MONITORING STUDY GROUP
CALIFORNIA STATE BOARD OF FORESTRY AND FIRE PROTECTION

Forest Practice Rules Implementation and Effectiveness Monitoring (FORPRIEM) Program

MONITORING RESULTS FROM 2008 THROUGH 2013

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Abstract

California's forested watersheds, including over seven million acres of private timberland, are a key source of high quality water. The California Forest Practice Act and Rules (Title 14, California Code of Regulations) are designed in large part to protect water quality and aquatic habitat in non-federal forested watersheds during and after silvicultural activities. The critical questions are (1) what are the rates of proper implementation of the water quality-related Forest Practice Rules (FPRs), and (2) when properly implemented, how effective are they in protecting water quality. Forest Practice Rules Implementation and Effectiveness Monitoring (FORPRIEM) addressed these two questions using forensic monitoring data collected on a random sample of harvesting plans and sites within those plans. Overall, the study found that the rate of compliance with FPRs designed to protect water quality and aquatic habitat is generally high, and that they are effective in preventing erosion, sedimentation, and sediment transport to channels when properly implemented.

KEY TERMS: water quality, aquatic habitat, forestry, monitoring, streams, California Forest Practice Rules (FPRs), Timber Harvesting Plans (THPs), Nonindustrial Timber Management Plans (NTMPs), Watercourse and Lake Protection Zones (WLPZs), roads, waterbreaks, watercourse crossings, WLPZ canopy, groundcover, erosion, sediment transport, and sediment transport to channels.

Monitoring Study Group

The Monitoring Study Group (MSG) has been an Advisory Committee to the Board of Forestry and Fire Protection (BOF) since July 1999. From 1989 to 1999, the MSG was an "ad hoc" committee which met periodically. The MSG has (1) helped develop a long-term program testing the effectiveness of California's Forest Practice Rules, and (2) provided guidance and oversight to the California Department of Forestry and Fire Protection (CAL FIRE) in implementing the program. CAL FIRE has funded monitoring efforts designed to ascertain if the Forest Practice Rules protecting beneficial uses of water are being implemented and are effective since 1990. Past MSG monitoring reports are posted at:
http://www.bof.fire.ca.gov/board_committees/monitoring_study_group/msg_monitoring_reports/
MSG supported monitoring reports are posted at:
http://www.bof.fire.ca.gov/board_committees/monitoring_study_group/msg_supported_reports/

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Forest Practice Rules Implementation and Effectiveness Monitoring Program (FORPRIEM): MONITORING RESULTS FROM 2008 THROUGH 2013

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Executive Summary

California's forested watersheds, including over seven million acres of private timberland, are a key source of high quality water. The California Forest Practice Act and Rules (Title 14, California Code of Regulations) are designed in large part to protect water quality and aquatic habitat in forested watersheds during and after silvicultural activities (Figure 1).

The critical questions are (1) at what rate are the water quality-related Forest Practice Rules (FPRs) being properly implemented, and (2) when properly implemented, how effective are these FPRs in protecting water quality and the beneficial uses of water, including aquatic habitat, by retaining riparian canopy and preventing erosion/sediment transport. Forest Practice Rules Implementation and Effectiveness Monitoring (FORPRIEM) addressed these two questions using forensic monitoring data collected from 2008 through 2013 on a random selection of 126 Timber Harvesting Plans (THPs) and 24 Nonindustrial Timber Management Plan–Notice of Timber Operations (NTMP-NTOs), and randomly selected sites within those plans.

Approximately half the THPs were from the California Department of Forestry and Fire Protection's (CAL FIRE's) Coast Region and half were from the Cascade and Sierra Regions (denoted as Inland North and Inland South). Over 90% of the NTMP-NTOs were located in the Coast Region. Implementation of selected water quality-related FPRs and effectiveness of the rules for THPs were rated by CAL FIRE Forest Practice Inspectors. CAL FIRE Inspectors, along with North Coast Regional Water Quality Control Board staff, made the evaluations for NTMP-NTOs.

The FORPRIEM monitoring study found, similar to earlier monitoring program results, that overall (1) the rate of compliance with FPRs designed to protect water quality and aquatic habitat is generally high, and (2) the FPRs evaluated are effective in preventing erosion, sedimentation and sediment transport to channels when properly implemented.

This report:

- Describes FORPRIEM monitoring conducted from 2008 through 2013.
- Summarizes and analyzes the FORPRIEM monitoring data, results, and QA/QC.
- Makes findings and recommendations using the study results.

Based on the findings of the earlier Hillslope Monitoring Program (HMP) (Cafferata and Munn 2002) and the Modified Completion Report (MCR) monitoring program (Brandow et al. 2006), FORPRIEM focused on the following high risk areas located within harvesting plans:

1) Watercourse and Lake Protection Zones (WLPZs), including:
    - WLPZ percent total canopy
    - WLPZ groundcover and erosion features
2) Roads
3) Watercourse Crossings

The *FORPRIEM Monitoring Procedures and Methods* are included as an Appendix of this report and are found on-line at: http://www.bof.fire.ca.gov/board_committees/monitoring_study_group/msg_archived_documents/. Summaries of the WLPZ, road, and crossing results are provided below.

Based on both measurements of WLPZ total canopy and ocular estimates of overstory, WLPZ canopy exceeds FPR standards for Class I and Class II watercourses in most cases. Statewide, THP WLPZs with completion inspections filed between 2008 and 2013 had an average percent total canopy of 82%, with a median of 84%. In the North Coast Hydrologic Region, NTMPs with NTOs filed between 2010 and 2012 had an average percent total canopy of 91%, with a median of 93%. FORPRIEM percent total WLPZ canopy was analyzed in several ways, including: Class I vs. Class II WLPZs, harvest vs. no harvest, Anadromous Salmonid Protection (ASP) rules area vs. non-ASP rules area, and coastal vs. inland regions. THP WLPZ percent total canopy for Class I watercourses suggests that it may be improving over time, based on a comparison of results from three monitoring studies conducted between 1999 and the present. Generally, the Forest Practice Rules appear to be working to retain high levels of post-harvest WLPZ canopy, particularly in the Coast and Inland South Regions of the state, and to prevent erosion in the WLPZ. Groundcover requirements for WLPZs were met in almost all cases and WLPZ erosion related to the current harvest entry were very rare.

When properly implemented, road-related FPRs were found to be highly effective in preventing erosion, sediment transport, and sediment transport to channels. Proper rule implementation rates for waterbreak (including waterbars, rolling dips and other types of drainage facilities) construction and discharge into cover were over 90% for both THP and NTMP-NTO randomly selected road segments. Proper rule implementation rates for waterbreak spacing was 88% for THP roads and 90% for NTMP-NTO road segments. The high rates of proper implementation resulted in low rates of road surface and fill slope erosion. As expected, the study found that correct waterbreak spacing is a critical factor in preventing erosion on road surfaces and fill slopes. For THP roads with correct spacing, 86% of the waterbreak intervals (the road surface between waterbreaks) had no related erosion, with 14% having related erosion. In contrast for THP roads with incorrect spacing, 63% of the waterbreak intervals had no related erosion and 37% had related erosion. For NTMP-NTO roads with correct spacing, 90% of the waterbreak intervals had no related erosion and 10% had related erosion. Fifty percent of the waterbreak intervals had no related erosion for NTMP-NTO roads with incorrect spacing and 50% had related erosion. These results show that correct waterbreak spacing is critical for minimizing road surface and fill slope erosion. Incidents of observable road-related sediment transport beyond the toe of the fill slope and sediment transport to channel were infrequent. The cause of each incident recorded during FORPRIEM monitoring and the related rule implementation ratings are documented.

Watercourse crossings present a higher risk of sediment discharge into streams than roads because, while some roads are close to streams, all watercourse crossings span watercourses. For THPs, 64% of crossings had all the FPR crossing requirements rated as meeting or exceeding rule standards; 24% had one or more marginally acceptable ratings, but no rule departures; and 12% of the crossings had one or more rule departure ratings. For effectiveness ratings, 13% of the THP crossings evaluated had one or more major problems. For NTMP-NTO crossing implementation, 70% of the crossings met or exceeded all FPRs, 11% had one or more marginally acceptable ratings, and 19% had at least one departure from the rule requirements. Ten percent of the NTMP-NTO crossings evaluated for effectiveness had one or more major problems. Common deficiencies for both THPs and NTMP-NTOs included culvert diversion potential, road cut-off drainage structure function, scour at the outlet of culverts, and culvert plugging. NTMP-NTO watercourse crossings appear to be generally comparable to THPs from a water quality standpoint, but the sample size is small. Watercourse crossing implementation and effectiveness ratings recorded with FORPRIEM suggest that there may be improvement when compared to ratings reported in two earlier monitoring programs, but lack of large stressing winter storm events for most of the state over the life of the study and differing entities collecting monitoring data make direct comparisons difficult.

These results for WLPZs, roads, and crossings, similar to results from two earlier monitoring programs, indicate that while overall rule implementation rates are high (approximately 90% or higher depending on rule section), further improvements are merited in some areas. In particular, improved road drainage at watercourse crossing approaches is required, as is further improvement for crossing design, construction, maintenance, and abandonment. Implementation of the new Road Rules, 2013 rule package in January 2015 provides an opportunity for this to occur. Crossing diversion potential and hydrologic disconnection on road approaches to crossings are high priority training items for both agency personnel and Registered Professional Foresters (RPFs). Education for Licensed Timber Operators (LTOs), as well as higher levels of enforcement with improved agency staffing levels, will be utilized with the implementation of the Road Rules, 2013 rule package. Additionally, it is anticipated that focused effectiveness monitoring for road, crossing, and WLPZ issues will be addressed with the Board's newly formed Effectiveness Monitoring Committee (EMC). The EMC's work will provide data for adaptive management and a policy feedback mechanism for determining if additional improvements in the FPRs are required. Changes in the Forest Practice Rules, including the ASP rules implemented in 2010 and the new Road Rules, 2013 rule package, will require significant modifications to the FORPRIEM monitoring procedures prior to future use.

Figure 1. A small watercourse or stream in a FORPRIEM-sampled THP located in northern California and a typical example of the watercourses the California Forest Practice Rules are designed to protect.

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List of Abbreviations

ASP	Anadromous Salmonid Protection
BMPs	Best Management Practices
BOF	California State Board of Forestry and Fire Protection
CAL FIRE	California Department of Forestry and Fire Protection
CCR	California Code of Regulations
CDFW	California Department of Fish and Wildlife
CDPR	California Department of Parks and Recreation
CFA	California Forestry Association
CGS	California Geological Survey
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
EMC	Effectiveness Monitoring Committee
ESU	Evolutionarily Significant Unit
FPA	Forest Practice Act
FPRs	Forest Practice Rules (Rules)
HMP	Hillslope Monitoring Program
HY	Hydrologic Year
LTMP	Long-Term Monitoring Program
LTO	Licensed Timber Operator
LWD	Large Woody Debris
MAA	Management Agency Agreement
MCR	Modified Completion Report Monitoring Program
MSG	Monitoring Study Group
NMFS	National Marine Fisheries Service
NPS	Nonpoint Source
NTMP	Nonindustrial 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	Pre-Harvest Inspection
PMP	Pilot Monitoring Program
QA/QC	Quality Assurance/Quality Control
RCD	Resource Conservation District
RPF	Registered Professional Forester
Rules	California 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
T/I	Threatened or Impaired Watersheds
UCCE	University of California Cooperative Extension
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Department of Agriculture, Forest Service
WB	Waterbreak
WLPZ	Watercourse and Lake Protection Zone
WTL	Watercourse Transition Line

Forest Practice Rules Implementation and Effectiveness Monitoring
—Final Report—

Introduction

The purpose of the Forest Practice Rules Implementation and Effectiveness (FORPRIEM) project is 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 CAL FIRE Forest Practice Inspectors during Timber Harvesting Plan (THP) completion report inspections and erosion control maintenance inspections, and similar Nonindustrial Timber Management Plan–Notice of Timber Operations (NTMP-NTOs) inspections. The FORPRIEM data were collected from 2008 through 2013. Based on the findings of CAL FIRE's earlier Modified Completion Report Program (Brandow et al. 2006) and the Hillslope Monitoring Program (Cafferata and Munn 2002), the FORPRIEM program focused on the following landscape features: (1) Watercourse and Lake Protection Zones (WLPZs), including WLPZ percent total canopy, groundcover, and erosion features; (2) roads; and (3) watercourse crossings.

Background Information

California's Z'berg-Nejedly Forest Practice Act (FPA) was adopted in 1973, with full field implementation occurring in 1975. During the subsequent four 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 (CAL FIRE) Forest Practice compliance inspection program that has been in place for nearly 40 years. Under the FPA, THPs and other types of harvesting documents must be submitted to CAL FIRE prior to conducting commercial timber harvesting on non-federal timberlands. These plans are 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, water quality and wildlife. Multi-disciplinary teams composed of representatives of CAL FIRE, the California Department of Fish and Wildlife (CDFW), Regional Water Quality Control Boards (RWQCBs), and the California Geological Survey (CGS), conduct Pre-Harvest Inspections (PHIs) of plan 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 plan 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 erosion control maintenance period when logging is completed ensure compliance with the Act, the FPRs, and specific provisions of the plan.

The State Water Resources Control Board (SWRCB) certified the California 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” (SWRCB 1987). The team recommended several changes to the FPRs based on their observations.

In 1988, the BOF, CAL FIRE, 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 CAL FIRE 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. The LTMP began in 1996 with the Hillslope Monitoring Program, and continued with the Modified Completion Report monitoring program in 2001 and FORPRIEM in 2008. Several cooperative instream monitoring projects have also been part of the LTMP.

A brief description of past monitoring programs implemented under the LTMP, as well as other monitoring work conducted in California and the western U.S., and how it relates to FORPRIEM results, is provided in the Literature Review chapter of this report.

Literature Review

Several water quality-related monitoring studies have been completed in California and the other western United States over the past four decades. A brief description of selected studies is provided below to provide context for the FORPRIEM study.

Overview of Approaches for Monitoring Forestry Impacts on Water Quality

The impacts of forestry operations on water quality and aquatic habitat have been studied for several decades, with greater emphasis occurring since the passage of the Federal Water Pollution Control Amendments of 1972 requiring control of nonpoint source pollution (Binkley and Brown 1993, Ice et al. 2004, CWSF 2007, Ice et al. 2010, Sugden et al. 2012). Both hillslope and instream monitoring approaches are available to landowners, agency personnel, and the public (MacDonald et al. 1991, Corner et al. 1996). Instream monitoring can provide useful information about long-term trends in water quality and the impacts of timber harvesting operations, but automated instream monitoring stations are expensive to install and maintain for the extended time periods needed to measure background, treatment, and post-treatment conditions (commonly a decade or more). In addition, instream measurements usually cannot be tied to a specific logging practice (Cafferata et al. 2008).

Hillslope monitoring provides qualitative estimates of Forest Practice Rule/BMP implementation and quantitative measurements of rills, gullies, landslides, riparian canopy cover, etc. It can be used to determine if forestry practices are effective at minimizing erosion and transport of sediment to watercourses. This type of monitoring has the advantage of providing a close linkage to impacts from contemporary timber operations. Additionally it can test implementation and effectiveness of individual logging practices and provide a rapid feedback loop to improve practices quickly. Hillslope monitoring, however, cannot provide direct information on impacts to habitat conditions for aquatic species, and it may miss long-term problems or delayed erosion sources triggered by infrequent, large storm events. Hillslope monitoring, such as FORPRIEM, complements more expensive (and hence limited) instream monitoring projects.

Brief Summary of Past Hillslope Monitoring Studies Conducted in California

Initial monitoring projects on non-federal forest lands in California focused on soil erosion related to timber harvesting and were developed and implemented under the Department's Soil Erosion Studies Project (Dodge et al. 1976, WESCO 1983, Durgin et al. 1989, Lewis and Rice 1989). The first evaluation of California FPRs was a qualitative assessment of 100 THPs conducted in 1986 by a team of four resource professionals on non-federal timberlands. The team concluded that the FPRs were generally effective when implemented on terrain that was not overly sensitive (i.e., erodible soils, high mass wasting potential), and that poor rule implementation was the most common cause of water quality impacts (SWRCB 1987).

This qualitative assessment completed in 1986 was not considered sufficient evidence for U.S. EPA certification of the state Forest Practice Rules as adequate BMPs. Therefore, in 1988, the Board formed an interagency task force to develop a monitoring program that could test the implementation and effectiveness of FPRs in protecting water quality. A pilot project was used to develop appropriate techniques for both hillslope and instream monitoring (Tuttle 1995, Rae 1995, Spittler 1995). The Hillslope Monitoring Program (HMP) pilot project developed (1) methods for measuring rule implementation and effectiveness by modifying previously developed USDA Forest Service hillslope monitoring forms (USFS 1992), and (2) new monitoring forms for practices that were unique in the FPRs (Tuttle 1995).

The HMP conducted a statewide evaluation of the implementation and effectiveness of FPRs beginning in 1996 using an annual random sample of 50 completed THPs that had over-wintered from one to four years. Detailed information was collected from sampled plans in the summer months and 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. The monitoring work was done by highly qualified independent contractors who acted as third party auditors by collecting field data and entering them into a monitoring database. An interim report was prepared in 1999 (BOF 1999), and a final report based on 300 projects was completed in 2002 (Cafferata and Munn 2002). Results showed that implementation rates of the FPRs related to water quality were high (averaging 94%) and that individual practices required by the rules were generally effective in preventing hillslope erosion when properly implemented. Roads and their associated crossings were found to have the greatest potential for sediment delivery to watercourses. Overall, 5.5% of the road drainage structures and facilities were found to have problems and approximately 15% of the inventoried road erosion features delivered sediment to stream channels. WLPZs were found to retain high levels of post-harvest total canopy and surface cover, and to prevent harvesting related sediment transport though the zone from upslope sources and erosion within the zone.

Similar to the HMP, the Modified Completion Report (MCR) monitoring program operated from 2001 to 2004 and documented implementation rates and effectiveness of the FPRs in protecting water quality (Brandow et al. 2006). This program utilized Forest Practice Inspectors rather than independent contractors to collect upslope monitoring information. Data were collected on a random selection of 281 completed THPs (a 12.5% random sample of plans). Based on the results from the HMP, high risk and highly sensitive parts of THPs were sampled (i.e., roads, watercourse crossings, and WLPZs). Comparable to the findings in the HMP, compliance with FPRs was high and FPRs were found to be highly effective when properly implemented. WLPZs were found to retain high levels of post-harvest total canopy and surface cover. Five percent of inventoried road-related features had improper implementation of rule requirements, and approximately eight percent of road erosion features delivered sediment to stream channels. There was a 10 times higher chance of sediment delivery to a stream channel if there was a FPR departure from the rule requirement. Road-related FPR departures were nearly always related to inadequate implementation of road drainage requirements. Watercourse crossing effectiveness ratings were generally similar to HMP results, with approximately 20% of the crossings in both the MCR and HMP projects having significant implementation and/or effectiveness problems. FORPRIEM is a continuation of the MCR monitoring program with slight modifications.

More recent state-sponsored upslope monitoring projects conducted on non-federal forest lands have reported results that are consistent with those from the HMP and MCR work. The Interagency Mitigation Monitoring Program (IMMP) implemented a pilot project from 2005-2007 to evaluate high risk (non-random) watercourse crossing sites, including those with added mitigation measures and special plan requirements (Longstreth et al. 2008). Two multi-agency state teams were used to provide greater public confidence in the monitoring results. Results from 54 crossings showed that (1) improper installation and/or maintenance of crossings and drainage structures near crossings and improper removal were the major causes of sediment input to watercourses, and (2) road approaches near crossings produced a high percentage of the documented sediment deposition problems.

The Battle Creek Task Force similarly used interagency teams in 2011 to qualitatively evaluate erosion associated with clearcutting on private forest land in the Battle Creek watershed, a tributary of the Sacramento River with listed anadromous salmonids (BCTF 2011). Non-random, high-risk sites were selected by the interagency teams, with the highest priority assigned to clearcuts with buffers on fish-bearing streams. Additionally, watercourse-adjacent road segments and landings, tractor crossings, and road crossings were evaluated. Two assessment teams surveyed 135 non-randomly located field sites located in five planning watersheds. The interface between clearcuts and riparian buffers was walked to look for sediment delivery (as described in Litschert and MacDonald 2009). The interagency teams reported that 39% of the sites delivered sediment, but only one of the clearcut units delivered material. Most of the sediment delivery was from road crossings and road segments located near watercourses. Primary report conclusions were that (1) there were no significant direct water quality impacts related specifically to harvest within the clearcut units, and (2) most sediment delivery originated from road crossings and watercourse-adjacent road segments.

On National Forests in California, the U.S. Forest Service collected data from 1992 through 2002 on over 3,100 randomly located sites to evaluate the implementation and effectiveness of its water quality BMPs (Staab 2004). The BMP Evaluation Program (BMPEP) used 29 different onsite monitoring protocols to evaluate BMP implementation and effectiveness, with the majority related to timber and engineering practices. Results showed that while some improvements to current practices were necessary, the program performed reasonably well in protecting water quality on National Forest lands. BMP implementation and effectiveness were relatively high for most activities (including timber and engineering) and impacts on water quality were relatively rare. Significant water quality impacts were typically caused by lack of or inadequate BMP implementation and mostly related to engineering practices (nearly 60%). Roads, and in particular stream crossings, were found to create the greatest number of problems.

Fifty-four percent of the sites where elevated water quality impacts were observed were associated with roads.

