (bench below road, sediment trap, sills); presence of seeps; road prism configuration (outsloped, insloped, crowned, rutted, flat). At each point along the p-line visually estimate the cutbank slope length and group into short (< 3 m), medium (3-10 m), and high (> 10 m) slope length categories and measure the cutbank slope angle by laying the rod against the cutbank and getting the degrees slope with the clinometer. Describe other factors that influence surface erosion and road prism stability between points as needed.

8. Continue moving along the road prism as outlined in steps 4, 5, 6, and 7 until the survey is finished. The road to be surveyed should be only that segment of road that directly contributes to a type I-V stream. Label the final point as "Px, last point" in the notebook.

9. Subsequent cutbank/fillslope surveys are conducted one to three years after the BMP has been implemented (depending on project and site considerations) and are used to determine change in features that have occurred over the study period.

Misc. Notes and Recommendations:

Capture the entire scale (one meter or one-half meter) when taking all photographs. Make sure the wide view of the scale is facing the camera.

Keep in mind that the final prints do not show the entire area inside the camera's viewfinder, shoot conservatively.

Never take the original photo survey field notes into the field. Take copies from the site tile only.

Do not take a series of photos of the same feature that will need to be pasted together later. Try to capture the entire feature in one photo.

Sediment Wedge Features:

Take the photos while looking down slope. Stand above or on top of the exposed soil and shoot down. Place the scale horizontal, parallel to the photo direction on top of the substrate.

Sediment Wedge Obstruction:

Take the photos while looking up slope. Place the scale vertically against the storage mechanism. to give a sense of the feature's height.

Road Cutbank Features:

Place photo points a maximum of 15 meters apart. Place photo points where changes in the cutbank will be seen (e.g. at an angle looking down the road, along the cutbank). Lean the scale vertically, along the slope distance, with the wide part facing the camera.

Road Fill Features:

Place photo points a maximum of 15 meters apart. Place photo points where changes in till slopes will be seen (e.g. from the bottom of the fill slope, looking along the bottom edge of the constructed road prism or from turning points where the till can be seen from the road edge). Lean the scale vertically, along the slope distance, with the wide part facing the camera.

Road Surface Features:

Take the photos looking down the road. Stand above or on top of the road surface and shoot down. Place the scale horizontal, parallel to the photo direction on top of the road surface.

Conceptual Rating Strategy:

Determination of BMP effectiveness using the cutbank/fillslope survey considers evidence of continuing erosion with sediment delivery to surface water and mass failure associated with the road prism.

The BMP is considered effective if there is no evidence of continuing erosion with sediment delivery to a stream.

Final decision criteria for determining whether water quality standards are achieved will be developed through a process that includes literature review and consultation with the TFW Water Quality Steering Committee, the Department of Ecology Water Quality Program, and other experts on water quality standards issues and beneficial uses as related to sediment impacts.

References:

Burroughs, E.R. Jr., and J.G. King. 1989. Reduction of soil erosion of forest roads. USDA Forest Service General Technical Report INT-264. p. 21.

Cutbank/Fillslope Survey

Study Site # ________________ Date ________________

Site Name. ________________ Time ________________

Survey ID # ________________ Surveyors ________________

Film Type ____________

Film Speed ____________

Camera Used: ____________

Weather ____________

Permanent Point Description:

From	To	Dist (m)	Azim	Road Grad	Hill Grad (%)	tbank rad	Cutbank Slope Length	Frame #	Evidence of Erosion	Evidence of Storage	Seep (y/n	Road Desi (in/outslop	eature &/or Notes

No. 352

Road Cutbank and Skid Trail Erosion Pin Survey

Purpose:
To document the amount and rate of surface erosion from contributing segments of road cutbanks and skid trails.

Materials:
sketch of skid trail or road cutbank with drainage features (constructed from photo point survey)
metric carpenters tape
survey rod
100 and 30 meter fiberglass tape
clinometer
2 mm welding rods, 0.5-I .2 meters in length (depending on soil depth at site)
3/8" rebar, 0.5-1.2 meters in length
survey flags
write-in-the-rain field notebook
erosion pin field forms
sharpie or grease pencils
lead pencils

Site Selection Criteria:
Sites for erosion pin networks to evaluate road construction and skid trail BMPs are selected at road or skid trail segments that contribute sediment directly to surface water or at cross drainage within 60 meters of surface water, where the survey is able to be conducted after BMP implementation, and prior to a high intensity rainfall/runoff event.

Method Summary:
Erosion pin networks are placed along newly constructed road cutbanks and skid trails prior to a high intensity rainfall/runoff event. A cutbank/fillslope survey or a skid trail photo point survey is conducted before initial pin placement. Transects are placed every 10 meters within a contributing mad or skid trail segment. A maximum of 10 and a minimum of 5 transects are placed along a representative portion of the contributing segment, keeping in mind that 10% coverage is optimal. Pins are measured, placed, and the exposed length of the pin is recorded. The network remeasured one or more times from one to three years later, depending on site and project considerations.

Assumptions:
Surface erosion documented using erosion pin networks at cutbanks or skid trials represents an increase over background levels of sediment production.

