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Wetland/Riparian Policy
Deadline: 5/15/07 12 noon

May 15, 2007

RECEIVED
MAY 15 2007
SWRCB EXECUTIVE

State Water Resources Control Board
Song Her
Executive Office
P.O. Box 100
Sacramento, California 95812-0100
commentletters@waterboards.ca.gov

Re: Comments on Proposed Wetland and Riparian Area Protection Plan

Board members:

The California Forestry Association (CFA) submitted comments on the Wetland and Riparian Area Protection Policy Scoping Document along with other organizations in a letter dated April 19, 2007. CFA incorporates those comments by reference here with the following additional comments specific to the concerns of commercial forestland owners and managers throughout the state.

Upon review of the proposed Wetland and Riparian Area Protection Plan (Proposed Plan), CFA is concerned that the stated goal "to fill any gaps in wetlands protection" resulting from recent U.S. Supreme Court decisions will be misused to expand regulatory requirements beyond wetlands and into managed riparian areas where no gap exists. Our concern is heightened by your consideration of Alternative 3 and Alternative 4 of the Proposed Plan.

While it is undisputed that the State Water Resources Control Board and the nine Regional Water Quality Control Boards are the state's primary water quality regulatory agencies, tasked with protecting the beneficial uses of waters of the state, your policy considerations should take into account the regulatory schemes already in effect that provide additional protection for California's riparian areas.

The most stringent state forestry laws and regulations in the nation govern private forestland owners in California: the California Forest Practice Act (FPA) and the Forest Practice Rules (FPR). The FPRs implement the FPA in a manner consistent with other laws, including, but not limited to the Timberland Productivity Act of 1982, the California Environmental Quality Act, the Porter-Cologne Water Quality Act, and the California Endangered Species Act. As a result, all timber operations on private lands in California must comply with a comprehensive regulatory regime.

A key objective of the FPRs is to protect the beneficial uses of water. To determine if this is being accomplished, the California Board of Forestry (Board) and CDF established a long-term monitoring program, which includes a number of monitoring projects. One such project resulted in a recent report prepared by the Board's Monitoring Study Group titled, *Modified Completion Report MONITORING PROGRAM Implementation and Effectiveness of Forest Practice Rules related to Water Quality Protection* (Report). The Report accessed the efficiency and effectiveness of the timber harvest review and approval process and the effectiveness of the FPRs to protect riparian areas.

Moreover, under California law, timber operations may only be conducted pursuant to an approved timber harvest plan (THP). The State Board and its regional water quality control boards have a statutorily designated role in the THP process. The regional boards participate on interdisciplinary review teams led by the California Department of Forestry and Fire Protection (CDF). These teams review plans and assist (CDF) in the evaluation of proposed timber operations and their impacts on the environment. Through this process, THP applicants must adequately address all concerns raised by water board staff.

Based on efficacy of the existing regulatory scheme that provides for the protection and enhancement of riparian areas in California's forestlands, CFA strongly recommends that you reject Alternative 3 and Alternative 4 since they exceed your stated goal for adoption of this Policy. Instead, we believe the scope of the Policy should be limited to Alternative 1 or Alternative 2, thereby acknowledging the regulatory schemes already in place for riparian areas.

CFA appreciates the opportunity to provide you with our comments and concerns in this matter, and would be happy to discuss any questions you have.

Sincerely,

Michele Dias

Michele Dias
VP, Legal and Environmental Affairs

MONITORING STUDY GROUP
CALIFORNIA STATE BOARD OF FORESTRY AND FIRE PROTECTION

Modified Completion Report
MONITORING PROGRAM

Implementation and Effectiveness of Forest Practice Rules related to Water Quality Protection

MONITORING RESULTS FROM 2001 THROUGH 2004

Ruben Grijalva
Director
Department of Forestry and Fire Protection

Mike Chrisman
Secretary for Resources
The Resources Agency

Arnold Schwarzenegger
Governor
State of California

July 2006
SACRAMENTO, CALIFORNIA

ABSTRACT

The California Forest Practice Rules (FPRs) (Title 14, California Code of Regulations) are designed in large part to protect water quality and aquatic habitat in forested watersheds during and after silviculture activities (Figure 1). The critical questions then become: 1) At what rate are the water quality related FPRs being properly implemented?, and 2) When properly implemented, how effective are these FPRS in protecting water quality by retaining canopy and groundcover in watercourse and lake protection zones (WLPZs), by preventing erosion, by preventing sediment transport, and/or by preventing sediment transport to stream channels? The Modified Completion Report (MCR) program focused on answering these two basic questions using forensic monitoring data collected on a random selection of 281 Timber Harvesting Plans (THPs) and randomly selected sites within those THPs. The data were collected in the field primarily by the California Department of Forestry and Fire Protection's (CDF's) Forest Practice Inspectors and were analyzed by CDF's watershed staff in Sacramento, California. Overall, the MCR monitoring study found that: 1) The rate of compliance with FPRs designed to protect water quality and aquatic habitat is generally high, and 2) FPRs are highly effective in preventing erosion, sedimentation and sediment transport to channels when properly implemented. There are specific areas where improvements in implementation and/or effectiveness could be made, and these are enumerated with specific recommendations at the end of this report. The findings of the MCR monitoring project are comparable to the findings of the earlier Hillslope Monitoring Program (HMP) project (Cafferata and Munn 2002).

KEY TERMS: water quality, aquatic habitat, forestry, monitoring, streams, California Forest Practice Rules (FPRs) (Title 14, California Code of Regulations), Timber Harvesting Plans (THPs) watercourse and lake protection zones (WLPZs), roads, watercourse crossings, WLPZ canopy, groundcover, erosion, sediment transport, and sediment transport to channels.

Figure 1. A small watercourse or stream in a forest in California.

CALIFORNIA DEPARTMENT OF FORESTRY AND FIRE PROTECTION

Modified Completion Report MONITORING PROGRAM: MONITORING RESULTS FROM 2001 THROUGH 2004

July 2006

by Clay A. Brandow, Peter H. Cafferata and John R. Munn
California Department of Forestry and Fire Protection

MONITORING STUDY GROUP

BOF	George Gentry, Tharon O'Dell (Chairman of MSG 1996-2005)
CDF	Pete Cafferata, John Munn, Clay Brandow, Dennis Hall, Duane Shintaku, Shane Cunningham, Anthony Lukacic
DFG	Brad Valentine, Dr. Marty Berbach, Joe Croteau, Curt Babcock
CGS	Tom Spittler, Dr. Michael Wopat, Dave Longstreth, Bill Short
NCRWQCB	Dave Hope, Adona White
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CCRWQCB	Chris Adair
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Public	Richard Gienger (HSC/SSRC), Mike Laing (NCCFFF)
Industry	Peter Ribar (CTM), Dr. Cajun James (SPI), Matt House (GDRCO), Rich Klug (Roseburg Resources)

The Monitoring Study Group (MSG) is a standing committee of the BOF made up of members of the public, resource agencies (both state and federal), three universities, and the timber industry. The agencies listed above make up the MSG; the names listed above are the current primary representatives for these agencies at MSG meetings. The MSG chair is appointed by the Board of Forestry and Fire Protection (BOF) and the group is staffed by CDF. Each agency and organization is responsible for determining the appropriate person(s) to serve as a representative on the MSG (i.e., the BOF does not make formal appointments to the MSG).

Modified Completion Report

Executive Summary

A key objective of California's Forest Practice Rules (FPRs) is to protect the beneficial uses of water (Figure 2). To determine whether this is being accomplished, the Board of Forestry and Fire Protection and the California Department of Forestry and Fire Protection (BOF/CDF) have established a long-term monitoring program, which includes a number of monitoring projects that are briefly described at the end of this Executive Summary. The Modified Completion Report (MCR) project is a major component of this long-term program. This report:

- Describes MCR monitoring conducted from 2001 through 2004,
- Summarizes and analyzes the MCR monitoring results, and
- Makes findings and recommendations based on those results.

The purpose of the MCR project has been to determine the adequacy of both implementation and effectiveness of the Forest Practice Rules (FPRs) that are used to protect water quality and riparian/aquatic habitat.

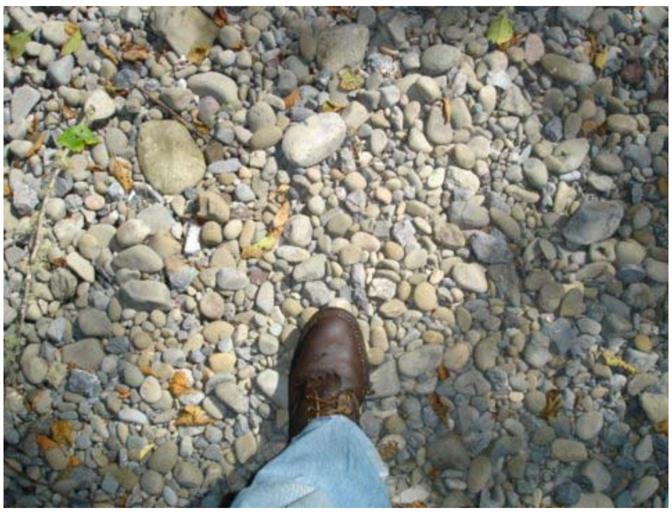

Figure 2. Substrate of a watercourse or stream in a forested watershed on the California coast. Reaches with clean gravel are an important habitat component of many forested streams. A key objective of the water quality related FPRs is to prevent transport of excessive fine sediment (e.g., sand and silt) to watercourse channels.

MCR monitoring is an extension of the normal timber harvest inspections and Completion Reports that CDF is required to conduct on timber harvesting plans (THPs) by the California Forest Practice Act and the FPRs. MCR data was collected by CDF Forest Practice Inspectors on a random sample of THPs at the time of plan completion and/or during the erosion control maintenance period.

Based on the findings of CDF's earlier Hillslope Monitoring Program (HMP) project (Cafferata and Munn 2002), the MCR project has focused on the following landscape features:

1) Watercourse and Lake Protection, including:
    - WLPZ Percent Total Canopy
    - WLPZ Groundcover and Erosion Features
2) Roads, and
3) Watercourse Crossings

Although the MCR project used a different random sample of THPs than the HMP (1996-2001) and was performed by CDF Inspectors instead of a third-party contractor, the results of these two studies are comparable. Furthermore, the MCR and HMP watercourse crossing effectiveness results compare well with findings of other California studies, such as the USDA Forest Service's Best Management Practices Effectiveness Program (BMPEP) (USFS 2004).

The *MCR Monitoring Procedures and Methods* are included in Appendix A of this report and are found on-line at:

http://www.bof.fire.ca.gov/board/msg_archives.asp

In both the MCR and the HMP studies, effectiveness of erosion control measures is based on the assumption that if soil is kept on site and out of stream systems, then water quality and riparian and aquatic habitat are protected from the effects of increased sedimentation.

Like HMP monitoring, MCR monitoring found that: 1) The rate of compliance with the FPRs designed to protect water quality and aquatic habitat is generally high, and 2) the FPRs are highly effective in preventing erosion, sedimentation and sediment transport to channels when properly implemented.

In most cases, Watercourse and Lake Protection Zone (WLPZ) canopy and groundcover exceeded Forest Practice Rule (FPR) standards. For Class I and Class II WLPZs, average total percent canopy was 84% for the Coast area (Region 1), 68% for the Inland North area (Region 2) and 73% for the Inland South area (Region 4). With rare exceptions, WLPZ groundcover exceeds 70%, patches of bare soil in WLPZs exceeding the FPR standards are rare, and erosion features within WLPZs related to current operations are uncommon. Moreover, in most cases, actual WLPZ widths were found to meet or exceed FPR standards and/or widths prescribed in the applicable THP.

There are rare instance were WLPZ canopy and groundcover do not meet FPR standards, either naturally or as a result of harvesting operations. Detection, and where possible, prevention or abatement of these rare occurrences is an important key to water quality protection. Because these occurrences are rare, rapid ocular inspection of as many high-risk WLPZs as possible is the recommended method of detection for enforcement purposes, saving the more rigorous and time consuming measurement method and procedures to follow up on observed problems and document possible WLPZ violations.

When properly implemented, road-related FPRs were found to be highly effective in preventing erosion, sedimentation and sediment transport to channels. Overall implementation of road-related rules was found to meet or exceed required standards 82% of the time, was marginally acceptable 14% of the time, and departed from the FPRs 4% of the time. Road-related rules most frequently cited for poor implementation were waterbreak spacing and the size, number and location of drainage structures.

This low rate of non-compliance is important because erosion and sedimentation was found to be much more likely at road-related features where the FPRs are not properly implemented. Additionally, erosion, sedimentation and sediment transport is much more likely at road-related features where there was a departure from the applicable FPRs. For example, when there is a departure from the rule, the chance of erosion is about 1 in 2, the chance of sediment transport is about 1 in 3, and the chance of sediment transport to a channel 1 in 10. But where the FPR implementation is acceptable or better, the chance of erosion is about 1 in 20, and the chance of sediment transport or sediment transport to a channel is equal to or less than 1 in 100. In addition, more than half of the departures from the FPRs are concentrated in the worst six percent of all road segments. Finding and fixing the drainage and discharge problems on these few bad segments would have the greatest impact on improving road-related water quality problems for the least cost.

Watercourse crossings present a higher risk of discharge into streams than roads, because while some roads are close to streams, all watercourse crossings straddle watercourses. Overall, 64% of watercourse crossings had acceptable implementation of all applicable FPRs, while 19% had at least one feature with marginally acceptable implementation and 17% had at least one departure from the FPRs. Common deficiencies included diversion potential, fill slope erosion, culvert plugging, and scour at the outlet.

All these topics and more are covered in detail in the full report. Findings and recommendations can be found at the end of the report.

MCR Project Context:
Brief Synopsis of BOF/CDF Long Term Monitoring Program

The BOF/CDF *Long Term Monitoring Program* (LTMP) has had three main components from 1996 through 2004. These are: 1) Modified Completion Report (MCR) Monitoring, 2) the Hillslope Monitoring Program (HMP), and 3) Cooperative Instream Monitoring Projects (CIMPs). An additional component, the *Interagency Mitigation Monitoring Program* (IMMP), will build on the HMP and the MCR projects and is currently being designed by an interagency team.

HMP monitoring was conducted from 1996 through 2002. MCR monitoring was conducted from 2001 through 2004. CDF plans to revise and re-start MCR monitoring in 2006. CIMPs began in 1997 and are ongoing. IMMP monitoring will begin as soon as the monitoring study design is completed.

MCR monitoring is an extension of the normal timber harvest inspections and Completion Reports that CDF is required to do on THPs under the California Forest Practice Act and the Forest Practice Rules (FPRs). MCRs are done by CDF Forest Practice Inspectors on a random sample of THPs at the time of THP completion and/or during the erosion control maintenance period. MCR used a different random sample of THPs than the HMP, but the results are comparable. The MCR random sample analyzed in this report included 281 plans, all THPs. The HMP random sample analyzed in Cafferata and Munn (2002) included 300 plans, of which 295 were THPs and five were Non-Industrial Timber Management Plan – Notices of Timber Operations (NTMP-NTOs). Plan submission dates in the two random samples ranged from 1993 to 2002 for the MCR random sample analyzed in this report and from 1991 to 2000 for the HMP random sample analyzed in Cafferata and Munn (2002).

HMP monitoring assessed a random sample of completed THPs that had over-wintered from one to four years, using an outside contractor. The objective of the HMP was to evaluate the implementation and effectiveness of Forest Practice Rules and special THP provisions specifically designed to protect water quality and riparian and aquatic habitat.

The CIMPs measure water quality and aquatic habitat parameters in selected basins. The objectives are two-fold: 1) to establish baselines and trends, and 2) to gage the effects of all activities in a watershed on the beneficial uses of water. It is often difficult to establish cause and effect (i.e., link current management practices to instream conditions), and instream monitoring is not specific to the impacts of timber management alone. Instream monitoring is important in establishing whether overall efforts to protect the beneficial uses of water are succeeding or failing, and can address cumulative watershed impacts.

The IMMP is being developed to provide information regarding forestry-related practices at high-risk sites where practices have been designed to protect water quality. The IMMP will use multi-agency teams composed of representatives from CDF, California Department of Fish and Game (CDFG), California Geological Survey (CGS), and the Regional Water Quality Control Boards (RWQCBs). It is anticipated that this team approach will provide a balance of interests for all the Review Team agencies and provide greater public confidence in the monitoring results.

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We would like to thank CDF's current and former Forest Practice Inspectors and their associates who helped revise the MCR methods and procedures, who completed the training, and who conducted the MCR monitoring in the field, including (in alphabetical order):

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17. Rich Elliot
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19. Joe Fassler
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*Indicates individuals who collected data on one or more THPs randomly selected for MCR Monitoring.

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1. Mike Alcorn* (Green Diamond)
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13. Jonathan Warmerdam (NCRWQCB)
14. Tom Williams* (NCRWQCB)

*Indicates individuals who assisted in the collection of MCR data on one or more randomly selected THPs.

Roger Poff of R.J. Poff and Associates worked with CDF staff to field train CDF Forest Practice Inspectors and interested RWQCB personnel on the MCR methods and procedures. CDF's State Forests Research Coordinator Tim Robards developed the PHI and enforcement procedure for evaluating WLPZ canopy, which was the model used for developing the MCR method. Mr. Robards also developed the computer program for randomly selecting THPs for MCR monitoring and provided invaluable advice on sampling and statistics.

Members of the Monitoring Study Group, an Advisory Committee to the California State Board of Forestry and Fire Protection (BOF), provided key support and guidance. Special thanks to former BOF member and former MSG chairman Tharon O'Dell. Finally we would like to acknowledge the support and guidance of current the and former CDF Staff Chiefs for Forest Practice Dennis Hall and Jerry Ahlstrom, current and former CDF Assistant Deputy Directors Duane Shintaku and Dean Lucke, and current and former CDF Deputy Directors for Resource Management Bill Snyder and Ross Johnson, as well as former CDF Directors Andrea Tuttle and Dale Geldert.

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List of Abbreviations

BMPs	Best Management Practices
BOF	California State Board of Forestry and Fire Protection
CDF	California Department of Forestry and Fire Protection
CDFG	California Department of Fish and Game
CDPR	California Department of Parks and Recreation
CFA	California Forestry Association
CGS	California Geological Survey
CIMP	Cooperative Instream Monitoring Project
CLFA	California Licensed Foresters Association
CPSS	Certified Professional Soil Scientist
CSES	Critical Sites Erosion Study
EEZ	Equipment Exclusion Zone
EHR	Erosion Hazard Rating
ELZ	Equipment Limitation Zone
ESU	Evolutionarily Significant Unit
PA	Forest Practice Act
FPRs	Forest Practice Rules (Rules)
HMP	Hillslope Monitoring Program
LTMP	Long-Term Monitoring Program
LTO	Licensed Timber Operator
LWD	Large Woody Debris
MAA	Management Agency Agreement
MCR	Modified Completion Report
MSG	Monitoring Study Group
NMFS	National Marine Fisheries Service
NPS	Non-point Source
NTMP	Non-industrial Timber Management Plan
NCRWQCB	North Coast Regional Water Quality Control Board
NTO	NTMP Notice of Timber Operations
PE	Professional Engineer
PG	Professional Geologist
PH	Professional Hydrologist
PHI	Preharvest Inspection
PMP	Pilot Monitoring Program
QA/QC	Quality Assurance/ Quality Control
RCD	Resource Conservation District
RPF	Registered Professional Forester
Rules	Forest Practice Rules (FPRs)
RWQCB	California Regional Water Quality Control Board
SMZ	Streamside Management Zone
SWRCB	State Water Resources Control Board
TMDL	Total Maximum Daily Load
THP	Timber Harvesting Plan
UCCE	University of California Cooperative Extension
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Department of Agriculture, Forest Service
WLPZ	Watercourse and Lake Protection Zone

Introduction

The purpose of the Modified Completion Report (MCR) project has been to determine the adequacy of the implementation and effectiveness of California's Forest Practice Rules (FPRs) used to protect water quality and riparian/aquatic habitat. This has been done using information collected by CDF Forest Practice Inspectors during Timber Harvesting Plan (THP) completion report inspections and erosion control maintenance inspections. The MCR data was collected from January 2001 to July 2004. Based on the findings of CDF's earlier Hillslope Monitoring Program (Cafferata and Munn 2002), the MCR project has focused on the following landscape features:

1) Watercourse and Lake Protection Zones, including:
- **WLPZ Percent Total Canopy**
- **WLPZ Groundcover and Erosion Features**

2) Roads, and
3) Watercourse Crossings

Background Information

California's modern Z'berg-Nejedly Forest Practice Act (FPA) was adopted in 1973, with full field implementation occurring in 1975. During the subsequent three decades, a variety of monitoring projects have examined the implementation and effectiveness of California's Forest Practice Rules in protecting water quality. These monitoring efforts are in addition to the California Department of Forestry and Fire Protection (CDF) Forest Practice compliance inspection program that has been in place for over 30 years. Under the FPA, Timber Harvesting Plans (THPs) must be submitted to CDF for review and approval prior to conducting commercial timber harvesting on non-federal timberlands. The THPs are then reviewed for compliance with the FPA and the Forest Practice Rules adopted by the Board of Forestry and Fire Protection (BOF), and for conformity with other state and federal regulations protecting watersheds and wildlife. Multi-disciplinary teams composed of representatives of CDF, the Department of Fish and Game (CDFG), Regional Water Quality Control Boards (RWQCBs), and the California Geological Survey (CGS), conduct Preharvest Inspections (PHIs) of THP areas to determine whether the proposed timber operations comply with requirements of the FPA and the FPRs. During PHIs, additional mitigation measures beyond the standard rules are often recommended based upon site-specific conditions. This report focuses on water quality issues, but the added THP mitigation also relates to habitat protection, public safety, and the protection of other public trust resources. Additional inspections during active timber operations and the post-harvest period when logging is completed ensure compliance with the Act, the FPRs, and specific provisions of the THP.

The State Water Resources Control Board (SWRCB) certified the Forest Practice Rules and review process as Best Management Practices (BMPs) under Section 208 of the Federal Clean Water Act in 1984, with a condition that a monitoring and assessment program be implemented. Initially, a one-year qualitative assessment of forest practices was undertaken in 1986 by a team of four resource professionals (Johnson 1993). The team audited 100 THPs distributed across the state and produced the final “208 Report” (California SWRCB 1987). This report indicated that the Rules were generally were effective when properly implemented on terrain that was not overly sensitive and that poor FPR implementation was the most common cause of observed water quality impacts. The team recommended several changes to the FPRs based on their observations.

The Critical Sites Erosion Study (CSES) was an additional water quality monitoring project in the 1980’s related to timber operations conducted within watersheds throughout northern California. The CSES project determined site characteristics on THPs that can be used to identify area susceptible to large erosion events and identified management factors that have contributed to erosion events. This project collected data during 1985 and 1986 on management and site factors associated with existing large erosion events on a random sample of 314 THPs covering over 60,000 acres (Durgin and others 1989, Lewis and Rice 1989, Rice and Lewis 1991).

In 1988, the BOF, CDF, and the SWRCB entered into a Management Agency Agreement (MAA) that required improvements in the FPRs for protection of water quality based on needs described in the “208 Report.” At this point, the SWRCB approved final certification of the FPRs as Best Management Practices. The U.S. EPA, however, withheld certification until the conditions of the MAA were satisfied, one of which was to develop a long-term monitoring program (LTMP).

In response to the MAA conditions, the BOF formed an interagency task force in 1989, later known as the Monitoring Study Group (MSG). The primary purpose of the MSG was to develop a long-term monitoring program that could test the implementation and effectiveness of the FPRs in protecting water quality. From 1989 to 1999, the MSG was an “ad hoc” committee of the BOF that met periodically to: 1) develop the long-term monitoring program, and 2) provide guidance to CDF in implementing monitoring programs. With public input, the MSG developed a LTMP with both implementation and effectiveness monitoring components, and conducted a pilot project to develop appropriate techniques for both hillslope and instream monitoring that was conducted from 1993 to 1995 (Rae 1995, Tuttle 1995, Spittler 1995, Lee 1997).

The primary goal of the MSG’s LTMP has been to provide timely information on the implementation and effectiveness of forest practices related to water quality for use by forest managers, agencies, and the public. Both CDF and the BOF placed initial emphasis on hillslope monitoring because it can provide a more immediate, cost effective and direct feedback on impacts from current timber operations when compared to instream monitoring (particularly channel monitoring which involves coarse sediment parameters) (Reid and Furniss 1999). As stated in Robben and Dent (2002), it is usually easier to identify a sediment source and quantify the volume of sediment it produced, compared to measuring sediment in the watercourse and tracing it to the source.