The USFS BMP monitoring work was updated in 2009, with data reported for BMP Evaluation Program sites evaluated from 2003-2007 (USFS 2009). A total of 2,861 BMPs were evaluated for implementation and effectiveness, again using 29 monitoring protocols, with 86% rated as being adequately implemented and 89% rated as being effective. Among the properly implemented BMPs, 93% were rated as effective. For all the sites rated, 92% were found to have no potential or actual adverse effects on water quality. BMP categories with the highest effectiveness ratings were timber, prescribed fire, and vegetation management, while BMPs requiring the greatest improvement in implementation were related to range and recreation activities. Overall, the BMPs most likely to be associated with measurable adverse water quality effects were found at (1) developed recreation sites, (2) water source development, and (3) stream crossings.

This work was updated again in 2013 for data collected from 2008-2010 (USFS 2013). BMP implementation scores for all activities increased between 1992 and 2010, but results for effectiveness of implemented BMPs were found to be less consistent than for implementation. Adverse water quality effects that extended to stream channels were observed for 12% of the evaluations. It was concluded that BMP effectiveness can be improved by implementing effective erosion control plans and wet-weather operating standards, outsloping roads, eliminating diversion potential at road-stream crossings, and using improved management practices for livestock in riparian zones.

Dr. Lee MacDonald, Professor Emeritus at Colorado State University, and his graduate students have documented hillslope erosion rates associated with forest roads, logging, and other land uses in the Sierra Nevada Mountains of California. The results have shown that native surface roads are the primary anthropogenic source of sediment in this region. High rates of sediment production were also documented for high severity wildfires and areas used for off-highway vehicles. On average, native-surface roads generated approximately seven times more sediment than harvest units and landings in the central Sierra Nevada (MacDonald et al. 2004). This work has shown that sediment production and delivery from forest roads can be reduced by (1) rocking road surfaces, particularly at approaches to stream crossings; (2) minimizing the number of stream crossings; (3) reducing the length of roads draining to stream crossings (i.e., hydrologic disconnection); (4) minimizing road grading; and (5) improving the number of road drainage structures, as well as their placement and construction (Coe 2006, Stafford 2011).

Brief Summary of Instream Monitoring Studies Conducted in California

The Caspar Creek watershed study is a long-term cooperative project conducted by the USFS Pacific Southwest Research Station and CAL FIRE since 1962. This 5,300 acre basin is located in western Mendocino County, primarily on Jackson Demonstration State Forest. The study has documented the impacts of logging second growth redwood forested watersheds with two separate experiments: South Fork (1962-1985), and North Fork (1985-present). The South Fork was logged from 1971-1973, prior to the implementation of the modern FPA and Rules, with crawler tractors. Suspended sediment yields increased four to five times over those expected for the first six years after tractor logging (Rice et al. 1979). The North Fork was mostly cable yarded under the modern FPRs, with approximately 50% of the basin clearcut harvested from 1985-1992 (Ziemer 1998). Selective tractor logging and roading along the stream in the South Fork was found to have increased suspended sediment yields 2.4 to 3.7 times over those measured with clearcutting and cable logging operations in the North Fork conducted under the modern FPRs (Lewis 1998, Lewis et al. 2001). Suspended sediment monitoring in the North Fork of Caspar Creek following clearcut harvesting of 37% of the watershed in three years 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. At the North Fork weir, a suspended sediment increase of 89% was mainly caused by a large landslide in a tributary that enters the North Fork just above the weir that occurred in January 1995 (Lewis et al. 2001). A third experiment is in the planning phases at Caspar Creek (Cafferata and Reid 2013).

The Judd Creek watershed has been studied by Dr. Cajun James, Sierra Pacific Industries (SPI), since 1999, initially for temperature and microclimate impacts associated with clearcut logging (James 2003), and later for sediment and turbidity. The monitored portion of the Judd Creek watershed covers 4,350 acres and is located in Tehama County in northeastern California. In 2007 extensive road work was conducted as part of a THP, and in 2009, 16% of the watershed was clearcut using 34 units, each approximately 20 acres. Annual suspended sediment yields are available for water years 2001-2012. Preliminary data analysis indicates that there was no signal from the roading work completed in 2007 or timber harvesting undertaken in 2009. Sediment yields were controlled primarily by inter-annual variations in precipitation. The combination of high infiltration rates, relatively permeable geology associated with volcanic terrain, and improved management practices all indicated that intensive forest management in the Judd Creek watershed did not have adverse effects on runoff or water quality. It was suggested that future work should focus on the effects of forest management in more erodible areas, such as highly weathered granitics (MacDonald and James 2012).

The Little Creek watershed, a 1,900 acre basin located in the Santa Cruz Mountains on Cal Poly San Luis Obispo's Swanton Pacific Ranch, has been the site of a long-term instream monitoring study conducted by Dr. Brian Dietterick since 2001 (Gaedeke 2006). Seven years of baseline (pre-project) monitoring data were available prior to a light selection harvest that impacted approximately 20% of the North Fork of Little Creek watershed in 2008. Three storm events occurred during the first winter following logging, but no significant change in suspended sediment yields over background levels were recorded (Skaugset et al. 2012). In 2009, approximately 90% of the Little Creek watershed was burned during the Lockheed Fire. Sediment yields the first winter after the fire were not significantly increased, since near-stream sediment contribution was minimal and hillslope-derived sediment sources were not hydrologically connected to the channel network (Loganbill 2013, Surfleet et al. 2014). CAL FIRE's Forest Practice Program has helped support both the Little Creek and Judd Creek projects.

In addition to these three cooperative instream monitoring projects, numerous other forestry-related instream monitoring projects are underway in California. These investigations include multiple stations associated with the Sierra Nevada Adaptive Management Project (SNAMP) (Conklin et al. 2012) and the Kings River Experimental Watershed (KREW) (Hunsaker and Neary 2012); additional SPI monitoring stations in the Sierra Nevada and Cascade Range; stations operated by Humboldt Redwood Company and Salmon Forever in the Freshwater Creek and Elk River watersheds in Humboldt County (Sullivan et al. 2012, Lewis 2013); Green Diamond Resource Company stations in Humboldt County (House et al. 2012); stations operated in Redwood National and State Parks (Klein et al. 2008); Campbell Global, LLC and Mendocino Redwood Company (MRC) monitoring stations in Mendocino County (RiverMetrics 2011, Vodopals 2011); and numerous additional stations operated by the USFS, California State Parks, watershed groups, and NGOs (Harris et al. 2007).

Comparison with Monitoring Study Results in Other Western U.S. States

The hillslope and instream monitoring results briefly summarized above are generally consistent with those reported for other western U.S. states. Ice et al. (2010) estimated a national forestry BMP implementation rate of 89% (92% average for WA, OR, MT, ID, and AK). Obermeyer and Shelly 2012, Robben and Dent 2002, Ziesak 2010, Andrea 2012, and AK DNR-DOF 2012 provide forestry BMP monitoring compliance data for Washington, Oregon, Montana, Idaho, and Alaska, respectively. BMP compliance data from these states compare favorably with the 94% estimate for California obtained with the HMP. Instream monitoring projects conducted in Oregon include the new Alsea Watershed Study (Ice et al. 2011) and the Hinkle Creek Watershed Study (Kibler 2007, Zegre 2008, Skaugset et al. 2013). Results from these projects conducted with contemporary forest practices show impacts to water quality and aquatic resources generally similar to those reported for the North Fork Caspar Creek, Judd Creek, and Little Creek studies in California.

Forest Practice Rules Implementation and Effectiveness Monitoring (FORPRIEM) 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 CAL FIRE 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. FORPRIEM, like Modified Completion Report (MCR) monitoring which preceded it, is a slight modification to this process. FORPRIEM adds a monitoring step independent of the required enforcement related inspections, which is designed to collect data on the implementation and effectiveness of the FPRs developed to protect water quality. Like MCR monitoring, FORPRIEM monitoring included three important protocols:

1) Random selection of completed plans (THPs and NTMP-NTOs) 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 or NTMP-NTO.

Random Selection of Plans

The FORPRIEM monitoring was performed on a random sample of completed THPs between 2008 and 2013. The target sample size was 10% of all THPs undergoing Work Completion Report inspections. NTMP-NTOs were added to the program in 2011, with a target sample size of 20% of the NTOs undergoing Work Completion Report inspections. The NTMP-NTO sample was initially limited to the North Coast Hydrologic Region in 2011, and later expanded statewide.

To obtain a random sample for THPs, pick-lists of randomly selected THP numbers were generated and distributed to CAL FIRE Forest Practice Inspectors with the FORPRIEM Procedures and Methods document. Separate lists of random THP numbers by filing year were generated for CAL FIRE Administrative Areas R-1, R-2, and R-4 (often denoted as “Regions”). These represent the Regions with significant timber harvest in California. The original random list covered THP filing years 2002 through 2011. Later, random lists covering filing years 2012 through 2016 were generated. A typical THP number appears as a series of three numbers, for example 01-14-091. In this example “01” stands for Region 1, “14” stands for the calendar year (2014) the THP was filed in and accepted by CAL FIRE for processing, and “091” is a sequential number indicating the order in which the Plan was submitted to the CAL FIRE Region. It is the sequential numbers which are picked at random for each Region for each year.

A program used to produce lists of random THP numbers was written by former CAL FIRE State Forests Research Coordinator Dr. Tim Robards, in collaboration with CAL FIRE 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 10% sample, “X” equals 10, and each THP number has an independently determined one-in-ten chance of being selected. This provides a random 10% sample of completed THPs, regardless of the number of THPs approved in any given year.

Overall, there were 182 THPs that were selected in the random sample. Of these 182 THPs, 126 were monitored, 10 were excluded for cause, and 46 were not monitored. The reasons for excluding THPs for cause included: THP expired with no operations (2); THP was converted to other land uses (3); THP was severely damaged by a major wildfire (1); THP was inside a subdivision with paved roads and other non-THP impacts (1); THP monitoring was on-hold due to pending litigation (1); THP was administratively closed (1); and THP was closed prior to FORPRIEM implementation (1). Legal access has expired for some of the 46 THPs that were not monitored. CAL FIRE staffing issues contributed to the Department’s inability to obtain a more complete sample in some instances. Overall, monitoring of the THP random sample was about 75% complete. This was computed by adding THPs monitored and the THPs excluded and dividing by the total number of THPs in the random sample. Monitoring completeness of the THP sample varied by Region. The Coast (R-1) was 78% complete, Inland North was 62% complete, and Inland South (R-4) was 95% complete. Completeness of the sample is important to avoid inadvertently adding bias.

FORPRIEM monitoring included NTMP-NTOs beginning in 2011 in the North Coast Hydrologic Region, and more recently expanded to statewide sampling. Only two of the 24 NTMP-NTOs in the sample analyzed in this report were located outside of the North Coast Hydrologic Region. NTMPs are long-term, perpetual plans to which Notice of Timber Operations (NTOs) are attached at the discretion of the landowner. NTOs are numbered sequentially, but it impossible to forecast which NTMP will have NTOs in any given year. As a result, it not possible to generate random pick-lists for a target sample size until the NTMP-NTOs have been filed and the population of NTMP-NTO numbers to be sampled is known. Random lists of NTMP-NTOs with a target sample size of 20% were generated from lists of filed NTMP-NTOs obtained from the CAL FIRE Forest Practice System (FPS) database.[1]

NTMP-NTOs were randomly selected in two batches. The first batch was a 20% sample of NTMP-NTOs filed with CAL FIRE and located within the North Coast Hydrologic Region between November 1, 2007 and July 5, 2011. This first batch was randomly selected in July 2011 and included 26 NTMP-NTOs. Of these 26 NTMP-NTOs, 23 were monitored, two were excluded for cause, and one was not monitored. The reasons for excluding NTMP-NTOs, included: one NTMP-NTO expired with no operations and one NTMP-NTO had a safety-of-access issue related to marijuana cultivation. Overall,

[1] The primary difference between THPs and NTMP-NTOs was that NTMP-NTOs were randomly selected after they were filed with CAL FIRE, while THPs were selected before they were filed with CAL FIRE.

monitoring of the NTMP-NTO random sample was about 96% complete. This was computed by adding NTMP-NTOs monitored and the NTMP-NTOs excluded and dividing by the total number of NTMP-NTOs in the random sample. A second batch of NTMP-NTOs consisting of a 20% random sample of NTMP-NTOs filed statewide between July 6, 2011 and June 30, 2012 was randomly selected in July 2012. Only one NTMP-NTO from this second batch of 15 was received in time to be included in this report. The NTMP-NTO data used in this report are a good representation of conditions for the North Coast Hydrologic Region for the November 2007 to July 2011 time period.

Data Collection

FORPRIEM monitoring data were collected by CAL FIRE Forest Practice Inspectors, with some assistance from CAL FIRE watershed staff. On a small number of the THPs and the majority of NTMP-NTOs evaluated, monitoring assistance was provided by North Coast Regional Water Quality Control Board staff and landowner representatives (generally the Registered Professional Foresters (RPFs) who prepared and/or administered the plan).

FORPRIEM data were recorded on paper forms. To avoid ambiguities from blanks in the data, responses such as “N/A” (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 possible 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 for data collection in this report are documented in *Forest Practice Rules Implementation and Effectiveness Monitoring Procedures and Methods* (revised September 14, 2007), which is included in this report as an Appendix and is available online at:
http://www.bof.fire.ca.gov/board_committees/monitoring_study_group/msg_archived_documents/msg_archived_documents_/forpriem_proceduresmethods_091407.pdf

Implementation and Effectiveness Evaluations

Four randomly located sites (i.e., one WLPZ segment, one road segment, and two watercourse crossings) were evaluated for FPR implementation after the final Work Completion Report was submitted to CAL FIRE by the RPF. The sample road segment and watercourse crossing 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 most cases, the implementation evaluation was conducted after one or more over-wintering period(s) and the effectiveness evaluation was done during 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 Forest Practice Rule 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, construction, and maintenance.

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 CAL FIRE Forest Practice Inspectors, (2) a detailed field training program, and (3) protocols provided in the *Forest Practice Rules Implementation and Effectiveness Monitoring Procedures and Methods* document (see the Appendix). Field training for the FORPRIEM procedures and methods was provided to most of the CAL FIRE Forest Practice Inspectors who did the monitoring. CAL FIRE Forest Practice Inspectors are California RPFs, or in some cases Forestry Assistants working under the direct supervision of CAL FIRE RPFs. Typically the training was done on actual FORPRIEM sampled THPs or NTMP-NTOs located within the Inspectors' home Units. Thirty-two CAL FIRE Inspectors received FORPRIEM training between 2007 and 2011. Additionally, 14 North Coast Regional Water Quality Control staff participated in a form of the training prior to beginning FORPRIEM monitoring of NTMP-NTOs in the North Coast Hydrologic Region.

The quality control program consisted of three components: (1) checking the completed data forms and resolving problems, (2) spot checking the database to ensure accurate data entry, and (3) a random re-sample and re-monitoring of five THPs (four percent of the total THP sample). Completed data forms were reviewed at the Unit level and then checked again by watershed staff in Sacramento. To the extent possible, questions were resolved through direct communication between the Forest Practice Inspectors, Audit Foresters, and Sacramento watershed staff. The data were entered into the FORPRIEM database by Sacramento watershed staff. Five FORPRIEM-monitored THPs were picked at random for re-monitoring (no NTMP-NTOs were resampled). QA/QC monitoring was conducted by Sacramento watershed staff in 2013 with the assistance of the Inspectors who performed the original evaluation. After the QA/QC monitoring was completed, results were compared with the results of the original monitoring. These comparisons for WLPZ percent total canopy, roads, and watercourse crossings can be found in this report in their respective sections.

To ensure completeness of the THP sample, lists of recently completed THPs subject to FORPRIEM Monitoring were generated quarterly using the FPS database and the FORPRIEM random pick-lists. These lists of THP numbers were checked against lists of FORPRIEM monitoring reports received in Sacramento, and responsible Forest Practice Inspectors were contacted regarding missing reports. A similar process was used for NTMP-NTOs. Completeness of the THP and NTO-NTMP samples is discussed above under the heading Random Selection of Plans.

Distribution of FORPRIEM THPs and Comparison to Previous Monitoring Programs

The Modified Completion Report monitoring program (MCR) and the Hillslope Monitoring Program (HMP) considered the geographic distribution of plans in terms of CAL FIRE's Administrative Areas. While FORPRIEM-monitored plans were also evaluated in that context, in light of FPR changes that were first part of the Threatened or Impaired (T/I) rules and later revised into the Anadromous Salmonid Protection (ASP) rule package, it is informative to look at the distribution of FORPRIEM-monitored THPs and NTMP-NTOs in ASP and non-ASP areas (Figure 2). Of 126 THPs in the FORPRIEM sample, 94 were located within the ASP rules area and 32 were outside the ASP rules area. All 24 of the NTMP-NTOs in the FORPRIEM sample were located within the ASP rules area.

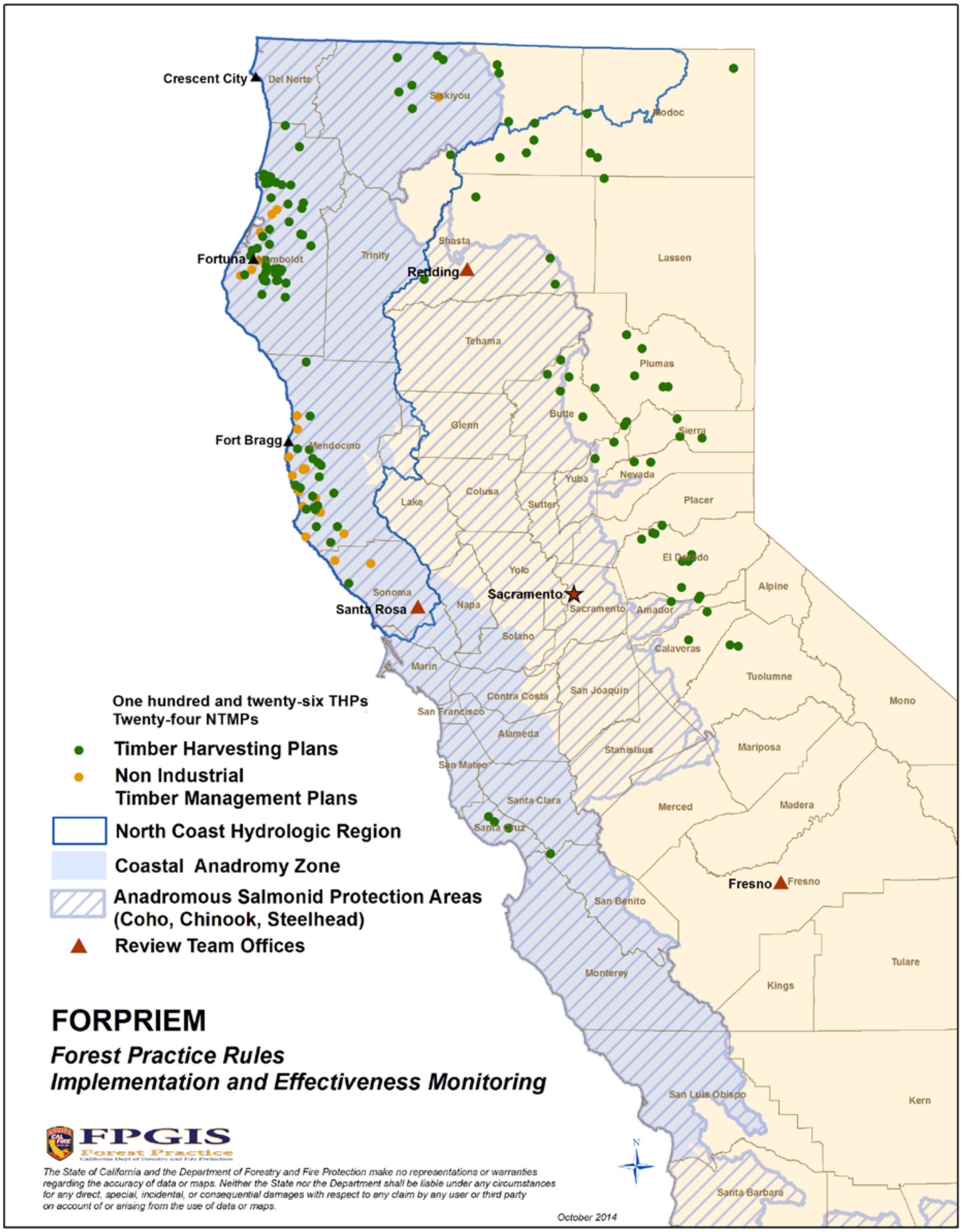

Figure 2. Map showing the geographic distribution of FORPRIEM-monitored THPs and NTMP-NTOs in the North Coast Hydrologic Region, Coastal Anadromy Zone, and the Anadromous Salmonid Protection (ASP) rules area.

CAL FIRE has four Administrative Areas, three of which were included in this monitoring study and will be referred in this report by short, descriptive names:

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

South 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. This region contains very little private or state commercial forest land and generates very few THPs. Consequently, South Region 3 was not included in this study. Also, in some portions of the report, the combined areas of Inland North and Inland South are referred in the aggregate as simply "Inland."

Locations of THPs and NTMP-NTOs randomly selected for FORPRIEM monitoring are shown plotted on a map with CAL FIRE Administration Areas in Figure 3.

FORPRIEM monitoring was conducted on 126 randomly sampled THPs, plus 24 NTMP-NTOs. In contrast, the MCR monitoring program utilized 281 randomly sampled THPs, while the HMP analyzed data from 300 plans (295 THPs and 5 NTMP-NTOs). The number of plans evaluated for FORPRIEM is considerably lower than the earlier monitoring programs due to (1) a lower number of plans submitted to CAL FIRE in recent years as the cost of plan preparation has risen (producing larger plans); and (2) the HMP had a set number of plans sampled every year (50 plans).