The erosion rate measured over the project study period within a representative portion of a contributing segment is able to be extrapolated to other contributing segments with similar areas (i.e. similar slopes, soils, etc.) of exposed soils at the study site.

Forest practice activities that do not expose or disturb the surface mineral soil are unlikely to increase surface erosion.

Most new road and skid trial related sediment from surface erosion is produced within the first three years following road construction or harvest activity.

At channel crossings and direct entry ditchlines along skid trails and roads the sediment delivery ratio is 100%. At cross drains located within 60 meters of surface water the probability of sediment delivery is less than 100% (Burroughs and King, 1989).

Survey Method:

1. Complete the following survey site information on the first page of the field notebook:

Study Site ID (e.g. E02)
Survey ID (e.g. EP01)
Brief Description of Features Surveyed, BMP studied, and Location of Unit
Date
Time
Weather
Permanent Point Description
Method Notes: length of segment; spacing of transects; etc.
Copies of original network notes if re-surveying the pin network

2. Identify the survey location on the unit map. Using p-line notes from the previously conducted photo point or cutbank/fillslope survey sketch the erosion pin network location within the contributing segment and in relation to stream crossings and other site features. Select a segment that is a maximum of 100 meters in length and a minimum of 50 meters in length, keeping in mind that 10% network coverage for the contributing segment is optimal.

3. Select a permanent point used for laying out the transects. Describe the features of the permanent point for future reference in the notebook. Use sketch if necessary. Flag the permanent point and label it PP (for "permanent point") with the survey number.

4. Lay out the pin network and record network information as described in the following steps:

For Road Cutbanks:

a. Lay the 100 meter measuring tape down the center of the ditchline, starting at the permanent point. Transects are set every 10 meters along the tape. Place a flag near the location of the transect, label it Tl (transect 1). Note the following information: transect number, slope of the cutbank, slope length of the cutbank, transect length, transect location, and flag placement on the left page of the field form. Obtain the slope angle of the cutbank by laying the rod on the cutbank and getting a slope (degrees) with a clinometer. Always start the network going down the road. "Left" and "right" direction notes refer to directions taken while looking down the road (down slope).

b. Place pins 1 meter apart going up the cutbank, starting at the ditch centerline along the inside of the road. At the top of the cutbank, place a pin at the bottom of the roots or vegetation and note the distance of the entire transect. Prior to pin placement, measure the entire length of the pin. After the pin has been placed, measure the exposed pin length. Note the pin # (l-n for each transect), total pin length, exposed pin length, and pin location on the right page of the field form. From the base of the pin placed at the bottom of the cutbank, measure the slope length and slope angle of the exposed surface of the cutbank. Obtain the slope angle of the cutbank by laying the rod on the cutbank and getting a slope (degrees) with a clinometer. Record the cutbank angle below the transect pin data on the left page of the field form.

c. Place a flag near the location of the next transect, label it, and record the location in the field notes. Repeat steps 4a.-b., continuing down the road in this manner until the survey is finished.

For Skid Trails:

d. Lay the 100 meter measuring tape down the center of the skid trail, starting at the permanent point. Transects are set every 10 meters along the tape. Measure the slope (%) from the permanent point to the first transect, the transect length, and note the transect location and flag placement on the field form. On the left page of the field form record: transect #, slope to next transect, transect length, transect location, and flag placement location. Place a flag near the location of the transect, label it Tl (transect 1) noting which side of the trail it was placed. Always put in a network going downslope. "Left" and "tight" references in the notebook always refer to directions read while looking down the skid trail (down slope).

e. Place pins 1 meter apart starting from the outer edge of the skid trail or decide upon which side the transects will start, right or left, and specify on the field form. At the edge of the skid trail, place a pin at the bottom of the cutbank or edge of exposed trail, and note the distance from the previous pin in the "pin location" column. Prior to pin placement, measure the entire length of the pin. After the pin has been placed, measure the exposed pin length. On the right page of the field form record: pin # (l-n for each transect), total pin length, exposed pin length, and pin location. From the base of the pin placed at the bottom of any cutbank, measure the slope length and slope angle of the exposed surface of the cutbank. Obtain the slope angle of the cutbank by laying the rod on the cutbank and getting a slope (degrees) with a clinometer. Write in the field notes below the transect pin data, on the right page.

f. Obtain the slope to the next transect (%). Place a flag near the location of the next transect, label it, and record the location in the field notes. Repeat steps 4d.-e., continuing down the skid trail in this manner until the survey is finished.

Conceptual Rating Strategy:

Determination of BMP effectiveness using erosion pin networks considers the evidence of continuing erosion with sediment delivery to surface water. The BMP is considered effective if there is no evidence of continuing erosion with sediment delivery to a stream.

Final decision criteria for determining whether water quality standards are achieved will be developed through a process that includes literature review and consultation with the TFW Water Quality Steering Committee, the Department of Ecology Water Quality Program, and other experts on water quality standards issues and beneficial uses as related to sediment impacts.

References:

Burroughs, E.R. Jr., J.G. King. 1989. Reduction of soil erosion of forest roads. USDA Forest Service General Technical Report INT-264. p. 2 1.