Two state-sponsored hillslope monitoring programs have been conducted from 1996 through 2004: first the Hillslope Monitoring Program (HMP) and then the Modified Completion Report (MCR) Monitoring Program. The HMP ran from 1996 to 2002, with data collection by highly qualified independent contractors. Interim and final reports were prepared by CDF (BOF 1999, Cafferata and Munn 2002). The first phase of the Modified Completion Report (MCR) monitoring program, which is the subject of this report, was implemented from 2001 to 2004 as a more cost-effective approach than the HMP, utilizing CDF Forest Practice Inspectors to collect onsite monitoring data as part of required Work Completion Reports.

Complementing these hillslope (onsite) monitoring efforts are several cooperative instream monitoring projects located throughout California. These include:

- Caspar Creek (CDF and USFS-Pacific Southwest Research Station)
- Garcia River (CDF, NCRWQCB, MCRCD, MRC, Maillard Ranch, The Conservation Fund)
- Wages Creek (CDF, Hawthorne Timber Company/Campbell Timberland Management)
- Judd Creek (CDF, Sierra Pacific Industries)
- Little Creek (CDF, Cal Poly San Luis Obispo, Sierra Pacific Industries)

The Caspar Creek project is a paired watershed study that has measured hydrologic changes, erosion impacts, sediment production, cumulative effects, and biological impacts from logging and road construction in second-growth redwood/Douglas-fir forests since 1962.[1] The Judd Creek and Wages Creek studies were developed to test the effectiveness of the FPRs and the THP review process in protecting water quality at the THP scale in Tehama and Mendocino Counties, respectively. The Garcia River project is designed to determine if sediment and turbidity conditions are improving for anadromous salmonids at five tributary stations (Barber and Birkas 2005). The Little Creek project is evaluating the effects of selective timber harvesting and will determine if current highly regulated practices in the Santa Cruz Mountains are adequately protecting the beneficial uses of water from adverse sediment-related impacts.

In addition to hillslope and instream monitoring efforts, numerous monitoring projects have been supported, or are currently being supported, by CDF that provide critical information related to monitoring techniques and/or answer key questions regarding forest practice implementation and effectiveness.[2] Examples of these projects include:

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[1] Caspar Creek published papers are found at: http://www.fs.fed.us/psw/topics/water/caspar/caspubs.shtml

[2] MSG reports and supported reports are found at: http://www.bof.fire.ca.gov/board/msg_supportedreports.asp

- Testing Indices of Cold Water Fish Habitat (Knoop 1993)
- V-Star Tests in Varying Geology (Lisle 1993, Lisle and Hilton 1999)
- Erodible Watershed Index (McKittrick 1994)
- Evaluation of Road Stream Crossings (Flanagan and others 1998)
- Sediment Storage and Transport in the South Fork Noyo River Watershed, Jackson Demonstration State Forest (Koehler and others 2001)
- Central Sierra Nevada Sediment Study (MacDonald and others 2004, Coe 2006)
- Sediment Composition as an Indicator of Stream Health (Madej 2005, Madej and others, in press)

Summary of Other Related Studies

Several monitoring-related studies have been completed in California over the past decade that are related to the monitoring work described in this report. A brief description of these related projects is given below, and a comparison of the results of these study results to those of MCR results is presented in the appropriate section of this report -- WLPZ and Groundcover Monitoring, Road Monitoring or Watercourse Crossing Monitoring.

<u>BOF/CDF Hillslope Monitoring Program (HMP)</u>
The HMP conducted a statewide evaluation of the implementation and effectiveness of California's Forest Practice Rules (FPRs) from 1996 through 2002 using an annual, random sample of 50 completed THPs and NTMPs that had over-wintered from one to four years. Detailed information was collected from sampled plans in the summer months. This included data on: (1) randomly located road, skid trail, and watercourse and lake protection zone (WLPZ) segments, as well as randomly located landings and watercourse crossings; and (2) large erosion events (e.g., mass wasting features) where they were encountered. Winter documentation of fine sediment delivery to streams was not undertaken by this program. The monitoring work was done by highly qualified independent contractors who acted as third party auditors (Ice and others 2004). A report of interim findings was prepared (California State BOF 1999), and a final report based on 300 plans was completed in 2002 (Cafferata and Munn 2002). Data revealed that implementation rates of the FPRs related to water quality were high, averaging 94%, and that individual practices required by the rules were effective in preventing hillslope erosion when properly implemented. WLPZs were found to retain high levels of post-harvest canopy and surface cover as required by the FPRs, and these high levels were found to be effective in preventing harvesting related erosion. In those instances where erosion sites were identified, they were nearly always associated with inadequate implementation of the appropriate rule required by the FPRs. Roads and associated watercourse crossings were found to have the highest frequency of problems. These conclusions were generally similar to those reached in an earlier audit of 100 THPs (California SWRCB 1987).

USFS Best Management Practices Evaluation Program (BMPEP)

Water quality monitoring data collected from 1992 through 2002 on National Forest lands located in California was reported in 2004, fulfilling monitoring commitments to the SWRCB (USFS 2004). Twenty-nine different on-site monitoring protocols were used to evaluate BMP implementation and effectiveness. Altogether, there were approximately 3,900 random evaluations made for the 18 National Forests, with the most occurring on the Klamath and the least on the Los Padres. Most of the observations were for engineering and timber-related BMPs. Both implementation and effectiveness for a BMP were rated at the same time following 1-2 overwintering periods. If impacts to water quality were found, the observer estimated the magnitude, duration, and extent of impacts. A statistically significant relationship between BMP implementation and effectiveness was found for 16 of the 29 BMP protocols. In general, the results show that while some improvements are necessary, the program performed reasonably well in protecting water quality on National Forest lands in California. BMP implementation and effectiveness were relatively high for most activities and elevated effects on water quality were relatively infrequent, particularly in recent years. For all activities combined, BMPs were implemented 85% of the time, and were effective at 92% of the sites at which they were implemented. Effects classified as elevated were typically caused by lack of or inadequate BMP implementation and most elevated effects were related to engineering practices. Roads, and in particular stream crossings, were found to be the most problematic.

Colorado State University (CSU) Sierra Nevada Sediment Study

Dr. Lee MacDonald and graduate student Drew Coe measured sediment production rates on the Eldorado National Forest and on Sierra Pacific Industries timberlands in the Central Sierra Nevada (Coe and MacDonald 2001, 2002; MacDonald and others 2004; Coe 2006). Approximately 150 sediment fences were installed in the summers of 1999 and 2000. Field investigations focused on (1) quantifying sediment production and sediment delivery from timber harvest, roads, wild and prescribed fires, off-road vehicles, and undisturbed areas; (2) quantifying the year-to-year variability in sediment production; and (3) determining the effect of key site variables (MacDonald and others 2004). MacDonald and others (2004) found that roads, high-severity wildfires, OHV trails, and certain skid trails on granitic soils were the dominant sediment sources. The mean road sediment production rate was 0.9 kg/m^2, 0.1 kg/m^2 from skid trails, 0.4 kg/m^2 from ORV trails, 1.1 kg/m^2 from high severity burn sites, and 0.001 kg/m^2 from minimally disturbed sites. Native surface roads produced 10-50 times more sediment than rocked roads and most sediment delivery related to roads occurred at or near stream crossings. Additionally, they found that sediment production rates were highly variable between sites within a year as well as between years. Multivariate analyses indicated that the dominant controls on road sediment production included road contributing area (A), road gradient (S), annual erosivity (E_A), and road surfacing (rock vs. native surface; T). An empirical model containing these variables explained 54% of the variability in annual road sediment production.

USFS-PSW Research Station and CDF—Caspar Creek Watershed Study

Suspended sediment and bedload have been measured at the North and South Forks of Caspar Creek for more than 40 years (Ziemer 1998, Lewis and others 2001, Keppeler and others 2003). Caspar Creek is a small coastal watershed situated between the Noyo and Big River drainages in western Mendocino County. The Caspar Creek data set is unique in California, since it is the only forested experimental watershed currently in operation with a continuous, long-term flow and sediment record (Ziemer and Ryan 2000). Results show that improved forestry practices after 1974 have significantly reduced sediment yields. Selection logging conducted prior to the implementation of the modern FPRs in the South Fork of Caspar Creek produced from 2.4 to 3.7 times more suspended sediment than clearcutting in the North Fork under the modern FPRs (Lewis 1998). In the North Fork of Caspar Creek following clearcut harvesting of almost half the watershed in three years under the modern FPRs, suspended sediment monitoring showed that annual sediment loads increased 123-269% in the tributaries. At main-stem stations, however, increased loads were detected only in small storms and there was little effect on annual sediment loads. Most of the suspended sediment measured at the North Fork weir resulted from one large landslide that occurred in January 1995. Road rehabilitation work was conducted during the summer of 1998 on three miles of road that had had been constructed along the South Fork in 1967. A total of 33 watercourse crossings were abandoned, removing a total of approximately 28,500 cubic yards of fill material. Surveys of the abandoned crossings have shown that downcutting following large winter storm events resulted in 854 cubic yards of sediment production, or three percent of the total amount of sediment removed, with an average loss of approximately 26 cubic yards per crossing. Over 70% of this material came from three crossings, or 9% of the abandoned crossings surveyed (Cafferata and Munn 2002).

Klein—Sanctuary Forest Stream Crossing Excavations in the Upper Mattole River Basin, 2002-2003

The Sanctuary Forest, Inc. is implementing an erosion control and prevention program to reduce long-term sediment yield in the upper Mattole River watershed, with the focus on decommissioning unneeded forest roads that pose sedimentation risks. Klein (2003) conducted a monitoring project to determine volumes of erosion following road removal at excavated crossings and impacts to water quality. Erosional void dimensions were measured at 18 excavated crossings. Both channel scour and bank slumps were documented for each crossing. Survey work was not conducted prior to the onset of winter rains, so channel scour was estimated by making field measurements of scarp heights and top widths at geometric transition points within the excavation. Most of the erosion was found in the excavated channel areas, but erosion was also documented above crossings where culverts had been located. The total sediment delivery for the first winter was 279 yds^3, with an average of 15.5 yds^3 per crossing. Sediment yield for individual crossings ranged from over 50 yds^3 to less than 2 yds^3. Four crossings (approximately 22% of the excavated crossings) produced roughly half the total sediment volume. In general, channel scour strongly dominated sediment yield. Bank slumps were relatively minor except at one removed crossing.

Modified Completion Report (MCR) Study Design

Overview

Under the FPA, Public Resources Code (PRC) Section 4586 requires that within six months of the receipt of the Work Completion Report specified in PRC Section 4585, the director shall determine, by inspection, whether the work described in the report has been properly completed in conformity with the rules and regulations. If so, a report of satisfactory completion is issued. If not, the director shall take such corrective action as he or she determines appropriate. MCR is a slight modification to this process. MCR adds a monitoring step, which is designed to collect data on the implementation and effectiveness of the FPRs designed to protect water quality.

The initial MCR monitoring design was a simple check list used in the late 1990's by CDF inspectors during the Work Completion Report inspection that is required on all THPs. This approach had several deficiencies. First, even though the check list forms were to be turned-in for all THPs undergoing Work Completion Report inspections, in practice forms were turned-in for only a small, non-random fraction of the completed THPs. Since the sample was not random, it was not possible to tell whether this was a representative sample of all THPs. Second, the check list only included categories for deficient implementation or effectiveness of listed FPRs. This implied that absence of a check mark always meant no deficiency, which was not always true. And third, because the check list instructions did not include criteria for site selection, it was not possible to determine what bias might have been introduced by the choice of sampling locations.

To solve these problems the MCR protocols were revised to include:

1) Random selection of THPs for monitoring to ensure a representative sample,
2) Forms that required a mark or an entry for each question to indicate whether it had been answered or deemed not applicable, and
3) Criteria for random selection of monitoring sites within each THP.

Random Selection of THPs

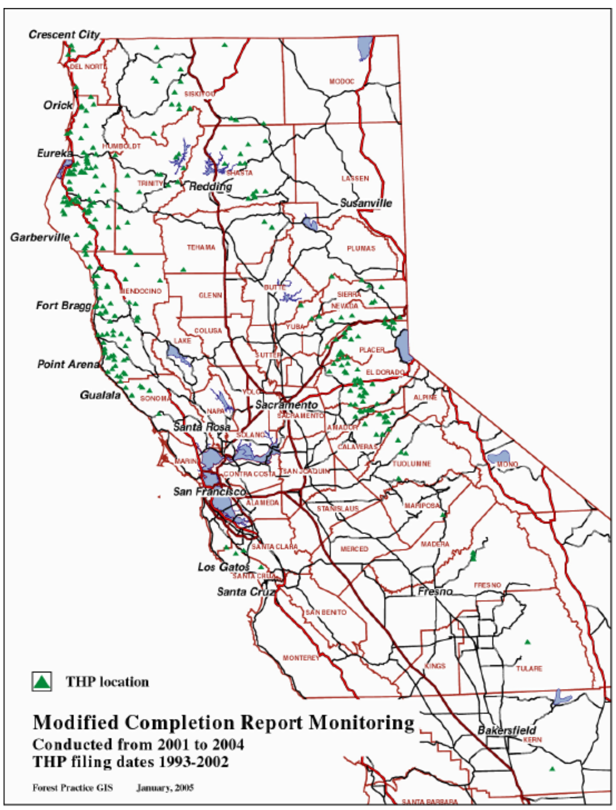
The MCR monitoring was performed on a random sample of completed THPs. The initial target sample size was 25% of all THPs undergoing Work Completion Report inspections. This percentage was subject to change based on staffing levels and workload, and the sample size was revised downward from 25% to 12.5% on February 25, 2002. A 12.5% sample represented about 125 THPs in 2002.

To obtain a random sample, pick-lists of randomly selected THP numbers were generated and distributed to Forest Practice Inspectors. One list was generated for THPs dated 1990 through 1999; and separate, annual lists were generated for THPs approved in 2000, 2001, 2002, and 2003. There were no THPs with a filing date of 2004 or later in this sample, because no plans filed in 2004 were completed by July 1, 2004. To avoid confusion, the same list of numbers was used for all three CDF

Regions. This does not affect the randomness of the sample because each region assigns its own, consecutive THP numbers, starting with 001, annually. If the THP number for a completed plan matched one of the numbers on the random list for a given year, then that THP was selected for monitoring.

A program used to produce lists of random THP numbers was written by State Forests Research Coordinator Tim Robards of CDF in collaboration with CDF watershed scientist Clay Brandow. In this approach, each number from 1 to 1000 is individually compared to a randomly generated number that gives a one in "X" chance of selection. For example, to get a 12.5% sample, "X" equals 8, and each THP number has an independently determined one-in-eight chance of being selected. This provides a random, 12.5% sample of completed THPs regardless of the number of THPs approved in any given year.

The MCR project has not yet included Non-Industrial Timber Management Plan (NTMP) Notices of Timber Operations (NTO), while the Hillslope Monitoring Program did include some NTMPs. Neither the MCR random sample nor the HMP random sample included harvesting operations conducted under Exemption or Emergency Notices.



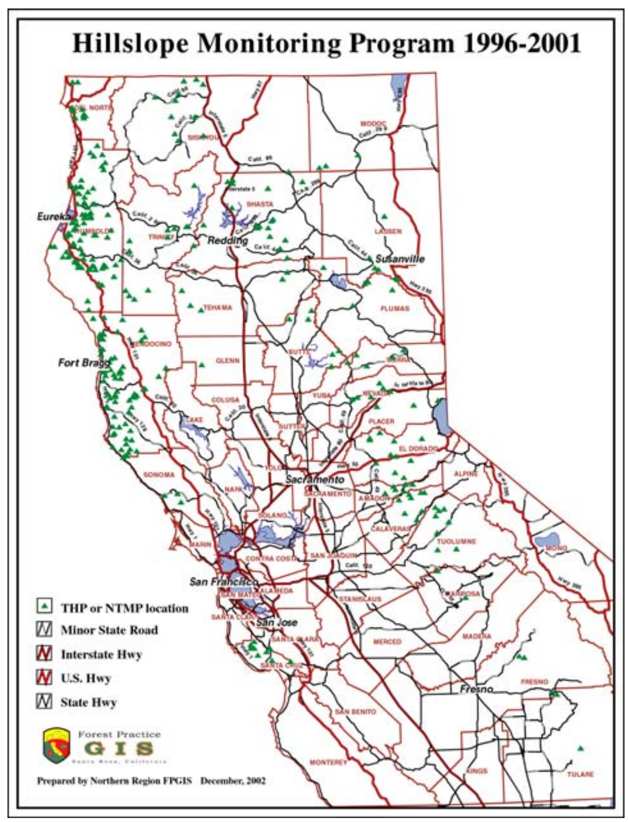


Figure 3. General locations of THPs randomly selected for MCR monitoring from 2001 to 2004 on the left, compared to the general locations of THPs randomly selected for HMP monitoring from 1996-2001 on the right.

Plotting the locations of THPs selected for MCR monitoring from 2001 to 2004 produces a statewide pattern of sampling sites that is remarkably similar to a plot of THP and NTMP sample sites selected for the HMP from 1996 through 2001 (See Figures 3 & 4).

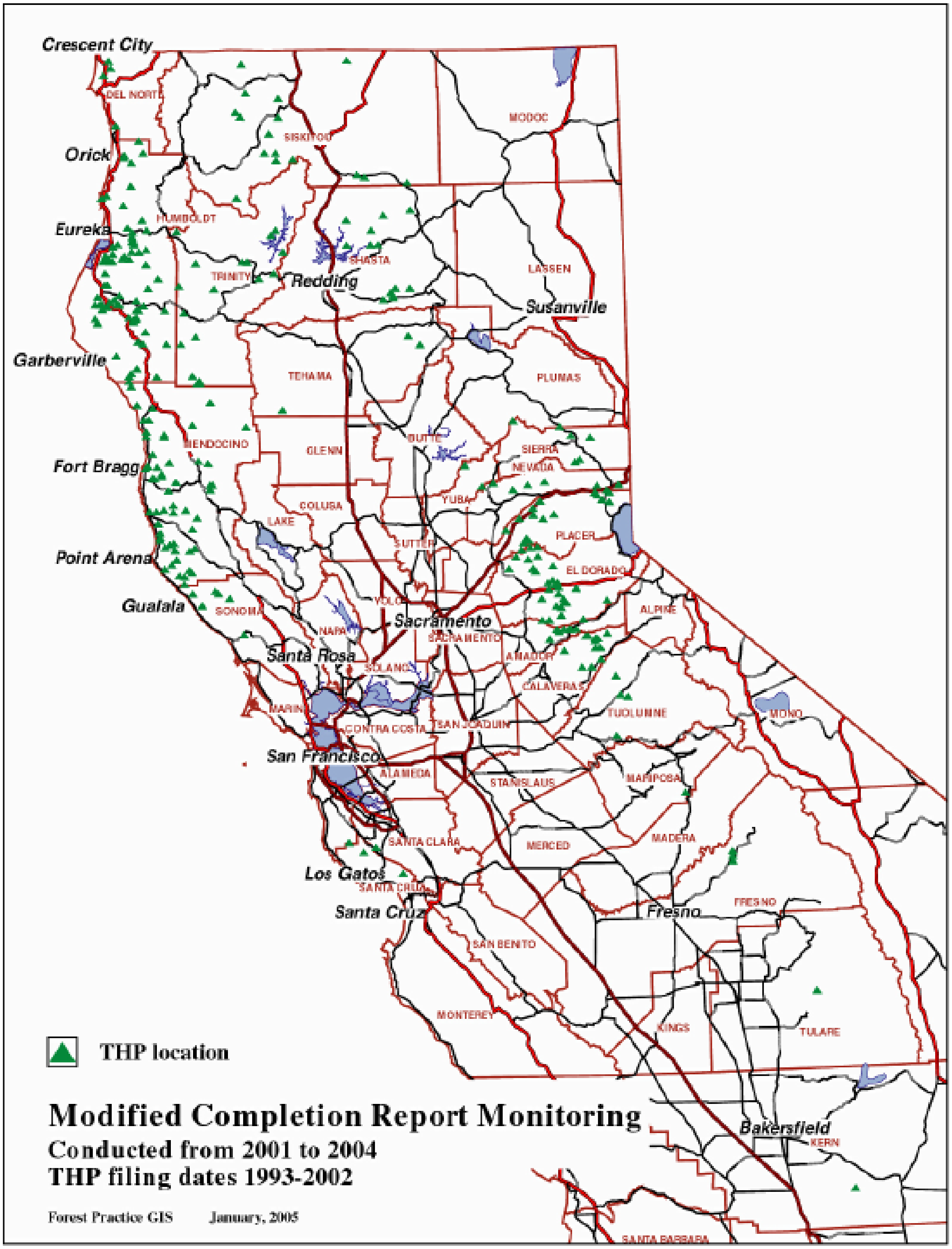


Figure 4. General locations of THPs randomly selected for MCR Monitoring from 2001 to 2004. This is simply an enlargement of the map of MCR THP distribution shown on the left in Figure 3.

The similarity of geographic patterns is the expected outcome, since MCR and HMP monitoring used independent, random samples of roughly equal size of THPs completed California. This similarity of geographic patterns is further evidence that both random samples are representative of the whole population.

Data Collection

Most of the MCR monitoring data was collected by CDF Forest Practice Inspectors, with some assistance from other CDF staff. On a small number of the THPs, monitoring assistance was provided by Regional Water Quality Control Board staff, California Department of Fish and Game staff, or landowner representatives (generally the Registered Professional Foresters (RPFs) who prepared and/or administered the THP).

Data was collected on paper forms. To avoid ambiguities from blanks in the data, responses such as "N/A" (for "not applicable") were required for all entries that might otherwise be left empty Despite training on filling out the data collection forms, blanks were still a problem. This has required some interpretation of the meaning of items left blank for subsequent data analyses. For future monitoring efforts, a solution to this problem is to use electronic data loggers that will not allow field observers to complete the form without all of the required entries.

The methods and procedures used in data collection for this report are documented in Modified Completion Report Monitoring Procedures and Methods (rev.4/9/03), which is listed in this report as Appendix A. An electronic copy of the *Modified Completion Report Monitoring Procedures and Methods (rev.4/9/03)* is available on line at:

http://www.bof.fire.ca.gov/board/msg_archives.asp

Implementation and Effectiveness Evaluations

All four sites (WLPZ segment, road segment, and two watercourse crossings) were evaluated for implementation at the time of the final Work Completion Report inspection(s). The sample road segment and watercourse crossings drainage structures were to be evaluated a second time for effectiveness during the post-completion erosion control maintenance inspection(s), after at least one over-wintering period. In some cases, the implementation evaluation was done after one or more over-wintering period(s) and the effectiveness evaluation was done on the same visit. In other cases, the effectiveness inspections were not done for lack of a second visit. Consequently, the subset of THPs with roads and crossings rated for effectiveness is smaller than the sub-set of the THPs with roads and crossings rated for implementation.

Effectiveness information recorded included erosion features present (if any), source and cause of erosion features, impact to water quality, and adequacy of road and crossing design and construction.

Between November 2000 and June 2003, field training sessions on MCR data collection were conducted on THPs located in several CDF units located around the state. Seventy-five individuals took part in the training. Most of these were CDF inspectors, but some RWQCB staff were also present.

Quality Assurance/Quality Control (QA/QC)

Quality assurance consists of actions to ensure adherence to data collection and analysis procedures, while quality control is associated with actions to maintain data collection and analysis consistent with study goals through checks of accuracy and precision. The quality assurance program was composed of three components: 1) qualifications and practical experience of CDF Forest Practice Inspectors, 2) a detailed field training program, and 3) protocols provided in the *Modified Completion Methods and Procedures* document (See Appendix A).

The quality control program consisted of self-evaluation of the data collection forms for completeness in the field and a second evaluation of the forms by watershed staff at CDF Headquarters. Questions were resolved through direct communication between the Forest Practice Inspectors and watershed staff.

To ensure completeness of THP samples, lists of recently completed THPs subject to MCR Monitoring were generated quarterly using the Forest Practice System (FPS) data base and the MCR random pick-lists. These lists of THP numbers were checked against lists of MCR monitoring reports received in Sacramento, and responsible Forest Practice Inspectors were contacted about missing reports.

Regional Distribution of Monitored THPs

CDF has four Administrative Regions, three of which are included in this monitoring and will be referred in this report by short, descriptive names:

1) North Coast Region 1 is referred to as **"Coast"**,
2) Cascade Region 2 is referred to as **"Inland North"**
3) Central Sierra Region 4 is referred to as **"Inland South"**

Southern Region 3, which includes southern California and the eastern slope of the Sierra Nevada south of the Carson River, is arid, except at the highest elevations, which are for the most part federal lands. The region contains very little private or state forest lands and generates very few THPs. Consequently, Southern Region 3 was not included in this study. Also, in some portions of the of the report, notably the section on roads, the combined areas of Inland North and Inland South are referred in the aggregate as simply **"Inland."**

All of the 281 plans selected for MCR monitoring were THPs, while the 300 plans selected and analyzed for the HMP included 295 THPs and 5 NTMPs.