The distribution of plans is generally similar for the FORPRIEM, MCR, and HMP monitoring programs. For FORPRIEM monitoring, the percentages of Coast (R-1), Inland North (R-2) and Inland South (R-4) plans were 52%, 34% and 14%, respectively (Figure 4). For MCR monitoring, the percentages of Coast (R-1), Inland North (R-2) and Inland South (R-4) plans were 52%, 27% and 21%, respectively (Figure 5). For the HMP, the percentages of Coast (R-1), Inland North (R-2), and Inland South (R-4) plans were 61%, 26% and 13%, respectively (Figure 6).[2] Simplifying the comparison by combining the inland categories gives a Coast vs. Inland ratio of approximately 50/50 for the FORPRIEM and MCR samples of THPs, and about 60/40 for the Hillslope Monitoring Program sample. The difference can be attributed to the fact that HMP plans were administratively closed and permission for access was required from the landowner. Permission was granted for all but one THP for large landowners, but more than 50% of the selected small nonindustrial timberland plans were excluded due to an inability to obtain legal access (weighting the sample toward the industrial timberlands). In contrast, FORPRIEM and MCR plans were not closed and written permission for access was not necessary, resulting in an unbiased sample.

[2] Note that CAL FIRE's Administrative Areas are different than the Forest Practice Districts established by the Forest Practice Act and used in the Forest Practice Rules.

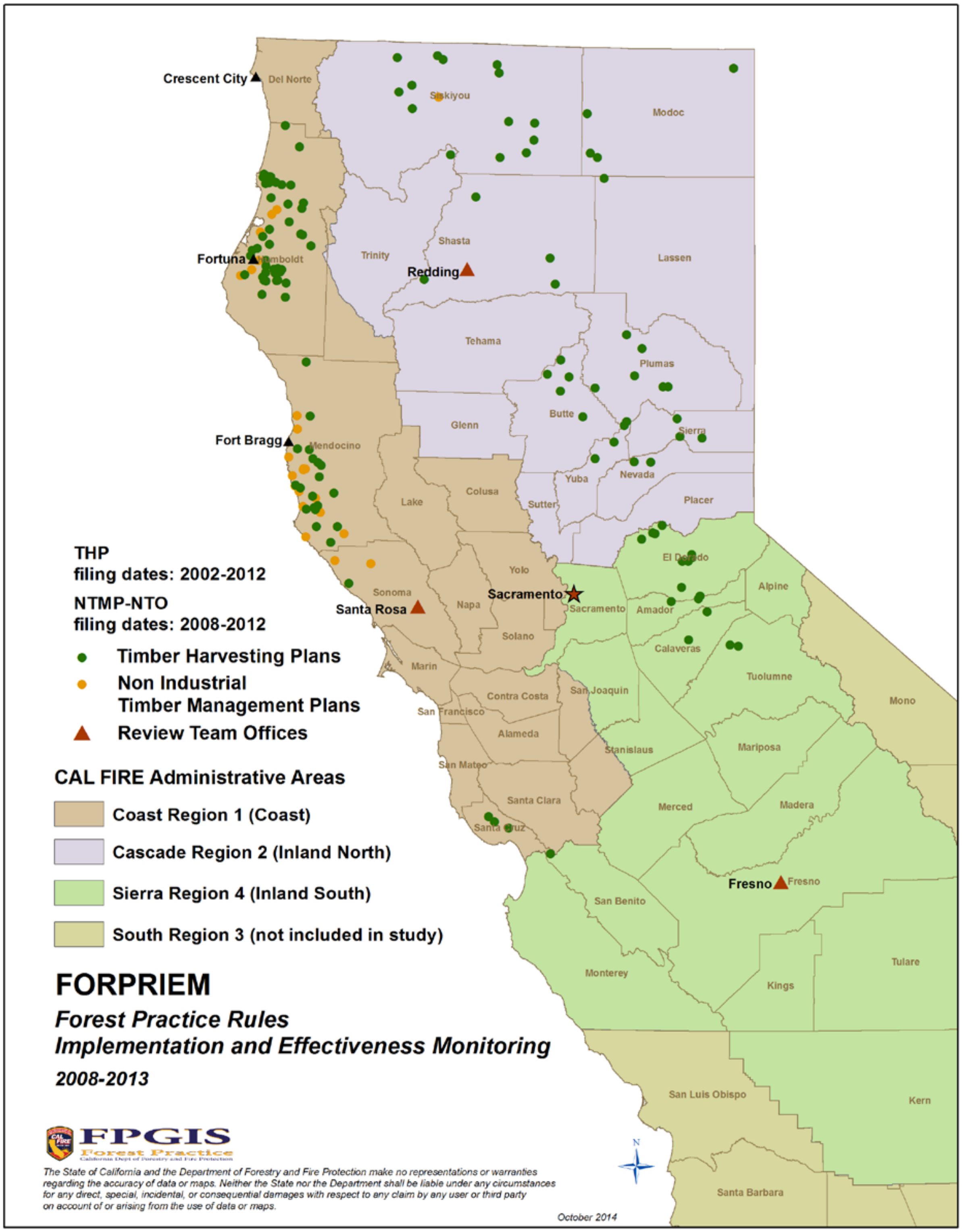

Figure 3. Map showing the geographic distribution of FORPRIEM-monitored THPs and NTMP-NTOs in relation to CAL FIRE Administrative Areas.

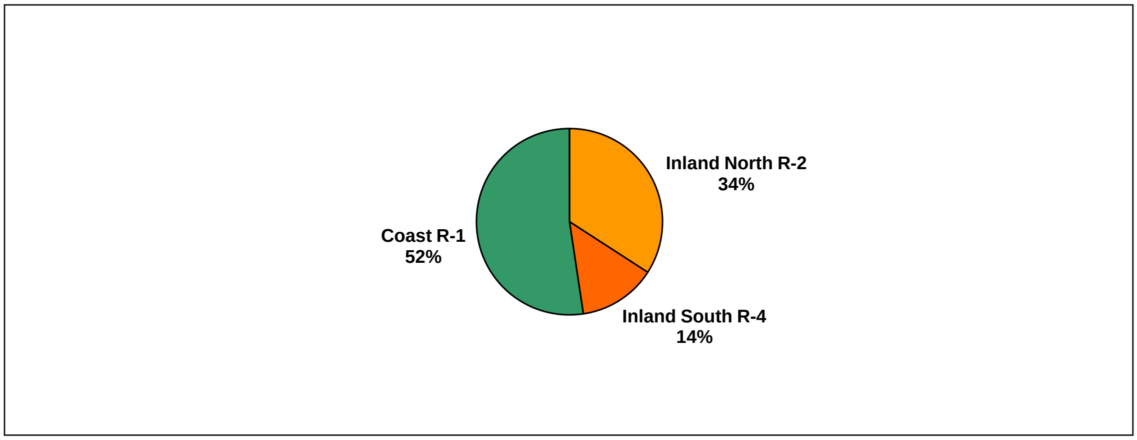

Figure 4. Distribution of FORPRIEM randomly sampled THPs by CAL FIRE Administrative Area.

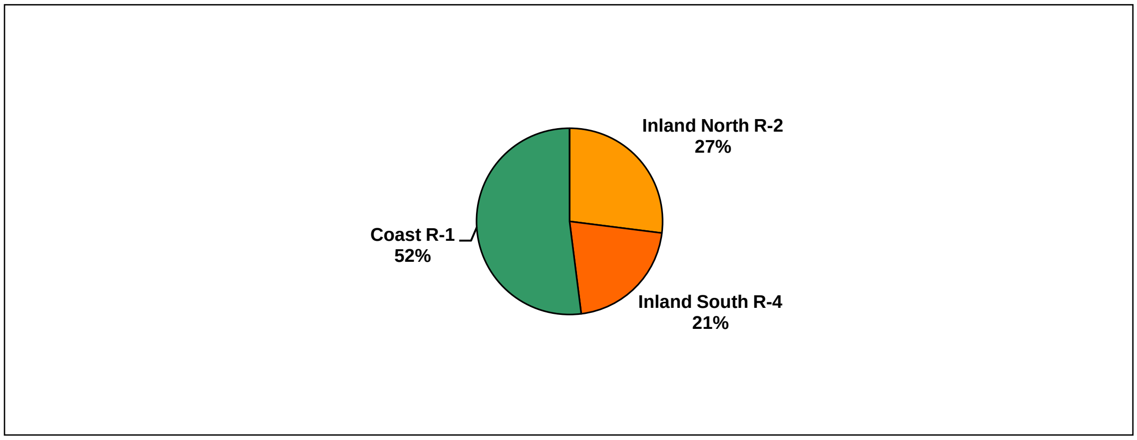

Figure 5. Distribution of MCR randomly sampled THPs by CAL FIRE Administrative Area.

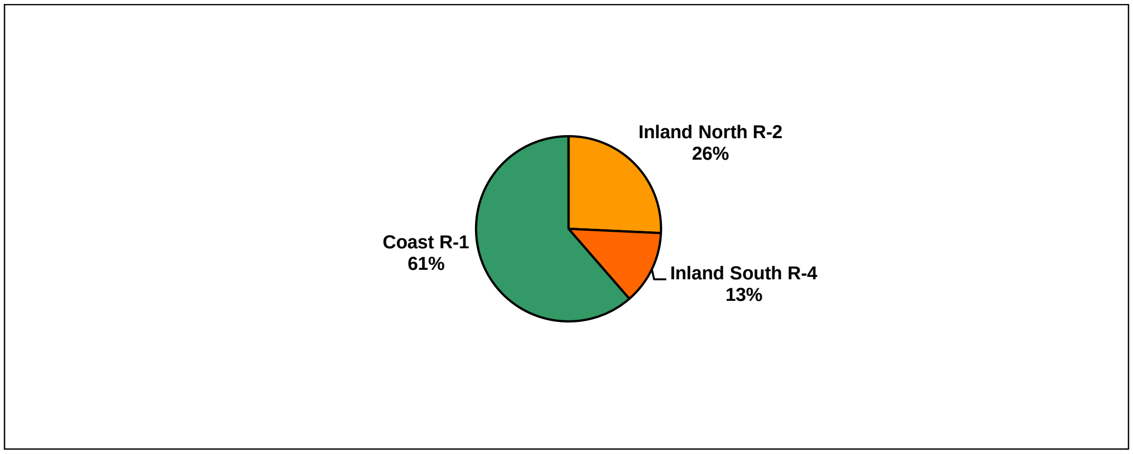

Figure 6. Distribution of HMP randomly sampled THPs by CAL FIRE Administrative Area.

Random Site Selection within Randomly Selected THPs and NTMP-NTOs

Up to four randomly located monitoring sites were selected for each THP or NTMP-NTO. These included:

1) A 200-foot WLPZ segment along a Class I or Class II watercourse,
2) A 660-foot (1/8-mile) road segment, and
3) Two crossings of Class I, Class II, or Class III watercourses.

For THPs and NTMP-NTOs that lacked one or more of these sites, forms were submitted with the notation: “Not applicable to this THP” or “Not applicable to this NTMP-NTO.”

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

The use of randomly selected sampling sites within the THP or NTMP-NTO allowed Forest Practice Inspectors to focus in detail on whether the FPRs applicable to that site (1) were properly implemented, and (2) appeared to be effective in protecting water quality by providing adequate riparian canopy and groundcover, as well as by preventing erosion, sediment transport, and discharge into channels.[3]

[3] Note that documentation of fine sediment delivery to watercourses during winter storm events was not undertaken with this program.

FORPRIEM Monitoring:
WLPZ Canopy, Groundcover, and Erosion

I. Methods

Monitoring Timelines and WLPZ Selection

A 200-foot long WLPZ segment was randomly selected for FORPRIEM monitoring from each of the randomly selected THPs and NTMP-NTOs with one or more WLPZ. This was not possible in some cases, because Class I or Class II watercourses were not present on all of the randomly selected plans. Within the WLPZ, sample segment zone width and percent total canopy were measured (Figure 7), 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 during this harvesting entry.

Figure 7. Ken Margiott, CAL FIRE, measures total canopy for FORPRIEM (92%) on August 16, 2011. WLPZ harvesting had occurred as part of this NTMP-NTO (1-97NTMP-018 MEN #6, Mill Creek NTMP).

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). A scale was then used to mark 200-foot segments along all of the delineated WLPZs and each of these segments was given a unique number in sequential order. A random number between one 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 watercourse 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 WLPZ canopy enforcement inspections. For enforcement purposes, segments are selected for canopy measurement based on apparent violations of the Forest Practice Rules. Therefore, enforcement data represents worst-case post-harvest WLPZ conditions, while FORPRIEM measurements represent average WLPZ conditions for the study period.

The FORPRIEM procedures used for WLPZ canopy measurement were essentially the same as the MCR procedures. MCR procedures were a modified version of the Pre-Harvest Inspection (PHI) and enforcement action procedures developed by Robards (1999). In all three procedures (FORPRIEM, MCR and PHI/enforcement action), canopy is determined using a vertical sighting tube[4], but the FORPRIEM and MCR procedures require 50 observations per WLPZ segment, compared to 100 observations for the PHI/enforcement action. Average WLPZ width for the FORPRIEM and MCR procedures was determined by pacing or measurement within the segment sampled for canopy cover, and groundcover was estimated by ocular observation. Additionally, fresh erosion features in the FORPRIEM 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 FORPRIEM sampling include 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 FORPRIEM sample length is 200 feet, this equation can be simplified to:

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[4] Robards et al. (2000) reported that use of the vertical siting tube on a systematic grid is the preferred method for accurate estimation of canopy. Analyses of the spherical densiometer as a tool for measuring vertical overstory canopy cover revealed that the sample collected did not enable an inference to the population and was biased.

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

When applied to standard WLPZ widths of 50, 75, 100, and 150 feet, D equals 14, 17, 20 and 24 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 (WTL), as defined in the Forest Practice Rules, 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.[5] The WLPZ transect was then turned 90º for distance D to start 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 8.

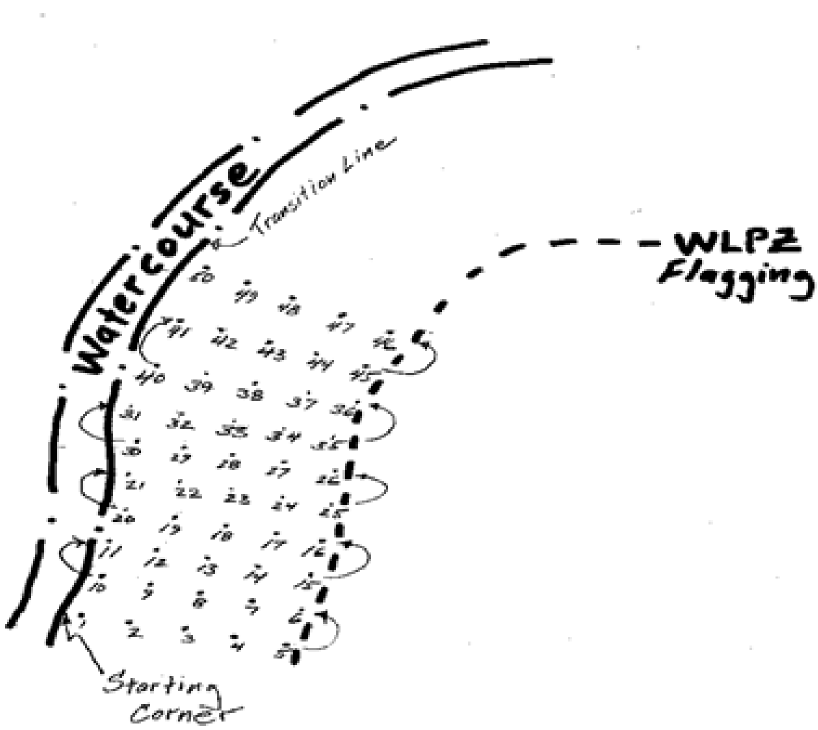

Figure 8. Typical pattern of canopy measurement points with a vertical sighting tube and groundcover observation points within a randomly sampled Class I or II WLPZ segment.

[5] On very steep ground, D was either estimated or measured with a loggers tape.

At each sample point, the Forest Practice Inspector recorded total canopy as either a hit or miss, using a sighting tube (Figure 9) as follows: (1) the sighting tube was leveled in front of one eye using the horizontal and vertical bubbles (Figure 10), (2) the dot in the center of the tube was lined up with the circle in the center of the tube, and (3) the dot was evaluated as to whether it intercepted vegetation above the observer, such as needles, a leaf, or a tree branch (Figures 11 and 12).[6] 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.

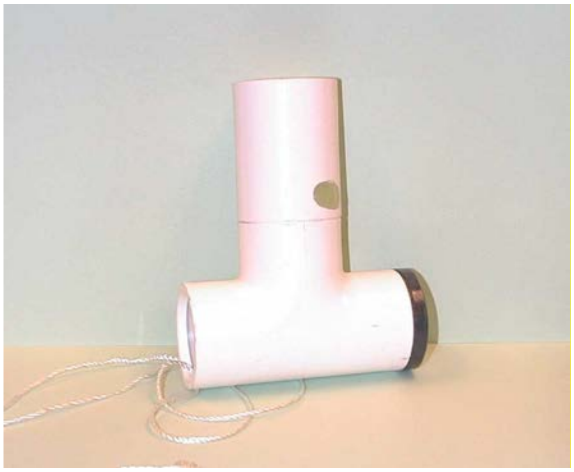

Figure 9. Example of a vertical sighting tube used for making WLPZ canopy measurements.

Figure 10. Standard procedures for use of the sighting tube included bringing the instrument up to the observer's eye, centering the two leveling bubbles, moving the observer's head slightly to center the dot in the circle, determining if canopy exists above the instrument, and recording a hit or miss on the data form.

[6] Overstory and understory vegetation were not differentiated in this program. Total canopy is composed of overstory and/or understory vegetation canopy.

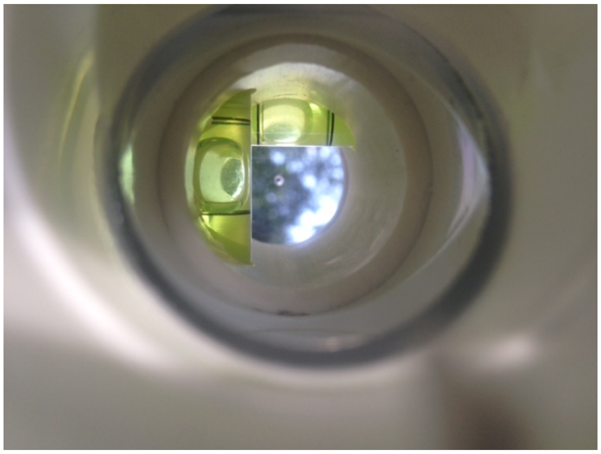

Figure 11. Example of a sighting tube “hit,” one of 50 hits and misses recorded in a total canopy WLPZ monitoring segment.

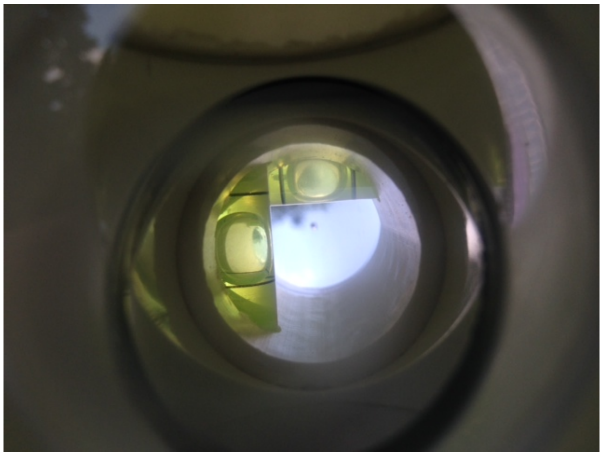

Figure 12. Example of a sighting tube “miss,” one of 50 hits and misses recorded in a total canopy WLPZ monitoring segment.

The proportion of the ground surface covered with duff, litter, gravel larger than ¾ inch, and other protective material was also estimated. 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); if there had been harvesting, how much canopy was removed in this entry using four categories: <10%, 10-30%, 30-50%, and >50%; if overstory canopy remaining after harvest equaled or exceeded 50% (ocular estimate); if understory canopy remaining equaled or exceeded 50% (ocular estimate); if the Class I watercourse was in a T/I or ASP rules watershed, and if so, if overstory canopy met these standards (ocular estimate); and if WLPZ groundcover equaled or exceeded 75%.[7]

An example of a completed form is included in the FORPRIEM Monitoring Procedures and Methods (see the Appendix).

II. THP WLPZ Results

WLPZ segments were located in 103 of the 126 THPs included in the FORPRIEM sample. The regional distribution was 60 WLPZ segments in the Coast (Region 1), 30 in the Inland North (Region 2), and 13 WLPZ segments in the Inland South (Region 4). In terms of watercourse classification, 23 of the WLPZ segments were along Class I watercourses and 80 were associated with Class II watercourses.

The total length of Class I WLPZ in the sampled THPs was 2,200 feet in the Coast Region (Region 1), 1,600 feet in the Inland North (Region 2), and 800 feet in the Inland South (Region 4). This equates to a total 4,600 feet or 0.9 miles. For Class II watercourses, the total WLPZ length in the sampled THPs was 9,800 feet in the Coast Region (Region 1), 4,400 feet in the Inland North (Region 2), and 1,800 feet in the Inland South (Region 4). The total Class II WLPZ length sampled was 16,000 feet or 3.0 miles.

THP Percent Total WLPZ Canopy

Statewide, THP WLPZs with completion inspections filed between 2008 and 2013 had an average percent total canopy of 82% (Table 1) The median value for WLPZ total canopy was slightly higher at 84%, due to the fact there are more values at the high end of the distribution than the low end (Figure 13).