Road Cutbank/Ditch Erosion Pin Network

Study Site #:______________________ Date: ________

Study Site Name:___________________ 'Time: ________

EP#:______________________________ Surveyors:_________

Weather:

Activity: Initial Placement

Interim Measurements

No. of Months Since Initial Measurement:

No. of Months Since Last Measurement:

Method Notes/Site Notes:

Transe #	cutbank slope (degrees)	cutbank length (m)	Transect Location

Pin #	Total Pin Length (cm)	Exposed Length	Pin Location Notes

Skid Trail Erosion Pin Network

Study Site #:________________________ Date:________

Study Site Name:____________________ Time:________

EP#:______________________________ surveyors: _________

/Weather:

Activity: Initial Placement

Interim Measurements

No. of Months Since Initial Measurement:

No. of Months Since Last Measurement:

Method Notes/Site Notes:

Transect #	Slope to Next Transect	transect length (m)	Transect Location Notes

Pin #	Total Pin Length (cm)	Exposed Length	Pin Location Notes

Road Surface Condition Survey

Purpose:
To evaluate the effectiveness of active haul road maintenance BMPs by assessing the condition of the road surface during periods of high truck use, particularly during wet weather.

Materials
study site map and aerial photos (if available)
100 and 30 meter measuring tapes
metric carpenter's tapes
camera with date-back feature
200 or 400 ASA print film
survey flags
write-in-the-ram field book
lead pencils
road condition survey field forms
surface probe (metal rod) marked off in half-centimeter increments
2 hand-held traffic counters
rite-in-rain graph paper & scales
compass
clinometer
Abney hand level & level rod
hand trowel & shovel
tipping bucket raingage with datalogger

Site Selection Criteria:
Sites for this survey will be selected along active main haul road segments in close proximity to streams, where the stream reach upstream of the road crossing is not traversed by a main haul road within about 1 kilometer. Main haul roads are heavy-use roads, defined as having traffic levels exceeding four log trucks per day.

Method Summary:
The surface conditions of main haul roads are assessed during wet weather surveys by sampling at transects established near a stream crossing. Conditions documented at each transect include condition of gravel surfacing, extent of tines/mud on the road surface, ruts and potholes, and microtopography of the road surface. Photographs are taken to document conditions at the transects. Surface drainage pathways are mapped along the study segment, and relative moisture condition of the road surface is assessed. A qualitative assessment is made of cut and fill slopes and ditches, noting evidence of erosion, vegetative cover, and slope length and angle for the contributing road segment. Log truck and light vehicle traffic is counted during the survey period. In addition, recent maintenance history for the road is obtained from the landowner. Runoff sampling is often conducted in conjunction with (i.e. on the same day) the road surface condition survey.

Assumptions:
The condition of the road surface during periods of heavy use in wet weather influences the production of fine sediments and introduction of fine sediment to streams.

Road surface conditions relevant to tine sediment production from haul roads may be sampled directly during periods of heavy use in wet weather.

At stream crossings and along segments of haul roads with ditchlines draining directly to streams, the sediment delivery ratio is 100% for fine sediment produced which is mobilized by runoff.

Runoff events selected for sampling represent typical conditions of BMP implementation.

Survey Method:

1) Install raingage: Upon arrival at the site, install the recording tipping bucket raingage in the vicinity, at a location free from overhead obstructions such as forest canopy. The datalogger is programmed to record tips at 15 minute intervals.

2) General Site Information: On the first page of field notes, using the road condition survey field form, the following general site and survey information should be recorded:

   Study Site ID (e.g. E-02)
   Survey ID (e.g. RS01)
   Location and Name of Road
   Date & Time (beginning and ending)
   Weather Conditions
   Length of contributing road segment
   Gradient of road segment
   Gravel type and source (obtained from landowner contact)
   Road drainage design (inslope/outslope, crowned, etc.).
   General description of road prism (cut/till slopes, etc.)
   Hillslope gradient above and below and road segment gradient

3) Sketch the study area and establish the road segment to be surveyed: Determine the contributing road segment (extends to road surface and/or ditchline drainage divides) and delineate on a sketch. Determine the portion draining directly to the stream crossing (e.g. downslope of relief culverts) and delineate drainage routes on the sketch of the study site. Show cutbanks, fillslopes, berms, and ditches on the sketch. Establish transects as described below in step 4), number the transects, and indicate the transects numbers on the sketch. Transects are numbered sequentially, from right to left (looking downstream from the crossing).

4) Establish transects and document a) condition of gravel surface. b) thickness of mud/fines at surface. c) extent of rutting, and d) microtopography of the road surface:

   Establish road transects at 10 meter intervals, along a 100 meter segment of road centered on the stream crossing. This will result in 11 transects, with one at the center of the stream crossing and five on either side of the stream.

a) Condition of the gravel surface: At each transect, establish points at two meter intervals along the travelway, with a point at each edge (i.e. outside of the travelway at shoulder or ditch). At each point, probe the surface with a metal rod and/or hand trowel and note whether there is a functional, compacted gravel surface on the field form. At the conclusion of transect measurements, make notes of general gravel layer conditions (e.g. apparent thickness of gravel surfacing) and gravel type, size, etc. Verify gravel type and source with road maintenance personnel. Collect a gravel sample for later comparison with other study sites.

b) Thickness of mud/fines: At the same measurement points where gravel condition is assessed, determine the thickness of tines/mud by inserting a calibrated metal rod, and record thickness to the nearest half centimeter.

c) Extent of rutting or potholes: For each transect that has visible ruts or potholes, measure the width with tape and depth with hand level and rod.

d) For each transect, note the width of the travelway, whether the road surface is insloped or outsloped, and whether or not a corrugated "washboard" surface is apparent.