The distribution of plans by CDF Administrative Region was somewhat different for the MCR project than in the HMP. For MCR Monitoring, percentages of Coast (R-1), Inland North (R-2) and Inland South (R-4) plans were 52%, 27% and 21%, respectively (see Figure 5). For the HMP, the percentages of Coast (R-1), Inland North (R-2) and Inland South (R-4) plans were 62%, 26% and 13%, respectively (see Figure 6). Simplifying the comparison by combining the inland categories gives a Coast vs. Inland ratio of about 50/50 for the MCR sample of THPs and about 60/40 for Hillslope Monitoring Program sample.

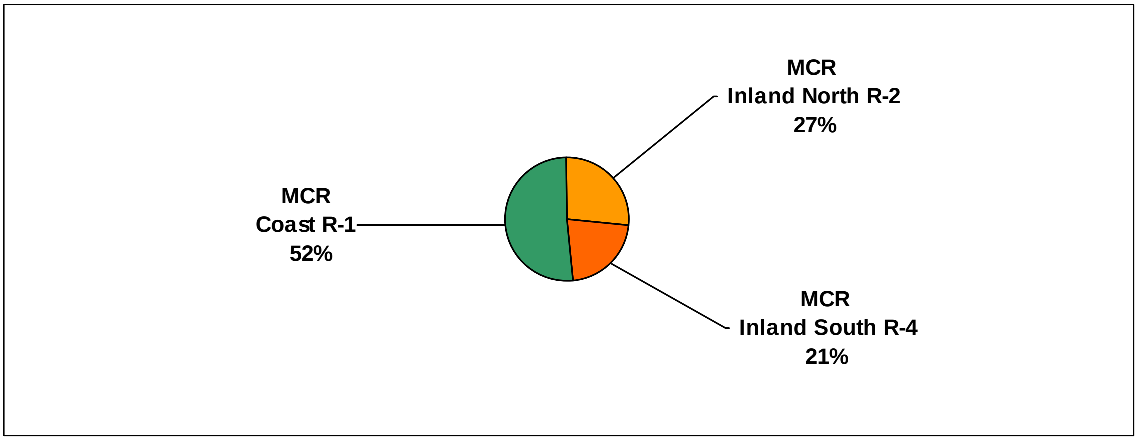


Figure 5. Distribution of MCR Monitoring Randomly Sampled THPs by Region.

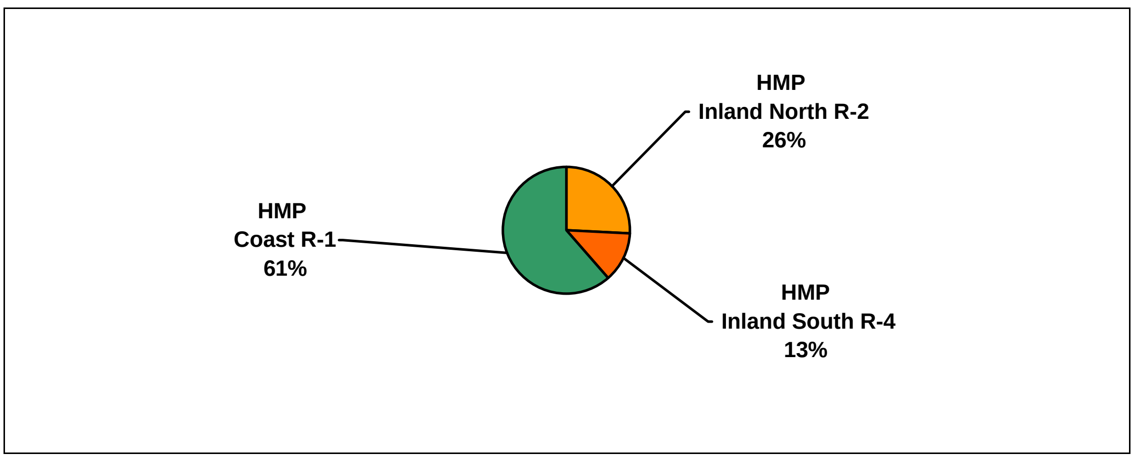


Figure 6. Distribution of HMP Randomly Sampled THPs by Region.

General locations of THPs randomly selected for MCR monitoring are shown plotted on the map of CDF Administration Regions below in Figure 7. Note the clustering; this clustering is representative of the clustering in the population of all THPs completed from 2001 through 2004. A similar pattern of clustering was observed in the HMP random sample (1999-2001).

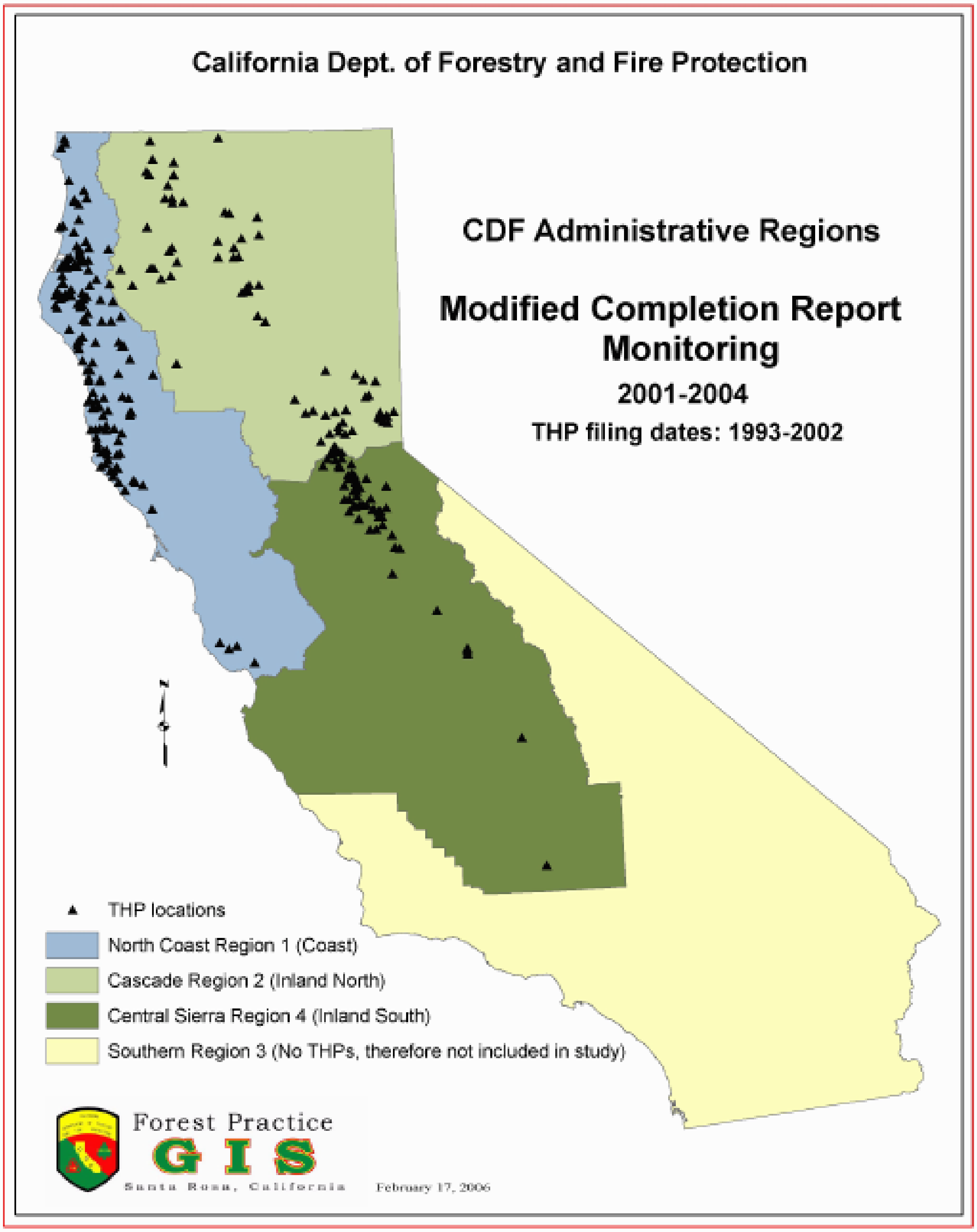


Figure 7. General locations of THPs randomly selected for MCR Monitoring from 2001 to 2004 by CDF Administrative Region.

Random Site Selection within Randomly Selected THPs

Up to four monitoring sites were located on each THP. These included:

1) A 200 foot WLPZ segment along a Class I or Class II watercourse,
2) A 1000 foot road segment, and
3) Two crossings of Class I, Class II or Class III watercourses.

For THPs that lacked one or more of these sites, forms were turned-in with the notation: "Not applicable to this THP."

Methods of random site selection for WLPZ segments, road segments, and watercourse crossings within a selected THP are described elsewhere in this report under the methods section for each of these features.

The use of randomly selected sampling sites within the THP allowed inspectors to focus in detail on whether the FPRs applicable to that site were: 1) properly implemented, and 2) effective in protecting water quality by preventing erosion, sediment transport, and discharge into channels.

MCR Monitoring:
WLPZ Canopy and Groundcover

I. Methods

Monitoring Timelines and WPLZ Selection

A 200-foot long WLPZ segment was randomly selected for MCR monitoring from each of the randomly selected THPs with one or more WLPZs. This was not possible in some cases, because Class I or Class II watercourses were not present on all of the randomly selected THPs. Within the WLPZ, sample segment zone width and percent total canopy were measured (Figure 8), and groundcover conditions were observed. Also, where they existed within the WLPZ segment, three additional items were observed and recorded: 1) erosion features, 2) untreated patches of bare mineral soil, and 3) timber harvesting that occurred on this entry.

Figure 8. Pete Cafferata, CDF, making canopy cover measurements using a sighting tube.

Selecting the 200-foot WLPZ segment began with the inspector delineating all of the Class I and Class II WLPZs on the THP map(s). Then a scale was used to mark 200 foot segments along all of the delineated WLPZs. Each of these segments was given a number. Then a random number between 1 and the maximum number of segments was identified using a random number table or a pocket calculator random number generator, and the segment number corresponding to the identified random number was selected for sampling. Where both sides of the creek were harvested, a coin flip was used to determine which side of the stream to monitor. Random selection of WLPZ reaches was used to capture a representative sample of WLPZ conditions. This is different than the objective of WPLZ enforcement inspections. For enforcement purposes, segments are selected for canopy measurement based on apparent violations. Therefore, enforcement data represents worst-case post-harvest WLPZ conditions, while MCR measurements represent average WLPZ conditions for the study period.

The MCR procedures used for WLPZ canopy measurement were modified from Preharvest Inspection (PHI) and enforcement action procedures developed by Robards (1999). In both procedures, canopy is determined using a sighting tube, but the number of observations for the MCR procedure is 50, as compared to 100 for the enforcement procedure. Average WLPZ width for the MCR was determined by pacing within the segment sampled for canopy cover, and groundcover was estimated by ocular observation. Additionally, fresh erosion features in the MCR sample segment (i.e. gullies, rills, or areas of sediment deposition) were noted. The advantages to using similar WLPZ canopy/surface cover sampling methods for PHIs, enforcement, and MCR sampling included continuity of techniques, reduced training needs, and data comparability.

Sampling Procedures

The following sampling procedures apply to both Class I and Class II WLPZs. The target sample size for canopy measurements was 50 sighting tube points, regardless of the size of the sampled area. The distance (D) between points was calculated using the following formula, where width and length refer to the width and length of the sampled WLPZ segment:

$$D = \sqrt{\frac{width \times length}{50}}$$

Since the standard MCR sample length is 200 feet, this equation can be simplified to:

$$D = 2\sqrt{width}$$

When applied to standard widths of 50, 75, 100 and 150 feet, D is 14, 17, 20 and 28 feet, respectively. For convenience, the WLPZ width stated in the THP was used to determine D for field measurements, even if the actual WLPZ width flagged on the ground was found to be different during subsequent field work.

WLPZ transects were started at the watercourse transition line at one end of the WLPZ segment. From there, the first sample point was located on a line perpendicular to the watercourse at a distance that was calculated using a random number between zero and one times the measurement interval distance D. From the first sample point, the distance D was paced perpendicular to the stream to reach the next sample point, and so on until the next point would exit the flagged WLPZ. The WLPZ transect was then turned 90º for distance D to start of a new line perpendicular to the stream. This procedure was repeated until 50 sample points were measured, whether this completed the final line or not. The resulting measurement pattern is similar to what is shown in Figure 9.

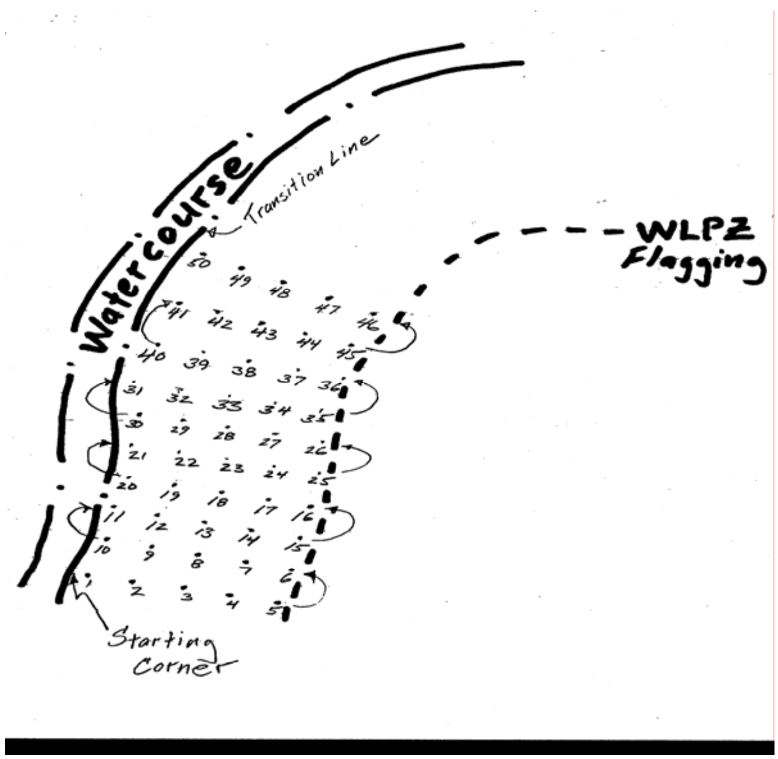


Figure 9. Typical pattern of canopy sighting and groundcover observation points within a typical randomly sampled WLPZ segment.

At each sample point, the inspector recorded total canopy as either a hit or miss, using a sighting tube (shown in Figure 10) as follows: (1) the sighting tube was leveled in front of one eye using the horizontal and vertical bubbles, (2) the dot in the center of the tube was lined up with circle in the center of the tube, and (3) the dot was evaluated as to whether it intercepted an object above the observer, such as needles, a leaf or a tree branch. Hits were recorded as “+” in the hit column and misses were recorded as “-” in the miss column on the WLPZ data form. When deciduous trees were encountered without leaves in the winter, it was assumed that leaf cover would be present in the summer months.

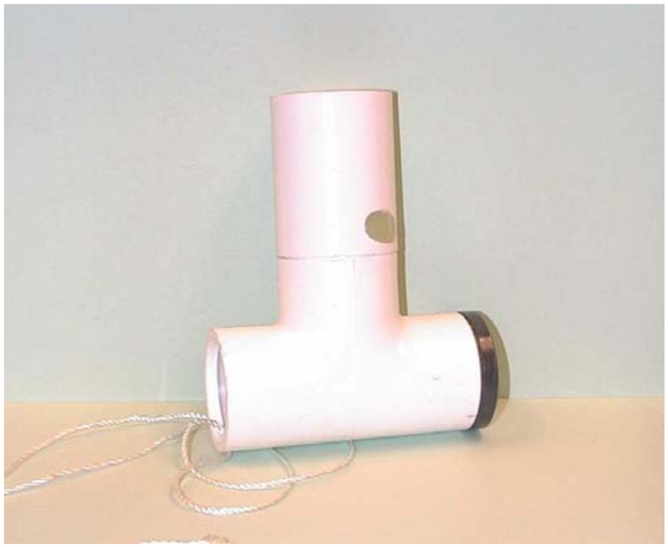


Figure 10. Example of a sighting tube used for making WLPZ canopy measurements.

The proportion of the ground surface covered with duff, litter, gravel larger than ¾ inch, and other protective material was also estimated and recorded at each sample point. In addition, the presence of erosion features or sediment deposition encountered during the transect was documented in association with the nearest sample point, along with information about feature type (i.e., gully, rilling, or areas of sediment deposition) and the feature's approximate size (width, depth, and length) in feet. Each erosion feature was recorded only one time, even if it was observed at more than one location, and a check box for "No erosion features observed in the sample WLPZ segment" was included on the data form to ensure that absence of recorded erosion features was not an oversight.

Following completion of the WLPZ transect, an overall assessment of conditions in the WLPZ segment was made, including whether or not there had been harvesting (yes or no), and if there had been harvesting how much canopy was removed, using three categories: <10%, 10-30%, and 30-50%.

An example of a completed form is included in the Modified Completion Report Methods and Procedures (see Appendix A).

II. Results

WLPZ segments were located in 187 of the 281 THPs included in the MCR sample. The regional distribution was 110 WLPZ segments on the Coast (CDF Region 1), 49 in the Inland North area (Region 2) and 28 WLPZ segments in the Inland South area (CDF Region 4.)

WLPZ Percent Total Canopy

Average percent total canopy cover in WLPZs was higher in the Coast than in the Inland areas. Looking at Class I and II watercourses together, average percentages for the Coast are in the mid to low eighties, and are around seventy for both Inland North and Inland South. In Table 1, below, the column for overall average includes all WLPZ results within each Region. The next two columns to the right split the overall sample into WLPZ segments with no harvest in this entry (the current THP) and WLPZ segments with harvest as part of this entry.

Class I & II WLPZs	Overall	No Harvest	Harvest
Coast (Region 1)	84% n = 110	86% n = 55	82% n = 55
Inland North (Region 2)	68% n = 49	72% n = 12	67% n = 37
Inland South (Region 4)	73% n = 28	69% n = 15	77% n = 13

Table 1. Average percent total canopy in WLPZs by Region for Class I and Class II watercourses combined. The number of segments included in each average equals "n."

Results for Class I watercourses alone are similar (Table 2). Note that the number of WLPZ segments (n) represented in some of these averages is very small. Consequently, the 10 percent difference between average percent canopy for harvested and unharvested WLPZs in the Inland South area is probably not meaningful.

Class I WLPZs	Overall	No Harvest	Harvest
Coast (Region 1)	84% n = 29	83% n = 14	84% n = 15
Inland North (Region 2)	69% n = 18	74% n = 3	68% n = 15
Inland South (Region 3)	71% n = 5	65% n = 2	75% n = 3

Table 2. Average percent total canopy in WLPZs by Region for Class I watercourses. The number of segments included in each average equals "n."

The percent total canopy results for WLPZs along Class II watercourses are also similar to both the combined and Class I results (Table 3).

Class II WLPZs	Overall	No Harvest	Harvest
Coast (Region 1)	84% n = 81	87% n = 41	81% n = 40
Inland North (Region 2)	67% n = 31	70% n = 9	65% n = 22
Inland South (Region 3)	73% n = 23	70% n = 13	78% n = 10

Table 3. Average percent total canopy in WLPZs by Region for Class II watercourses. The number of segments included in each average equals "n."

The MCR percent total canopy results for WLPZs are strikingly similar to the findings of the Hillslope Monitoring Program, which used similar canopy measurement techniques, but was based on a completely different random sample of THPs. The importance of this will be covered in more depth in the WLPZ discussion section.

WLPZ Erosion Features

Of the 187 WLPZs sampled, 19 (~10 percent) had one or more erosion features. Of the 19 WLPZs with erosion features, only 2 (or about one percent) had erosion features related to current timber operations. Of the two WLPZ segments with erosion features related to current timber operations, one involved sediment deposition from erosion on a landing upslope, and the other was a gully that resulted from soil with less than 70% groundcover. In the first case, the WLPZ functioned as it should to intercept sediment originating from upslope erosion. In the second case, removal of groundcover as part of the timber operation led to erosion and sediment production, based on field observation.

The causes of the 17 WLPZ erosion features not related to current timber operations were described as follows:

- 6 inner gorge erosion sites,
- 2 streambank failures,
- 1 sediment deposition from a scarp,
- 4 originated from old skid trails/roads,
- 1 gully from a county road,
- 1 eroding cow trail, and
- 1 breached irrigation ditch.

Inner gorge erosion, streambank failures and scarps are natural features of the California landscape, and are common on California's north coast. County roads, cow trails, and irrigation ditches are land management features related to uses other than timber harvesting. Skid trails and skid roads from past timber operations reflect past practices that are not generally permitted under current FPRs.

Other WLPZ Results

Other WLPZ information collected as part of the MCR inspections included WLPZ length, width, canopy removal, understory canopy, and groundcover. Blanks have been interpreted as missing data and were not included in the calculation of average values. In some cases, however, data points with a value of zero may have been left blank.

The average total length of Class I WLPZ in the sampled THPs was 1,309 feet on the Coast (Region 1) and 1,770 feet in the Inland areas (Regions 2&4). The average total length of Class II WLPZ in the sampled THPs was 3,369 feet on the Coast and 3,396 feet Inland.

For all Regions, actual WLPZ widths as paced were equal (within ±5 feet) to the width prescribed in the THP 58% of the time, greater than prescribed 35% of the time, and less than prescribed 7% of time.

The average prescribed WLPZ widths for Class I streams were 129 feet, 92 feet and 75 feet for the Coast, Inland North and Inland South, respectively. WLPZ widths measured on the ground were generally wider than prescribed widths. The average actual widths for Class I streams were 145 feet, 94 feet and 94 feet for the Coast, Inland North and Inland South, respectively. On Class II watercourses, the average prescribed WLPZ widths were 85 feet, 64 feet and 63 feet for the Coast, Inland North and Inland South, respectively. Again, the actual widths were wider than the prescribed widths on average. The average measured widths were 93 feet, 69 feet and 67 feet for the Coast, Inland North and Inland South, respectively.

Canopy removal by current timber operations within sampled WLPZ segments was extremely variable. For Class I watercourses in all Regions, 18 WLPZ segments had no canopy removal, 19 had less than 10% of the canopy removed, 12 had 10% to 30% of the canopy removed, and none had more than 30% canopy removal. For Class II watercourses in all Regions, 64 WLPZ segments had no canopy removal, 44 had less than 10% removed, 25 had 10% to 30% removed, and none had more than 30% canopy removal.

Total canopy has two components: understory canopy and overstory canopy. Based on ocular estimates, the remaining understory canopy in Class I WLPZs was 50% or greater 92% of the time, and the remaining overstory canopy was 50% or greater 96% of the time. Likewise for Class II WLPZs, remaining understory canopy was 50% or greater 91% of the time, and remaining overstory was 50% or greater 92% of the time.

The “Threatened and Impaired Watershed Rule Package Requirements (T&I Standards)” for overstory canopy came into effect on July 1, 2000. They only apply to Class I watercourses in specific watersheds in THPs filed after mid-year 2000. To the question “Does this Class I watercourse meet the T&I standards?” inspectors answered 25 WLPZs did meet the standards, 6 did not, and in 10 the standards were not applicable. There were 11 instances of apparent missing data were the question was not answered.

Regarding WLPZ groundcover, both live and dead, 70% groundcover is a threshold at which surface erosion is normally prevented. Class I WLPZ percent groundcover was equal to or greater than 70% on average 93%, 81%, and 60% of the time for the Coast, Inland North and Inland South, respectively. Similarly, Class II WLPZ percent groundcover was equal to or greater than 70% on average, 93%, 90%, and 71% of the time for the Coast, Inland North and Inland South, respectively. Untreated patches of bare mineral soil equal to or greater than 800 square-feet, or greater than a threshold specified in the THP, were reported in only one Class I WLPZ, which was located on the Coast, and in three Class II WLPZs, one of which was on the Coast and two of which were in the Inland South.

III. Discussion

The MCR results for percent WLPZ total canopy are strikingly similar to the earlier findings of the Hillslope Monitoring Program (Cafferata and Munn 2002), which used similar canopy measurement techniques but was based on a completely different random sample of THPs. Comparisons of these results for Class I watercourses are shown in Table 4 and Figure 11, and Class II watercourse comparisons are shown in Table 5 and Figure 12. Such similarity of results from two independent studies indicates that these averages are a true representation of the current status of WLPZ total canopy cover on recently completed THPs in California.

Table 4. Comparison of MCR (2001-2004) and Hillslope Monitoring Program (1999-2001) results for average percent WLPZ total canopy by Region for Class I watercourses. The number of segments represented in each average equals "n."