Comparing THP WLPZ percent total canopy for Class I and Class II watercourses, the means are 81% and 82%, respectively. The median values are 82% and 85%, respectively (Table 2). Again the medians are slightly higher than the means due to the distribution of the data.

[7] Robards et al. (2000) reported that ocular estimates of overstory canopy underestimated true overstory canopy values for a test area in the northern part of the Coast Ranges of California.

Table 1. Overall THP WLPZ percent total canopy.

THP WLPZ Total Canopy Overall
Mean = 82% **s.d. = 15** **n = 103** Median = 84%

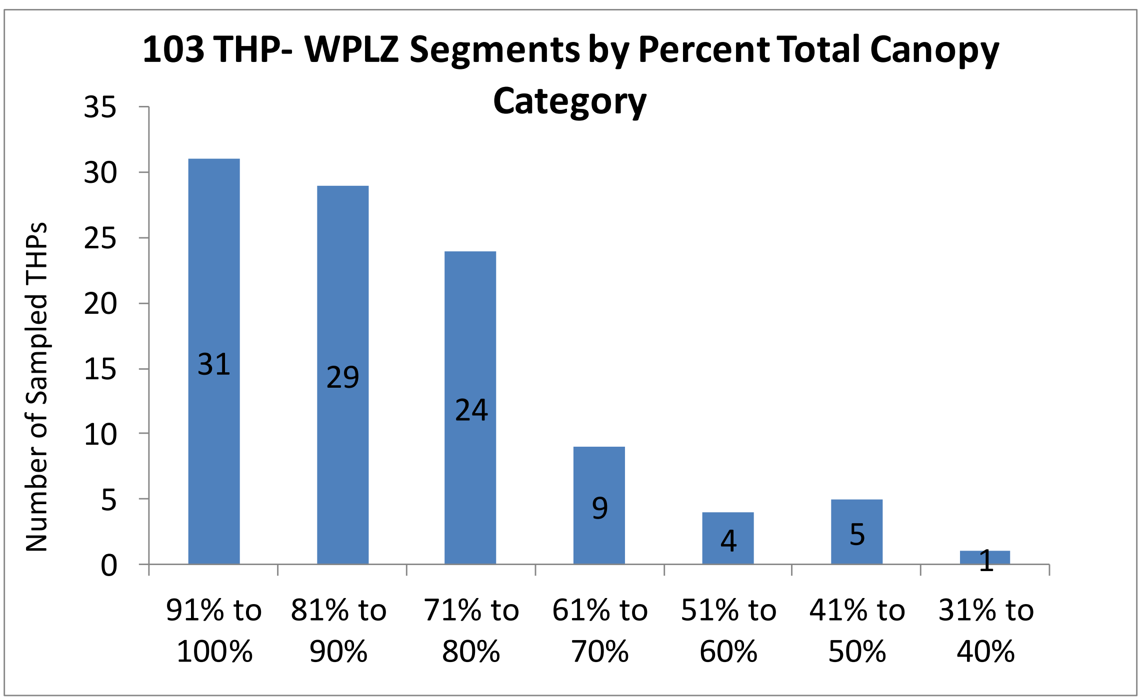

Figure 13. Distribution of the 103 THP WLPZ segments by percent total canopy category. There are more segments at the high end of the distribution than at low end. As a consequence, the median is slightly higher than the mean.

Table 2. THP WLPZ percent total canopy by watercourse class.

THP WLPZ Total Canopy Class I Watercourses	THP WLPZ Total Canopy Class II Watercourses
Mean = 81% **s.d. = 18** **n = 23** Median = 82%	Mean = 82% **s.d. = 14** **n = 80** Median = 85%

Comparing THP WLPZ percent total canopy for segments with no harvest versus harvested segments, the means are 80% and 82%, respectively. The median values are 87% and 82%, respectively (Table 3).

Table 3. THP WLPZ percent total canopy by no harvest vs. harvest in the WLPZ.

THP WLPZ Total Canopy No Harvest	THP WLPZ Total Canopy Harvest
Mean = 80% **s.d. = 18** **n = 52** Median = 87%	Mean = 82% **s.d. = 10** **n = 51** Median = 82%

Among the 52 THP WLPZ total canopy values with no harvest, there were six very low values (<50%), all in the Inland Regions (R-2 and R-4). There were no values below 50% in the 51 THP WLPZ total canopy values with harvest. These six low values among the no harvest sample population resulted in the WLPZ with no harvest mean being slightly lower than the WLPZ with harvest mean. Calculation of median values, where half the values are higher and half are lower, tends to discount a small number of very low values, resulting in the WLPZ median with no harvest being higher than the WLPZ median with harvest, as would be expected.

The oldest THP in the FORPRIEM random sample was submitted for approval to CAL FIRE in 2002. This means that all of the sampled THPs that were within what is now known as the ASP rules area had to either comply with the Threatened or Impaired (T/I) rules (THPs submitted July 2000-2009) or the ASP rules (2010-present). The THPs in the sample located outside the ASP rules area do not. Out of 103 THP WLPZs in in the sample, 70 were in the T/I or ASP rules area. Figure 14 shows the distribution of their submission dates to CAL FIRE for approval.

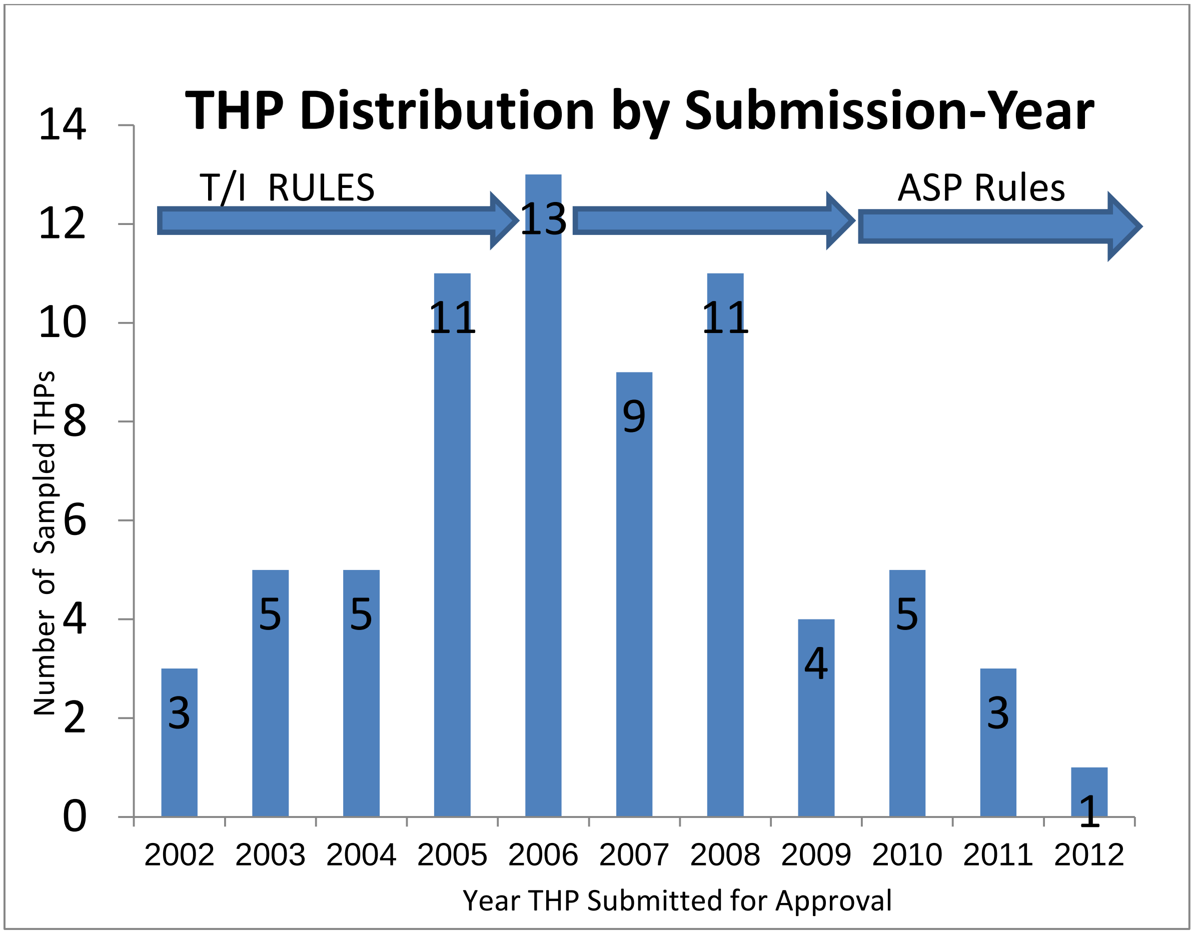

Figure 14. Distribution of the 70 THP WLPZ segments within the ASP rules area by the years that the THPs were submitted to CAL FIRE for approval.

Because WLPZ canopy is a critical issue for salmonid protection, it is useful to sort the sampled THPs by ASP rules area and non-ASP rules area. Comparing THP WLPZ percent total canopy for the area covered by the ASP rules versus outside the ASP rules area, the means are 86% and 73%, respectively.[8] The median values are 88% and 72%, respectively. Both the mean and median values for WLPZ percent total canopy are higher for the ASP rules area than for the non-ASP rules area (Table 4).

[8] A two sample T test comparing mean canopy values revealed that the means of these groups are significantly different at alpha = 0.01.

Table 4. Comparison of THP WLPZ percent total canopy by ASP rules area versus non-ASP rules area for several categories (overall, Class I watercourses, Class II watercourses, no harvest and harvest in the WLPZ).

	THP WLPZ Total Canopy ASP Rules Area	THP WLPZ Total Canopy Non-ASP Rules Area
Overall	Mean = 86% **s.d. = 13** **n = 70** Median = 88%	Mean = 73% **s.d. = 16** **n = 33** Median = 72%
Class I	Mean = 88% **s.d. = 11** **n = 15** Median = 88%	Mean = 67% **s.d. = 24** **n = 8** Median = 69%
Class II	Mean = 85% **s.d. = 16** **n = 55** Median = 88%	Mean = 73% **s.d. = 15** **n = 25** Median = 74%
No Harvest	Mean = 86% **s.d. = 15** **n = 38** Median = 90%	Mean = 67% **s.d. = 20** **n = 14** Median = 69%
Harvest	Mean = 87% **s.d. = 24** **n = 32** Median = 86%	Mean = 75% **s.d. = 11** **n = 19** Median = 78%

The ASP rules area versus non-ASP rules area values can be further sorted by watercourse class, and also by harvest versus no harvest (Table 4).   In all cases, THP WLPZ percent total canopy is higher for the ASP rules area than for non-ASP rules area.

This is partially a function of higher requirements for canopy, but also a function of the fact that the ASP rules area is predominantly coastal and the non-ASP rules area is predominantly inland. Lower inland canopy values are likely related to warmer, drier conditions and the presence of slower growing tree species. Generally the inland areas have lower site productivity relative to the coastal areas.

Another way to sort the WLPZ canopy data, as has been used in the past monitoring programs, is by CAL FIRE Administrative Area (Figure 3): Coast Region 1, Cascade Region 2 (Inland North) and Sierra Region 4 (Inland South) (Tables 5 and 6). Figure 15 compares THP WLPZ percent total canopy for Class I and Class II watercourses by Administrative Area. In each Administrative Area, the Class I and Class II values are similar. As was found in previous studies, the Coast Region has higher average values than the Inland North and Inland South Regions. As previously stated for the ASP rules area vs. non-ASP rules area comparison, the primary reasons are (1) higher canopy rule requirements in the ASP rules area; and (2) greater precipitation in the Coast Region, which results in more rapid conifer and hardwood growth rates (Figure 16).

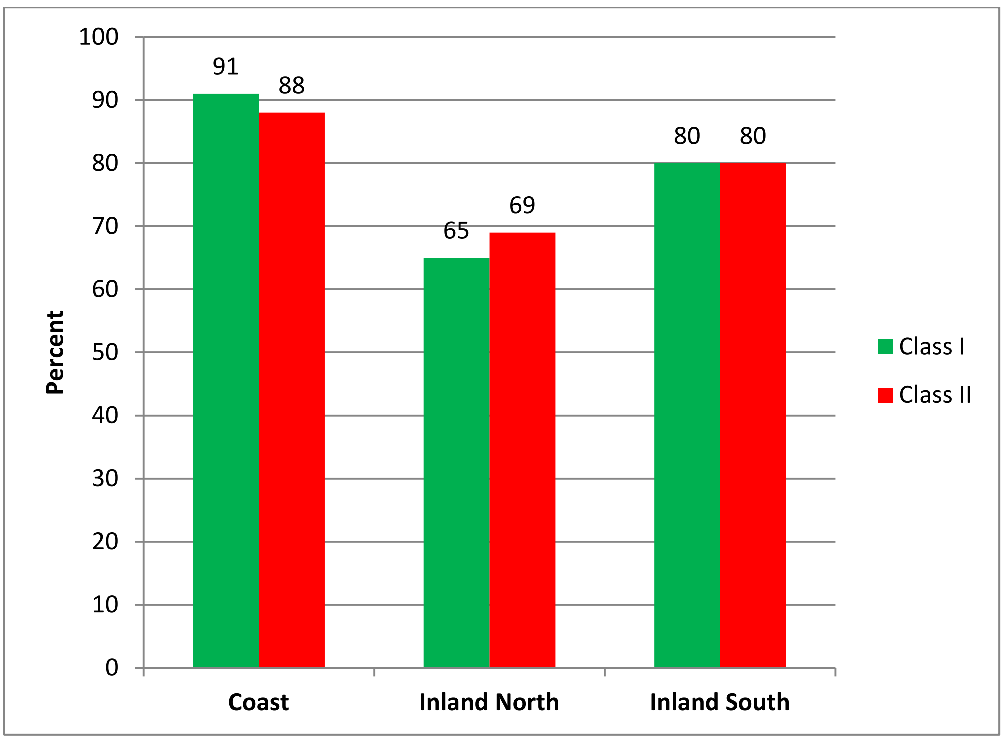

Figure 15. THP WLPZ percent total canopy by CAL FIRE Administrative Area, comparing Class I and Class II watercourses.

Table 5. Average percent total canopy in WLPZs by CAL FIRE Administrative Area—overall, no harvest, and harvest. The number of segments included in each average equals "n."

	THP WLPZ Total Canopy Overall	THP WLPZ Total Canopy No Harvest	THP WLPZ Total Canopy Harvest
Coast (Region 1)	Mean = 89% **s.d. = 10** **n = 60** Median = 90%	Mean = 90% **s.d. = 12** **n = 28** Median = 92%	Mean = 87% **s.d. = 9** **n = 32** Median = 87%
Inland North (Region 2)	Mean = 68% **s.d. = 15** **n = 30** Median = 68%	Mean = 68% **s.d. = 18** **n = 20** Median = 69%	Mean = 68% **s.d. = 9** **n = 10** Median = 67%
Inland South (Region 4)	Mean = 80% **s.d. = 13** **n = 13** Median = 82%	Mean = 75% **s.d. = 23** **n = 3** Median = 74%	Mean = 82% **s.d. = 9** **n = 10** Median = 85%

Table 6. Average percent total canopy in WLPZs by CAL FIRE Administrative Area for Class I and Class II watercourses. The number of segments included in each average equals “n.”

	THP WLPZ Total Canopy Overall	THP WLPZ Total Canopy Class I	THP WLPZ Total Canopy Class II
Coast (Region 1)	Mean = 89% **s.d. = 10** **n = 60** Median = 90%	Mean = 91% **s.d. = 9** **n = 11** Median = 98%	Mean = 88% **s.d. = 11** **n = 49** Median = 90%
Inland North (Region 2)	Mean = 68% **s.d. = 15** **n = 30** Median = 68%	Mean = 65% **s.d. = 20** **n = 8** Median = 67%	Mean = 69% **s.d. = 14** **n = 22** Median = 68%
Inland South (Region 4)	Mean = 80% **s.d. = 13** **n = 13** Median = 82%	Mean = 80% **s.d. = 11** **n = 4** Median = 81%	Mean = 80% **s.d. = 14** **n = 4** Median = 82%

Figure 16. Example of a Coast Region Class II WLPZ in the FORPRIEM THP sample. Total canopy was 82% (THP 01-05-246 HUM).

THP WLPZ Erosion

Of the 103 THP WLPZs sampled, 12 (~12%) had one or more erosion features recorded, mostly not related to the current harvesting operation. Only one of 103 THP WLPZs sample segments had erosion (rilling) related to the current entry. The cause was a patch of bare soil exceeding the size allowed by the Forest Practice Rules.

Other THP WLPZ Results

Other WLPZ information collected as part of FORPRIEM included ocular estimates of canopy removal, overstory canopy, understory canopy, and groundcover.

For all three Administrative Areas (Coast, Cascade, and Sierra Regions), actual Class I WLPZ widths as paced or measured were equal (within ± 10 feet) to the width prescribed in the THP 65% of the time, greater than prescribed 35% of the time, and less than prescribed zero percent of the time. For Class II WLPZ widths using the same criteria, WLPZ widths as paced or measured were equal to the width prescribed in the THP 61% of the time, greater than prescribed 38% of the time, and less than prescribed one percent of the time.

The average prescribed WLPZ widths for Class I watercourses were 149 feet, 86 feet, and 94 feet for the Coast, Inland North, and Inland South, respectively. As stated above, WLPZ widths measured on the ground were generally wider than prescribed widths. The average actual widths for Class I watercourses were 161 feet, 86 feet, and 134 feet for the Coast, Inland North, and Inland South, respectively. On Class II watercourses, the average prescribed WLPZ widths were 91 feet, 64 feet, and 67 feet for the Coast, Inland North, and Inland South, respectively. As with Class I watercourses, the actual widths were wider than the prescribed widths on average. The average measured widths were 100 feet, 69 feet, and 79 feet for the Coast, Inland North, and Inland South, respectively.

Canopy removal by current timber operations within sampled WLPZ segments was minimal in most cases. For Class I watercourses in all Regions, 14 of the 23 WLPZ segments had no canopy removal, eight had less than 10% of the canopy removed, one had 10% to 30% of the canopy removed, and none had more than 30% canopy removal. For Class II watercourses in all Regions, 41 of the 80 WLPZ segments had no canopy removal, 23 had less than 10% removed, 10 had 10% to 30% removed, three had 30-50% removed, and three had more than 50% canopy removal.

Total canopy has two components: understory canopy and overstory canopy.[9] Based on ocular estimates, the remaining understory canopy in Class I WLPZs was 50% or greater 96% of the time, and the remaining overstory canopy was 50% or greater 91% of the time. Likewise for Class II WLPZs, remaining understory canopy was 50% or greater 90% of the time, and remaining overstory was 50% or greater 90% of the time.

The interim Threatened or Impaired Watershed Rule Package Requirements (T/I Standards) for overstory canopy came into effect on July 1, 2000, and the permanent ASP rules became effective January 1, 2010. The T/I rules only applied to Class I watercourses in watersheds with listed salmonids for THPs filed after mid-year 2000, while the ASP rules apply to both Class I and II watercourses.[10] To the question "Does this Class I watercourse meet the T/I standards?", Inspectors answered 15 WLPZs met the standards, zero did not, and for eight the standards were not applicable.

Groundcover of 75% or greater is the standard used in the FPRs; 70% groundcover has been found to be a threshold needed to reduce surface erosion in forested watersheds (Robichaud 2004). Class I WLPZ percent groundcover was estimated to be equal to or greater than 75% on average 96% of the time for all the Regions combined, and 100%, 88%, and 100% of the time for the Coast, Inland North, and Inland South, respectively. Class II WLPZ percent groundcover was equal to or greater than 75% on 100% of the plans evaluated. Untreated patches of bare mineral soil equal to or greater than 800 square feet, the threshold specified for non-ASP areas in the FPRs, were not reported in any of the Class I or Class II WLPZs.

[9] Overstory, as defined by the Forest Practice Rules, is that portion of the trees, in a forest of more than one story, forming the upper canopy layers. Overstory is to be considered in the context of the entire WLPZ area being sampled, not based on the particular tree relative to its immediate neighbors.

[10] The FORPRIEM monitoring program did not account for changes incorporated with the ASP rules, since it began prior to ASP rules implementation in January 2010.

III. NTMP-NTO WLPZ Results

FORPRIEM monitoring was expanded to include a random sample of NTMP–NTOs in 2011. Of the 24 NTMP–NTOs monitored through 2013, 22 were in the Coast Region, one was in Inland North Region, and one was in the Inland South Region. Twenty of the 24 NTMP–NTOs had monitored WLPZs, 19 of which were located in the Coast Region; all 20 were in the North Coast Hydrologic Region and the ASP rules area (Figure 2). One NTMP-NTO WLPZ was located in the Inland North Region. In terms of watercourse classification, four of the WLPZ segments were located along Class I watercourses and 16 were associated with Class II watercourses.

The total length of Class I WLPZ in the sampled NTMP-NTOs was 800 feet (0.1 miles). For Class II watercourses, the total WLPZ length in the sampled NTMP-NTOs was 3,200 feet or 0.6 miles.[11]

NTMP-NTO Percent Total WLPZ Canopy

The overall average NTMP-NTO total WLPZ canopy was 91%. The median value for WLPZ total canopy was slightly higher at 93%, due to the fact that there are more values at the high end of the distribution than the low end (Table 7, Figure 17).

Table 7. NTMP-NTO WLPZ percent total canopy for the North Coast Hydrologic Region.

NTMP - NTO WLPZ Total Canopy ASP Rules Area
Mean = 91% **s.d. = 11** **n = 20** Median = 93%

[11] Since 19 of the 20 NTMP-NTO WLPZs were located in Coast Region 1 and all were in the North Coast Hydrologic Region, only totals are reported here.