5) Photograph each transect: Establish photo-points to document the road surface and drainage characteristics. Photo-points are co-located with transects, although additional points may be included. Points are marked with survey flags at the edge of the right-of-way, with photos taken from the points as well as from offset locations on the road. Frame numbers of photos are noted in the "Comments" column of the transect notes.

6) Road surface drainage mapping: Where runoff is apparent, make a scaled drawing of surface water pathways on the road prism, including ruts, ditches, and culverts. Include portions of the contributing road segment which are outside of the part sampled by transects.

7) Assessment of road cuts and fills, culverts. and ditches: Based on a walking survey of the contributing road segment, make a qualitative assessment of the condition of road cuts and tills, noting the slope length, slope angle, degree of cover, extent of surface erosion, etc. Describe the condition of drainage ditches and culverts. These features may also be documented by photo-points where they are outside of the portion of the road sampled by transects. Evaluate the entire contributing road segment and assess the similarity of the intensively sampled portion to the remainder of the contributing segment.

8) Traffic count: During the field survey period, count each vehicle that passes the survey segment. Use one hand-held counter for log trucks and other heavy vehicles (e.g. dump trucks) and one for light (i.e. 4-wheel) vehicles. At the end of the survey period, note the number of vehicles of each type on the field form. In addition, obtain truck traffic data (e.g. trip tickets, best estimates) for the 30 days prior to the survey from the landowner.

9) Maintenance Information: Obtain best available maintenance records for the 6 months prior to survey from the landowner (interviews with maintenance personnel, etc.)

10) Moisture level: In the field, visually determine the relative soil moisture of the road surface layer by probing several locations along the road segment sampled, and categorize the soil material as dry, moist, or saturated according to the following classifications:

saturated: infiltration capacity is exceeded, runoff or standing water is apparent;
moist: precipitation is infiltrating, with no apparent standing water;
dry: fine material crumbles in palm of hand, no obvious moisture.

Conceptual Rating Strategy:
The integrity of the gravel surface, extent of surface tines and muddiness, the degree of rutting, potholes and other surface irregularities, and surface runoff drainage patterns are indicators of BMP effectiveness. The BMP is considered effective if there is no evidence of fine sediment production with delivery to streams. Such evidence may include surface muddiness or rutting within a contributing segment, visible cutbank or ditch erosion within a contributing segment, and/or visible delivery of sediment to streams. Results of runoff sampling are also considered where such sampling is conducted in conjunction with the road surface condition survey.

Final decision criteria for determining' whether water quality standards are achieved will be developed through a process that includes literature review and consultation with the TFW Water Quality Steering Committee, the Department of Ecology Water Quality Program, and other experts on water quality standards issues and beneficial uses as related to sediment impacts.

Road Surface Condition Survey Field Form

Study Site ID ____________ Date: ____________

Survey ID RS-________ Road Name/Location ____________

____

Time: Start ____________ End ____________

Weather ______________________

Length of Road Surveyed (Meters) ____________

Gradient of Study Segment % ____________

Gravel Type ______________________

Gravel Source ______________________

Road Drainage Design (inslope/outslope, etc.) ____________

____

General Description of Road Prism (cut/fill, etc.) ____________

____

Hillslope Gradient Above and Below Road (%)

Range ____________ Average ____________

Traffic Count: Beginning Time: ____ End Time ____

Log Trucks   Light Vehicles

Soil Moisture: Saturated   Moist   Dry

Comments:

Transects Placed at 10 meter intervals

Transect #	Point #	unctiona Gravel Surface (Y/N)	Fines Thick. (cm)	Rutting/Potholes Width (m)	Edge Elev. (m)	Rutting/Potholes Bottom Elev.	Edne Elev.	Depth (m)	In: Ou	e/ pe	wash-board YIN	Comments

No. 352

Runoff Sampling

purpose:
To assess fine sediment loading to streams from road surfaces and other disturbed areas where forest practices have occurred near streams.

Materials:
100 and 30 meter measuring tapes
survey flags
field book
runoff sampling field forms
channel condition survey field forms
lead pencils
Model DH-81/D-77 and DH-48 Suspended Sediment Samplers
1000 and 500 ml plastic sample bottles
ice chest with ice and packaging materials
wristwatch and/or alarm clock
tipping bucket ram gauge and d&logger loaded with scheme
topographic map of the location
bucket of known volume
flexible flume for ditch flow measurement
stopwatch
Marsh McBirney flow meter
capacitive depth probe and datalogger or staff gage
manual traffic counters

Site Selection Criteria:
Sites for runoff sampling will be selected at locations where main haul roads, newly constructed roads, or skid trails cross streams in such a manner that a control reach can be located immediately upstream of the crossing or harvest unit.