Class I WLPZ Comparison	MCR Monitoring (2001-2004) Class I WLPZ percent total canopy	HMP (1999-2001) Class I WLPZ percent total canopy
Coast (Region 1)	84% n = 29	83% n = 27
Inland North (Region 2)	69% n = 18	61% n = 17
Inland South (Region 4)	71% n = 5	67% n = 13
Inland (Regions 2&4 combined)	69% n = 23	64% n = 30

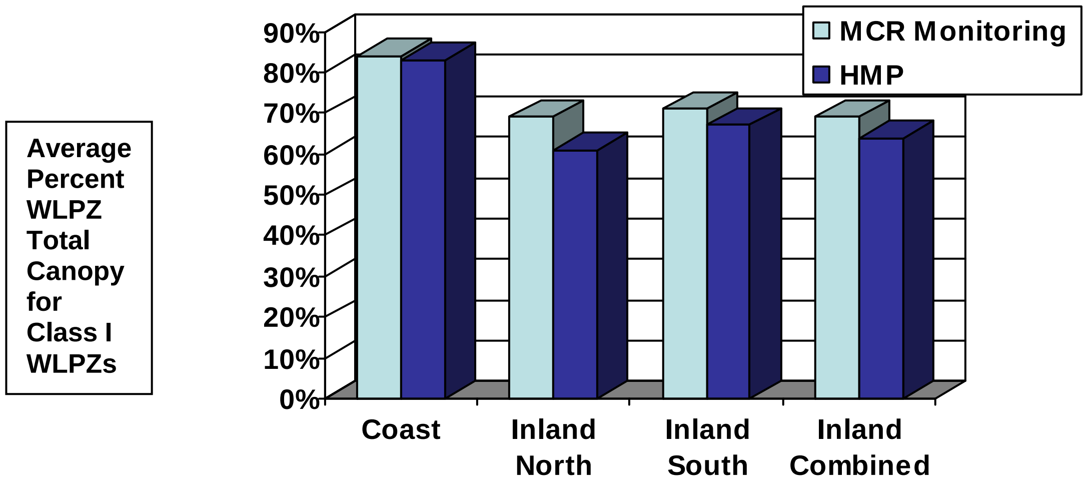


Figure 11. Graphic comparison of MCR (2001-2004) and Hillslope Monitoring Program (1999-2001) results for average percent WLPZ total canopy by Region for Class I watercourses.

Table 5. Comparison of MCR (2001-2004) and Hillslope Monitoring Program (1999-2001) results for average percent WLPZ canopy by Region for Class II watercourses. Number of segments represented in each average equals "n."

Class II WLPZ Comparison	MCR Monitoring (2001-2004) Class II WLPZ percent total canopy	HMP (1999-2001) Class II WLPZ percent total canopy
Coast (Region 1)	84% n = 81	80% n = 109
Inland North (Region 2)	67% n = 31	62% n = 46
Inland South (Region 4)	73% n = 23	74% n = 19
Inland (Regions 2&4 combined)	70% n = 54	66% n = 65

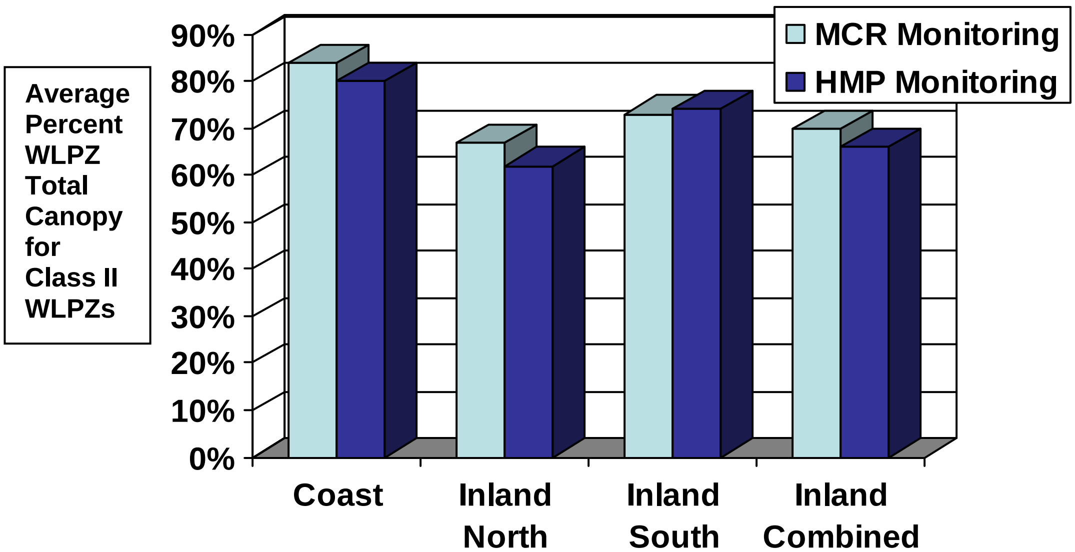


Figure 12. Graphic comparison of MCR (2001-2004) and Hillslope Monitoring Program (1999-2001) results for average percent WLPZ total canopy by Region for Class II watercourses.

Both the MCR and HMP results for percent WLPZ canopy indicate that the FPR standards are generally being met; however, there are rare instances of WLPZs with harvesting done under a current THP that do not meet FPR standards, which are potentially citable violations. Consequently for enforcement purposes, the best strategy to detect such infrequent violations is do quick ocular assessments of as many WLPZs as possible, and reserve more accurate but time-consuming canopy measuring techniques for WLPZs that appear to be probable violations. This observation will be reflected in the recommendations at the conclusion on this report.

Also, as in the HMP, MCR observations of WLPZ groundcover and erosion indicate that WLPZs function well to prevent erosion and sediment transport from current timber operations, assuming they have adequate groundcover and are free of significant patches of bare soil, which was generally found to be the case.

MCR Monitoring:
Roads

I. Methods

Road Segment Selection and Monitoring Timelines

The procedure for randomly selecting a road segment on a THP is described in detail in the *Modified Completion Report Monitoring Procedures and Methods* (see Appendix A). Briefly, a single 1,000-foot long road segment was selected for monitoring on each THP selected for MCR Monitoring (Figure 13). The basic concept is that results from randomly selected segments when aggregated provide unbiased estimates of hillslope erosion, sediment transport off the road prism, and sediment transport to channels.

Figure 13. Pete Cafferata, CDF, recording road observations at a rolling dip. Orange box on his right hip is a hip-chain which meters-out string for tracking distances of specific road-related features along a 1000-foot sample segment.

The initial study design included visiting each road segment twice: first during the Work Completion Report inspection to evaluate implementation, and then during the erosion control maintenance period to evaluate effectiveness after at least one overwintering period. In practice, most of the randomly selected road segments had been through at least one overwintering period prior to the Work Completion Report inspection, therefore most of the evaluations of implementation and effectiveness were done on the first visit.

Segments of roughly equal length (approximately 500 to 1,000 feet) were marked along all of the roads shown on the 1:24,000 scale THP road map. Each segment was then assigned a number. Using either a random number table or function on a calculator, a random number was generated between 1 and the highest numbered segment. The mid-point of the road segment matching the random number was used as the starting point for the 1,000-foot road segment. Direction from the starting point was decided by a coin flip, assuming a 1,000- foot sample road segment could be obtained in either direction.

Not all of the randomly sampled THPs had a single, 1,000-foot long road segment that was suitable for sampling. In these cases, where possible, a sample segment shorter than 1000-feet was monitored. On randomly selected THPs without roads suitable for monitoring (e.g., all of the roads used in the THP were either public roads or residential driveways), no road monitoring was done.

The location of the starting point was marked in the field, often by writing a message such as "Begin MCR Road Sample Segment" and noting the date on flagging attached to a nearby permanent object or vegetation. The *hip-chain* string would then be attached to the starting point and the counter set to zero. While walking the sample road segment, each road-related feature was evaluated and its distance from the start point recorded using the *hip-chain*, until reaching approximately 1,000 feet from the starting point or the end of the road, whichever came first.

Both the procedure and the form used for evaluating road segments were similar to those used in the HMP. Specific methods and the road form are available in the *Modified Completion Report Monitoring Procedures and Methods* (Appendix A). In short, the beginning and ending distances from the segment starting point of all road-related features (e.g., inside ditches, cut banks, waterbreaks, cross drains, etc.) were recorded, regardless of whether or not they presented a water quality problem. Consecutive numbers were assigned to each recorded feature, which, in combination with the THP and segment number, became a unique identifier for that feature. Then codes were recorded to indicate the type of feature and any associated drainage problems, erosion causes, erosion source areas, and sediment production. The dimensions of erosion features were also to be recorded, but this was not done consistently.

The rule numbers used in MCR monitoring were based on the California Forest Practice Rules (CDF 2000) (see Table 6). Unfortunately, the numbering of the FPRs tends to change from year to year with each new version of the rule book. Also, because the road-related rules are located in several sections of the book and because there is often more than one FPR from more one section of the book that covers a road-related feature or issue, the road-related rules tend to be complex. The roads discussion section describes what is being done to remedy this situation.

The California Forest Practice Rules for 2006, with the complete wording of each rule, is available in hardcopy from CDF Headquarters in Sacramento and on-line at http://www.fire.ca.gov/php/rsrc-mgt_forestpractice.php.

Table 6. Summary of road-related Forest Practice Rules that were available for selection for the implementation and effectiveness evaluations for each sample road segment.

Modified Completion Report **Road FPR Pick List (Column C)** Revised 8-11-00		
Type	Rule No.	Description
Waterbreaks	914.6(c) 934.6(c) 954.6(c)	Waterbreak spacing according to standards.
	914.6 (f) 934.6 (f) 954.6 (f)	Where waterbreaks don't work--other erosion controls.
	914.6(g) 914.6(g) 954.6(g)	Waterbreaks constructed with a depth of at least 6 inches cut into firm roadbed.
Roads	923.1(a) 943.1(a) 963.1(a)	Road shown on THP map correctly.
	923.1(a) 943.1(a) 963.1(a)	If landing on road >1/4 ac or required substantial excavation-shown on map.
	923.1(c) 943.1(c) 963.1(c)	Logging roads and landings shall be planned and located, when feasible, to avoid unstable areas.
	923.1(d) 943.1(d) 963.1(d)	For slopes >65% or 50% within 100 feet of WLPZ, soil treated to minimize erosion.
	923.1(e) 943.1(e) 963.1(e)	New logging roads shall not exceed a grade of 15%, except that for 500-foot pitches with max. 20% grades.
	923.1(f) 943.1(f) 963.1(f)	Adequate numbers of drainage facilities provided to minimize erosion.

Type	Rule No.	Description
Roads (continued)	923.1(g) 943.1(g) 963.1(g)	New roads shall be single lane with turnouts, and constructed with balanced cut and fills where feasible.
	923.1(h) 943.1(h) 963.1(h)	Road construction shall be planned to stay out of WLPZs.
	923.1(h) 943.1(h) 963.1(h)	If logging roads will be used from the period of October 15 to May 1, hauling shall not occur when saturated soil conditions exist on the road.
	923.2(b) 943.2(b) 963.2(b)	Sidecast minimized for slopes >65% for distances >100 feet.
	923.2(c) 943.2(c) 963.2(c)	Compacted fill on roads with >50% sideslopes.
	923.2(d) 943.2(d) 963.2(d)	Fills constructed with insloping approaches, etc.
	923.2(e) 943.2(e) 963.2(e)	Breaks in grade above/below throughfill.
	923.2(f) 943.2(f) 963.2(f)	On 35% sideslopes remove organic layer of soil prior to placing fill.
	923.2(g) 943.2(g) 963.2(g)	Proper placement of excess material to avoid polluting streams.
	923.2(h) 943.2(h) 963.2(h)	Drainage structures of sufficient size, number and location to carry runoff water.
	923.2(h) 943.2(h) 963.2(h)	Drainage structures of sufficient size, number and location to minimize erosion.
	923.2(i) 943.2(i) 963.2(i)	Trash racks, etc. installed where appropriate.
	923.2(j) 943.2(j) 963.2(j)	No wood debris in road fills.

Type	Rule No.	Description
Roads (continued)	923.2(k) 943.2(k) 963.2(k)	No overhanging banks.
	923.2(l) 943.2(l) 963.2(l)	Fell trees >12" dbh with >25% of roots exposed by road.
	923.2(m) 943.2(m) 963.2(m)	Sidecast extending >20 ft treated to avoid erosion.
	923.2(o) 943.2(o) 963.2(o)	Discharge onto erodible fill prevented waterbreaks installed to discharge into cover.
	923.2(p) 943.2(p) 963.2(p)	Waterbreaks installed according to standards in FPR 914.6 [934.6, 954.6].
	923.2(q) 943.2(q) 963.2(q)	Drainage facilities in place and functional by October 15, except waterbreaks on roads in use until rains begin to produce overland flow.
	923.2(s) 943.2(s) 963.2(s)	Completed road construction shall be drained by outsloping, waterbreaks, and/or cross-draining by October15.
	923.2(t) 943.2(t) 963.2(t)	Winter roads surfaced where necessary.
	923.2(u) 943.2(u) 963.2(u)	Slash and other debris from road construction placed so as not to discharge into Class I and II streams.
	923.2(v) 943.2(v) 963.2(v)	Road construction activities in the WLPZ, except for stream crossings or specified in the THP, shall be prohibited.
	923.4(a) 943.4(a) 963.4(a)	Road maintenance completed during erosion control period.
	923.4(b) 943.4(b) 963.4(b)	Upon completion of timber operations, temporary roads and associated landing shall be abandoned properly FPR 923.8).
	923.4(c) 943.4(c) 963.4(c)	Waterbreaks maintained to minimize erosion. Erosion controls maintained during maintenance period.

Type	Rule No.	Description
Roads (continued)	923.4(d) 943.4(d) 963.4(d)	Watercourse crossings facilities and drainage structures shall be kept open.
	923.4(e) 943.4(e) 963.4(e)	Roadside berm removed or breached, except where needed for erosion control.
	923.4(f) 943.4(f) 963.4(f)	50-year flow design minimum for drainage structures.
	923.4(g) 943.4(g) 963.4(g)	Temporary roads blocked by start of winter.
	923.4(h) 943.4(h) 963.4(h)	Prevent excessive loss of road surface.
	923.4(i) 943.4(i) 963.4(i)	Soil stabilization where needed to prevent discharge.
	923.4(j) 943.4(j) 963.4(j)	Drainage ditches maintained to allow flow of water.
	923.4(k) 943.4(k) 963.4(k)	Prevent discharge from cuts, fills and sidecast. slopes.
	923.4(l) 943.4(l) 963.4(l)	Maintain trash racks.
	923.4(m) 943.4(m) 963.4(m)	Maintain drainage structures to prevent discharge.
	923.4(n) 943.4(n) 963.4(n)	Maintain drainage structures to prevent diversions.
	923.4(o) 943.4(o) 963.4(o)	Use heavy of equipment, road maintenance in WLPZ is prohibited during the wet season, except in emergencies.
	923.6 943.6 963.6	Wet spots rocked or otherwise treated.

II. Results

Two-hundred and forty-four (244) road segments were rated for implementation of FPRs related to water quality protection. Most of these segments were approximately 1,000 feet long. Some segments were shorter, commonly on plans without a single 1,000 foot long segment, and a few were longer. Using an average length of 1,000 feet, 244 segments equates to approximately 46 miles of road, which is about the distance from Sacramento to Stockton or from San Francisco to San Jose.

Implementation

In this random sample of road segments, a total of 1,991 road features were evaluated for implementation of the FPRs, which gives an average of 43 features per mile of road. Of these 1,991 features, there were 83 departures from the FPRs, or about 1.8 departures per mile of road. It is important to note that these departures tend to be clustered on short sections of bad road. For example, just five road segments out of the total of 244 segments account for 33 of the departures. In other words, the worst 2% of the road mileage accounted for 40% of the departures. This finding has important implications for both road managers and regulators that will be discussed more fully in roads discussion section.

As shown below in Figure 14, of the 1,991 implementation evaluations, 4% were rated as departures from the FPRs, 14% were rated as marginally acceptable, 76% were rated as acceptable, and 6% were rated as exceeding the FPR requirements (greater than acceptable implementation).

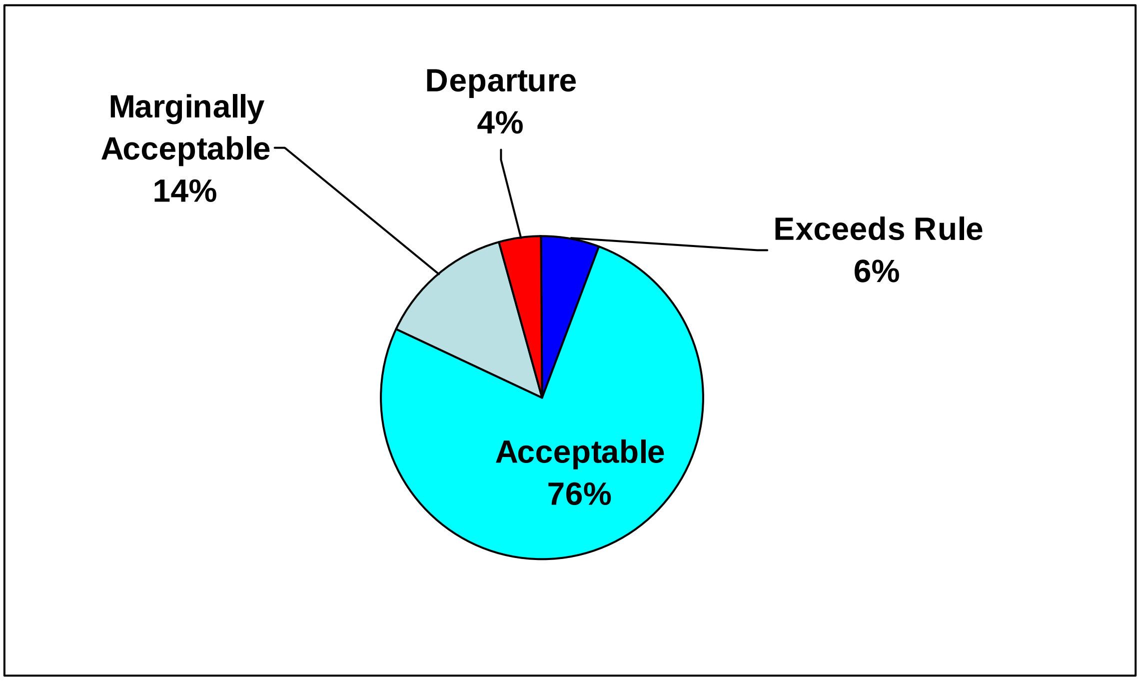


Figure 14. Overall road-related features rated for implementation (n = 1,991).

The Coast (CDF Region 1) accounted for 1,285 of the total 1,991 road features rated for implementation, and 706 were Inland (CDF Regions 2 &4). On the Coast, 2% of the evaluated road features were rated as departures from the FPRs, 15% were rated as marginally acceptable, 76% were rated as acceptable, and 7% were rated as exceeding the FPR requirements (Figure 15).

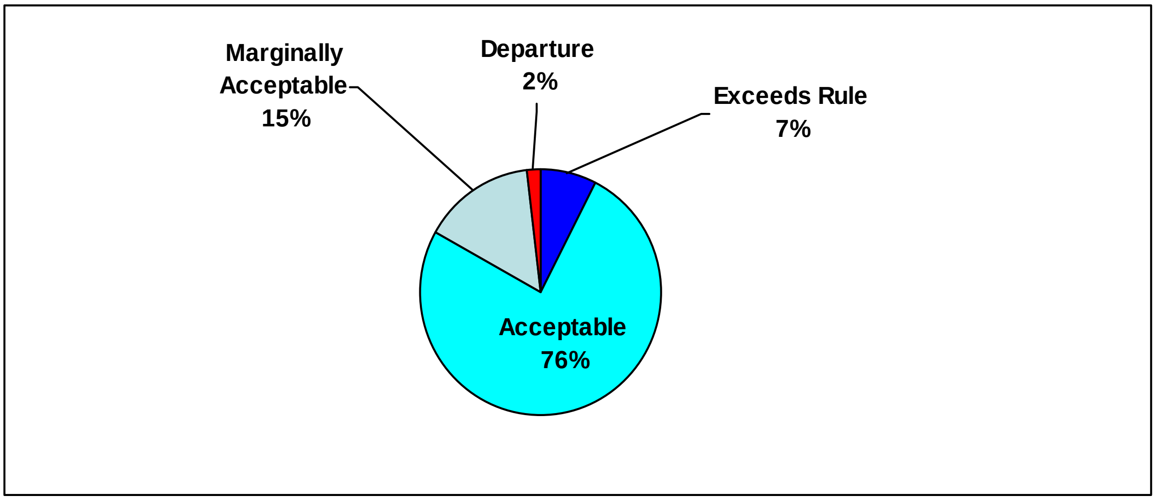


Figure 15. Coast (CDF Region 1) road-related features rated for implementation (n = 1,285).

Inland, 8% of the evaluated road features were rated as departures from the FPRs, 11% were rated as marginally acceptable, 78% were rated as acceptable, and 3% were rated as exceeding the rule (Figure 16).

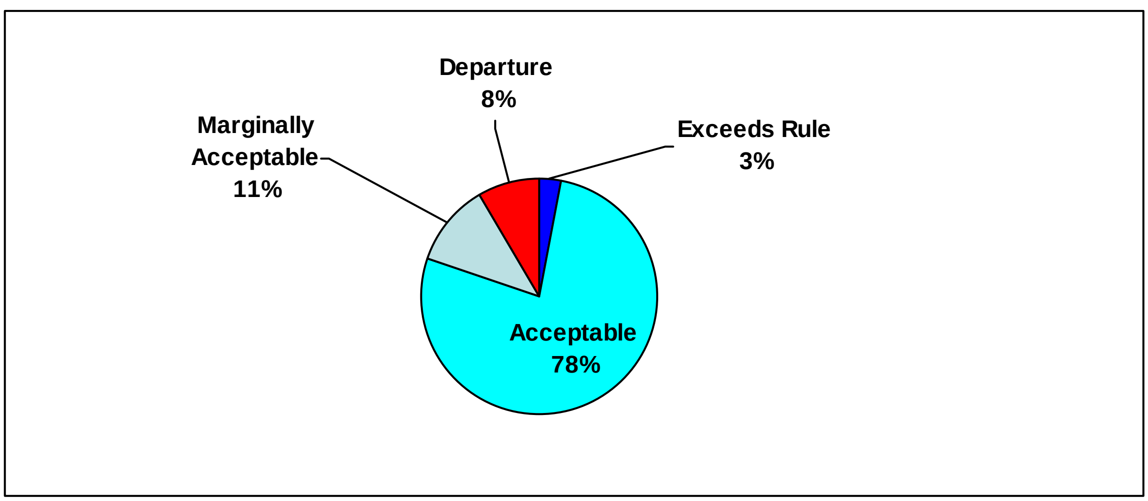


Figure 16. Inland (Regions 2 & 4) road-related features rated for implementation (n = 706).

There is a notable difference between the departure rates of 2% and 8% for coastal and inland regions, respectively. Combining the departure and marginally acceptable ratings for the coast region and also for the inland regions gives much closer results of 17% and 18%. Therefore, it is possible that the difference in departure rates could be an artifact of where inspectors conducting the MCR evaluations in the different regions choose to draw the line between departures vs. marginally acceptable implementations of FPRs. Determining whether this difference is real or not would require having personnel conducting the MCR inspections work and/or train across regions.

Assuming that departure rates for the Coast and Inland regions have been consistently evaluated, there are greater opportunities for improved implementation Inland, where the worst 6% of road segments account for three-quarters of the observed departures. Consequently, preventing departures on the worst 6% of the road mileage would hypothetically reduce the inland departure rate from 8% to a much more acceptable 2%, as shown in Figure 17, below.

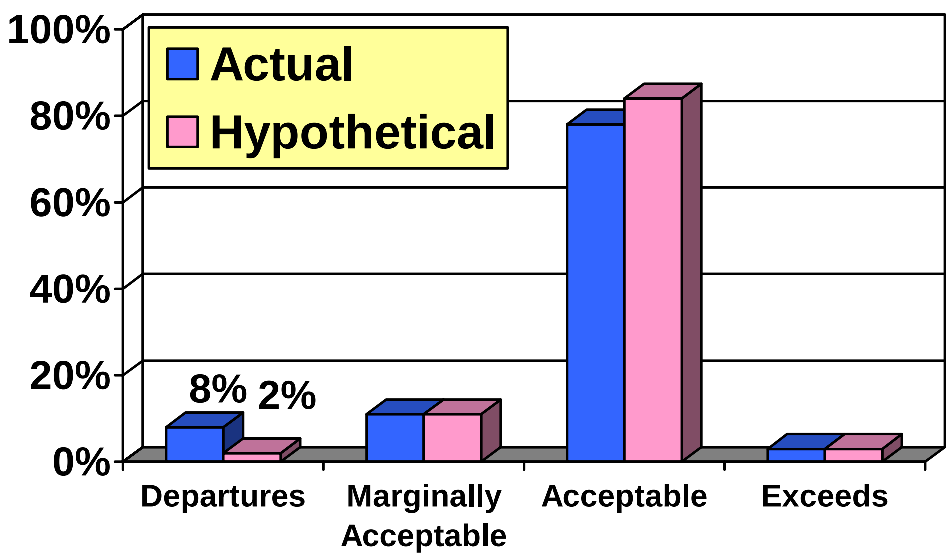


Figure 17. Inland (CDF Regions 2 & 4) hypothetical exercise: What would happen to the departure rate if we found and fixed the worst 6% of all road segments? Answer, the departure rate would hypothetically drop significantly from 8% to 2%.