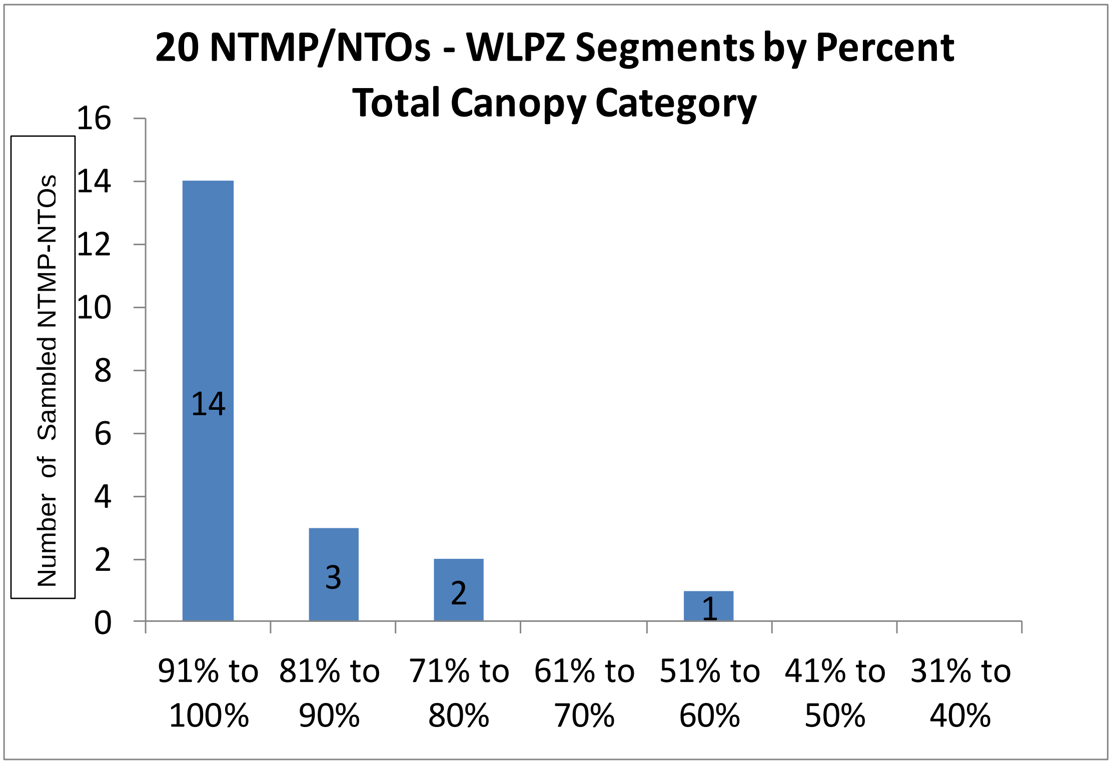

Figure 17. Distribution of the 20 NTMP-NTO WLPZ segments by percent total canopy category. There are more segments at the high end of the distribution than at low end. As a consequence, the median is slightly higher than the mean.

The NTMP–NTO total canopy average of 91% is slightly higher than the average value of 86% determined for the THP ASP rules area (Table 8). This may reflect that less intensive silviculture is a requirement for NTMPs.

Additionally, the NTMP-NTO total canopy data were stratified by Class I and Class II watercourse and by harvest vs. no harvest (Table 9). In all cases, WLPZ percent

Table 8. NTMP-NTO vs. THP WLPZ percent total canopy for the ASP rules area.

NTMP - NTO WLPZ Total Canopy ASP Rules Area	THP WLPZ Total Canopy ASP Rules Area
Mean = 91% **s.d. = 11** **n = 20** Median = 93%	Mean = 86% **s.d. = 13** **n = 70** Median = 88%

Table 9. NTMP-NTO vs. THP WLPZ percent total canopy for the ASP rules area, using the following categories: overall, Class I watercourses, Class II watercourses, no harvest and harvest in the WLPZ.

	NTMP - NTO WLPZ Total Canopy ASP Rules Area	THP WLPZ Total Canopy ASP Rules Area
Overall	Mean = 91% **s.d. = 11** **n = 20** Median = 93%	Mean = 86% **s.d. = 13** **n = 70** Median = 88%
Class I	Mean = 93% **s.d. = 8** **n = 4** Median = 88%	Mean = 88% **s.d. = 11** **n = 15** Median = 88%
Class II	Mean = 91% **s.d. = 19** **n = 12** Median = 88%	Mean = 85% **s.d. = 16** **n = 55** Median = 88%
No Harvest	Mean = 91% **s.d. = 13** **n = 12** Median = 94%	Mean = 86% **s.d. = 15** **n = 38** Median = 90%
Harvest	Mean = 92% **s.d. = 7** **n = 8** Median = 93%	Mean = 87% **s.d. = 24** **n = 32** Median = 86%

Figure 18. Example of an NTMP-NTO Class II WLPZ measured for total canopy in Humboldt County (01-97NTMP-001).

total canopy was consistently higher for NTMP-NTOs than for similar THP categories (Figure 18). It should be noted that the sample size (n) for some of these categories is very small.

Other NTMP-NTO WLPZ Results

Actual Class I WLPZ widths as paced or measured were equal (within ± 10 feet) to the width prescribed in the NTMP-NTO 50% of the time and greater than prescribed 50% of the time. For Class II WLPZ widths using the same criteria, WLPZ widths as paced or measured were equal to the width prescribed in the NTMP-NTO 56% of the time and greater than prescribed 44% of the time.[12]

The average prescribed WLPZ width for Class I watercourses was 125 feet, while the average actual width for Class I watercourses on the ground was 141 feet. On Class II watercourses, the average prescribed WLPZ width was 81 feet and the average measured width was 91 feet.

As was the case with THPs, canopy removal by current timber operations within sampled WLPZ segments was minimal. For Class I watercourses, one of the four WLPZ segments had no canopy removal and three had less than 10% of the canopy removed. For Class II watercourses, 11 of the 16 WLPZ segments had no canopy removal, four had less than 10% removed, and one had 10% to 30% removed.

[12] Since 19 of the 20 NTMP-NTO WLPZs were located in Coast Region 1 and all were in the North Coast Hydrologic Region, only totals are reported in this section of the report.

Based on ocular estimates, the remaining understory and overstory canopy for Class I WLPZs was estimated to be 50% or greater in all cases. For Class II WLPZs, understory canopy was equal to or greater than 50% in all 16 cases, and for overstory canopy it was estimated to be 50% or greater 94% of the time. To the question “Does this Class I watercourse meet the T/I standards?”, Inspectors answered that all four WLPZs met the standards.

Regarding WLPZ groundcover, Class I and II WLPZ percent groundcover was estimated to be equal to or greater than 75% for all the WLPZs sampled. Similarly, untreated patches of bare mineral soil equal to or greater than 800 square feet were not reported in any of the NTMP-NTO Class I or Class II WLPZs.

WLPZ Erosion

None of the 20 NTMP-NTO WLPZ sample segments had any erosion features recorded.

IV. WLPZ QA/QC

As stated in the Study Design section of this report, field training for sampling and monitoring WLPZ percent total canopy using the FORPRIEM methods was provided to most of the CAL FIRE Forest Practice Inspectors who conducted the monitoring. The data were checked as they were sent to Sacramento for entry in the database. The data in the database were spot checked to make sure they were entered correctly.

Five FORPRIEM-monitored THPs were picked at random for re-monitoring. Four of the five THPs had monitored WLPZ segments. The THPs were revisited and the same four WLPZ segments were re-monitored (Figure 19). The results for WLPZ percent total canopy were similar for the first (original) site visit and the second (QA/QC) site visit.

Specifically, the original monitoring of the THP 1-05-064 HUM segment on February 27, 2013 produced a WLPZ percent total canopy of 86%; re-monitoring on August 23, 2013 produced a result of 86% (Figure 20). The original monitoring of THP 1-09-026 HUM on November 24, 2010 had a result of 100%; re-monitoring on August 22, 2013 produced a result of 98%. The original monitoring of THP 1-10-021 HUM on February 3, 2012 produced a result of 78%; re-monitoring on August 21, 2013 produced a result of 80%. The original monitoring of THP 2-04-193 SHA on May 1, 2013 produced a result of 80%; re-monitoring on August 16, 2013 produced a result of 82%. Based on the consistency and repeatability of these results, FORPRIEM appears to have produced high quality WLPZ percent total canopy data.

Figure 19. Measurement of total canopy in a Class II WLPZ as part of the QA/QC re-measurement for THP 2-04-193.

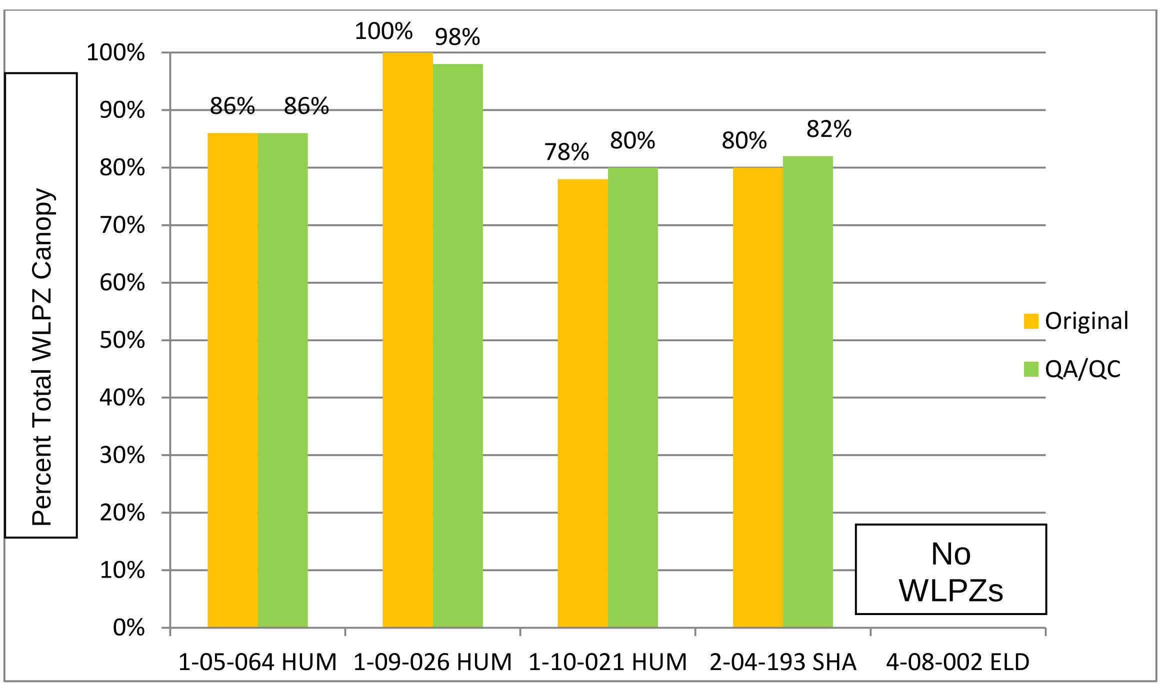

Figure 20. QA/QC – THP WLPZ percent total canopy. Five FORPRIEM-monitored THPs were picked at random for re-monitoring. Four of the five THPs had monitored WLPZ segments.

V. Discussion

FORPRIEM monitoring has shown that WLPZ percent total canopy is higher on average in the T/I and current ASP rules areas than outside these areas. Additionally, in the ASP rules area, average WLPZ percent total canopy is slightly higher for NTMP–NTOs than for THPs.

The FORPRIEM WLPZ total canopy data can be compared with the data reported earlier for previous monitoring programs, including the Hillslope Monitoring Program (HMP), with data collected between 1999 and 2001, and Modified Completion Report (MCR) monitoring, with data collected between 2001 and 2004. Comparing THP Class I WLPZ percent total canopy data for all three regions, there appears to be an improving trend over time: HMP 73%, MCR 78%, and FORPRIEM 81% (Figure 21). When the data are broken down by individual Region, there appears to be improvement in the Coast and Inland South Regions (Figure 22). Implementation of the T/I rules and later the ASP rules for Class I watercourses, requiring considerably higher post-harvest WLPZ canopy, likely explains improvement in the Coast Region.

Generally, the Forest Practice Rules retain high levels of post-harvest WLPZ canopy and prevent erosion in the WLPZ.

FORPRIEM results, as well as the earlier MCR and HMP results for WLPZ percent total canopy and groundcover, indicate that the FPR standards are generally being met.[13] 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.

FORPRIEM observations of WLPZ groundcover and erosion, similar to the earlier monitoring program results, indicate that WLPZs function well to prevent surface erosion in riparian zones.

[13] Post-harvest overstory canopy measurements were not made, precluding firm conclusions regarding compliance for Class I watercourse overstory canopy requirements.

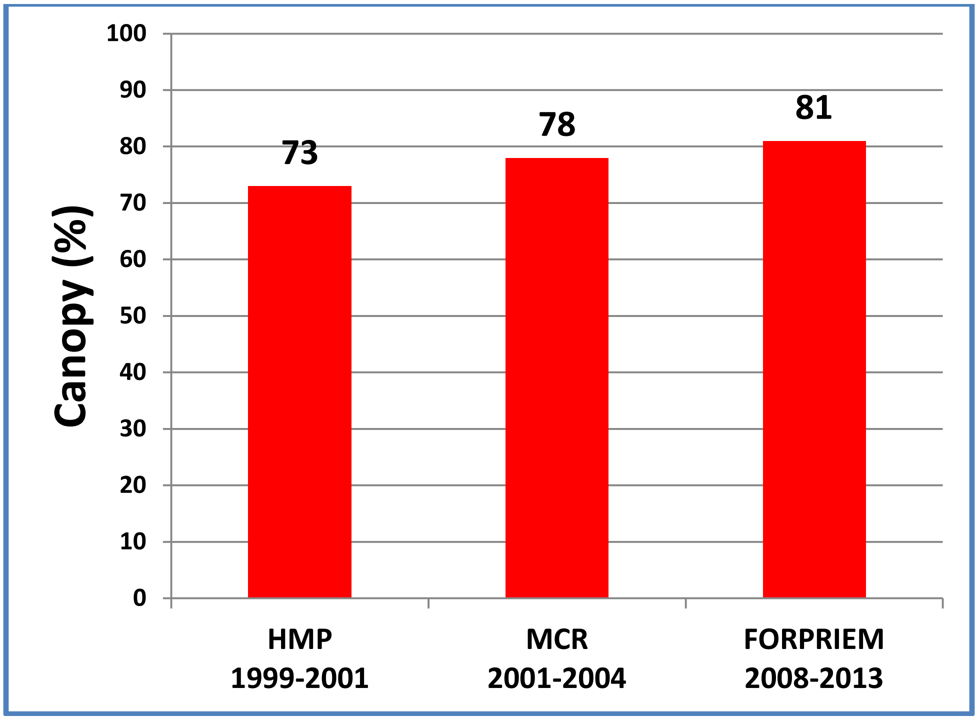

Figure 21. Comparison of THP Class I WLPZ percent total canopy measured with a sighting tube for three studies (HMP 1999-2001, MCR 2001-2004 and FORPRIEM 2008-2013).

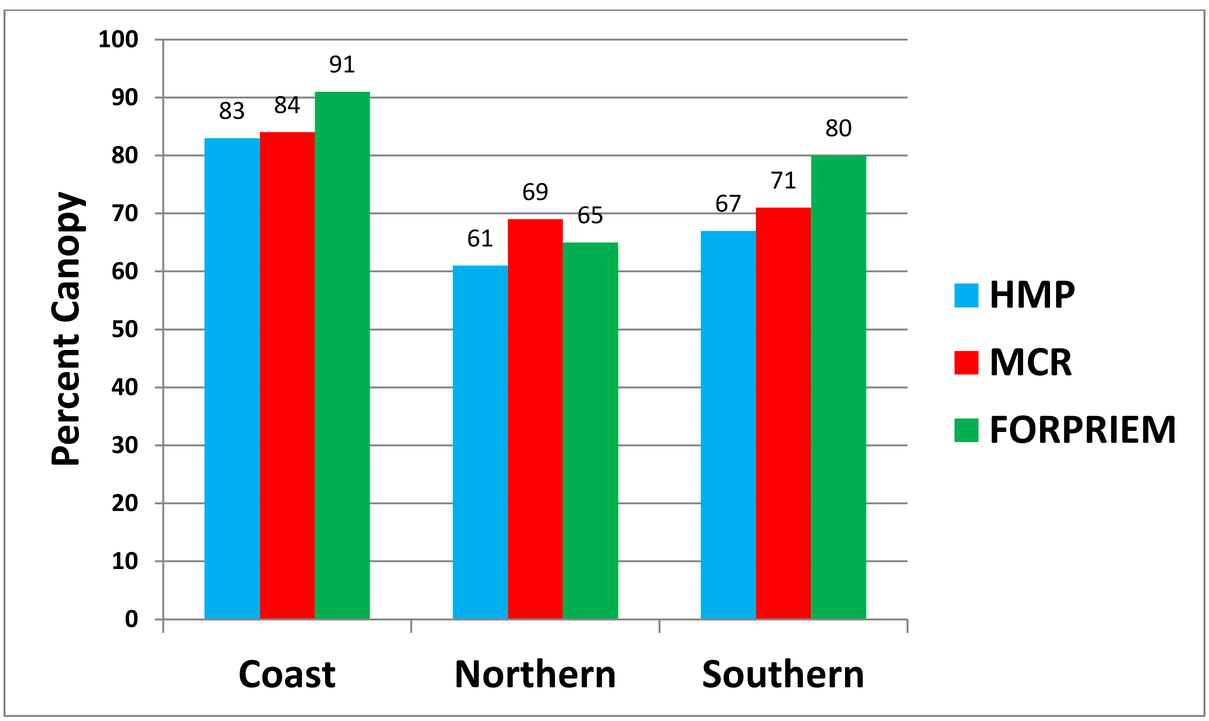

Figure 22. Comparison of THP Class I WLPZ percent total canopy by monitoring program and Region.

FORPRIEM Monitoring: Roads

I. Methods

Road Segment Selection and Monitoring Timelines

A 660-foot (1/8 mile) long road segment was randomly selected for FORPRIEM monitoring from each of the randomly selected THPs and NTMP–NTOs with logging roads suitable for monitoring. Results from randomly selected road segments when aggregated provide unbiased estimates of hillslope erosion, sediment transport off the road prism, and sediment transport to watercourse channels.

Selecting the 660-foot long road segment began with the CAL FIRE Forest Practice Inspector delineating the roads in the logging area, including appurtenant roads, on the plan map(s).[14] The Inspector divided these mapped roads into 660-foot segments and then numbered the road segments consecutively. Next, using a random number table or a random number generator, a numbered segment was selected at random for monitoring (Figures 23 and 24). In other words, the road segment corresponding to the random number was the one monitored in the field.

The randomly selected road segments were monitored twice: once for Forest Practice Rule implementation and once for effectiveness. The effectiveness monitoring was done after at least one overwintering period. Two site visits were required if the road segment had not gone through at least one winter period at the time of the effectiveness monitoring. Implementation and effectiveness monitoring were commonly completed during the same site visit if the road segment had gone through at least one winter season.

The tools needed to complete FORPRIEM road monitoring were (1) a pocket tape measure for documenting lengths, widths, and depths of erosion voids; (2) a string box (hip chain) for measuring distances; and (3) a clinometer for measuring road and side slope gradients (Figure 25). A roll of white flagging and a marking pen were used for marking and identifying both ends of the road segment. A set of FORPRIEM road monitoring forms and a clipboard were required for recording measurements and observations. A digital camera was optional for taking photographs of the road segment.[15]

[14] Roads that the landowner did not control road use and maintenance (e.g., county roads) were not included in this sample.
[15] Digital photographs were also optional for FORPRIEM watercourse crossings.