Method Summary:
Water samples are collected during runoff events and analyzed for turbidity and total suspended solids to assess fine sediment loading from road or skid trail crossings of streams. Samples are collected at multiple sampling stations in the stream above and below the road or skid trail crossings, as well as from road ditches. Ancillary information collected during the sampling period includes rainfall amount and intensity, streamflow, study site descriptions, and vehicle traffic.

Assumptions:
Turbidity and total suspended solids measured at sampling stations immediately upstream of BMPs establish the background conditions against which the effects of the forest practice, including fine sediment loading to the stream, can be compared.

Excessive fine sediment loading at road crossings and harvest units has the potential to exceed turbidity standards and adversely impact aquatic habitat.

Survey Method:

1) Upon arrival at the site, the recording tipping bucket raingage is set up in the vicinity, at a location free from overhead obstructions such as forest canopy. The datalogger is programmed to record tips at 15 minute intervals.

2) The following general site information is recorded in the field book:

Study Site ID (e.g. S-01)
Survey ID (e.g. RO01)
Name of Road or Unit
Date and Time
Length of contributing road segment or skid trail
Gradient of road or skid trail contributing segment
Road or skid trail design info (inslope/outslope; ditches; waterbars; surface; etc.)
Type of crossing (culvert; bridge; ford; etc.)
Hillslope gradient in vicinity of crossing

3) Four to six runoff sampling stations are established as follows:

- 2 background stations are established upstream of the road/skid trail crossings, or upstream of the harvest unit, spaced no more than 5 channel widths apart;
- 2 stations are established downstream of the road/skid trail crossing (below the immediate ditch outflow or crossing site), spaced no more than 5 channel widths apart;
- for roads with ditches draining to stream, 1 station is established in the stream in the immediate vicinity of the ditch outflow (i.e. mixing area), and 1 station is established to sample the ditch flow immediately above the ditch outflow;
- for skid trail crossings, there will generally be no outflow or ditch samples.

Stations are marked with survey flags. A sketch of the study site is made in the field book. The sketch shows the general configuration of the stream and contributing road or skid trail segments, noting the locations of sampling stations. Where feasible, sampling stations are established and flagged during site reconnaissance. On a day prior to sampling or following the completion of runoff sampling, stream distance from the crossings to sampling stations are measured by tape and noted on the sketch. Significant local erosional features are noted on the sketch.

4) The sampling schedule is established, indicating times to start each sampling sequence. Each station will be sampled two to four times, spaced at approximately two hour intervals.

5) The first samples are collected according to the established schedule, in a sequence that begins with the station farthest downstream and working upstream so as not to disturb upstream areas prior to sampling. At each stream station, a depth-integrated sample is collected from the thalweg using the Model DH-81/D-77 and/or DH-48 Suspended Sediment Sampler (Guy and Norman, 1970). Sample size required is 1000 to 1500 ml depending on the turbidity level (the greater the turbidity, the less volume required). The sampler is lowered to the stream bottom and raised at a constant rate. For sampling ditches, samples are hand collected in plastic bottles by dipping directly in ditch flow, taking care not to disturb

the bottom of ditch. In the case of very shallow streams, all samples are collected by hand dipping. In addition to these samples, two field replicate samples are collected during the sampling period. These replicates are samples collected at the same time and place as another sample, which are given unique sample ID numbers and submitted to the laboratory as "blind" replicates (i.e. the lab doesn't know they are replicates). They facilitate an evaluation of field and laboratory precision. (In addition, the laboratory runs duplicate analyses as a part of their internal quality control practice.) All samples are stored in ice and delivered to Ecology's Manchester Laboratory within 48 hours of collection for total suspended solids and turbidity analysis.

6) Streamflow is gaged twice during the sampling period at one upstream and one downstream station, and the ditch discharge is gaged as well, if present. The first gaging is done after the initial sampling sequence and the second is done at the conclusion of sampling. For stream stations, a cross-section with relatively uniform flow is gaged using a Marsh McBirney flowmeter to take measurements of velocity at multiple points along the cross-section, with cross-sectional area measured by wading rod and tape. At ditch outfalls, discharge is measures by stopwatch and bucket technique: the entire discharge is directed into a bucket of known volume and the time required to till the bucket is determined with a stopwatch. This is repeated three times and the average discharge is recorded. Where necessary, a flexible flume is used to capture and direct the ditch flow into the bucket.

In order to record a more complete record of streamflow during the sampling period, a capacitive depth probe stage height recorder is installed in the stream at the downstream streamflow gaging location, with the datalogger programmed to record stage height at 15 minute intervals. Alternatively, a staff gage may be temporarily installed and stage heights recorded manually in the field notes throughout the sampling period. This allows a better determination of whether samples were collected on the rising or falling limb of the hydrograph.

7) For road crossing sites, vehicle traffic during the sampling period is counted using two hand-held counters; one for log trucks and other heavy vehicles and one for light vehicles. The counts are maintained throughout the day. If a vehicle passes at, or within one minute of, the time of sample collection for the ditch or ditch outflow sampling station, the time the vehicle passes is noted in the "Comments" column of the field form.