On the Coast, the departure rate is already a relatively low 2%, and fixing the worst 6% of the road mileage brings the departure rate down to 1% (Figure 18).

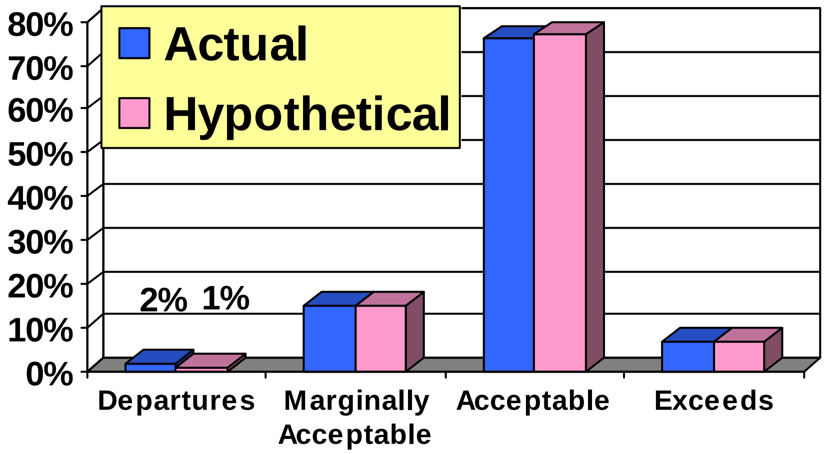


Figure 18. Coast (CDF Region 1) hypothetical exercise: What would happen to the departure rate if we found and fixed the worst 6% of all road segments? Answer, the departure rate would hypothetically drop slightly from 2% to 1%.

Figure 19. Example of road segment built to drain properly in wet weather. Note the two functional dips and their spacing.

The monitoring results demonstrate that most road features are implemented properly (figure 19), since 96% of the road features were rated marginally acceptable or above, as shown in Figure 14 presented earlier. However, there is still room for improvement, and these improvements can and should be focused on areas where it is possible to further reduce the impacts of roads on water quality.

When looking at specific types of features related to observed departures from the FPRs, there is very a definite pattern. Overall, 95% of the observed road-related departures involve FPRs directly related to providing proper drainage. Some of the remaining five percent of departures may also be directly or indirectly affected by drainage. Figure 20, shown below, groups the 95% of departures that are definitively related to drainage into five major categories, and a list of these departures by specific FPR is provided at the end of this section.

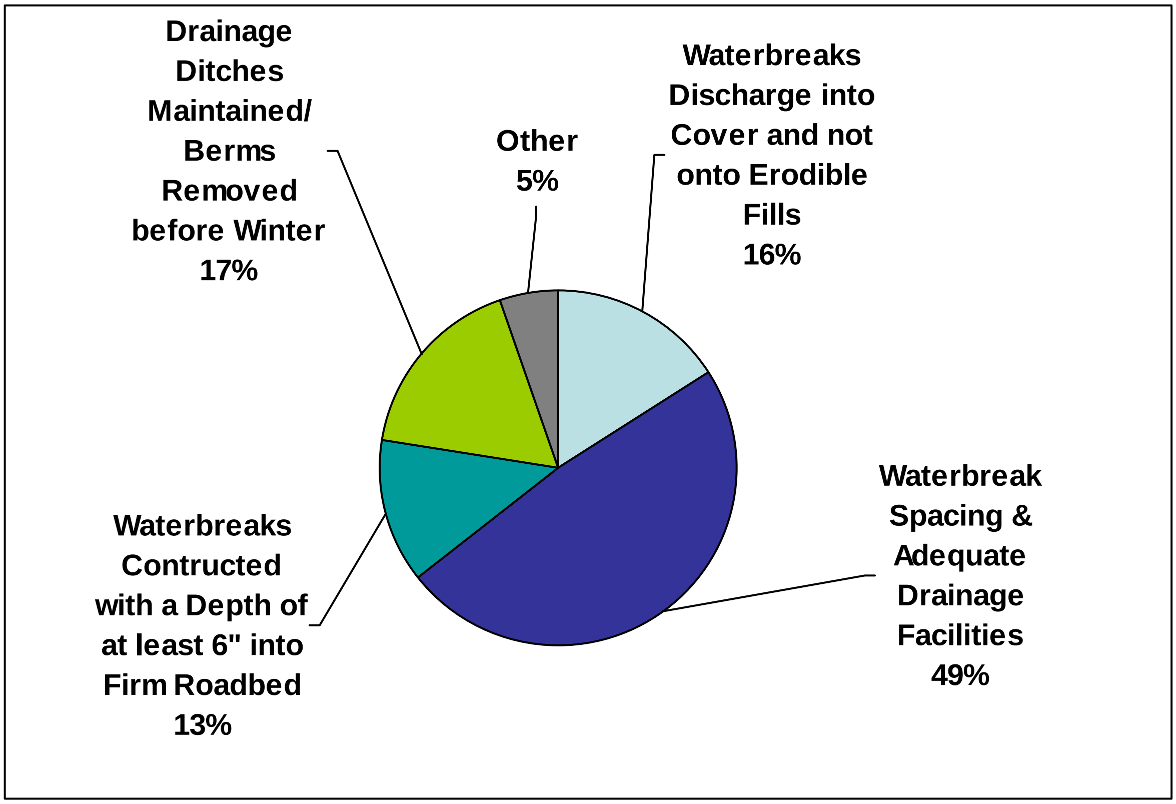


Figure 20. Departures from the road-related FPRs – percentages by category.

As demonstrated in Figure 20, the waterbreak spacing and adequate drainage category accounts for about half of the departures; drainage ditches maintained/ berms removed before winter category accounts for 17%. The waterbreaks discharge into cover and not onto erodible fills category accounts for 16%. The waterbreaks constructed with a depth of at least six inches into firm roadbed category accounts for 13%, and the catch-all category of "other" accounts for only 5% of the departures.

Effectiveness

A total of 130 out of the 244 sampled road segments were rated for FPR effectiveness, which (assuming an average segment length of 1,000 feet, as described above) equates to about 24 miles of sampled roads. These 130 road segments included 1,147 road-related features that were evaluated and rated for effectiveness and are subsets of the 244 road segments and 1,991 features rated for implementation, respectively.

All road segments rated for effectiveness had been through at least one wet season. An important caveat is that selection of road segments rated for effectiveness was not completely random, but neither was it systematic. At the time the monitoring study was designed, it was thought that all road segments in the sample would eventually be rated for effectiveness. This topic is discussed further in the discussion section.

As shown in Figure 21, below, evidence of erosion was found on 109 of the 1,147 road-related features rated for effectiveness. Sediment transport was found associated with 36 of the 109 erosion features, and 9 of those 36 features had evidence of sediment transport to a watercourse channel.

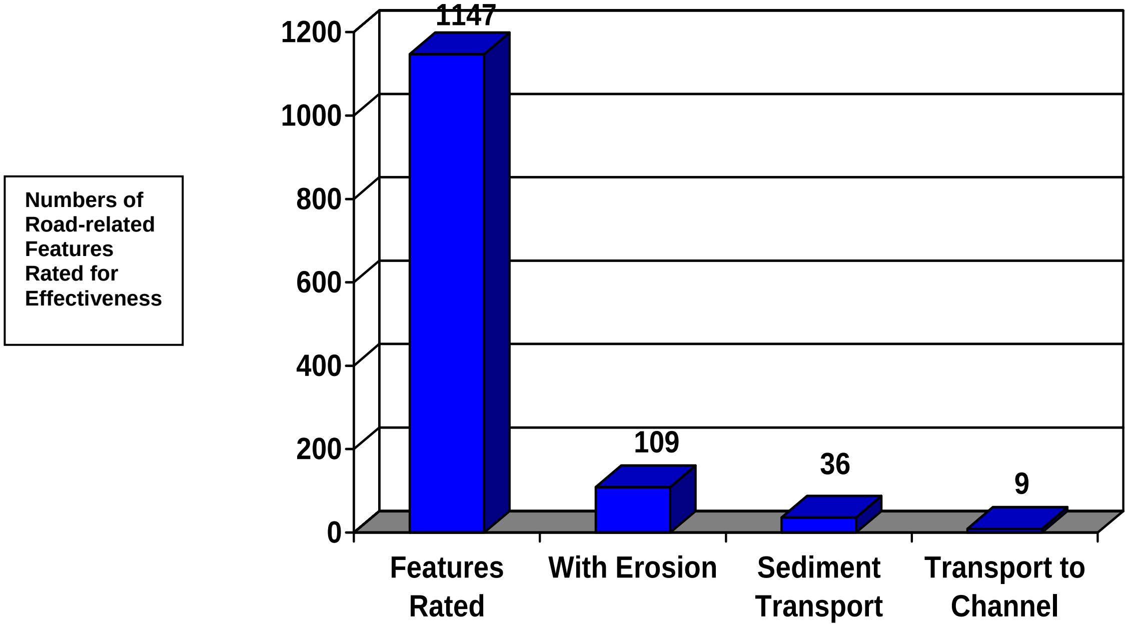


Figure 21. Road-related features rated for effectiveness, comparing the total features rated to the number with evidence of erosion, sediment transport and transport to channel.

When calculated as a percentage of the total features rated, 9.5% of the road features evaluated for effectiveness had erosion, 3.1% showed signs of sediment transport, and 0.8% showed evidence of sediment transport to a channel, as shown in Figure 22.

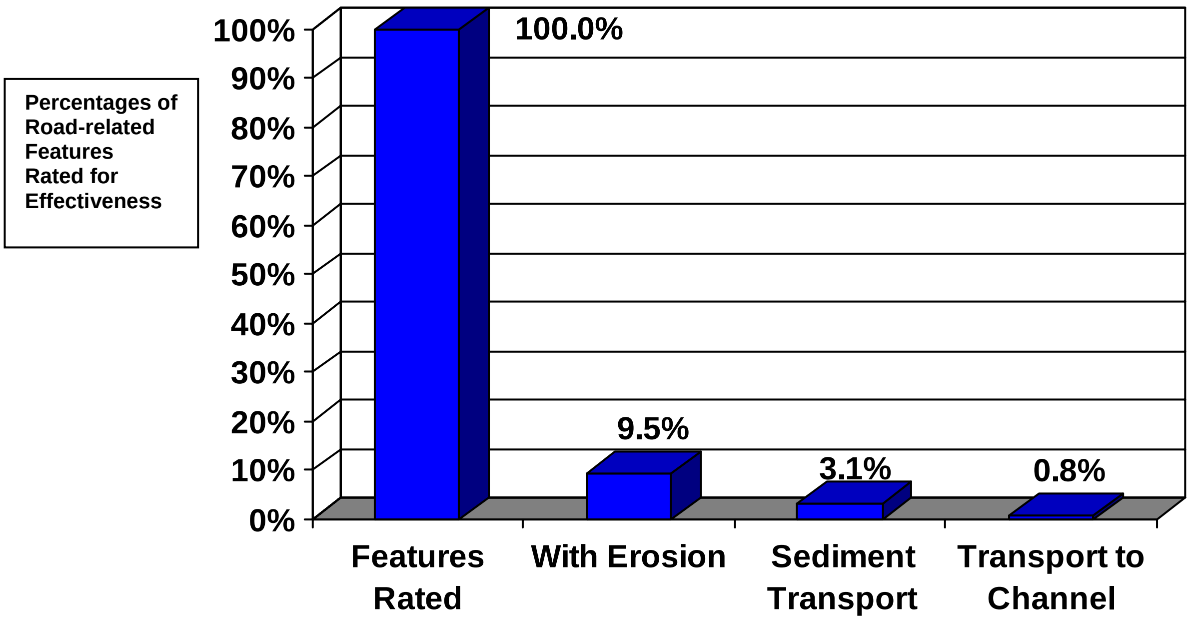


Figure 22. Road-related features rated for effectiveness as percentages, comparing the total features rated to the number with evidence of erosion, sediment transport and transport to channel.

Dividing the data into regions yields 639 road-related features rated for effectiveness on the Coast (CDF Region 1) and 508 Inland (CDF Regions 2 & 4). Of these, 35 and 74 had evidence of erosion, 9 and 27 showed evidence of sediment transport, and 4 and 5 had evidence of transport to a channel for the coast and inland regions, respectively, as shown in Figure 23.

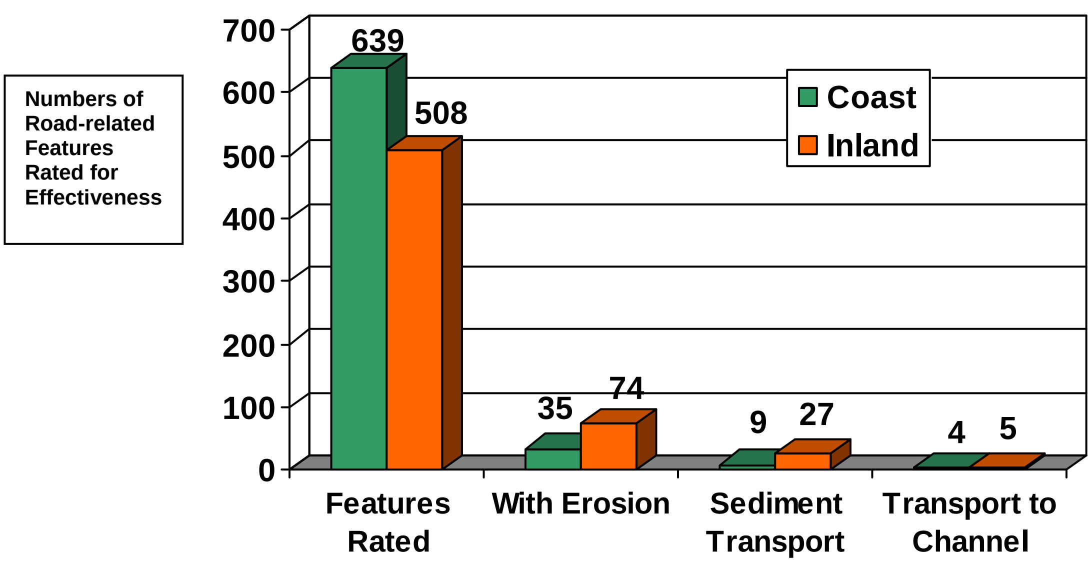


Figure 23. Coast vs. Inland road-related features rated for effectiveness, comparing the total features rated to the number of features with evidence of erosion, sediment transport and transport to channel.

Expressing these results as percentages, as shown in Figure 24, allows an easier comparison between regions. Erosion was found on 5.5% of the road-related features on the Coast versus a much higher 14.5% Inland. Evidence of sediment transport was observed on 1.4% of road-related features on the Coast and on 5.3% Inland. Evidence of sediment transport to channels was found on 0.6% of the road-related features on the Coast and 0.9% Inland.

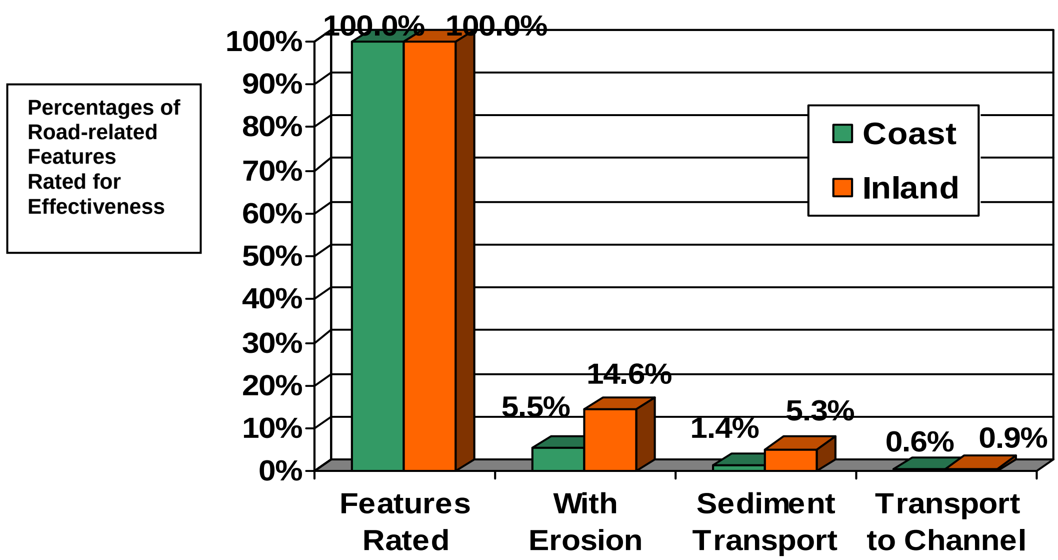


Figure 24. Coast vs. Inland road-related features rated for effectiveness as percentages, comparing the total features rated to the percentage of features with evidence of erosion, sediment transport and transport to channel.

Inland road-related features show signs of erosion and sediment transport more frequently than road-related features on the Coast; however, the percentage of road-related features showing evidence of sediment transport to channels is about the same on the Coast and Inland. One possible explanation for this is that timberlands on the Coast generally get more rainfall than timberlands in Inland and consequently develop denser networks of natural channels, which put road-related features closer to more channels.

Implementation vs. Effectiveness

Better implementation of the road-related FPRs resulted in greater effectiveness in preventing erosion, sediment transport, and sediment transport to channels. While properly implemented road FPRs occasionally failed to prevent erosion, sediment transport, and discharge, improperly implemented FPRs failed at a much higher rate.

Of the 1,147 road-related features that were evaluated for both implementation and effectiveness, 5% had implementation that exceeded the FPR, 78% had acceptable implementation, 12% had marginally acceptable implementation, and 5% were departures from the rule (unacceptable implementation). The effectiveness of each of these implementation categories in preventing erosion, sediment transport and sediment transport to channel is shown in Table 7, below.

Road-related Features Implementation Rating	Effectiveness Problems		
	Erosion	Sediment Transport	Transport to Channel
Exceeds Rule/THP requirement n = 57	2%	0%	0%
Acceptable n = 893	5%	1%	1%
Marginally Acceptable n = 142	23%	9%	1%
Departures n = 55	53%	35%	11%

Table 7. FPR effectiveness: road-related feature implementation ratings vs. percent of features with effectiveness problems.

The results shown in Table 7 demonstrate that the FPRs were very effective in preventing erosion and sediment transport related to roads. When implementation exceeded the rule requirements, erosion was found only 2% of the time, and no evidence of sediment transport or sediment transport to a channel was observed. With acceptable implementation of the FPRs, erosion was found 5% of the time, and evidence of sediment transport or sediment transport to a channel was observed only 1% of the time. However, when implementation of the FPRs was marginally acceptable, erosion was found 23% of the time, sediment transport was seen at 9% of the evaluated features, but evidence of sediment transport to a channel was still observed only 1 percent of the time. When implementation was rated as departing from the FPRs, erosion was found at more than half of the road-related features, sediment transport was seen 35% of the time, and evidence of sediment transport to channels was found at 11% of the evaluated sites, which indicates a noticeable reduction in water quality protection.

In summary for roads, when there is a departure from the rule, the chance of erosion is about 1 in 2, the chance sediment transport is about 1 in 3, and the chance of sediment transport to a channel 1 in 10.   But where the FPR implementation is acceptable or better, the chance of erosion is about 1 in 20, and the chance of sediment transport or sediment transport to a channel is equal to or less than 1 in 100.

Sediment transport to a channel can lead to water quality impacts. Evidence of transport to channels was seen on 9 road-related features out 1,147 rated for effectiveness, which is about 0.8 percent. Implementation ratings for these nine road-related features included three rated as acceptable, one rated as marginally acceptable and five rated as departures from the rule. Two of three features rated as acceptable and the one feature rated as marginally acceptable were located at watercourse crossings in the sampled road segments. The remaining feature rated as acceptable involved a road drainage site impacted by a high-intensity storm. Of the five features rated as departures, two involved discharges onto erodible material or failure to discharge into cover.   The other three departures were related to inadequate numbers of drainage facilities/structures or inadequate spacing.

III. Discussion

The FPRs related to roads were found to be properly implemented 96% of the time and, when properly implemented, effectively prevented erosion from most road features. Where erosion did occur, proper rule implementation prevented nearly all road-related sediment transport and discharge into channels. The infrequent departures from the road rules were associated with most of the road-related erosion, sediment transport, and sediment deposition in channels. Departures with potential to impact water quality were generally related to inadequate drainage and failure to discharge onto non-erodible sites. From a management and regulatory standpoint, it is useful to note that departures with potential to impact water quality occur on only 5% to 6% of road segments, or about one mile out of every twenty miles of THP roads. As a result, finding and fixing drainage problems on the worst 5% of all road segments would produce the greatest reduction in road-related water quality impacts for the least amount of money.

The MCR road results compare reasonably well with earlier monitoring work conducted in California on non-federal timberlands. In the HMP, Cafferata and Munn (2002) reported that 93.2% of the road rules evaluated for implementation were rated as acceptable.   Where there was sediment transport to watercourse channels documented, erosion features were usually caused by a drainage feature deficiency, and the FPRs rated at these problem sites were nearly always found to be out of compliance. Most of the identified road problems were related to inadequate size, number, and location of drainage structures; inadequate waterbreak spacing; and lack of cover at waterbreak discharge points. Approximately 15% of the inventoried erosion features delivered sediment to watercourse channels, compared to 11% percent sediment delivery at rule departure sites in the MCR. Only 5.5% of the drainage structures evaluated along the road transects in the HMP were found to have problems.

The FPRs do not apply to federal lands, but the USFS has an analogous set of road-related BMPs. The USFS (2004) reported that from 1992 through 2002 on California National Forests, BMPs for road surface, drainage, and slope protection were implemented at 85% of the 284 sites evaluated. At the 40 sites where these BMPs were not implemented, consistency of drainage structure repair with road management objectives was the criterion for which both minor and major departures were most common. BMPs were effective 90% of the time that they were implemented. At the sites where effectiveness objectives were not met, minor departures were most frequently associated with rilling on road surfaces and fillslopes. Sediment discharges to stream management zones (SMZs) or stream channels were the most common type of major departures. Effects were classified as elevated at less than 5% of the sites. Inadequate BMP implementation caused the elevated effects at all but one of these sites.

In their current form, the road-related FPRs are complicated and not organized well in the Forest Practice Rule Book. A Road Rules Committee of the Board of Forestry and Fire Protection is currently working on ways to revise and streamline these rules. This has the potential to further improve the effectiveness of road-related FPRs by making them easier to implement and enforce and also has the potential to make the rules easier to monitor in future MCR efforts.

The form used for data collection by this MCR monitoring study needs to be revised for future MCR monitoring. The current form was modeled after the form used in the HMP, where most of the observations were made by one team of observers (a single contractor) working closely together in the field. In contrast, the MCR observations were made by multiple observers (CDF Forest Practice Inspectors), and the complexity of the form caused inconsistencies in data collection from multiple observers working at various, disparate locations. Therefore, the data collection form should be simplified to focus on factors related to drainage spacing and adequacy, discharge into groundcover, and percent road grade between drainage structures that this study and others have found to be most closely associated with erosion and sediment transport. A revised road form for future MCR monitoring is currently being developed and will be available for field testing later in 2006.

MCR Monitoring:
Watercourse Crossings

I. Methods

Monitoring Timelines and Site Selection

The first two permanent or abandoned crossings on Class I, II, or III watercourses encountered along the randomly located 1000-foot road transect (as described in the Road Section of this report) were selected for MCR monitoring (Figure 25). Inspectors were instructed to sample the first crossing that was available and to not be concerned whether these features were distributed throughout the THP area or whether similar types of crossings were being evaluated.