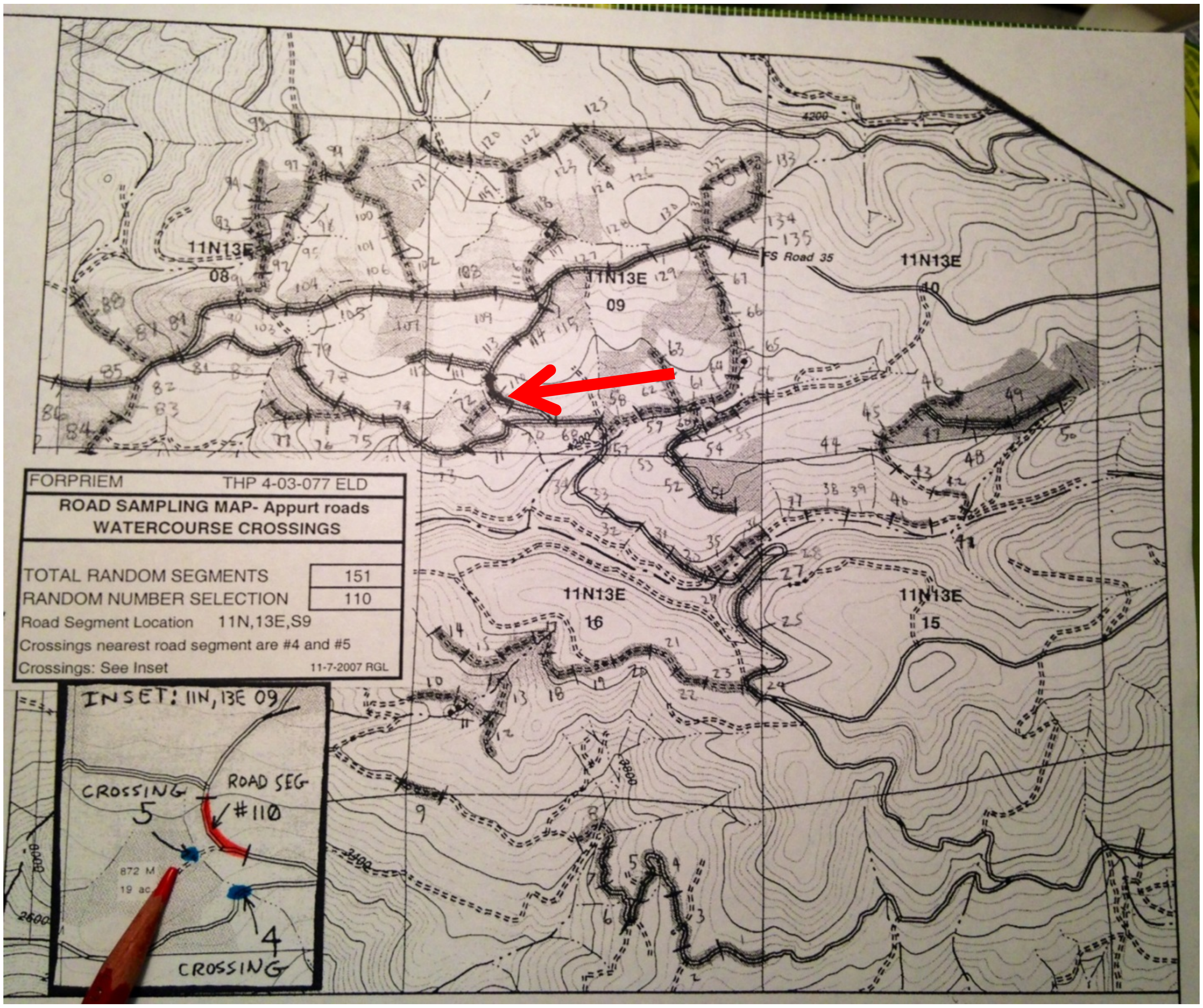

Figure 23. Example of a THP road map used in the FORPRIEM sample showing logging roads segmented and numbered. Road segment #110 (see arrow and inset) was randomly selected for monitoring using a random number generator. The two randomly selected watercourse crossings (Numbers 4 and 5) are also shown in the insert (see the Watercourse Crossing section of this report for additional information).

The FORPRIEM road form completed by CAL FIRE Forest Practice Inspectors was composed of six pages. The first page was used for recording site information (e.g., Erosion Hazard Rating (EHR), type of road, type of surfacing, position of the road on the hillslope, date of construction, and current status (existing or abandoned). Pages two through four were used to record information related to Forest Practice Rule implementation, and pages five and six were used to record information on effectiveness.

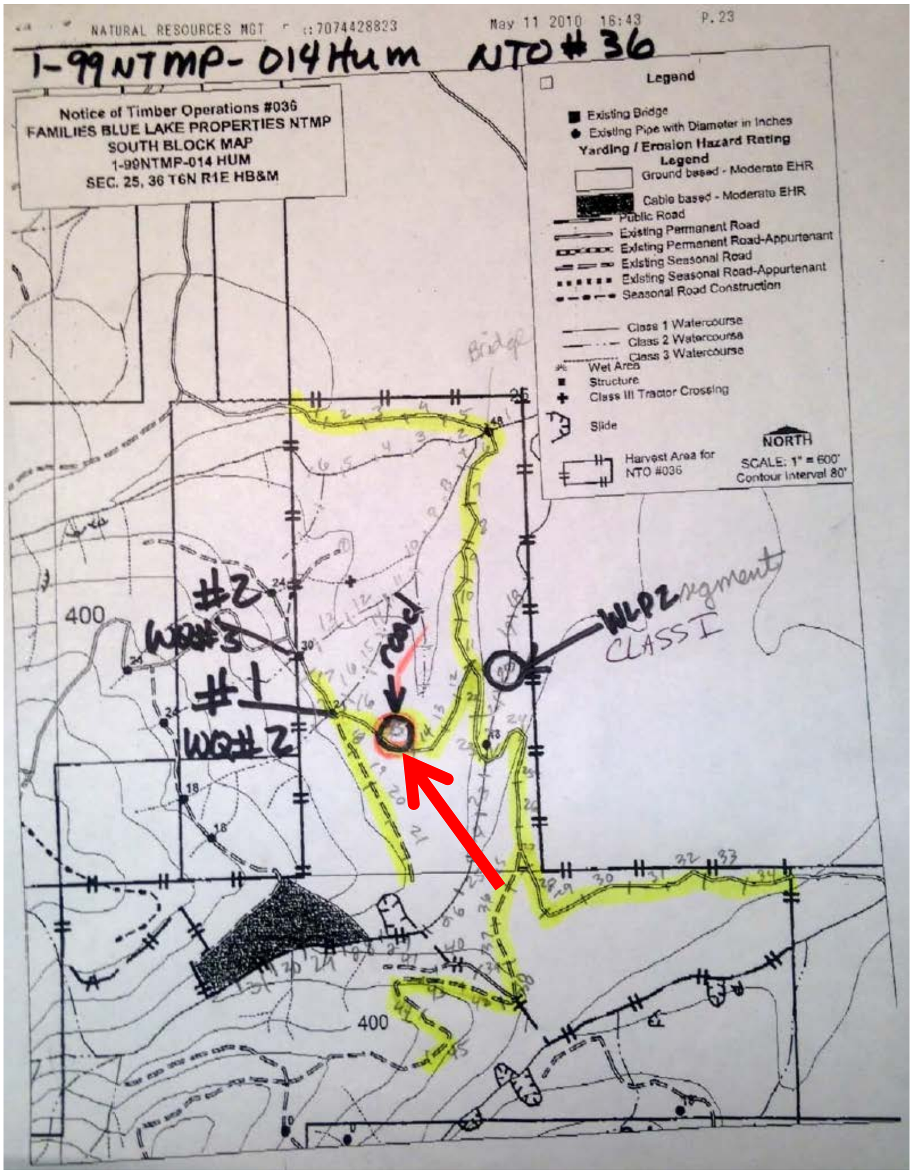

Figure 24. Example NTMP–NTO road map showing logging roads segmented and numbered for FORPRIEM sampling. Road segment #15 (red arrow) was randomly selected for monitoring using a random number generator.

After locating the start of the 660-foot road segment, distances along the reach were measured with the string box (hip chain) (Figure 26). The 660-foot road segment was divided into 10-foot increments for recording data (66 increments per 660 foot segment) (Figure 27). The location and type of road drainage facilities, generically referred to as waterbreaks (WBs) in this study, and drainage structures (e.g., ditch relief culverts) were recorded on the implementation forms where they were found along the segment.[16]

[16] The 14 CCR § 895.1 definition for drainage facilities includes waterbreaks and rolling dips, while the definition of drainage structures includes ditch drains and culverts.

Figure 25. The tools needed to complete road monitoring included (1) pocket tape measure (erosion void dimensions), (2) string box (distances), and 3) clinometer (gradients). Also needed were the FORPRIEM road forms and a digital camera (optional).

Additionally, the percent road gradient between road drainage facilities and structures was recorded, as well as the side slope gradient. Forest Practice Rule requirements related to road drainage facility construction (e.g., waterbar, rolling dip) and discharge into cover were rated using one of the following four implementation codes:

ER - Exceeds Rule
A - Acceptable
MA - Marginally Acceptable
D - Departure

Road maintenance of an inside ditchline and ditch relief were also rated with these implementation codes where appropriate. Additionally, other types of information were recorded for each 10-foot increment, including road construction type (e.g., cut and fill), locations of watercourse crossings, and road drainage type (e.g., insloped, crowned).

Following completion of the Forest Practice Rule implementation rating for the 660-foot segment, the Forest Practice Inspector returned to the initial starting point and began a second transect for effectiveness ratings, tying off the string box for distance measurement a second time. The 660-foot road segment was again divided into the same 10-foot increments for recording effectiveness data. Where erosion features were observed, the type of feature was recorded at the appropriate 10-foot increment (e.g., rills, gullies, mass wasting, cutbank sloughing, ruts), and the distance it was observed along the road segment was recorded (e.g., gully observed for increment 100-110 to increment 170-180). Erosion features were observed to determine if there was sediment transport beyond the road prism or transport to a watercourse channel. Appropriate codes were used to record sediment transport for each road erosion feature encountered on the 660-foot segment.

Similar to previous, comparable monitoring studies (e.g., HMP and MCR), FORPRIEM only recorded evidence of observable erosion and sediment transport remaining after the overwintering period(s). FORPRIEM was not designed to record hard to detect erosion and sediment transport which leaves no evidence, such as the road dust that washes off native surface roads. Grading and heavy traffic can potentially obliterate evidence of erosion, such as rilling, and the likelihood of this occurring increases as time since harvest increases. When FORPRIEM effectiveness monitoring was done following the first overwintering after BMP implementation, this is not thought to be a significant problem.

Complete instructions for road monitoring and an example of a set of completed forms are included in the Appendix, "*FORPRIEM Monitoring Procedures and Methods* (revised 9-14-2007)."

Figure 26. Clay Brandow recording road rule implementation and effectiveness data along a randomly located 660-foot road segment included in the FORPRIEM THP sample.

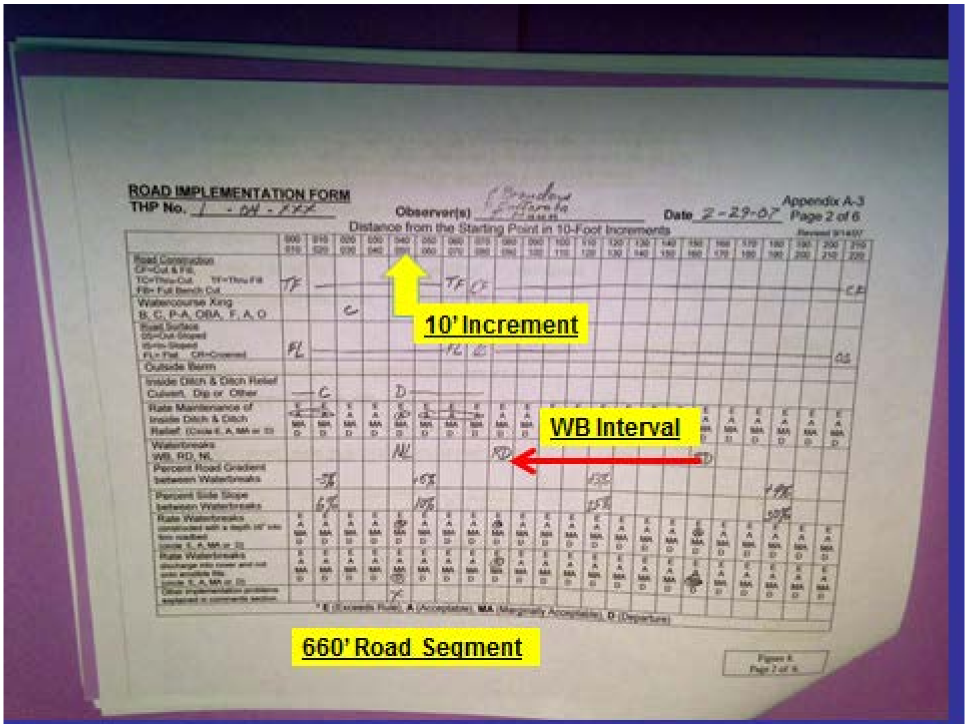

Figure 27. Three key road terms used in FORPRIEM road monitoring: 660-foot road segment divided into 10-foot increments, and waterbreak (WB) intervals between road drainage structures. This form is page 2 of 6 of the FORPRIEM road form package.

II. THP Road Results

Of the 126 THPs sampled, 125 had logging road segments acceptable for FORPRIEM monitoring. These 125 segments at 660 feet each equate to 82,500 feet or 15.6 miles of road. Approximately 81% of the road segments were classified as seasonal roads, 17% as permanent roads, and 2% as abandoned or other type. In terms of road surfacing, about 76% of the segments were native surfaced, 22% rocked, and 2% had other types of surfacing. Approximately 82% of the road segments existed prior to the THP and 18% were constructed as part of the plan.

The location of the THP road sample segments on the hillslope were: 4% in the WLPZ, 11% adjacent to the WLPZ, 39% midslope, 30% upper slope, and 13% on top of a ridge. Another 3% of THP sampled road segments were on flat terrain. The positon of the road on the hillslope is important, since sediment from roads located close to a watercourse is more likely to be discharged into watercourses. Sediment from roads further upslope is more likely to be intercepted by and deposited in the groundcover on the intervening terrain due to the additional buffering capacity provided by longer hillslopes.

THP Road Rule Implementation Results

Based on results from previous monitoring studies, FORPRIEM focused on three key Forest Practice Rules for roads: (1) waterbreak construction, (2) discharge into cover, and (3) waterbreak spacing.[17] Each was rated for implementation or compliance with the applicable FPR, and for effectiveness or success in preventing erosion, sediment transport, and sediment transport to watercourse channels. The waterbreak construction FPR (14 CCR § 914.6 [934.6, 954.6] (g)) states:

> "Waterbreaks shall be cut diagonally a minimum of 15.2 cm (6 inches) into the firm roadbed, cable road, skid trail or firebreak surface and shall have a continuous firm embankment of at least 15.2 cm (6 in.) in height immediately adjacent to the lower edge of the waterbreak cut."[18]

For the purpose of this report, waterbreaks include waterbars, rolling dips, natural lows, natural highs, and other features such as lead-out ditches. In this report, waterbreaks are not limited to waterbars. Waterbreaks are the features which define the beginning and end of the longest distance water can run down the road before it is diverted off the road surface. This distance is referred to in this report as the waterbreak interval (WBI).

Specific construction standards for rolling dips and lead-out ditches are not provided in the current Forest Practice Rules, but 14 CCR § 923.2 [943.2, 963.2] (h) specifies that road drainage structures and facilities shall be of sufficient size, number, and location to carry runoff water off of roadbeds, landings, and fill slopes.

As defined above, waterbreaks in the THP sample for road segments were roughly half waterbars (51%), one quarter rolling dips (27%), and one quarter a combination of natural lows (11%), natural highs (5%), and other features such as lead-out ditches (6%).[19]

Construction of THP waterbars, rolling dips, and other types of road drainage facilities monitored for implementation in the sample were rated as follows: 12% exceeding the FPR requirements, 78% acceptable, 7% marginally acceptable, and 3% departures from these requirements (not acceptable). In other words, 97% met the FPR requirements at some level and 3% did not (Figure 28). Rule departures are the kind of deficiencies that could result in a CAL FIRE Notice of Violation if they were numerous throughout the plan area.

The waterbreak discharge into cover FPR (14 CCR § 914.6 [934.6, 954.6] (f)) states:

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[17] Forest Practice Rule 14 CCR § 923.2 [943.2, 963.2] (p) states that where roads do not have permanent and adequate drainage, the specifications of Section 914.6 [934.6, 954.6] shall be followed.

[18] The 14 CCR § 895.1 definition of waterbreak states that waterbreaks are synonymous with waterbars, but it was broadened for this study.

[19] Natural high points and low points along a road segment are not waterbreaks as per the FPRs, but function to define the length of road reach contributing runoff to a drainage facility or structure. Many of the THP road segments utilized a combination of waterbars, rolling dips, and ditch relief culverts.

> “Waterbreaks shall be located to allow water to be discharged into some form of vegetative cover, duff, slash, rocks, or less erodible material wherever possible, and shall be constructed to provide for unrestricted discharge at the lower end of the waterbreak so that water will be discharged and spread in such a manner that erosion shall be minimized. Where waterbreaks cannot effectively disperse surface runoff, including where waterbreaks on roads and skid trails cause surface run-off to be concentrated on downslopes, roads or skid trails, other erosion controls shall be installed as needed to comply with Title 14 CCR 914 [934, 954].”

Similarly, 14 CCR § 923.2 [943.2, 963.2] (o) states the following for logging roads:

> “Drainage structures and drainage facilities on logging roads shall not discharge on erodible fill or other erodible material unless suitable energy dissipators are used. Energy dissipators suitable for use with waterbreaks are described in 14 CCR 914.6(f) [934.6(f), 954.6(f)].”

Discharge into cover for THP waterbreaks (waterbars, rolling dips, and other types of road drainage facilities) monitored for implementation in the sample were rated as

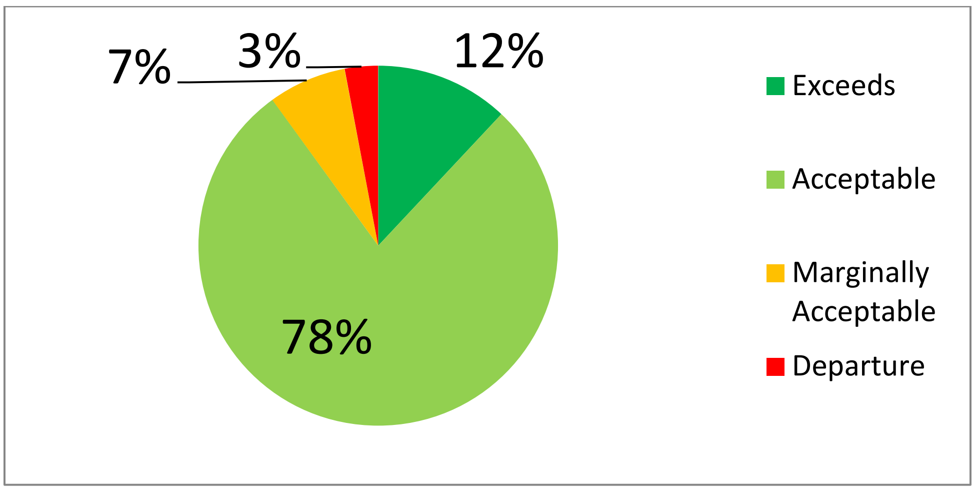

Figure 28. FORPRIEM THP waterbreak construction ratings. Forest Practice Rule 14 CCR § 914.6 [934.6, 954.6] (g).

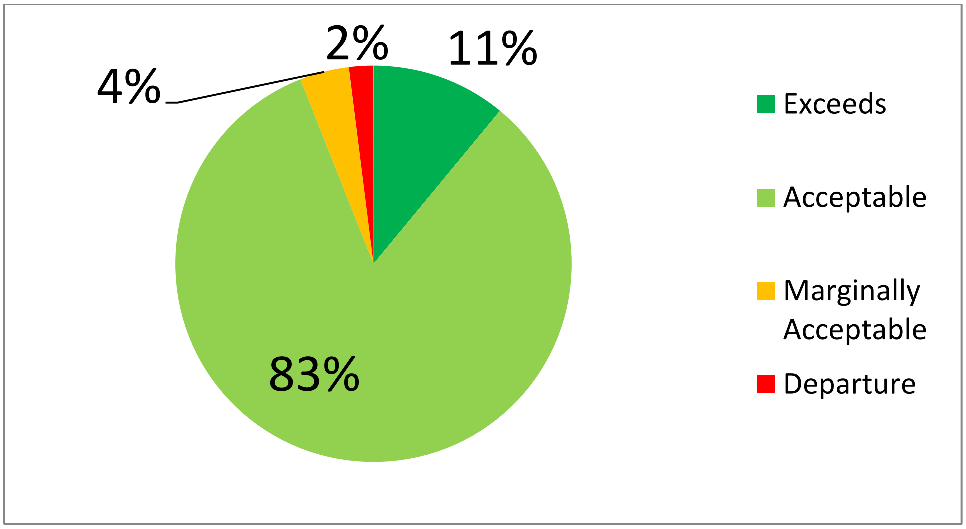

Figure 29. FORPRIEM THP waterbreak ratings for discharge into cover. Forest Practice Rule 14 CCR §§ 914.6 [934.6, 954.6] (f) and 923.2 [943.2, 963.2] (o).

follows: 11% exceeding the FPR requirements, 83% acceptable, 4% marginally acceptable, and 2% departures from the requirements of the FPRs (not acceptable). In other words, 98% met the discharge into cover FPRs at some level and 2% did not (Figure 29). Again, the departures are the kind of deficiencies that could result in a Notice of Violation if they were widespread through a plan area.

The waterbreak construction FPR (14 CCR § 914.6 [934.6, 954.6] (c)) states:

> "Distances between waterbreaks shall not exceed the following standards:

MAXIMUM DISTANCE BETWEEN WATERBREAKS

Estimated Hazard Rating	U.S. Equivalent Measure Road or Trail Gradient (in percent)				Metric Measure Road or Trail Gradient (in percent)			
	10 or less	11-25	26-50	>50	10 or less	11-25	26-50	>50
	Feet	Feet	Feet	Feet	Meters	Meters	Meters	Meters
Extreme	100	75	50	50	30.48	22.86	15.24	15.24
High	150	100	75	50	45.72	30.48	22.35	15.24
Moderate	200	150	100	75	60.96	45.72	30.48	22.35
Low	300	200	150	100	91.44	60.96	45.72	30.48

The appropriate waterbreak spacing shall be based upon the erosion hazard rating and road or trail gradient."

The Forest Practice Rules do not provide specific spacing requirements for rolling dips.[20] For the purposes of this report, rolling dip spacing requirements were assumed to be similar to that used for other forms of waterbreaks (e.g., waterbars). This is a conservative approach, since rolling dip spacing is generally greater than that for waterbars, commonly ranging from 100-400 feet depending on road gradient and soil type (Kocher et al. 2006, Keller and Sherar 2003).

FORPRIEM road monitoring collected segment data on waterbreak interval distance and gradient. In order to look at waterbreak spacing, intervals that were insloped and drained primarily by an inside ditch leading to a ditch relief culvert were extracted and considered separately.