8) Upstream and downstream study reaches are evaluated for potential in-stream sources of suspended sediment (e.g. actively eroding banks) between upstream and downstream study sites. The Channel Condition Survey field form is used for this evaluation, which may be done at the conclusion of runoff sampling (so as not to disturb sediments by walking the reaches during the sampling period), if it has not been done on a prior site visit.

Conceptual Rating Strategy:
Determination of BMP effectiveness is based on comparisons of downstream turbidity and total suspended solids concentrations to local background conditions as reflected in the results from the upstream sampling sites.

The BMP is considered effective if there are no violations of the numeric water quality standards for turbidity or increases in total suspended solids which indicate impairment of beneficial uses. Evaluation of impairment due to total suspended solids will consider direct effects on aquatic life due to high water concentrations as well as siltation effects on downstream habitats from fine sediment loading.

Final decision criteria for determining whether water quality standards are achieved will be developed through a process that includes literature review and consultation with the TFW Water Quality Steering Committee, the Department of Ecology Water Quality Program, and other experts on water quality standards issues and beneficial uses as related to sediment impacts.

References:

Guy, H.P. and V.W. Norman. 1970. Field Measurements for Measurement of Fluvial Sediment. Techniques of Water Resources Investigation, Book 3, Chapter C2. United States Geological Survey. Washington D.C.

Runoff Sampli Field Form

Study Site ID #: ______ Date: ______

Road or Unit Name: ______

Survey IDX: RO- ______

Length of Contributing Road or Sl Trail Segment:

Road or Skid Trail Design Info: ______

Construction Technique: ______

Drainage Control: ______

Surfacing: ______

Hillslope Gradient (%): ______

Road/Skid Trail Gradient (%): ______

Datalogger Scheme for Raingage: ______

Datalogger Scheme for Stage Hei ______

other Comments:

Traffic Count: Heavy Trucks Lieht Vehicles

Sketch of Study Site:

Site ID#: ________________ Survey ID#: RO-_______________

Run-Off Sampli Field Form

Study Site ID # ____ Date ______

Surveyors ____________________

Sampling Station Number	Field Bottle ID #	ManLab ID #	Time Sample Collected	Comments:

No. 352

Sediment Routing Survey Using Sequential Aerial Photography

Purpose:
To document surface erosion and sediment storage at sites with ground based harvesting near streams or where RMZs and RLTAs are left as water quality protection measures. To record the type, size, and, proximity of surface erosion features to streams. To document whether sediment from surface erosion features is routed to streams over the study period.

Materials:
extra fine point sharpies; blue, black, green, red
100 and 30 meter fiberglass tape
clinometer
compass
lead pencils
laminated aerial photos: scale 1:4800 and/or 1:480
camera
bright pink meter stick for scale
survey flags
200 or 400 ASA print film
mirror stereoscope
write-in-the-rain field book
sediment routing field forms

Site Selection Criteria:
Sites selected for sediment routing surveys are sites with recently completed ground based harvesting near streams or sites where RMZs and RLTAs are left as water quality protection measures.

Method Summary:
Low altitude, large scale aerial photographs are obtained for selected BMP sites. Custom photography is flown by the Department of Transportation. Initial photos and reconnaissance of the sites are conducted as soon as practical after BMP implementation. Features visible on the initial photos flown at 1:4800, such as length of road between identified culverts, etc., are measured to create scaled enlargements (1:480). Skid trails, water bars, and other drainage features near and adjacent to stream margins are monitored. Major sediment features with a high potential of being delivered to surface water are photographed and measured during site visits. Existing erosional features and drainage at the time of flight are ground verified and noted on the photos, especially in areas where shadows obscure features on the aerial photos. Sediment pathways between erosional features and drainage features are noted on laminated photos to document sediment routing survey results. Additional flights are flown one to three years later, depending on site and project considerations.

Assumptions:
Appropriately timed aerial photography and walking surveys of sites are able to detect and display surface erosion features, routes of sediment transport, and locations of sediment storage, deposition, and delivery to streams.

Any delivery of sediment to surface water from surface erosion features due to ground based harvesting or yarding practices is an increase over background levels.

Survey Method:

1. Custom stereo aerial photos are taken by Dept. of Transportation, flown at a scale of 1:4800. The BMP site plus the upstream contributing area are flown as soon as practical after the practice has been completed. Measurements between two identifiable points on the photos is taken for scaled enlargements. Photos are enlarged 10 times to a final scale of 1:480.

2. Define the area to be studied on the initial 1:4800 aerial photo and on the 1:480 enlargements.

3. Use stereo pairs photographed at the 1:4800 scale for in office preliminary mapping. Map skid trails, roads, drainage features, large erosion scars, and other features which are obvious on the photo and near the RMZ or type I-V stream margins. Use a mirror stereo scope to identify features.