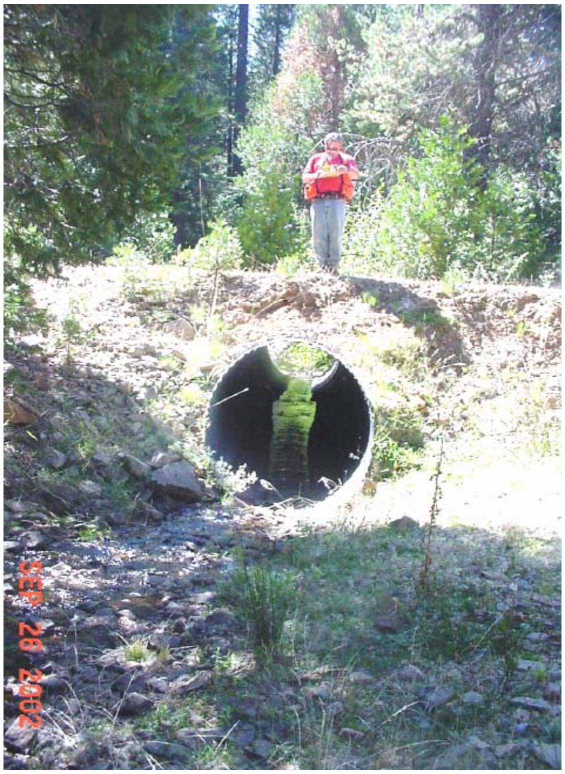


Figure 25. Clay Brandow, CDF, rating implementation and effectiveness for a Modified Completion Report watercourse crossing in the central Sierra Nevada Mountains.

If no crossings were noted within the 1000-foot road transect, then inspectors selected the closest watercourse crossings shown on the THP map relative to the randomly chosen road transect. If there were no watercourse crossings associated with roads, then the nearest skid trail crossings were evaluated. If there were no watercourse crossings within the THP, this information was recorded at the beginning of the

Watercourse Crossing form package.

The area to be included in the watercourse crossing evaluation was determined by inspecting the road prism in both directions from the crossing and identifying the points where drainage from the road surface, cuts, and fills was no longer transported to the crossing. The evaluation also included the drainage structures on the road immediately upslope from the crossing that should route water away from the crossing (e.g., “cut-off” waterbar). The road length for evaluation was located between these points.

The *MCR Methods and Procedures* guidelines specified that each of the selected crossings was to be rated on two separate occasions:

1) During field inspection of the THP Work Completion Report, CDF’s Forest Practice Inspector recorded site information on the MCR field form and rated implementation of applicable Forest Practice Rules for the selected watercourse crossing; and

2) The Inspector was asked to use the same form to rate rule effectiveness after at least one over-wintering period during the Erosion Control Maintenance Period.[3]

Watercourse Crossing Site Information

The following site information was included on the Watercourse Crossing Implementation Form:

- watercourse class (i.e., I, II, III, or IV – see glossary for definitions),
- road type (i.e., permanent, seasonal, temporary, or abandoned),
- crossing type (i.e., culvert, ford, bridge, etc.),
- crossing status (i.e., existing or abandoned),
- culvert diameter (if appropriate), and
- installation date (i.e., installed prior to the THP or newly installed as part of THP).

The crossing site information and implementation field form is displayed in Appendix A.

Watercourse Crossing Forest Practice Rule Implementation Rating

Following completion of the site information portion of the form, the Inspector rated implementation of 27 FPR requirements for roads and crossings found in 14 CCR § 923 [943, 963] and three Rule requirements for skid trails and crossings (referred to as tractor roads in the FPRs) found in 14 CCR § 914 [934, 954] using one of the following five implementation codes:

[3] This did not occur on a majority of the evaluated sites. Data on a second time period effectiveness evaluation is provided in the watercourse crossing results section.

D - Departure
MA - Marginally Acceptable
A - Acceptable
ER - Exceeds Rule/THP Requirements
N/A - Not Applicable

Watercourse Crossing Effectiveness Rating

The Watercourse Crossing Effectiveness Form was patterned after the crossing form (E09) developed by the USFS as part of their Best Management Practices (BMP) Evaluation Program (USFS 1992; USFS 2004), as well as a simplified version of the field forms developed for the BOF's Hillslope Monitoring Program (Cafferata and Munn 2002). Features rated for effectiveness were included within the following major categories: fill slopes, road surface drainage to the crossing, culvert design/ configuration, non-culverted crossings, and removed/abandoned crossings. In most cases, the effectiveness rating was selected from a description that generally can be summarized by one of the following four categories: not applicable (N/A), not a problem ("none" or "slight"), a minor problem, or a major problem. The Watercourse Crossing Effectiveness Form is displayed in Appendix A, and the following is a description of the rating criteria used for the 27 different crossing features.

FILL SLOPES

Gullies: Gullies were defined as being greater than 6 inches deep. The major problem category was checked if the gullies were significant and appeared to be enlarging.

Cracks: Cracks on fill slopes were assessed to determine whether they appeared to be stabilized or were widening, threatening the integrity of the fill.

Slope Failures: Slope failures were defined as movement of soil in blocks, rather than by rills, gullies or sheet erosion. The Inspector estimated whether fill slope failure(s) at the crossing site totaled between 0 and 1 cubic yard (minor problem), or greater than one cubic yard (major problem).

ROAD SURFACE DRAINING TO THE CROSSING

Gullies: Gullies on the road surface draining towards the crossing were rated as a major problem if they appeared to be enlarging or depositing sediment into a watercourse channel.

Cutoff Drainage Structure: Cutoff drainage structures were evaluated to determine if they were preventing water from reaching the crossing location. The major problem category was selected when water was reaching the crossing.

Inside Ditch Condition: When an inside ditch was present, its condition was evaluated to determine how functional it was in routing water to the culvert inlet. The major problem category was picked if the ditch was blocked with sediment or debris.

Ponding: The road surface was inspected for evidence of surface water ponding. A major problem was defined as ponding that threatened the integrity of the fill material.

Rutting (from vehicles): When vehicle ruts were present, the major problem category was selected if they impaired road drainage.

CULVERT DESIGN/CONFIGURATION

Crossing Failure: The Inspector determined whether the crossing had failed (yes/no) and recorded an estimate of cubic yards of fill lost at failure sites.[4]

Scour at Inlet and Outlet: The total amount of scour that had occurred and was likely to occur in the next two years at both the inlet and outlet of the culvert was estimated. The presence of significant scour, which may have undercut the fill material, was used to identify major problems.

Diversion Potential: Diversion of streamflow at crossings can transport large amounts of sediment to stream channels. The amount and direction of road surface slope at the crossing was used to determine whether the stream would be diverted down the roadway if flow exceeded the culvert capacity or the culvert was plugged with wood or sediment.

Plugging: The inlet and outlet of the culvert were inspected to determine the presence of debris (i.e., small wood, soil or rock) and, if debris was present, the degree of blockage. The major problem category was selected if more than 30% of the pipe opening was obstructed.

Alignment: The channel configuration was evaluated at the culvert inlet to determine if the pipe was properly aligned with the channel. A major problem was indicated by the presence of a considerable angle for the channel approach.

Degree of Corrosion: For steel pipes, the competency of the metal was evaluated. The major problem category was assigned if the pipe could be easily punctured.

Crushed Inlet/Outlet: The Inspector determined if the pipe inlet or outlet had been deformed. Less than 30% blockage by crushing was defined as a minor problem, and greater than 30% was a major problem.

Pipe Length: Pipe length was evaluated to determine if it was appropriate for the fill placed at the crossing, or whether insufficient culvert length was causing significant erosion problems.

Gradient: Improper culvert gradient was indicated when the pipe inlet was set too low

[4] This data was frequently not recorded.

or too high in the fill causing debris accumulation, unless this was intended for fish passage and the remaining culvert area provided sufficient flow capacity.

Piping: The crossing fill was inspected to determine if streamflow was passing beneath or around the culvert, without being routed through the pipe.

NON-CULVERT CROSSINGS (e.g., Rocked Ford)

Armoring: The amount and size of applied rock and cobbles at the crossing were observed to determine if minor or major downcutting was occurring at the crossing site.

Scour at Outlet: The total amount of scour that had occurred and was likely to occur in the next two years was observed at the crossing outlet. The presence of noticeable scour was used to indicate a major problem.

Diversion Potential: The watercourse crossing and approaches were examined to determine if they would prevent diversion of stream overflow down the road if the drainage structure became blocked. A major problem was indicated if water had or would flow down the road instead of being directed off the road surface.

REMOVED OR ABANDONED CROSSINGS

Bank Stabilization: Bank cuts were evaluated to determine if cover prevented transport of exposed surface soil to a watercourse. The major problem category was selected when less than 50% of the banks had effective cover.

Gullies: Gullies were defined as being greater than 6 inches deep. The major problem category was used when large gullies were present and appeared to be enlarging.

Slope Failure: The volume of fill slope failure(s) at the crossing was estimated and ratings were assigned based on totals of less than 1 cubic yard (slight), greater than 1 cubic yard without channel entry (minor), or greater than 1 cubic yard and deposition into a stream channel (major).

Channel Configuration: The restored channel configuration was examined at abandoned and removed crossings to determine if it was wider than the natural channel and as close as feasible to the natural watercourse grade and orientation. Small differences from natural channel width, grade, or orientation were rated as a minor problem, while a major problem was assigned when there were significant differences from natural channel width, grade, or orientation.

Excavated Material: The channel was observed to determine if banks had been sloped back and stabilized to prevent slumping and minimize sediment input into the channel. A minor problem was defined as having less than 1 cubic yard of excavated material transported to the channel, and a major problem was identified when greater than 1 cubic yard of material had entered the channel.

Maintenance Free Drainage: The abandonment procedure was evaluated to determine if it was providing permanent, maintenance free drainage, or if minor/major problems were noted.

II. Watercourse Crossing Results

General Results

A total of 357 watercourse crossings were rated for implementation from 2001 through 2004, and 289 of these crossings were rated for effectiveness (Table 8.) Of these crossings, 63% were located on the Coast (CDF Region 1), 25% were in Inland North (CDF Region 2), and 12% were in Inland South (CDF Region 4). The intention was to rate all 357 watercourse crossings for effectiveness; however, 68 had not been rated for effectiveness by July 2004 when MCR data collection was suspended due to budget uncertainties.

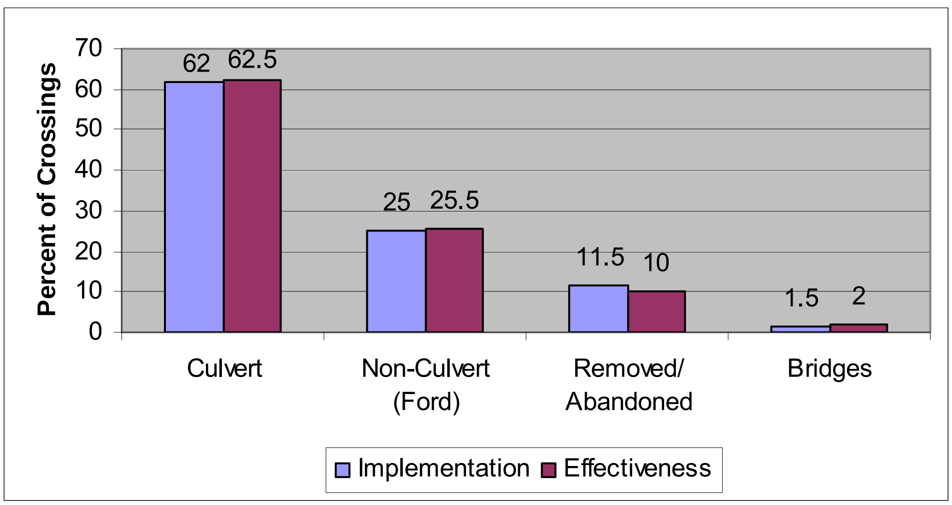


Figure 26. Distribution of watercourse crossing types for both the implementation and effectiveness evaluations.

Watercourse Crossing Type	Implementation	Effectiveness
Culvert	221	181
Non-culvert (ford)	89	74
Removed/Abandoned	41	29
Bridge	6	5
Total	**357**	**289**

Table 8. Distribution of watercourse crossing types rated for implementation and effectiveness from 2001 through 2004.

The proportions of crossing types were very similar in both implementation and effectiveness data sets (Figure 26, Table 8). For the implementation ratings, approximately 62% of the crossings were culverts, 25% were non-culverted crossings (mainly fords), 11.5% were removed or abandoned crossings, and 1.5% were bridges. Of the crossings rated for implementation, 59% were located in Class III watercourses, 34% were in Class II watercourses, 4% were in Class I's, and 1% were in Class IV watercourses (with missing data on 2%) (Figure 27). Nearly all the non-culverted crossings were in Class III watercourses, while the proportions of crossings with culverts were nearly the same in Class II and III watercourses. Bridges were almost entirely associated with Class I watercourses, and removed/abandoned crossings were mostly found in Class II and III watercourses (Table 9).

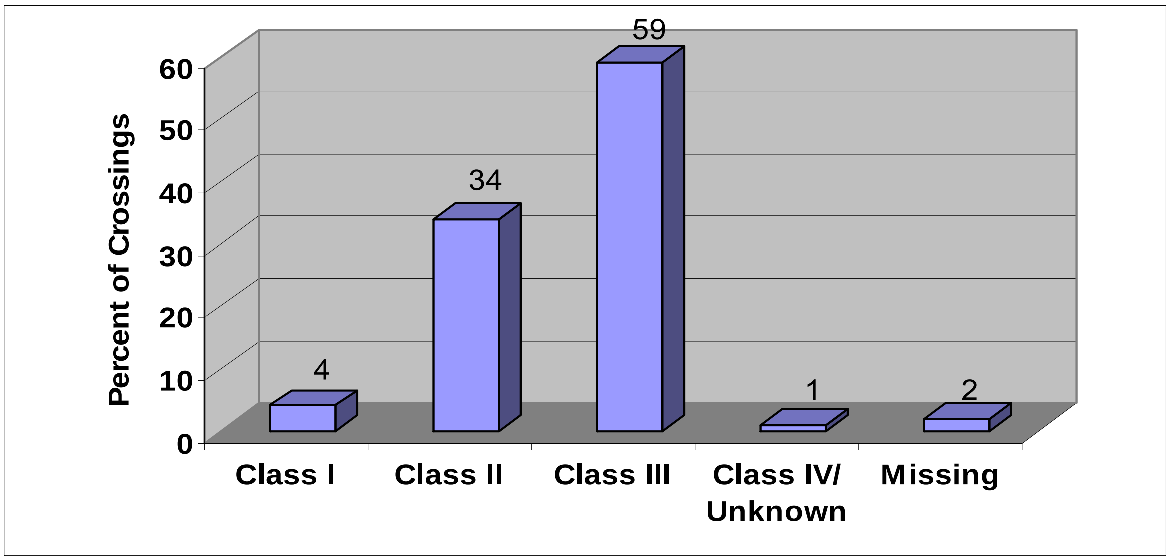


Figure 27. Percentages of the sampled watercourse classes.

Watercourse Class	Bridge	Culvert	Non-Culvert (Ford)	Removed/ Abandoned	Total
I	5	6	0	4	15
II	1	94	8	17	120
III	0	112	79	20	211
IV	0	4	0	0	4
Missing Data	0	5	2	0	7
Total	**6**	**221**	**89**	**41**	**357**

Table 9. Watercourse classes summarized by watercourse crossing types.

Almost three-quarters (74%) of the crossings with culverts were found on seasonal roads, and about a quarter (24%) were on permanent roads (Table 10). Similarly, 83% of the non-culverted crossings were associated with seasonal roads. Removed or abandoned crossings were approximately equally distributed between seasonal roads and skid trails, and were found to a lesser degree on temporary roads. Bridges were found on permanent and seasonal roads.

Road Type	Bridge	Culvert	Non-Culvert (Ford)	Removed/ Abandoned	Total
Permanent	2	54	3	0	59
Seasonal	4	163	74	17	258
Temporary	0	2	3	8	13
Skid Road	0	2	7	14	23
Combined Categories	0	0	2	0	2
Missing Data	0	0	0	2	2
Total	**6**	**221**	**89**	**41**	**357**

Table 10. Distribution of watercourse crossing types summarized by road type.

For crossings with culverts, 67% had pre-existing culverts and 33% of the crossings had new pipes installed as part of the THP. Roughly half the non-culverted and removed/abandoned crossings (46% and 51% respectively) were new, and one-third (33%) of the evaluated bridges were classified as being installed as part of the plan (Table 11).

Crossing Status	Bridge	Culvert	Non-Culvert (Ford)	Removed/ Abandoned	Total
Existing	4	149	48	16	217
New	2	72	41	21	136
Missing Data	0	0	0	4	4
Total	**6**	**221**	**89**	**41**	**357**

Table 11. Crossing types installed as part of the plan or prior to the plan date.

The distribution of pipe sizes for crossings with culverts is displayed in Figure 28. This diagram shows that approximately 41% of the pipes were 18 inches in diameter, 21% were 24 inches, 12% were 36 inches, and 7% were 48 inches or larger. Figure 29 illustrates that the majority of the Class III watercourses had 18 inch diameter pipes, while Class II watercourses had a more equal distribution of 18, 24, and 36 inch pipes. Class I watercourses had 48 inch and larger CMPs installed, while Class IV's had 24 inch and smaller diameter pipes.

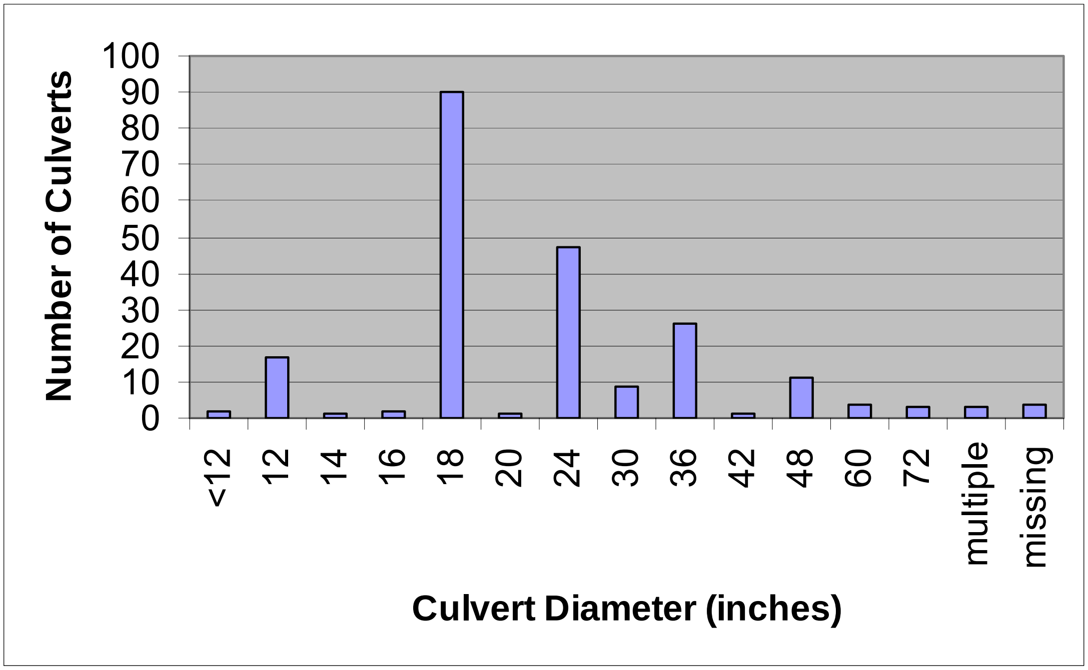


Figure 28. Culvert size distribution for watercourse crossings with pipes.

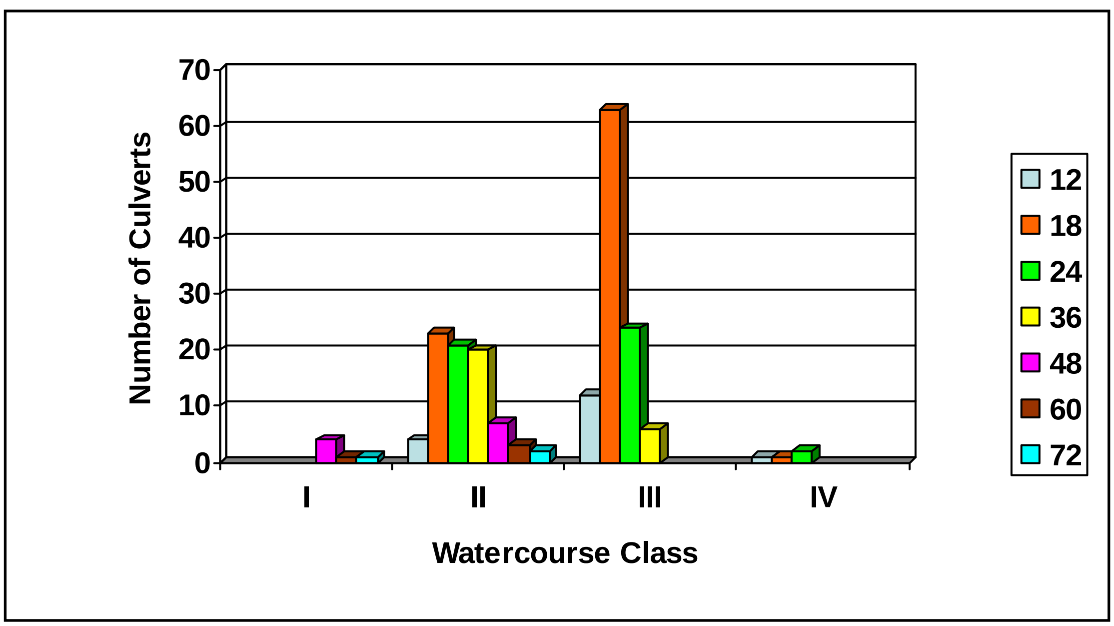


Figure 29. Distribution of culvert diameter categories (inches) by watercourse classes.

Approximately 80% of the watercourse crossings rated for implementation were also rated for effectiveness. These effectiveness ratings occurred at three different times, depending on the crossing being monitored (Table 12). About three-quarters (76%) of the effectiveness ratings were done on or about the same day as implementation ratings. Effectiveness ratings were made during a second field visit 13% of time, which usually took place one to two years later. In addition, 11% of the crossings had effectiveness evaluations conducted both when the initial implementation rating was done and a second time one to two years later. Therefore, almost 25% of the time, watercourse crossings were rated for effectiveness one to two years following an initial implementation rating.

Effectiveness Rating	Bridge	Culvert	Non-Culvert (Ford)	Removed/ Abandoned	Total	Percent
Only at time of Implementation	4	136	60	19	219	**76%**
Only at second visit	0	26	6	6	38	**13%**
Second rating at second visit	1	19	8	4	32	**11%**
Total	**5**	**181**	**74**	**29**	**89**	**100%**

Table 12. Distribution of effectiveness rating time periods for different watercourse crossing types.

Watercourse Crossing Implementation Results

Implementation of FPR requirements was rated using the following compliance categories: Departure (D), Marginally Acceptable (MA), Acceptable (A), Exceeds Rule/THP Requirement (ER), and Not Applicable (NA). These criteria were applied to 30 individual rule requirements, including 27 road rules found in 14 CCR § 923 [943, 963] and three rules related to skid trails found in 14 CCR § 914 [934, 954]. Implementation data is presented below in Table 13 for all the crossing types combined; and separately for existing culverts, new culverts, non-culverted crossings and removed/abandoned crossings (combined), and bridges.[5]

[5] Note that the numbers of crossings included for each crossing type for implementation are slightly different than those presented in the previous section due to minor adjustments made when compiling data with hand counts.

Rule Number	Rule Description	Total Obs. (w/out NA)	Departure (%)	Departure plus Marginally Acceptable (%)
923.3(d)(1) 943.3(d)(1) 963.3(d)(1)	Removed crossings—fills excavated to adequately reform channel	91	7.4	21.3
923.4(n) 943.4(n) 963.4(n)	Crossing/approaches maintained to prevent diversion	246	6.9	18.7
923.2(i) 943.2(i) 963.2(i)	Where needed, trash racks installed to minimize blockage	65	6.2	23.1
923.8 943.8 963.8	Abandoned crossings—maintenance-free drainage	35	5.7	14.3
923.8 943.8 963.8	Abandoned crossings—minimizes concentration of runoff	35	5.7	8.6
923.8(b) 943.8(b) 963.8(b)	Abandoned crossings—stabilization of cuts/fills appropriate	35	5.7	8.6
923.8(c) 943.8(c) 963.8(c)	Abandoned crossings—grading of road for dispersal of flow	36	5.6	11.1
923.4(m) 943.4(m) 963.4(m)	Inlet/outlet structures, etc. repaired/replaced/installed	130	5.4	19.2
923.3(f) 943.3(f) 963.3(f)	Crossings/fills built/maintained to prevent diversion	301	5.0	18.3
923.4(l) 943.4(l) 963.4(l)	Drainage structure/trash rack maintained/repaired as needed	127	4.7	11.0

Table 13. Forest Practice Rule requirements for all watercourse crossing types with at least four percent departures based on at least 30 observations where implementation could be rated (i.e., excludes N/A observations).