About 6% of the sample THP road segment length was drained in this way. There were five THP road segments that were primarily drained using insloping and inside ditches, and nine THP road segments that were partially drained in this way, having one or more intervals with insloping and inside ditches. Overall, there were 21 intervals on THP road segments drained with this method, ranging in length from 660 feet (or the full road segment length) to 20 feet. The average interval length was 213 feet, with a median length of 140 feet. Five of the 21 intervals or about 24% had some rilling erosion on the road surface. No sediment transport beyond the road prism and no sediment transport to a channel were recorded for these 21 intervals. This is an area that needs more focused monitoring in the future.

For the purposes of FORPRIEM, waterbreaks included waterbars, rolling dips, natural lows, natural highs, and other features that marked the beginning or end point that water could travel on the road surface before being diverted off the road. THPs and NTMPs include Erosion Hazard Ratings (EHRs), and these were recorded in the road site information forms. All of the randomly sampled road segments had waterbreak interval gradients that fell into either the “10% or less” gradient category or the “11% to 25%” gradient category. It is important to note that 25% is very steep road. The steeper gradient in this FPR (26% and up) apply primarily to waterbreak spacing for tractor roads (i.e., skid trails) used by ground skidding equipment such as crawler tractors. THPs in the random sample had EHRs mostly in the moderate category. The EHR distribution for THPs was: 1% extreme, 10% high, 76% moderate, and 13% low.

[20] 14 CCR § 923.2 [943.2, 963.2] (h) specifies that road drainage structures and facilities shall be of sufficient size, number, and location to carry runoff water off of roadbeds, landings, and fill slopes. The Road Rules, 2013 rule package, to be implemented January 1, 2015, provides guidance for rolling dip and road cross drain spacing in Technical Rule Addendum No. 5 (see Table 1), but not mandatory spacing requirements similar to those for waterbreaks.

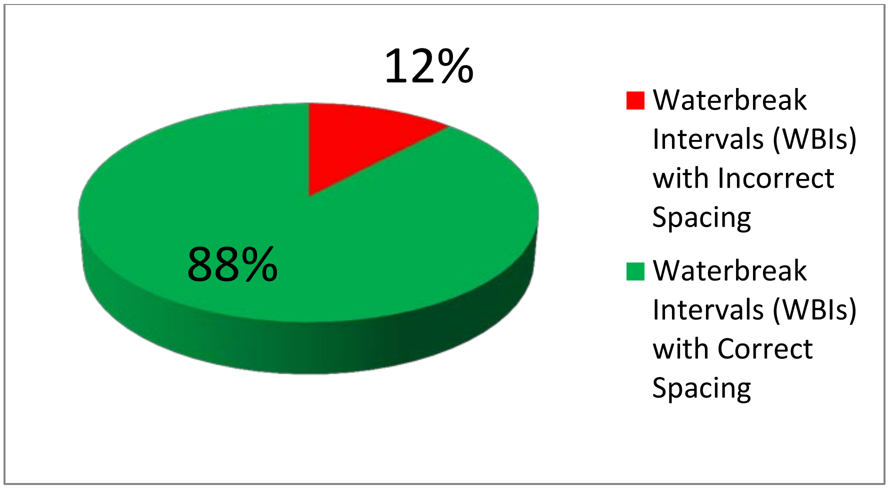

Figure 30. FORPRIEM THP waterbreak spacing. Waterbreak intervals (WBIs) with the correct spacing vs. incorrect spacing. Forest Practice Rule 14 CCR § 914.6 [934.6, 954.6] (c).

Taking into consideration EHR, road distance, and road gradient, 88% of the THP waterbreak intervals monitored met or exceeded the FPR and had the correct waterbreak spacing, and 12% did not (Figure 30).

Another way to look at the data is to count the number of waterbreak interval spacing problems per monitored segment of road, again discounting road segments predominantly drained by insloping and inside ditches. Looking at the data this way, 55% of the THP road segments had no waterbreak spacing problems, 30% had one problem, 12% had two problems, and 3% had three problems (Figures 31 and 32). While it is useful to look at how waterbreak spacing problems are distributed, it is important to remember that nine times out of ten, waterbreak spacing was correctly implemented.

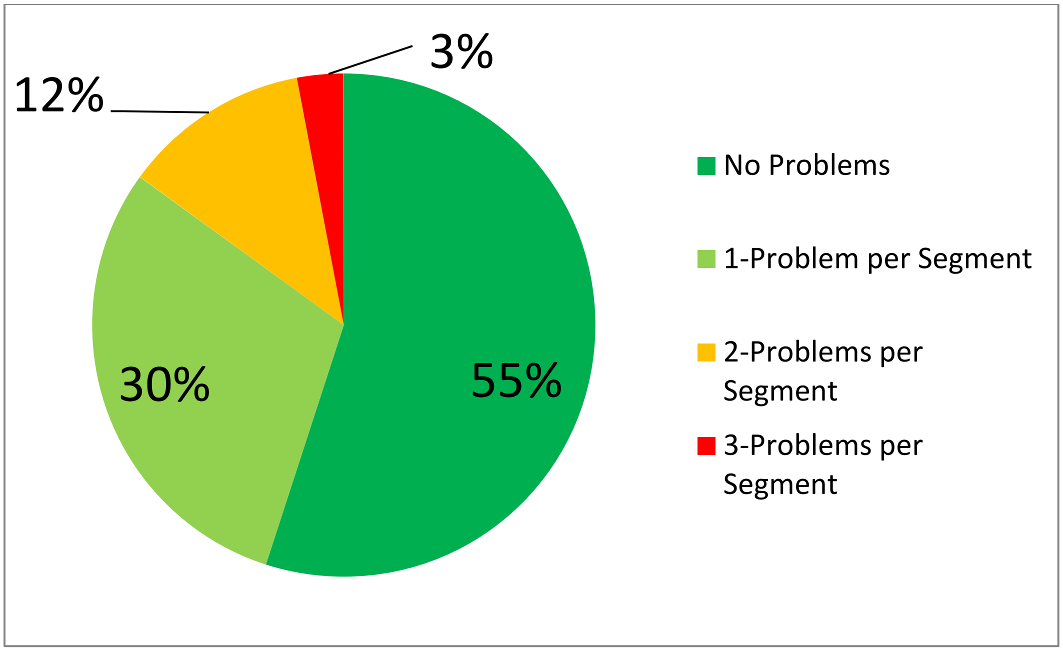

Figure 31. Distribution of THP waterbreak spacing problems by sampled road segment. Forest Practice Rule 14 CCR § 914.6 [934.6, 954.6] (c).

Figure 32. Example of a seasonal road with a properly installed waterbreak (THP in the FORPRIEM sample in Humboldt County).

THP Road Effectiveness Results

Effectiveness monitoring was conducted after the road segment had overwintered at least one year. Of the 125 road segments rated for FPR implementation, 122 road segments were rated for effectiveness after at least one over-wintering period for this report. Three were not. Of the 122 THP road segments with both implementation and effectiveness monitoring, five road segments were primarily drained by insloping with inside ditches and were considered separately from the road segments primarily drained by waterbreaks. Effectiveness results for these segments are reported in the previous section.

Observations were made and recorded by road interval for the following: (1) erosion on the road cut slope (Figure 33), surface, and fill slope, plus evidence of mass wasting or landslides; (2) sediment transport beyond the road prism; and (3) sediment transport to watercourse channels. Evidence of erosion observed and recorded included voids such as rills and gullies. Evidence of sediment transport included deposition beyond the road prism. Evidence of sediment transport to channels included deposition beyond the road prism and to at least the watercourse transition line (i.e., sediment plumes that extended to approximately the high water line of the channel or flood prone area).

Figure 33. Example of sediment deposition onto a randomly located THP road segment in the FORPRIEM sample.

Approximately 4% of the linear feet of THP road segments monitored had erosion on the cut slope and 96% did not (Figure 34). About 9% of the linear feet of THP road had erosion on the road surface, mostly rilling, and 91% did not. Roughly 1% of the linear feet of THP road monitored had erosion on the fill slope and 99% did not. Note that erosion on the fill slope is usually transverse (perpendicular) to the center line of the road, so significant erosion can occur in a small number of linear road feet.

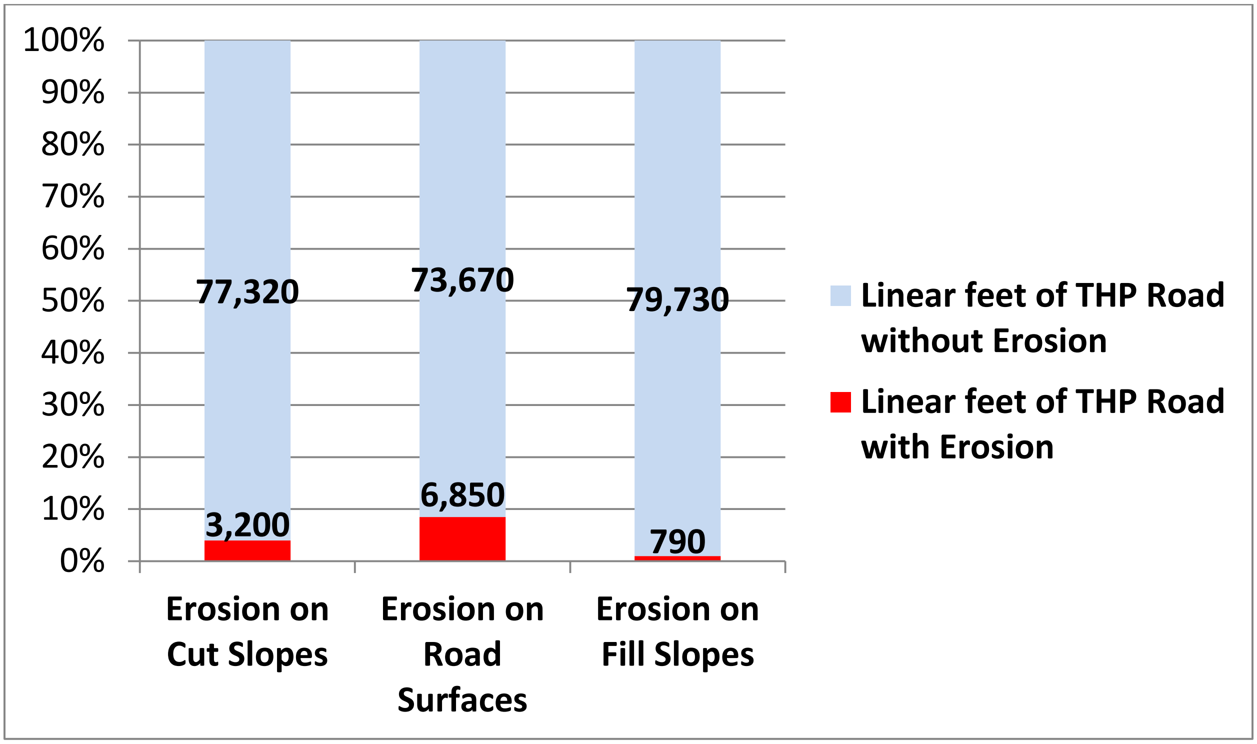

Figure 34. Percentage of the total THP road length monitored with erosion on the cut slope, erosion on the road surface, and erosion on the fill slope.

Erosion on the cut slope is not related to waterbreak spacing problems. Nor is road surface rutting, which is normally the result of traffic during wet weather when native road surfaces are soft and slick. This is a particular problem on roads with steep gradients. Mass wasting is normally related to instability of fills or native soils, often associated with improper road construction techniques or poor road placement. However, road drainage can increase the likelihood of mass wasting (Montgomery 1994).

Other types of road erosion features, including rills and gullies on road surfaces and fill slopes, are often related to the spacing of waterbreaks (e.g., waterbar and rolling dip). The distance (or spacing) between the waterbreaks is defined as the waterbreak interval (WBI). The types of erosion affected by the length of the waterbreak interval are collectively referred to in this report as WBI-related erosion.

Looking at the distribution of WBI-related erosion detectable by forensic monitoring for THP road segments of all types, 39% of the road segments had some erosion and 61% did not (Figure 35).

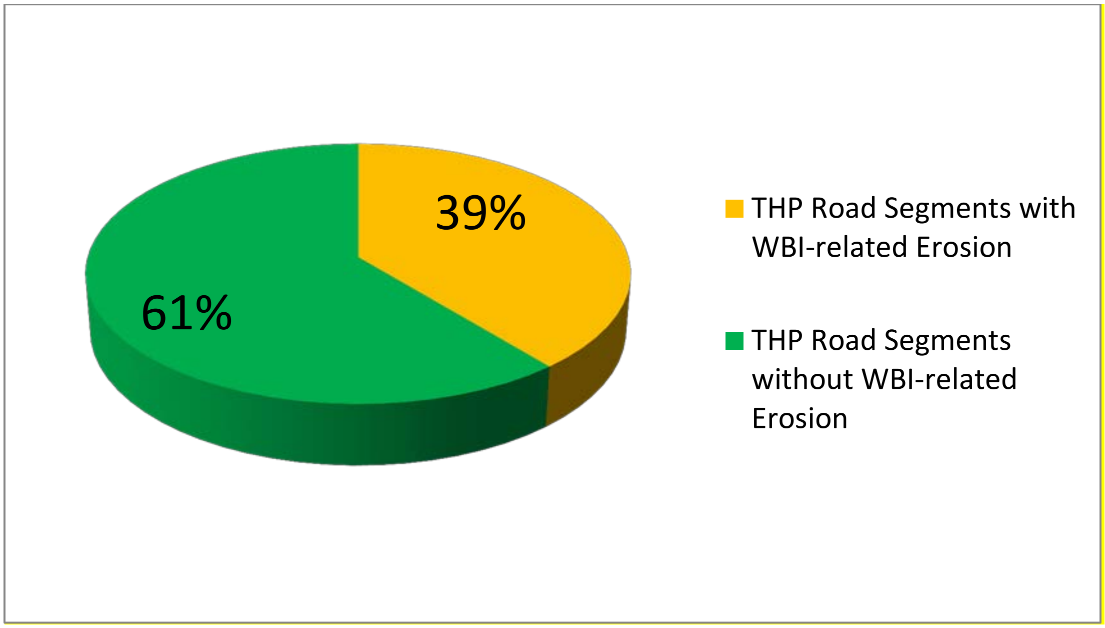

Figure 35. THP road segments with and without WBI-related erosion. WBI-related erosion includes erosion on the road surface (except rutting) and on fill slopes. WBI-related erosion does not include erosion on cut slopes.

There were 576 THP road intervals monitored for effectiveness, including 555 drained by waterbreaks and 21 drained by inside ditches with insloping. Of these 576 intervals, 101 (18%) had WBI-related erosion, five (1%) had sediment transport beyond the road prism, and one of these transported sediment to a channel (Figure 36).

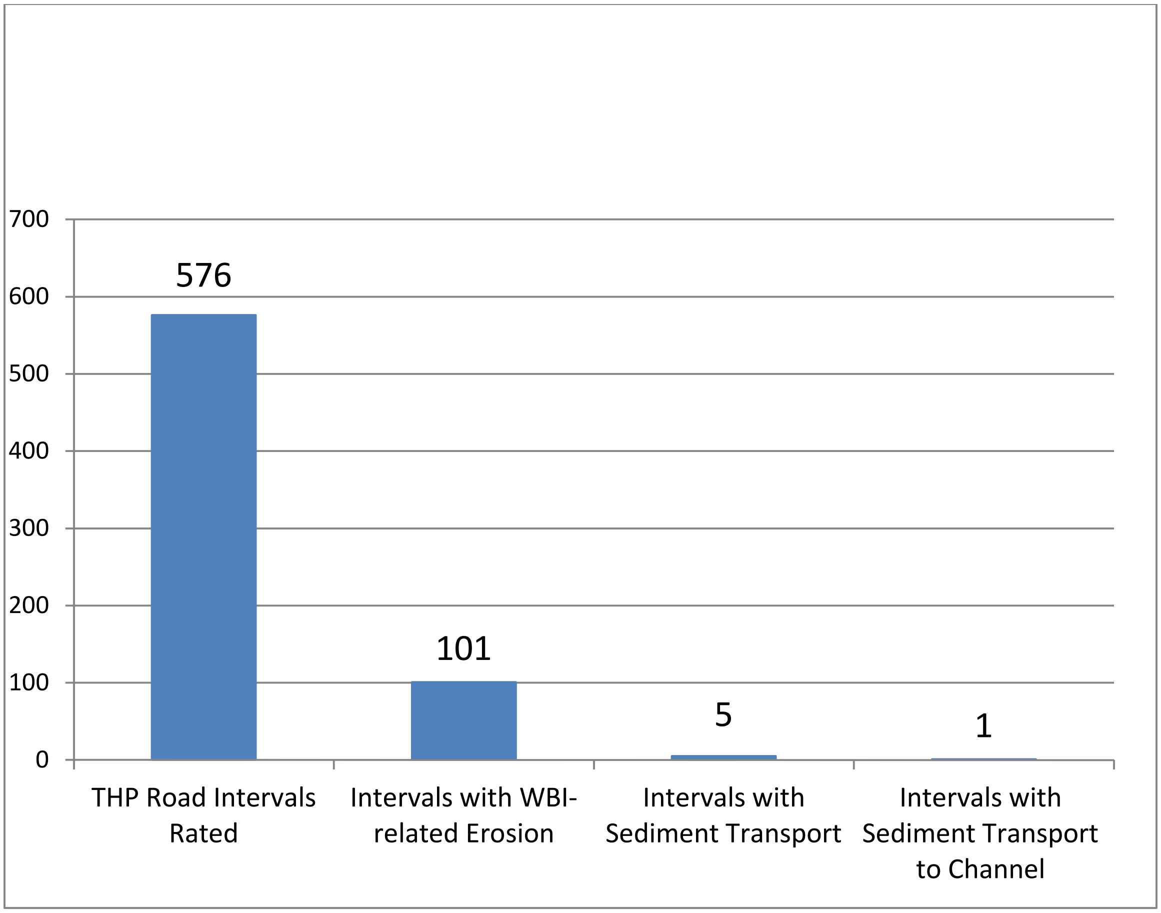

Figure 36. THP road intervals monitored (including both intervals drained by waterbreaks and those drained by inside ditches with insloping) compared to the number with erosion, with sediment transport, and sediment transport to the channel.

Of the THP waterbreak intervals with correct spacing, 86% had no WBI-related erosion and 14% had some WBI-related erosion (Figures 37, 38, and 39). By comparison, of the THP waterbreak intervals with incorrect spacing, 37% had WBI-related erosion and 63% had no WBI-related erosion (Figure 38). Insufficient waterbreak spacing does not always result in erosion after the first few overwintering periods and correct waterbreak spacing does not always prevent erosion. However, during this monitoring period, incorrect waterbreak spacing was approximately two and half times as likely to result in erosion as correct waterbreak spacing.

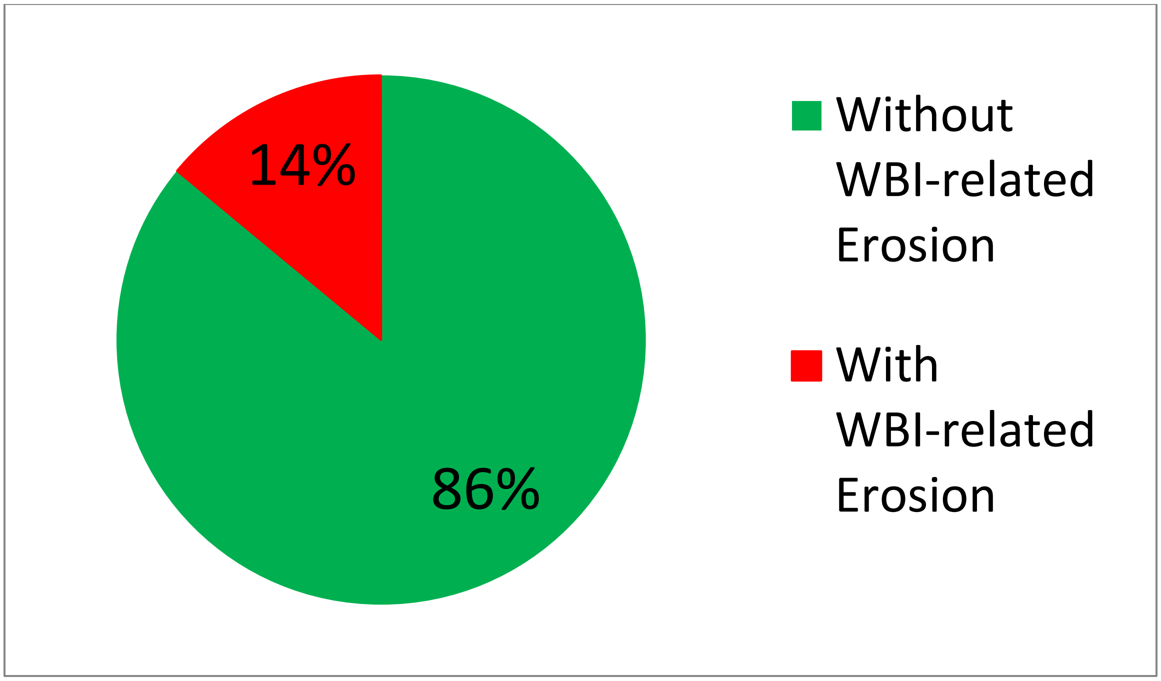

Figure 37. THP random road segments with correct waterbreak-interval spacing, and resulting percentages of segments with and without WBI-related erosion features. Does not include five segments primarily insloped and drained with inside ditches.