4. Field Survey:

a. During a fair weather survey (sharpies do not work in the rain!) walk the edge of the RMZ or type I-V stream margin. Identify and number erosional features and on the 1:480 enlargements. Look for skid trails, wind throw, roads, etc., that have exposed soil with delivery potential to the stream, including those not visible on the aerial photos. Note the existing drainage features and streams within the unit on the aerial photos. In some cases mapping will be done using 1:4800 stereo pairs and no enlargement will be made.

b. Measure the length and average width of surface erosion features. Record the feature number, the type (skid trail, wind throw, road, yarding scar, etc.), the length, average width, indicate whether the feature is within 10 meters of surface water, whether any sediment has entered or is entering surface water, and note any sediment storage features which may impact the sediment deliverability of the surface erosion feature. Survey only those areas which have a high potential to deliver sediment to type I-V streams. Draw surface sediment pathways from erosional features to streams and drainage.

c. Take oblique angle photographs of selected sediment source and depositional features of interest, using the 1 meter pink rod for scale, from good viewing locations such as the opposite streambank. Note the location of the photo point and label it (A, B, C, etc.) on the enlarged laminated photo. Place a survey flag with photo point designation and date. at the location from which the photos are taken. Record the photo point location, the feature photographed, etc. in a field book.

d. At selected features mark the extent of sediment transport by placing stakes or survey flags along the down slope margin of fresh, loose sediment (i.e. boundaries of the sediment plume). Stakes/flags are marked with the survey date.

5. Order a second set of stereo photos at the same scale one to three years later. Preferably, these should be taken at the same time of year. Make enlargements at the same scale as the first set.

6. With the second photo series,. resurvey the site for erosional features, both new and old, on the new aerial photos (see step 4). On subsequent surveys map changes to the drainage features, relocate and remeasure the surface erosion features, note if the features are within 10 meters of surface water, and take oblique angle photographs of sediment source features of interest. Re-stake the margins of sediment plumes and measure the distance of sediment migration using fiberglass tape. When feasible, conduct interim surveys after the initial winter storms and prior to spring greening in order to document sediment routing at the time of high impact risk.

Mii. Notes and Recommendations:

Aerial Photography Considerations

North facing slopes need to have aerial photos taken when the sun angle is high (between spring and fall equinox) to reduce tree shading that may obstruct viewing the site features.

For Department of Transportation aerial photo orders it is recommended that the following steps be taken: delineate the area to be flown on a USGS topographic map; list the management practices and expected completion date; and meet to discuss photo needs (scale, area, features, etc.) with the pilot.

Areas within RMZs are difficult to view from the air. Tree shading and/or narrow zones of disturbances make it necessary to delineate all erosional features during field reconnaissance only.

Guidelines for Minimum Feature Sizes Monitored:

Erosion Scars - greater than or equal to 3 meters in length and/or 2 square meters surface area

Hillslope Storage Features and Deposits greater than or equal to 1 square meter surface area

Instream Deposits - no minimum size, any obvious fresh deposits are mapped

Conceptual Rating Strategy:

Determination of BMP effectiveness using the sediment routing survey considers the evidence of continuing erosion with sediment delivery to streams. The BMP is considered effective if there is no evidence of continuing erosion with sediment delivery to a stream.

Final decision criteria for determining whether water quality standards are achieved will be developed through a process that includes literature review and consultation with the TFW Water Quality Steering Committee, the Department of Ecology Water Quality Program, and other experts on water quality standards issues and beneficial uses as related to sediment impacts.

Sediment Routing Survey

Study Site # ________________ Date ________________

Site Name ________________ Time ________________

Survey ID # ________________ surveyors ________________

Film Type __________

Film Speed _ _ _

Camera Used __________

Weather ____________

Study Site Description (drainage. etc.):

Feature #	Type: Trail, Rd, Yarding, Wind Throw, Storage Sill, LWD, etc.	Length (m)	Ave. Width (m)	w/in 10 m (y/n)	entering or in water (y/n)	Notes

Amphibian Survey

Purpose:
To evaluate the stream amphibian communities and habitats that may be affected by forest practices and document changes in amphibian communities following BMP implementation.

Materials:
30 and/or 100 meter measuring tape
plastic bags and plastic buckets
flagging
field book, data sheets, and pencils
dip nets
hardware cloth screen
metric rulers
clinometer
thermometer

Site Selection:
Sites for conducting amphibian surveys arc harvest units which have first or second order, perennial streams. Off-site control streams are generally established in the general vicinity.

Method Summary:
Sampling procedures described by Bury and Corn (1991) are employed in western Washington to characterize amphibian communities and habitats in treatment and control streams. These procedures involve selection of three ten meter sampling reaches in each stream, characterizing the habitat of the reach, conducting hand searches to capture all stream amphibians within the reach, and describing the animals captured and microhabitat for each capture. Sampling is conducted on both treatment and control streams before and following BMP implementation. Stream amphibian sampling in western Washington is conducted primarily by cooperators with the University of Washington as a part of ongoing forest practices research projects (Kelsey, personal communications). Because of differences in life histories of eastern Washington amphibians, an alternate method using time-constrained searches of aquatic and riparian habitats and pitfall trapping is used to sample amphibian communities (O'Connell and Hallett, 1992). Amphibian sampling in eastern Washington is conducted by investigators from Eastern Washington University as part of the ongoing Wildlife-RMZ research project. We have co-located our BMP effectiveness study sites at the amphibian sampling locations to obtain information on the effects of forest practices on biological communities to use in conjunction with other survey results.

Assumptions:
The status of and changes in stream amphibian communities in control streams represent baseline conditions against which changes in amphibian communities in treatment reaches can be compared, and observed differences in the response of stream amphibians communities (e.g. diversity and abundance) may be attributed to the effects of the forest practice.