The number of observations available for analysis is not the same for each rule requirement because many requirements were not applicable at all crossing sites. There are also different numbers of observations for each crossing type, which leads to large differences in numbers of observations among rule and crossing type combinations. As a result, the following discussion of combined crossing types has been limited to those rules with as least 30 observations to include results from both active and abandoned/removed crossings, and discussion of results for individual crossings types is limited to rules that are applied on at least 20% of the applicable sites.

All Crossing Types

Twenty-five specific FPRs related to watercourse crossings were observed and rated for implementation at 30 or more crossings. Ten of these 25 FPRs had departure rates of 4% or higher, as shown in Table 13, and most of these had departure rates between 5% and 7%.[6] Five of these ten FPR requirements relate to removed or abandoned crossings. When crossings with marginally acceptable ratings are included, the proportion of sites with implementation problems ranges from about 9% to 23%.

The FPR requirement with the highest overall departure rate was 14 CCR § 923 [943, 963], which requires removed crossings to have fills excavated to form a channel that is as close as feasible to the natural watercourse grade and orientation and is wider than the natural channel.[7] The FPRs requiring crossings to be constructed or maintained to prevent diversion potential, 14 CCR § 923.4 [943.4, 963.4] (n) and § 923.3 [943.4, 963.4] (f), had departure rates of 6.9 and 5.0%, respectively. A complete list of the implementation ratings for all the watercourse crossing Forest Practice Rule requirements is shown in Table 14, beginning on the next page. For watercourse crossings with implementation evaluations, 64% had all the crossing rules rated as meeting or exceeding Forest Practice Rule requirements; 19% had one or more marginally acceptable ratings, but no departures; and 17% had one or more departures ratings (Figure 30).

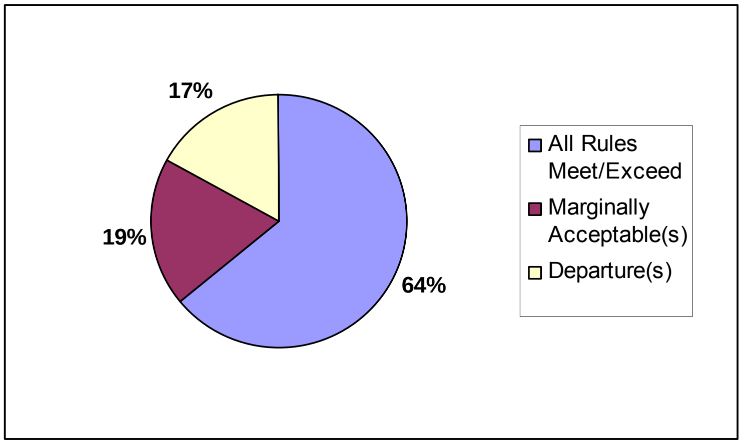


Figure 30. Percentages of watercourse crossings rated for Forest Practice Rule implementation having different implementation codes.

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[6] The minimum value of 30 observations (where the Forest Practice Inspector assigned a rating of D, MA, A, or ER) is similar to the value used in the earlier Hillslope Monitoring Program final report (Cafferata and Munn 2002), and represents nearly 10% of the possible implementation ratings available for each rule requirement.

[7] As shown in Table 14, 14 CCR § 923.3(a) has the overall highest rate of departure at 9.6%, but this rule only applies to new permanent crossings and temporary crossings within the WLPZ. Since it was rated as a departure for 18 existing culverts, it was concluded that spurious data was recorded for this requirement and it is not included.

Table 14. All Forest Practice Rule requirements rated for implementation (NA = Not Applicable).

Rule Number	Rule Description	Total Obs. (w/o NA)	Departure (%)	Departure + Marginally Acceptable (%)
923.2(d)(C) 943.2(d)(C) 963.2(d)(C)	Fills across channels built to minimize erosion	262	1.9	9.9
923.2(h) 943.2(h) 963.2(h)	Size, number, location of structures installed to carry runoff	287	2.4	8.0
923.2(h) 943.2(h) 963.2(h)	Size, number, location of structures installed to minimize erosion	285	2.8	8.4
923.2(h) 943.2(h) 963.2(h)	Size, number, location of structures installed to maintain or restore the natural drainage pattern	287	2.4	7.7
923.2(i) 943.2(i) 963.2(i)	Where needed, trash racks installed to minimize blockage	65	6.2	23.1
923.2(o) 943.2(o) 963.2(o)	No discharge onto fill unless energy dissipators installed	255	2.4	14.1
923.3(a) 943.3(a) 963.3(a)	Permanent new crossings shown on THP map	188	9.6	11.7
923.3(c) 943.3(c) 963.3(c)	Unrestricted passage of fish allowed	21	4.8	4.8
923.3(d)(1) 943.3(d)(1) 963.3(d)(1)	Removed crossings—fills excavated to adequately reform channel	94	7.4	21.3
923.3(d)(2) 943.3(d)(2) 963.3(d)(2)	Removed crossings-- cut bank sloped back to prevent slumping and minimize soil erosion	95	3.2	11.6
923.3(d)(2) 943.3(d)(2) 963.3(d)(2)	Where needed, stabilizing treatment applied	200	2.0	10.0
923.3(f) 943.3(f) 963.3(f)	Crossings/fills built/maintained to prevent diversion	301	5.0	18.3
923.4(c) 943.4(c) 963.4(c)	Waterbreaks maintained as specified in 14 CCR 914.6	240	3.8	14.2
923.4(d) 943.4(d) 963.4(d)	Crossing open to unrestricted passage of water	316	3.5	12.3
923.4(d) 943.4(d) 963.4(d)	Trash racks installed where needed at inlets	125	3.2	12.0
923.4(f) 943.4(f) 963.4(f)	50-year flood flow requirement met or removed	228	2.2	7.5

Table 14 (continued.) All Forest Practice Rule requirements rated for implementation (NA = Not Applicable).

Rule Number	Rule Description	Total Obs. (w/o NA)	Departure (%)	Departure + Marginally Acceptable (%)
923.4(l) 943.4(l) 963.4(l)	Drainage structure/trash rack maintained/repaired as needed	127	4.7	11.0
923.4(m) 943.4(m) 963.4(m)	Inlet/outlet structures, etc. repaired/replaced/installed	130	5.4	19.2
923.4(n) 943.4(n) 963.4(n)	Crossing/approaches maintained to prevent diversion	246	6.9	18.7
923.8 943.8 963.8	Abandoned crossings—maintenance-free drainage	35	5.7	14.3
923.8 943.8 963.8	Abandoned crossings—minimizes concentration of runoff	35	5.7	8.6
923.8(b) 943.8(b) 963.8(b)	Abandoned crossings—stabilization of cuts/fills appropriate	35	5.7	8.6
923.8(c) 943.8(c) 963.8(c)	Abandoned crossings—grading of road for dispersal of flow	36	5.6	11.1
923.8(d) 943.8(d) 963.8(d)	Abandoned crossings—pulling/shaping of fills appropriate	31	3.2	9.7
923.8(e) 943.8(e) 963.8(e)	Abandoned crossings—fills excavated to reform channel	35	2.9	20.0
923.8(e) 943.8(e) 963.8(e)	Abandoned crossings—cutbanks sloped back	30	3.3	6.7
923.8(e) 943.8(e) 963.8(e)	Abandon crossings—removal not feasible but diversion potential addressed	12	0.0	16.7
914.8(b) 934.8(b) 954.8(b)	Drainage structure used where water present during life of crossing	6	0.0	0.0
914.8(c) 934.8(c) 954.8(c)	Unrestricted fish passage in Class I watercourses	1	0.0	0.0
914.8(d) 934.8(d) 954.8(d)	Skid road crossing fill removed and banks sloped properly	23	4.3	8.7

Existing Culverts

Nineteen FPRs related to existing culverts were rated. These 19 FPRs do not include FPRs related to removed/ abandoned culverts and skid road culverts. Sixteen of these 19 FPRs were observed at 30 or more existing watercourse crossings. Nine of the 16 FPRs with 30 or more observations had departure rates of 4% or more, as shown in Table 15. For existing culverts, the FPR rule with the highest departure rate was 14 CCR § 923.4 [943.4, 963.4] (n), which requires crossings and their approaches to be maintained to avoid diversion of flow should the pipe become plugged. Other FPRs with high departure rates include FPRs requiring: 1) installation/maintenance of trash racks to minimize blockage (where required), 2) repair and replacement of crossing inlet and outlet structures, 3) maintenance of crossing openings for unrestricted passage of water, 4) waterbreak maintenance, and 5) culvert sizing for the required flood flow recurrence interval or removal of undersized culverts by the start of the winter period.

Table 15. Watercourse crossing related Forest Practice Rule requirements for existing culverts with at least four percent departures based on at least 30 observations (i.e., 20% of sample size) where implementation could be rated (i.e., excludes N/A observations).

Rule Number	Rule Description	Departure (%)	Departure plus Marginally Acceptable (%)
923.4(n) 943.4(n) 963.4(n)	Crossing/approaches maintained to avoid diversion	12.4	27.8
923.2(i) 943.2(i) 963.2(i)	Where needed, trash racks installed to minimize blockage	11.4	37.1
923.4(l) 943.4(l) 963.4(l)	Drainage structure/trash rack maintained/repaired as needed	7.5	17.9
923.4(m) 943.4(m) 963.4(m)	Inlet/outlet structures, etc. repaired/replaced/installed	7.2	23.2
923.4(d) 943.4(d) 963.4(d)	Trash racks installed where needed at inlets	6.8	27.3
923.4(d) 943.4(d) 963.4(d)	Crossing open to unrestricted passage of water	6.5	17.4
923.4(c) 943.4(c) 963.4(c)	Waterbreaks maintained as specified in 14 CCR 914.6	6.3	22.1
923.3(f) 943.3(f) 963.3(f)	Crossings/fills built/maintained to prevent diversion	6.1	23.5
923.4(f) 943.4(f) 963.4(f)	Crossing meets 50-yr flood flow requirement or is removed by first day of the winter period	4.4	13.3

New Culverts

For culverts installed as part of the THP, only one rule requirement was found with greater than a 4% departure rate. 14 CCR § 923.3 [943.3, 963.3] (f), which requires crossings and associated fills to be constructed and maintained to prevent diversion, had a departure rate of 4.1% and a departure plus marginally acceptable rate of 13.7%.

Non-Culvert Crossings and Removed/Abandoned Crossings

Non-culvert crossings and removed/abandoned crossings were combined for rating FPR implementation because, in many cases, rules related to crossing removal were also rated for existing non-culvert crossings. This occurred since some removed crossings are fords that are drivable with four-wheel drive vehicles—and hence were considered existing crossings. Thirty FPR requirements were applicable to this combined category.

Of 20 FPRs with at least 26 observations (i.e., 20 percent of the sample size), 13 FPRs had a departure rate of 4% or higher, as shown in Table 16 (next page). The rule with the highest departure rate was 14 CCR § 923.2 [943.2, 963.2] (h), which requires the installation of drainage structures that are of sufficient size, number and location to carry runoff water in a manner that minimizes erosion, ensures proper functioning, and maintains or restores the natural drainage pattern. Additional FPRs with at least 4% departure rates specify that: 1) fills across channels must be constructed in a manner that minimizes erosion, 2) drainage structures do not discharge water onto fill without energy dissipators, and 3) crossings/approaches must be built and maintained to prevent diversion.

The removal and abandonment rule requirement with the highest overall departure rate was 14 CCR § 923.3 [943.3, 963.3] (d)(1), which specifies that fills for removed crossings must be excavated to form a channel that is as close as feasible to the natural watercourse grade and orientation and is wider than the natural channel. 14 CCR § 923.3 [943.3, 963.3] (d)(2), requiring removed crossings to have cut banks that are sloped back from the channel and stabilized to prevent slumping and minimize soil erosion, had a slightly lower departure rate. Other rule requirements with at least 4% departure rates were: 14 CCR § 923.8 [943.8, 963.8], which requires, among other items, that abandoned crossings provide permanent maintenance-free drainage and minimize the concentration of runoff; 14 CCR § 923.8 [943.8, 963.8] (b), which states that exposed soil on cut and fill slopes of abandoned crossings must be stabilized; and 14 CCR § 923.8 [943.8, 963.8] (c), requiring abandoned crossings to be graded and shaped in a manner that disperses water flow.

Bridges

No departures were assigned to the few bridges evaluated as part of the MCR monitoring work, and there was only one marginally acceptable rating. The FPR requirement 14 CCR § 923.4 [943.4, 963.4] (c), which specifies that waterbreaks on roads are to be maintained as specified under 14 CCR § 914.6 [934.6, 954.6], was cited once as being marginally acceptable for the road segments draining to the bridge.

Table 16. Forest Practice Rule requirements for non-culvert and removed/abandoned crossings with at least four percent departures based on at least 26 observations (i.e., 20% of sample size).

Rule Number	Rule Description	Percent Departure	% Departure plus Marginally Acceptable
923.2(h) 943.2(h) 963.2(h)	Size, number, location of structures minimizes erosion	8.8	20.6
923.3(d)(1) 943.3(d)(1) 963.3(d)(1)	Removed crossings—fills excavated to reform a channel similar to the natural channel grade, but wider	7.5	26.9
923.2(h) 943.3(h) 963.3(h)	Size, number, location of drainage structures sufficient to carry runoff	6.5	13.0
923.8 943.8 963.8	Abandoned crossings—maintenance-free drainage	5.7	14.3
923.8 943.8 963.8	Abandoned crossings—minimizes concentration of runoff	5.7	8.6
923.8(b) 943.8(b) 963.8(b)	Abandoned crossings—stabilization of cuts/fills	5.7	8.6
923.3(d)(1) 943.3(d)(1)	Fills across channels built to minimize erosion	5.6	22.2
923.8(c) 943.8(c) 963.8(c)	Abandoned crossings—grading of road for dispersal of flow	5.6	11.1
923.3(d)(2) 943.3(d)(2) 963.3(d)(2)	Removed crossings—cut bank slope	4.8	17.7
923.2(o) 943.2(o) 963.2(o)	No discharge on fill without energy dissipators	4.6	23.1
923.3(f) 943.3(f) 963.3(f)	Crossings/fills built/maintained to prevent diversion	4.4	15.4
923.2(h) 943.2(h) 963.2(h)	Size, number, location of structures installed to maintain or restore the natural drainage pattern	4.3	13.0
923.4(n) 943.4(n) 963.4(n)	Crossing/approaches maintained to prevent diversion	4.0	16.0

Watercourse Crossing Effectiveness Results

Watercourse crossing effectiveness was evaluated by applying one of the following four ratings to 27 crossing-related parameters: not applicable (N/A), not a problem (usually "none" or "slight"), a minor problem, or a major problem.[8] Examples of crossings rated for effectiveness are shown in Figures 31 and 32. On nearly 25 percent of the 289 crossings rated for effectiveness, this evaluation was conducted one or more years after the implementation ratings were made. The rest of the crossings with effectiveness ratings were evaluated for implementation and effectiveness at the same, or nearly the same, time. Table 17 shows the percentage of major and minor problems when all crossing types are combined. The percentage of crossings with major and minor problems for different combinations of crossing types, crossing features, and problem types is displayed in Table 18.

Figure 31. Example of an existing culvert with scour at the outlet for a central Sierra Nevada THP included in the MCR sample.

Figure 32. Example of an existing culvert that is partially plugged with sediment on a central Sierra Nevada THP included in the MCR sample.

[8] For rutting, N/A was not provided on the field form. For culvert-related piping, the minor category was not provided as an option. The N/A option was not provided for any of the effectiveness parameters on the initial field form provided at the beginning of the MCR monitoring program.

Table 17. Watercourse crossing effectiveness ratings (excludes NA ratings).

Crossing Feature	Problem Type	Total # (w/out NA)	Major Only (%)	Major + Minor (%)
Fill Slopes	Gullies	253	1.2	11.5
	Cracks	253	0.0	2.4
	Slope Failure	254	1.2	5.1
Road Surface Draining		0	0.0	0.0
To Crossing	Gullies	272	0.4	6.3
	Cutoff Drainage Structure	225	4.0	24.9
	Inside Ditch Condition	119	0.8	18.5
	Ponding	261	0.0	12.6
	Rutting	248	0.8	16.5
Culvert Crossing	Scour at Inlet	182	1.1	15.9
	Scour at outlet	182	1.1	33.5
	Diversion Potential	179	10.6	35.2
	Plugging	182	5.5	17.6
	Alignment	180	1.7	5.6
	Degree of Corrosion	169	1.8	7.7
	Crushing	181	0.6	5.0
	Pipe length	182	0.0	4.9
	Gradient	182	2.7	8.2
	Piping	180	2.2	2.2
Non-Culverted Crossing	Armoring	58	1.7	32.8
	Scour at outlet	71	0.0	43.7
	Diversion Potential	73	5.5	23.3
Abandoned/Removed	Bank stabilization	36	0.0	22.2
	Gullies	36	0.0	8.3
	Slope Failure	16	0.0	0.0
	Channel Configuration	38	7.9	28.9
	Excavated Material	33	0.0	12.1
	Maintenance Free Drainage	45	0.0	17.8

Table 18. Modified Completion Report—Watercourse Crossing Effectiveness Ratings (% major, % minor, % major + minor) [excludes NA ratings].

Crossing Feature	Problem Type	Existing Culverts	New Culverts	Non-Culvert	Removed/Abandoned	Bridge
Fill Slopes	Gullies	2.6/ 8.7/ 11.3	0/ 10.0/ 10.0	0/17.2/ 17.2	NA	0/ 0/ 0
	Cracks	0/ 2.4/ 2.4	0/ 3.9/ 3.9	0/ 1.8/ 1.8	NA	0/ 0/ 0
	Slope Failure	1.6/ 3.2/ 4.8	1.9/ 1.9/ 3.8	0/ 8.8/ 8.8	NA	0/ 0/ 0
Road Surface Draining to Crossing	Gullies	0.8/ 4.9/ 5.7	0/ 0/ 0	0/ 10.7/ 10.7	0/ 11.1/ 11.1	0/ 0/ 0
	Cutoff Drainage Structure	6.5/ 27.8/ 34.3	2.1/ 23.4/ 25.5	2.0/ 12.0/ 14.0	0/ 0/ 0	0/ 0/ 0
	Inside Ditch Condition	1.4/ 20.3/ 21.7	0/ 8.0/ 8.0	0/ 26.7/ 26.7	0/ 0/ 0	0/ 25.0/ 25.0
	Ponding	0/ 13.5/ 13.5	0/ 18.0/18.0	0/ 9.4/ 9.4	0/ 6.3/ 6.3	0/ 0/ 0
Culvert	Scour at Inlet	1.6/ 16.3/ 17.8	0/ 11.3/ 11.3	NA	NA	NA
	Scour at outlet	1.6/ 36.4/ 38.0	0/ 22.6/ 22.6	NA	NA	NA
	Diversion Potential	11.9/ 26.2/ 38.1	7.5/ 20.8/ 28.3	NA	NA	NA
	Plugging	7.8/ 14.0/ 21.7	0/ 7.5/ 7.5	NA	NA	NA
	Alignment	1.6/ 4.7/ 6.3	1.9/ 1.9/ 3.8	NA	NA	NA
	Degree of Corrosion	2.4/ 8.1/ 10.6	0/ 0/ 0	NA	NA	NA
	Crushing	0.8/ 5.5/ 6.3	0/ 1.9/ 1.9	NA	NA	NA
	Pipe length	0/ 5.4/ 5.4	0/ 3.8/ 3.8	NA	NA	NA
	Gradient	3.8/ 7.7/ 11.5	0/ 0/ 0	NA	NA	NA
	Piping	3.1/ 0/ 3.1	0/ 0/ 0	NA	NA	NA
Non-Culverted Crossing	Armoring	NA	NA	1.8/ 32.1/ 33.9	0/ 0/ 0	NA
	Scour at outlet	NA	NA	0/ 42.6/ 42.6	0/ 66.7/ 66.7	NA
	Diversion Potential	NA	NA	4.3/ 18.6/ 22.9	33.3/ 0/ 33.3	NA
Removed/Abandoned	Bank stabilization	NA	NA	0/ 21.4/ 21.4	0/ 22.7/ 22.7	NA
	Gullies	NA	NA	0/ 6.3/ 6.3	0/ 10.0/ 10.0	NA
	Slope Failure	NA	NA	0/ 0/ 0	0/ 0/ 0	NA
	Channel Configuration	NA	NA	12.5/ 37.5/ 50.0	4.5/ 9.1/ 13.6	NA
	Excavated Material	NA	NA	0/ 33.3/ 33.3	0/ 0/ 0	NA
	Maintenance Free Drainage	NA	NA	0/ 21.7/ 21.7	0/ 13.6/ 13.6	NA

All Crossing Types

When all crossing types are combined, major problems were found a total of 76 times on 53 crossings. The most frequently cited effectiveness problems were associated with culvert diversion potential (19), followed by culvert plugging (10), and road cutoff drainage structure function (9) (see Figure 33). Other parameters identified as having major problems four or more times included: culvert gradient, culvert piping, and non-culvert crossing diversion potential. Overall, 18% of the crossings evaluated for effectiveness had one or more major problems.

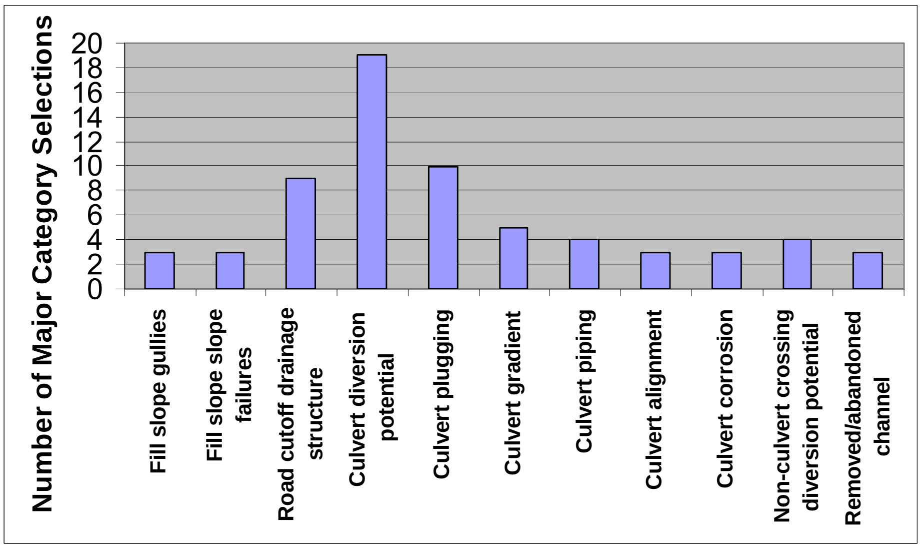

Figure 33. Major problem effectiveness categories for all crossing types.

When the major and minor problem categories were combined, the most frequently cited feature remained culvert diversion (63 selections), but secondary parameters were somewhat different. They included: culvert scour at the outlet (61), road cut-off waterbar function (56), road rutting (41), road ponding (33), culvert plugging (32), and non-culvert crossing scour at the outlet (31).

For new and existing culverts, 10.6% had a major diversion problem, 5.5% had a major plugging concern, 4.0% had a cutoff drainage structure problem, 2.7% had a significant gradient issue, and 2.2% had a major piping concern. For non-culverted crossings, 5.5% had a major diversion potential problem (Table 17).

Existing Culverts

For existing culverts, 11.9% of the pipes had a major problem with diversion potential, while 7.8% had a major problem with inlet or outlet plugging, as shown in Table 18. Road cut-off drainage structures were identified as a major problem for 6.5% of the crossings, and approximately 3% of the road fills at crossings had significant gullying present. For combined major and minor effectiveness ratings, the following features were selected greater than 30% of the time: culvert scour at the outlet (38.0%), culvert diversion potential (38.1%), and road cutoff drainage structure (34.3%). Culvert plugging and road inside ditch condition were selected more than 20% of the time for both effectiveness ratings.

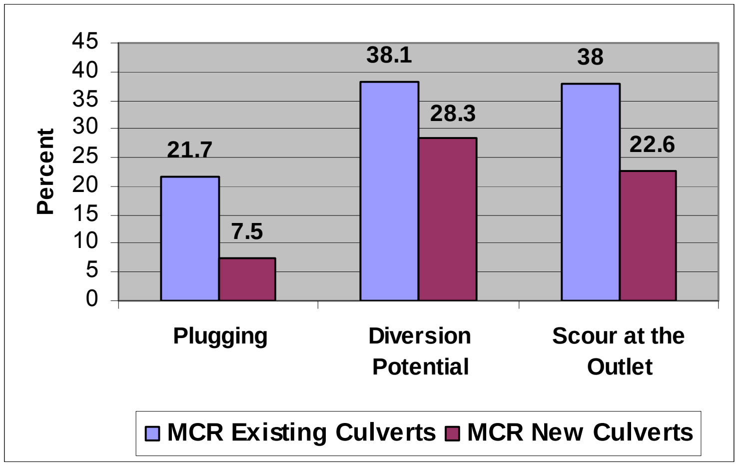

Figure 34. Comparison of three culvert effectiveness categories for new culverts installed as part of the THP vs. existing culverts installed before the plan. Data shown is for both major and minor effectiveness categories combined.

New Culverts

The percentage of major and minor problems was smaller for new culverts that were installed as part of the most recent THP, when compared to existing culverts. This can be attributed to improved practices and/or fewer overwintering periods with stressing storm events (Figure 34). As displayed in Table 18, 7.5% of the new culverts had significant diversion potential, 2.1% had major problems with road cutoff drainage structures, and 1.9% had major problems with culvert alignment and fill slope failures. For combined major and minor effectiveness ratings, the following features were found to have problems more than 20% of the time: culvert diversion potential (28.3%), culvert scour at the outlet (22.6%), and road cutoff drainage structures (25.5%).

Non-Culvert and Removed/Abandoned Crossings

There were major diversion potential problems on 4.3% of the non-culvert crossings and minor problems on an additional 18.6%, for a combined total of 22.9%. For both removed/abandoned crossings and non-culvert crossing types, channel configuration following crossing removal had the highest percentage of problems, with 7.9% of the crossings rated as having a major problem and 21.0% receiving a minor problem, for a combined rating of 28.9%.

Bridges

None of the five bridges rated for effectiveness had any major problems identified. The condition of the road inside ditch was selected once as a minor problem.

III. Discussion

Watercourse crossing implementation ratings are generally similar to findings from the earlier HMP (Cafferata and Munn 2002). For example, the departure rates in the HMP for 14 CCR § 923.3 [943.3, 963.3] (f) [requiring construction to prevent diversion] were 5.5% major departures and 14.6% major plus minor departures, respectively; which are similar to the 5.0% and 18.3% rates for departure and departure plus marginally acceptable ratings in the MCR work.[9] Additionally, abandonment rules 14 CCR § 923.8 [943.8, 963.8], 923.8 [943.8, 963.8] (b), and 923.8 [943.8, 963.8] (c) in the HMP had major departure rates of 4.6%, 4.8%, and 4.8%, respectively, while the MCR monitoring results for these rules had departure rates of 5.7%, 5.7%, and 5.6%. The FPRs 14 CCR § 923.3 [943.1, 963.1] (d)(1), 923.4 [943.4, 963.4] (l), and 923.4 [943.4, 963.4] (n) were also listed as having relatively high departure rates in both monitoring programs. In addition, in the final HMP data set (1996 through 2002), one or more major rule departures were found for 19.5% of the watercourse crossings, compared to 17% of crossings with departures in the MCR work.

Similarly, MCR watercourse crossing effectiveness results compare well with the findings of previous watercourse crossing studies in California, both with studies done on private and state lands (HMP) and studies done on federal National Forest System (NFS) lands (Figure 35). For example, the HMP (Cafferata and Munn 2002) reported that 9.0% of culverted crossings had major diversion potential problems, which compares well with the 10.6% rate reported in this study based on analysis of MCR data (see Figure 36 for an example of a crossing without diversion potential). Both the HMP and MCR monitoring sampled sites on private and state lands in California, and as such are directly comparable. The USFS (2004) BMP Evaluation Program sampled federal (NFS) lands in California and found major diversion problems on 8.9% of culverted crossings, which is also compares well with both the HMP (9.0%) and MCR (10.6%) results. For culvert plugging, the HMP and USFS BMP documents reported problems on 8.6% and 3.0% of crossings, respectively, while the rate is 5.5% based on the MCR data. Data for scour at the outlet of a culvert is less consistent between these three recent monitoring programs, probably due to differing instructions and definitions.[10] A more detailed comparison of the HMP and MCR crossing effectiveness data is provided in Table 19.

[9] FPR 14 CCR § 923.3(f) is referred to in Cafferata and Munn (2002) as 923.3(e).

[10] For example, in the HMP major scour at the outlet was defined as extending more than two channel widths below the pipe outlet, or scour that is undercutting the crossing fill, while in MCR monitoring, it was simply defined as “major scour, maybe undercutting fill material.”

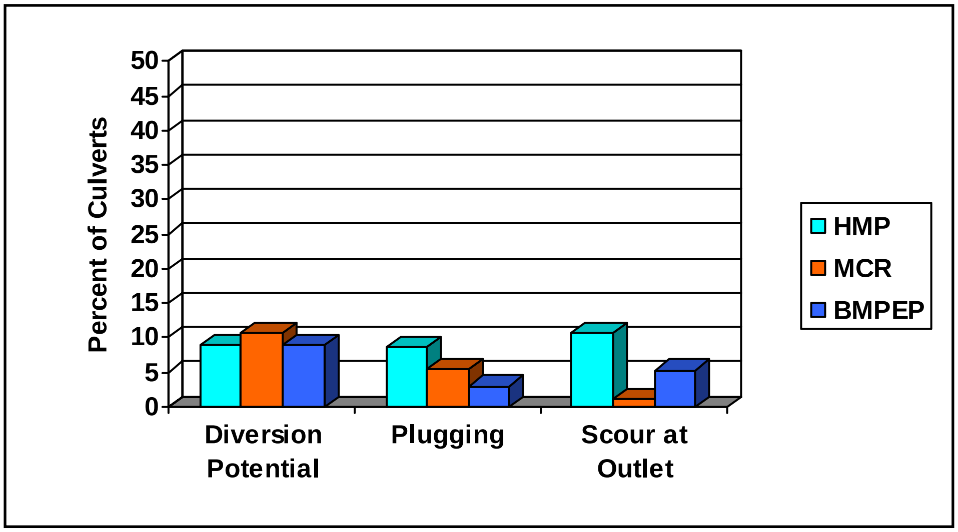

Figure 35. Comparison of three Modified Completion Report (MCR) culvert crossing effectiveness categories to results from the Hillslope Monitoring Program (HMP) and USFS BMP Evaluation Program. Ratings are for major effectiveness categories for the HMP and MCR programs.

Table 19. Comparison of MCR and HMP crossing effectiveness data for selected categories.

Monitoring Program	Culvert Plugging	Culvert Diversion Potential	Culvert Scour At the Outlet	Removed/Abandoned Channel Configuration
MCR Problems				
Major	5.5 %	10.6%	1.1%	7.9%
Minor	12.1%	24.6%	32.4%	21.0%
Total	17.6%	35.2%	33.5%	28.9%
HMP Problems				
Major	8.6%	9.0%	10.7%	3.6%
Minor	14.9%	18.5%	22%	14.3%
Total	23.5%	27.5%	32.7%	17.9%

Figure 36. John Munn, CDF, at a culverted watercourse crossing in a forested watershed on the North Coast of California without diversion potential. Munn is standing in the critical dip.

Conclusions and Recommendations

Overall Findings and Recommendations

Findings: Overall, the Modified Completion Report monitoring work found that:

1) The rate of compliance with FPRs designed to protect water quality and aquatic habitat is generally high, and
2) FPRs are highly effective in preventing erosion, sedimentation and sediment transport to channels when properly implemented.

Recommendations: The Forest Practice Program should continue to emphasize education, licensing, inspection and enforcement to ensure proper implementation of the FPRs designed to protect water quality. Since departures from the FPRs were found to be rare, the best inspection strategy is to have the inspectors focus on THPs and locations where their experience and previous plan review indicate that problems are most likely to occur. After a quick prioritization, inspectors should visually observe as much ground as possible to maximize detection of departures from FPRs, which are important but uncommon occurrences.

Because straightforward, clearly stated rules are more likely to be properly implemented, they are more likely to protect water quality. They are also easier to inspect, enforce and monitor. Therefore, the BOF should avoid unnecessary complexity and ambiguous language when revising or adding to the existing FPRs.

MCR monitoring should be revised according the specific recommendations for WLPZs, roads and watercourse crossings, which are outlined below.

Watercourse and Lake Protection Zones (WLPZs) Findings and Recommendations

Findings: With few exceptions, Watercourse and Lake Protection Zone (WLPZ) canopy and groundcover met Forest Practice Rule (FPR) standards. Patches of bare soil in WLPZs exceeding the FPR standards are rare, erosion features within WLPZs related to current operations are uncommon, and there are few instances where WLPZ canopy standards are not being met. Prevention, detection and abatement of these rare occurrences is an important key to improving water quality protection.

Recommendations: The Forest Practice Program should emphasize prevention, detection and abatement of WLPZ problems through rapid ocular inspections of WLPZs. The use of time-consuming canopy and ground cover measuring techniques should be reserved for enforcement where a rapid inspection has detected WLPZ canopy and/or groundcover conditions that may not meet minimum standards set by the FPRs or special provisions of the THP.

To provide more time for rapid ocular inspections, WPLZ trend monitoring conducted by Forest Practice Inspectors, such as with MCR inspections, should use the smallest random sample size that will produce repeatable and reliable results.   As a starting point, a WLPZ sample size of 5 percent of all THPs undergoing Work Completion Report Inspections is recommended. This may then be adjusted up or down annually based on an analysis of the prior year's data.

The current MCR data collection methods and procedures for WLPZs work well and, with some minor revisions to the WLPZ form, are suitable for use in the next phase of MCR Monitoring.

Road Findings and Recommendations

Findings: Properly implemented Forest Practice Rules are highly effective in preventing road erosion and sediment transport from roads to channels. Erosion and sedimentation is more likely to occur at road-related features where the implementation of the applicable FPR(s) is only marginally acceptable. Erosion and sediment transport are much more likely at road-related features where there was a departure from the applicable FPR(s) (See Table 7 on page 40).   For example, at sites where there is a departure from the rule, the chance of erosion is about 1 in 2, the chance sediment transport is about 1 in 3, and the chance of sediment transport to a channel 1 in 10.   In comparison, where FPR implementation is acceptable or better, the chance of erosion is about 1 in 20, and the chance of sediment transport to a channel is 1 in 100 or less.

Drainage problems (including drainage feature spacing, design, construction and maintenance) and failure to discharge into non-erodible cover are the most frequent types of departures from the road-related FPRs. Specifically, the following four categories of FPRs accounted for 95% of the departures: waterbreak spacing [49%], drainage ditches maintained/berms removed [17%], waterbreak discharge into cover [16%], and waterbreaks constructed to appropriate depth [13%]. These departures from the rules are also the most frequent causes of road-related erosion and sediment transport to channels.

Departure rates for the road-related features were 2% for the Coast (Region 1) and 8% for the Inland Area (Regions 2 &4). Most of these departures are clustered in a few poorly built and/or poorly maintained road segments. For example, just 6% of the sampled road segments, which would represent about sixth-tenths of a mile in 10 road miles, accounted for half the departures on Coast THPs and about three-quarters of the departures on Inland THPs.

The current MCR data collection methods and procedures for roads were found to be cumbersome, and both implementation and enforcement could be improved by focusing on two items critical to water quality protection: 1) the spacing and adequacy of the drainage features and, 2) discharge of road drainage into cover or non-erodible sites. These results are based on drainage spacing evaluations conducted during field inspections. No secondary analysis of drainage spacing could be conducted because FPR drainage spacing requirements are based on the Erosion Hazard Rating (EHR) and the road grade between drainage features, but these two pieces of data were not recorded on the MCR road form.

Recommendations: The Forest Practice Program should continue to emphasize proper implementation of the road-related FPRs through education and enforcement. Streamlining and consolidating the road-related rules to make them easier to understand, implement and enforce is expected to improve FPR effectiveness in protecting water quality.

Finding and fixing the worst 6% of THP road segments would yield the largest improvement in THP road-related water quality protection. The Forest Practice Program should encourage landowners, Registered Professional Foresters (RPFs) and Licensed Timber Operators (LTOs) to find and repair these problem sites. A standard, recommended methodology for finding and fixing the worst 6% of THP road segments may prove useful and could be developed by a subcommittee of the BOF, such as the MSG.

In addition, the current MCR data collection procedures should be revised to account for the types of water quality problems most commonly found on roads. Focus should be placed on: 1) the spacing and adequacy of drainage features and, 2) discharge of road drainage into cover or non-erodible sites. To allow a secondary check of appropriate drainage spacing according to the FPRs, the data collected for each road segment should also include the grade between drainage features (as measured in the field with a clinometer) and the Erosion Hazard Rating (EHR) assigned to the portion of the THP that includes the road segment.

Watercourse Crossing Findings and Recommendations

Findings: A total of 357 watercourse crossings were rated for FPR implementation. Approximately 62% of these were culverts, 25% were fords, 11% were removed or abandoned crossings, and 2% were bridges. Almost 60% of the crossings were in Class III watercourses, and close to 75% were associated with seasonal roads.

Ten FPR requirements (out of 30 rated) were found to have departure rates of 4% or higher. Five of these ten FPRs related to removed or abandoned crossings. The one rule with the highest departure rate (7.4%) requires fills to be excavated to form a channel that is similar to the natural watercourse grade and orientation and is wider than the natural channel.

For crossings with implementation evaluations, 64% had all the crossing rules rated as meeting or exceeding the FPRs; 19% had one or more marginally acceptable ratings, but no departures; and 17% had one or more departure rating(s). This compares well with the earlier HMP results, which had 19.5% of the crossings with one or more major departures.

Out of the twenty-seven items rated on each of the 289 crossings evaluated for crossing effectiveness, major problems were found a total of 76 times on 53 crossings (i.e., 18% of the crossings had significant effectiveness problems). For all new and existing culverts, 10.6% had a major diversion problem, 5.5% had a major plugging concern, and 4.0% had a major cutoff drainage structure problem. The percentage of major and minor problems was smaller for new culverts installed as part of the current THP when compared to existing culverts.

Recommendations: The Forest Practice Program should re-emphasize, through both education and enforcement, proper implementation of five aspects of culvert design, installation and maintenance included in the FPRs:

1. Proper design for passage of wood and sediment, as well as 100-years flood flows (Cafferata and others 2004),
2. Installation of functional critical dips at culvert crossings (Weaver and Hagans 1994),
3. Installation and maintenance of cutoff-drainage structures designed to prevent direct discharge to watercourse channels and erosion of crossing fills (Figure 37),
4. Proper maintenance to prevent plugging from wood and sediment, and
5. The complete excavation of fills at removed crossings to form a channel that is similar to the natural watercourse grade and orientation and is wider than the natural channel.

Figure 37. Pete Cafferata, CDF, points to the outlet of a uniquely-designed 3-rail cutoff-drainage structure on the approach to a watercourse crossing located in a forested watershed on the North Coast of California. Features like this, commonly a rolling dip without the rails, are used to prevent direct discharge of road runoff into watercourse channels.

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Glossary

Abandonment – Leaving a logging road reasonably impassable to standard production four-wheel-drive highway vehicles, and leaving a logging road and landings, in a condition which provides for long-term functioning of erosion controls with little or no continuing maintenance (14 CCR § 895.1).

Alternative practice – Prescriptions for the protection of watercourses and lakes that may be developed by the RPF or proposed by the Director of CDF on a site-specific basis provided that several conditions are complied with and the alternative prescriptions will achieve compliance with the standards set forth in 14 CCR § 916.3 (936.3, 956.3) and § 916.4(b) [(936.4(b), 956.4(b)]. 14 CCR § 916.6 (936.6, 956.6) More general alternative practices are permitted under 14 § CCR 897(e).

Beneficial uses of water - As described in the Porter-Cologne Water Quality Control Act, beneficial uses of water include, but are not limited to: domestic, municipal, agricultural, and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish and wildlife, and other aquatic resources or preserves. In Water Quality Control Plans, the beneficial uses designated for a given body of water typically include: domestic, municipal, agricultural, and industrial supply; industrial process; water contact recreation and non-water contact recreation; hydropower generation; navigation; groundwater recharge; fish spawning, rearing, and migration; aquatic habitat for warm-water species; aquatic habitat for coldwater species; and aquatic habitat for rare, threatened, and/or endangered species (Lee 1997).

Best management practice (BMP) - A practice or set of practices that is the most effective means of preventing or reducing the generation of nonpoint source pollution from a particular type of land use (e.g., silviculture) that is feasible, given environmental, economic, institutional, and technical constraints. Application of BMPs is intended to achieve compliance with applicable water quality requirements (Lee 1997).

Canopy - the foliage, branches, and trunks of vegetation that blocks a view of the sky along a vertical projection. The Forest Practice Rules define canopy as “the more or less continuous cover of branches and foliage formed collectively by the crowns of adjacent trees and other woody species” (14 CCR § 895.1).

Critical dip – a dip over or near a culverted watercourse crossing designed to minimize the loss of road fill and the subsequent discharge of sediment into the affected watercourse in the event the culvert plugs.

Cutbank/sidecast sloughing – Shallow, surficial sliding associated with either the cutbank or fill material along a forest road or skid trail, with smaller dimensions than would be associated with mass failures.

Exception – A non-standard practice for limitations on tractor operations, 14 CCR § 914.2(f)(3) [934.2(f)(3), 954.2(f)(3)].

Gully - Erosion channels deeper than 6 inches (no limitation on length or width). Gully dimensions were estimated.

In-lieu practice – These practices apply to FPR sections for watercourse protection where provision is made for site-specific practices to be proposed by the RPF, approved by the Director and included in the THP in lieu of a stated Rule. The RPF must reference the standard Rule, explain and describe each proposed practice, how it differs from the standard practice, indicate the specific locations where it will be applied, and explain and justify how the protection provided by the proposed practice is at least equal to the protection provided by the standard Rule 14 CCR § 916.1 [936.1, 956.1].

Mass failure – Downslope movement of soil and subsurface material that occurs when its internal strength is exceeded by the combination of gravitational and other forces. Mass erosion processes include slow moving, deep-seated earthflows and rotational failures, as well as rapid, shallow movements on hillslopes (debris slides) and in downstream channels (debris torrents).

Non-standard practice - A practice other than a standard practice, but allowable by the FPR as an alternative practice, in-lieu practice, waiver, exclusion, or exemption (Lee 1997).

Permanent road – A road which is planed and constructed to be part of a permanent all-season transportation facility. These roads have a surface which is suitable for the hauling of forest products throughout the entire winter period and have drainage structures, if any, at watercourse crossings which will accommodate the 50-year flow. Normally they are maintained during the winter period (14 CCR 895.1). After July 1, 2000, watercourse crossings associated with permanent roads have been required to accommodate the estimated 100-year flood flow, including debris and sediment loads.

Process - The procedures through which the FPRs/BMPs are administered and implemented, including: (a) THP preparation, information content, review and approval by RPFs, Review Team agencies, and CDF decision-makers, and (b) the timber operations completion, oversight, and inspection by LTOs, RPFs, and CDF inspectors (Lee 1997).

Quality assurance - The steps taken to ensure that a product (i.e., monitoring data) meets specified objectives or standards. This can include: specification of the objectives for the program and for data (i.e., precision, accuracy, completeness, representativeness, comparability, and repeatability), minimum personnel qualifications (i.e., education, training, experience), training programs, reference materials (i.e., protocols, instructions, guidelines, forms) for use in the field, laboratory, office, and data management system (Lee 1997).

Quality control - The steps taken to ensure that products which do not meet specified objectives or standards (i.e., data errors and omissions, analytical errors) are detected and either eliminated or corrected (Lee 1997).

Repeatability – The degree of agreement between measurements or values of a monitoring parameter made under the same conditions by different observers (Lee 1997).

Rill - Small surface erosion channels that (1) are greater than 2 inches deep at the upslope end when found singly or greater than 1 inch deep where there are two or more, and (2) are longer than 20 feet if on a road surface or of any length when located on a cut bank, fill slope, cross drain ditch, or cross drain outlet. Dimensions were not recorded.

Rules - Those Rules that are related to protection of the quality and beneficial uses of water and have been certified by the SWRCB as BMPs for protecting the quality and beneficial uses of water to a degree that achieves compliance with applicable water quality requirements (Lee 1997). Forest Practice Rules are included in Title 14 of the California Code of Regulations (14 CCR).

Seasonal road – A road which is planned and constructed as part of a permanent transportation facility where: 1) commercial hauling may be discontinued during the winter period, or 2) the landowner desires continuation of access for fire control, forest management activities, Christmas tree growing, or for occasional or incidental use for harvesting of minor forest products, or similar activities. These roads have a surface adequate for hauling of forest products in the non-winter period; and have drainage structures, if any, at watercourse crossings which will accommodate the fifty-year flood flow. Some maintenance usually is required (14 CCR § 895.1). After July 1, 2000, all permanent watercourse crossings have been required to accommodate the estimated 100-year flood flow, including debris and sediment loads.

Standard practice - A practice prescribed or proscribed by the Rules (Lee 1997).

Surface cover – The cover of litter, downed woody material (including slash, living vegetation in contact with the ground, and loose rocks (excluding rock outcrops) that resist erosion by raindrop impact and surface flow (14 CCR § 895.1).

Temporary road – A road that is to be used only during the timber operation. These roads have a surface adequate for seasonal logging use and have drainage structures, if any, adequate to carry the anticipated flow of water during the period of use (14 CCR § 895.1).

Waterbreak – A ditch, dike, or dip, or a combination thereof, constructed diagonally across logging roads, tractor roads and firebreaks so that water flow is effectively diverted. Waterbreaks are synonymous with waterbars (14 CCR § 895.1).

Watercourse – Any well-defined channel with distinguishable bed and bank showing evidence of having contained flowing water indicated by deposit of rock, sand, gravel or soil including but not limited to , streams as defined in PRC 4528(f). Watercourse also includes manmade watercourses (14 CCR § 895.1).

Watercourse class - Classification of watercourses into one four groups (Classes I, II, III and IV) is based characteristics or key indicators of beneficial uses as described in 14 CCR § 916.5 (936.5, 956.5).

- Class I watercourses include: 1) Domestic supplies, including springs, on site and/or within 100 feet of downstream of the operations area and/or, 2) Fish always or seasonally present onsite, includes habitat to sustain fish migration and spawning.
- Class II watercourses include: 1) Fish always or seasonally present offsite within 1000 feet downstream and/or 2) Aquatic habitat for nonfish aquatic species. Excludes Class III waters that are tributary to Class I waters.
- Class III watercourses include: 1) No aquatic life present, watercourse showing evidence of being capable of sediment transport to Class I and II waters under normal high water flow conditions after completion of timber operations.
- Class IV watercourses include: Manmade watercourses, usually downstream, established domestic, agricultural, hydroelectric supply, or other beneficial uses.

Rill - Small surface erosion channels that (1) are greater than 2 inches deep at the upslope end when found singly or greater than 1 inch deep where there are two or more, and (2) are longer than 20 feet if on a road surface or of any length when located on a cut bank, fill slope, cross drain ditch, or cross drain outlet. Dimensions were not recorded.

Rules - Those Rules that are related to protection of the quality and beneficial uses of water and have been certified by the SWRCB as BMPs for protecting the quality and beneficial uses of water to a degree that achieves compliance with applicable water quality requirements (Lee 1997). Forest Practice Rules are included in Title 14 of the California Code of Regulations (14 CCR).

Seasonal road – A road which is planned and constructed as part of a permanent transportation facility where: 1) commercial hauling may be discontinued during the winter period, or 2) the landowner desires continuation of access for fire control, forest management activities, Christmas tree growing, or for occasional or incidental use for harvesting of minor forest products, or similar activities. These roads have a surface adequate for hauling of forest products in the non-winter period; and have drainage structures, if any, at watercourse crossings which will accommodate the fifty-year flood flow. Some maintenance usually is required (14 CCR 895.1). After July 1, 2000, all permanent watercourse crossings have been required to accommodate the estimated 100-year flood flow, including debris and sediment loads.

Standard practice - A practice prescribed or proscribed by the Rules (Lee 1997).

Surface cover – The cover of litter, downed woody material (including slash, living vegetation in contact with the ground, and loose rocks (excluding rock outcrops) that resist erosion by raindrop impact and surface flow (14 CCR 895.1).

Temporary road – A road that is to be used only during the timber operation. These roads have a surface adequate for seasonal logging use and have drainage structures, if any, adequate to carry the anticipated flow of water during the period of use (14 CCR 895.1).

Waterbreak – A ditch, dike, or dip, or a combination thereof, constructed diagonally across logging roads, tractor roads and firebreaks so that water flow is effectively diverted. Waterbreaks are synonymous with waterbars (14 CCR 895.1).

Appendix A:

Modified Completion Report Methods and Procedures

(revised April 9, 2003)

An electronic copy of the *Modified Completion Report Monitoring Procedures and Methods (rev.4/9/03)* is available on line at:

http://www.bof.fire.ca.gov/board/msg_archives.asp