Stream amphibians are dependent on stable stream channels and banks, interstitial space habitat and cover, and other riparian habitat conditions, and their response to forest practices is an indicator of BMP effectiveness.

Survey Method:

Detailed sampling methods are described in Bury and Corn (1991) and O'Connell and Hallett (1992).

Conceptual Rating Strategy:

Determination of BMP effectiveness considers the type of changes in amphibian communities and habitats in the treatment stream relative to that of the control streams. The BMP is considered effective if there is no evidence of reduced diversity and/or abundance in amphibian communities associated with aquatic habitat degradation or direct effects of the forest practice on stream amphibians.

Final decision criteria for determining whether water quality standards are achieved will be developed through a process that includes literature review and consultation with the TFW Water Quality Steering Committee, the Department of Ecology Water Quality Program, and other experts on water quality standards issues and beneficial uses as related to sediment impacts.

References:

Bury, R.B. and P.S. Corn. 1991. Sampling Methods for Amohibians in Streams in the Pacific Northwest, General Technical Report PNW-GTR-275. USDA Forest Service, Pacific Northwest Research Station. Portland, Oregon.

Kelsey, K. A. 1992-3. Personal communications regarding stream amphibian research projects. University of Washington, Center for Streamside Studies. Seattle, Washington

O'Connell, M.A. and J.T. Hallett. 1992. Sampling Methods for Amphibians and Reptiles in the Forests of Northeast Washington - Riparian Management Zone Study. Appendix I of Eastside RMZ Study June 1992 Progress Report to TFW Wildlife Steering Committee. Eastern Washington University, Cheney, Washington.

Macroinvertebrate Survey

Purpose:
To evaluate the stream macroinvertebrate communities and habitats that may be affected by forest practices and document changes in macroinvertebrate communities following BMP implementation.

Materials:
30 and/or 100 meter measuring tape
0.3 m^2 (D-frame) and 1 m^2 kick nets
plastic bags and other sample containers
sample preservatives
field sorting trays
flagging
field book, data sheets, and pencils
dip nets

Site Selection:
Sites for conducting macroinvertebrate surveys are harvest units or roads with first through third order streams. Control reaches will generally be located upstream of the BMP, but in some cases off-site control streams in the general vicinity may be used.

Method Summary:
Sampling and analytical procedures described by Plafkin et al. (1989) and Plotnikoff (1992) are employed to characterize macroinvertebrate communities and habitats in study stream reaches. An upstream/downstream sampling design will generally be employed to compare treatment and control reaches. Sampling procedures involve selection of at least two transects within each study reach, with one kick sample from each of the predominant habitat types (e.g. riffles, pools, etc.) composited at each transect. For small streams with limited or very discrete macroinvertebrate habitat zones, four samples kick samples will be collected for compositing. Additional discrete samples may be collected for assessment of variability. Habitat for the study reaches is described according to the habitat assessment protocol developed for bioassessment in the Pacific Northwest (EPA, 1992). Sampling is conducted on both treatment and control streams before and following BMP implementation. Macroinvertebrate sampling is conducted primarily by cooperators within the Department of Ecology as a part of ongoing bioassessment activities. Certain BMP effectiveness study sites will be co-located with macroinvertebrate sampling locations to obtain information on the effects of forest practices on biological communities to use in conjunction with other survey results.

Assumptions:
The status of and changes in stream macroinvertebrate communities in control reaches located immediately upstream of BMPs (or suitable off-site control streams) represent baseline conditions against which changes in macroinvertebrate communities in treatment reaches can be compared, and observed differences in the response of macroinvertebrate communities (e.g. diversity and abundance) may be attributed to the effects of the forest practice.

Stream macroinvertebrates are dependent on certain habitat elements found in stable stream channels, interstitial space habitat, and other habitat conditions, and their response to forest practices is an indicator of BMP effectiveness"

Survey Method:
Detailed sampling methods are described in Plafkin et al. (1989), Plotnikoff (1992) and EPA (1992).

Conceptual Rating Strategy:
Determination of BMP effectiveness considers the type of changes in macroinvertebrate communities and habitats in the treatment reach relative to that of the control reach. The BMP is considered effective if there is no evidence of reduced diversity and/or abundance in macroinvertebrate communities associated with habitat degradation or other effects of the forest practice.

Final decision criteria for determining whether water quality standards are achieved will be developed through a process that includes literature review and consultation with the TFW Water Quality Steering Committee, the Department of Ecology Water Quality Program, and other experts on water quality standards issues and beneficial uses as related to sediment impacts.

References:

Environmental Protection Agency. 1992. Draft Reeion 10 In-Stream Biological Monitoring Handbook for Wadable Streams in the Pacific Northwest. G. A. Hayslip, ed. EPA 910/9-92-013. U.S. Environmental Protection Agency, Region 10. Seattle, Washington.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish. EPA/444/4-89-001. U.S. Environmental Protection Agency. Washington, D.C.

Plotnikoff, R.W. 1992. Timber/Fish/Wildlife Ecoregion Bioassessment Pilot Project. TFW-WQ1 l-92-001, Ecology Publication No. 92-63. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program. Olympia, Washington.