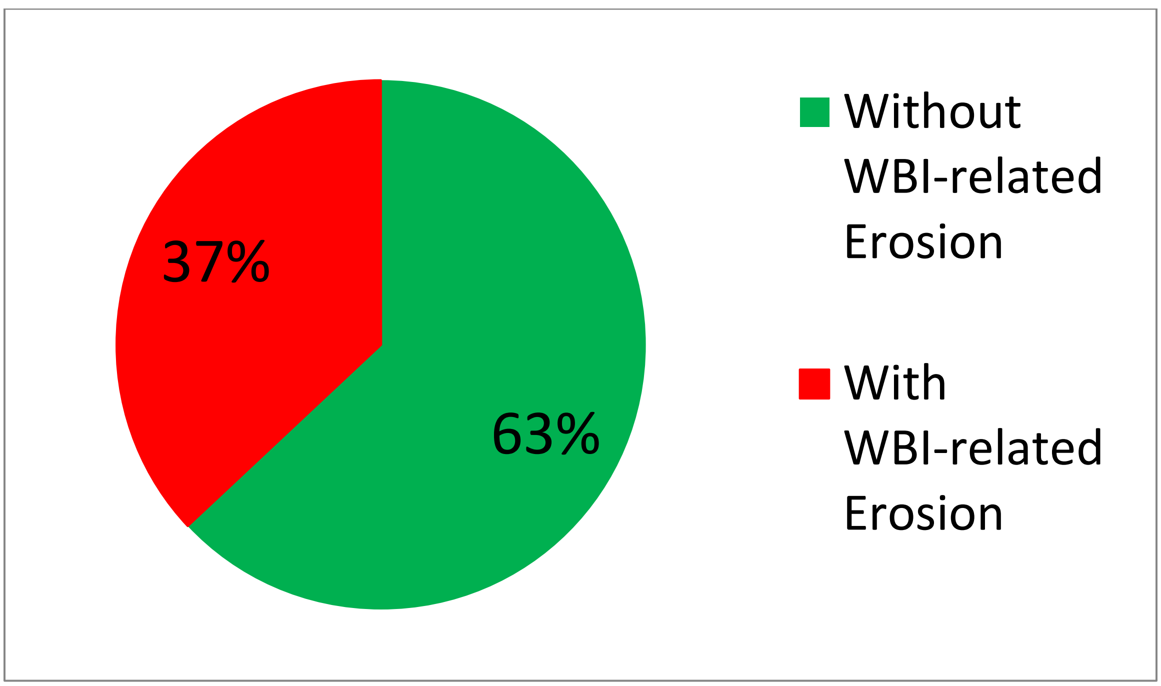

Figure 38. THP random road segments with incorrect waterbreak-interval spacing, and resulting percentages of segments with and without WBI-related erosion features. Does not include five segments primarily insloped and drained with inside ditches.

The incidence of sediment transport and sediment transport to channels are few enough it is possible to relate each instance to the FPR implementation ratings for waterbreak spacing, waterbreak construction, and discharge into cover at each site (Table 10).

Figure 39. Examples of road segments in the FORPRIEM sample with appropriate road drainage facility spacing and without erosion features.

Table 10. Specific incidents of THP road sediment transport and transport to channels found among the 576 waterbreak intervals monitored.

THP	Waterbreak Spacing	Waterbreak Construction	Discharge into Cover	Evidence of Discharge to Channel	Notes
THP 1-02-236 HUM	Major Departure	N/A	N/A	None Reported. Upper-slope road.	Mass wasting. Slide occurred just below the road: 300' long x 120' wide x 20' deep.
THP 1-05-134 MEN	Acceptable	Exceeds	Acceptable	No	Waterbreak outlet at natural grade but dozer carried soil beyond road surface.
THP 1-07-131 HUM	Acceptable	Acceptable	Acceptable	No	Rills on road. Sediment plume beyond end of WB. Does not reach watercourse.
THP 1-08-014 HUM	Acceptable	Marginally Acceptable	Marginally Acceptable	Yes	Ruts on road surface in thru-cut. Road surface sediment transported to Class II watercourse.
THP 4-04-033 ELD	Major Departure	Acceptable	Marginally Acceptable	No	Gully erosion on road surface.

III. NTMP-NTO Road Results

Of the 24 NTMP-NTOs sampled, all 24 had logging road segments acceptable for FORPRIEM monitoring. The 24 segments at 660 feet equate to 15,840 feet or 3.0 miles of road. Approximately 79% of the road segments were classified as seasonal roads and 21% as permanent roads. For road surfacing, about 83% of the segments were native surfaced, 13% rocked, and 4% had other types of surfacing. Approximately 83% of the road segments existed prior to the THP and 17% were constructed as part of the plan. The locations of the NTMP-NTO road sample segments on the hillslope were: 8% adjacent to the WLPZ, 55% midslope, 29% upper slope, and 8% on top of a ridge. There were no NTMP-NTO road sample segments in the WLPZ or on flat terrain. Overall, the descriptive category results for the randomly sampled NTMP-NTO road segments were similar to those for THPs.

NTMP-NTO Road Rule Implementation Results

Waterbreaks in the NTMP-NTO sample road segments were roughly half waterbars (51%), one quarter rolling dips (25%), and one quarter a combination of natural lows (10%), natural highs (8%), and other features (6%). Insloping with inside ditches was not a significant factor in the NTMP-NTO road sample. Only one interval 60 feet in length was drained this way, and it was not separated out in this report.

Construction of NTMP-NTO waterbreaks (waterbars, rolling dips, and other types of road drainage facilities) monitored for implementation in the sample was rated as follows: 6% exceeding the FPR requirements, 84% acceptable, 9% marginally acceptable, and 1% departures (Figure 40). In this case, 99% met the construction FPRs at some level and 1% did not.

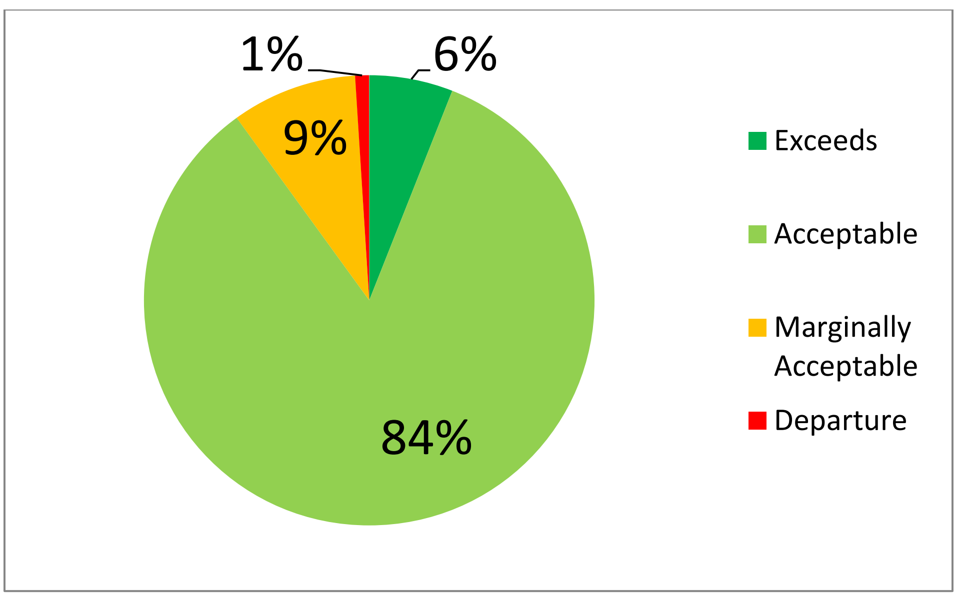

Figure 40. FORPRIEM NTO-NTMPs waterbreak construction ratings. Forest Practice Rule 14 CCR § 914.6 [934.6, 954.6] (g).

Discharge into cover for NTMP-NTO waterbreaks monitored for implementation in the sample was rated as 1% exceeding the FPR requirements, 95% acceptable, 2% marginally acceptable, and 2% departures (Figure 41). In other words, 98% met the discharge into cover FPRs at some level and 2% did not.

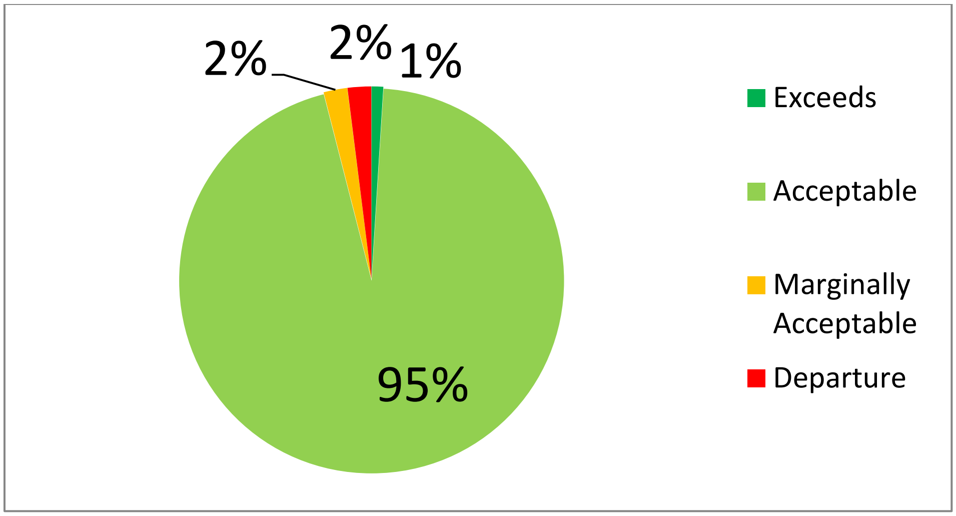

Figure 41. FORPRIEM NTO-NTMP waterbreak ratings for discharge into cover. Forest Practice Rules 14 CCR §§ 914.6 [934.6, 954.6] (f) and 923.2 [943.2, 963.2] (o).

The EHR distribution for NTMP-NTO road segments was: none in the extreme category, 9% high, 87% moderate, and 4% low. As with THP road segments, for the purposes of this report, NTMP-NTO rolling dip spacing requirements were assumed to be similar to that used for waterbreaks. For NTMP-NTOs, 90% of the waterbreak intervals had the correct spacing and 10% did not. Overall, nine times out of ten, waterbreak spacing was correct (Figure 42).

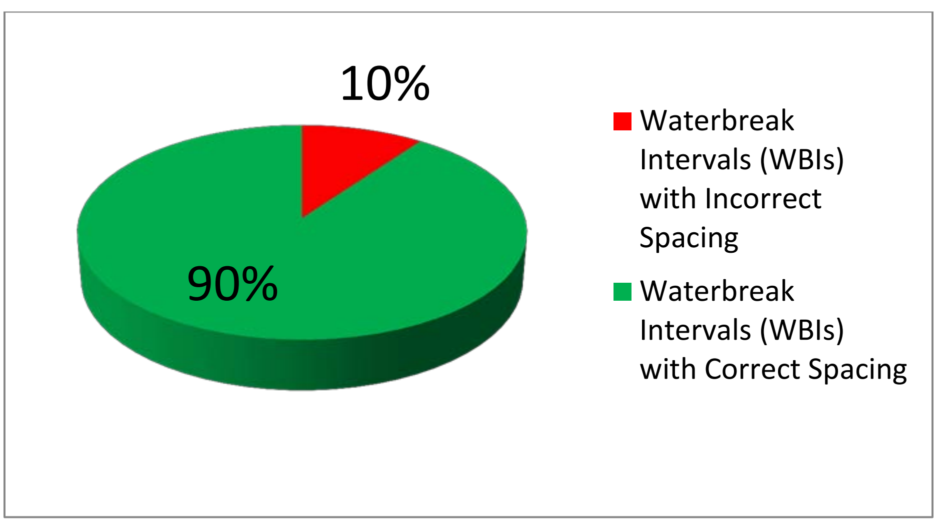

Figure 42. FORPRIEM waterbreak spacing for NTMP-NTOs. Waterbreak Intervals (WBIs) with the correct spacing vs. incorrect spacing. Forest Practice Rule 14 CCR § 914.6 [934.6, 954.6] (c).

As with THPs, a second way to look at the data is to count the number of waterbreak interval spacing problems per monitored segment of road. Examining the NTMP-NTO road data in this manner, 54% had no waterbreak spacing problems, 42% had one problem, 4% had two problems, and none had three or more problems (Figure 43).

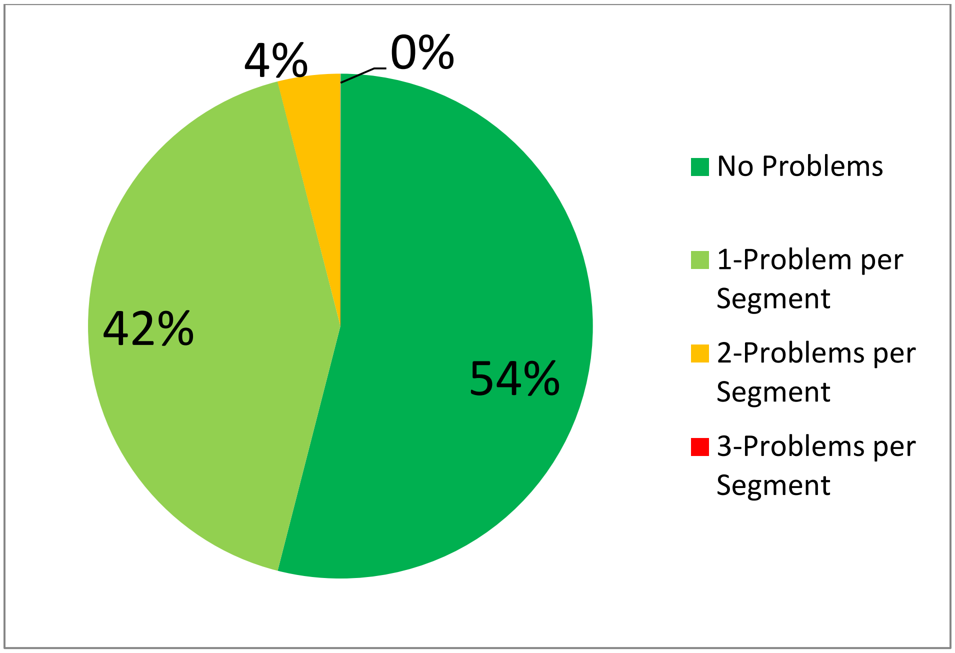

Figure 43. Distribution of NTMP-NTO waterbreak spacing problems by sampled road segment. Forest Practice Rule 14 CCR § 914.6 [934.6, 954.6] (c).

NTMP-NTO Road Effectiveness Results

Effectiveness monitoring was performed on 23 of 24 road segments in the FORPRIEM NTMP-NTO sample. All 23 NTMP-NTO road segments with effectiveness monitoring were within the North Coast Hydrologic Region. Approximately 3% of the linear feet of NTMP-NTO road monitored had erosion on the cut slope and 97% did not (Figure 44). About 9% of the linear feet of NTMP-NTO road had erosion on the road surface, mostly rilling, and 91% did not. Roughly 1% of the linear feet of NTMP-NTO road monitored had erosion on the fill slope and 99% did not (Figure 45). Again note that erosion on the fill slope is usually transverse (perpendicular) to the center line of the road, so significant erosion can occur in a small number of linear road feet.

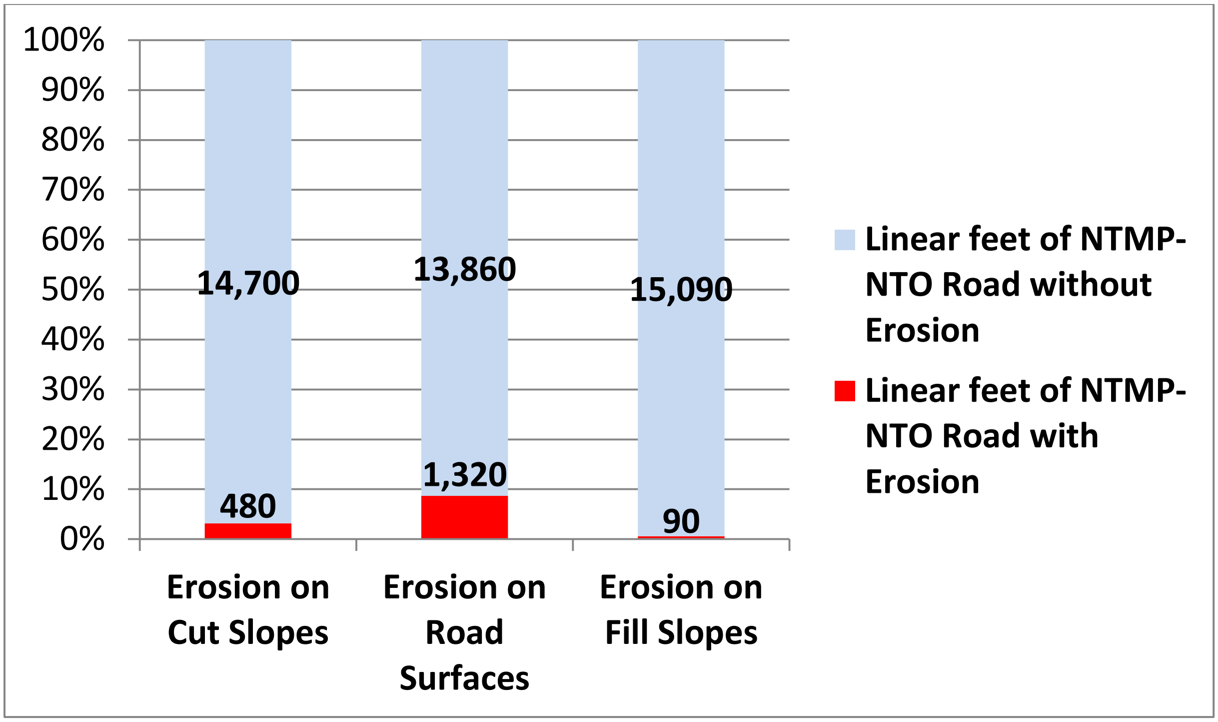

Figure 44. Percentage of the total NTMP-NTO road length monitored with erosion on the cut slope, erosion on the road surface, and erosion on the fill slope.

Figure 45. Some of the FORPRIEM monitoring, particularly the NTMP-NTO monitoring, was done jointly with staff from sister agencies, such as the NCRWQCB. These photos show 60 feet of road fill slope erosion on a monitored road transect (left) and tension cracks on the road surface (right).

Considering the distribution of WBI-related erosion by NTMP-NTO road segment for all types detectable by forensic monitoring, half the NTMP-NTO road segments had some WBI-related erosion reported and half did not (Figure 46). Therefore, NTMP-NTO WBI-related erosion was slightly more widely distributed than that found for THPs (where 61% of the segments did not have WBI-related erosion).

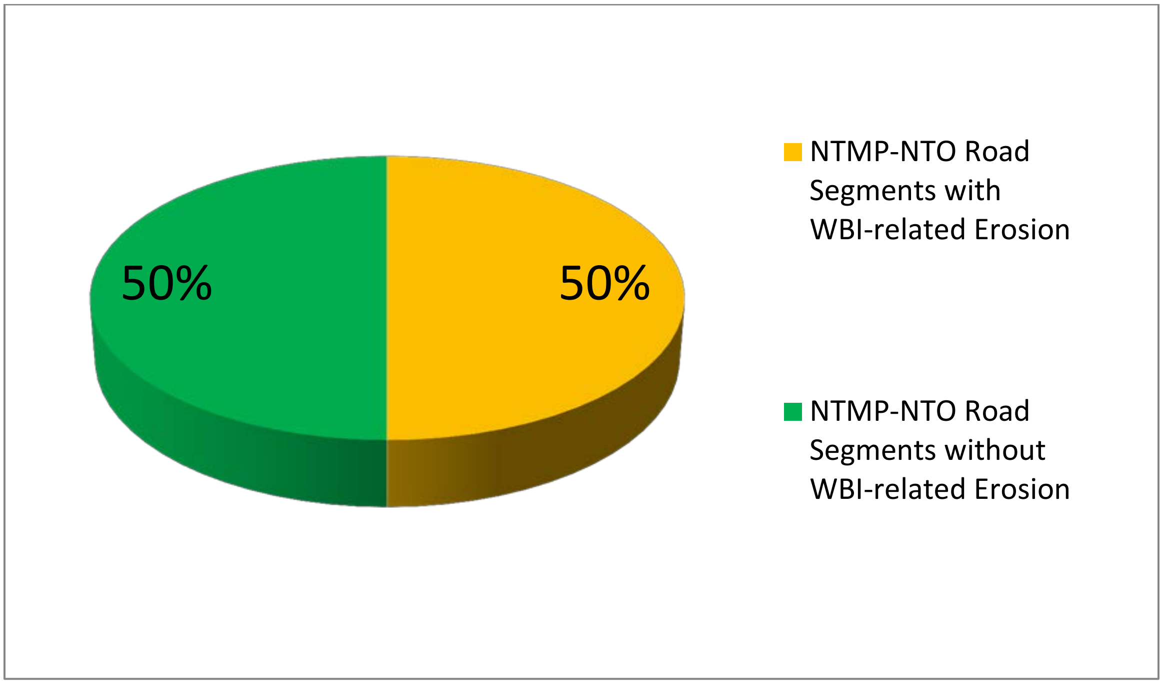

Figure 46. NTMP-NTO road segments with and without WBI-related erosion. WBI-related erosion includes erosion on the road surface (with the exception of rutting) and fill slopes. It does not include erosion on the cut slopes.

There were 125 NTMP-NTO road waterbreak intervals monitored for effectiveness. Of these, 19 (15%) had WBI-related erosion. Four (3%) had sediment transport beyond the road prism. One interval had transported sediment to a channel (Figure 47); however, this was not related to a waterbreak spacing problem. A road surface sinkhole had developed over a failed culvert, allowing sediment to move into a small headwater channel in Humboldt County (Table 11).

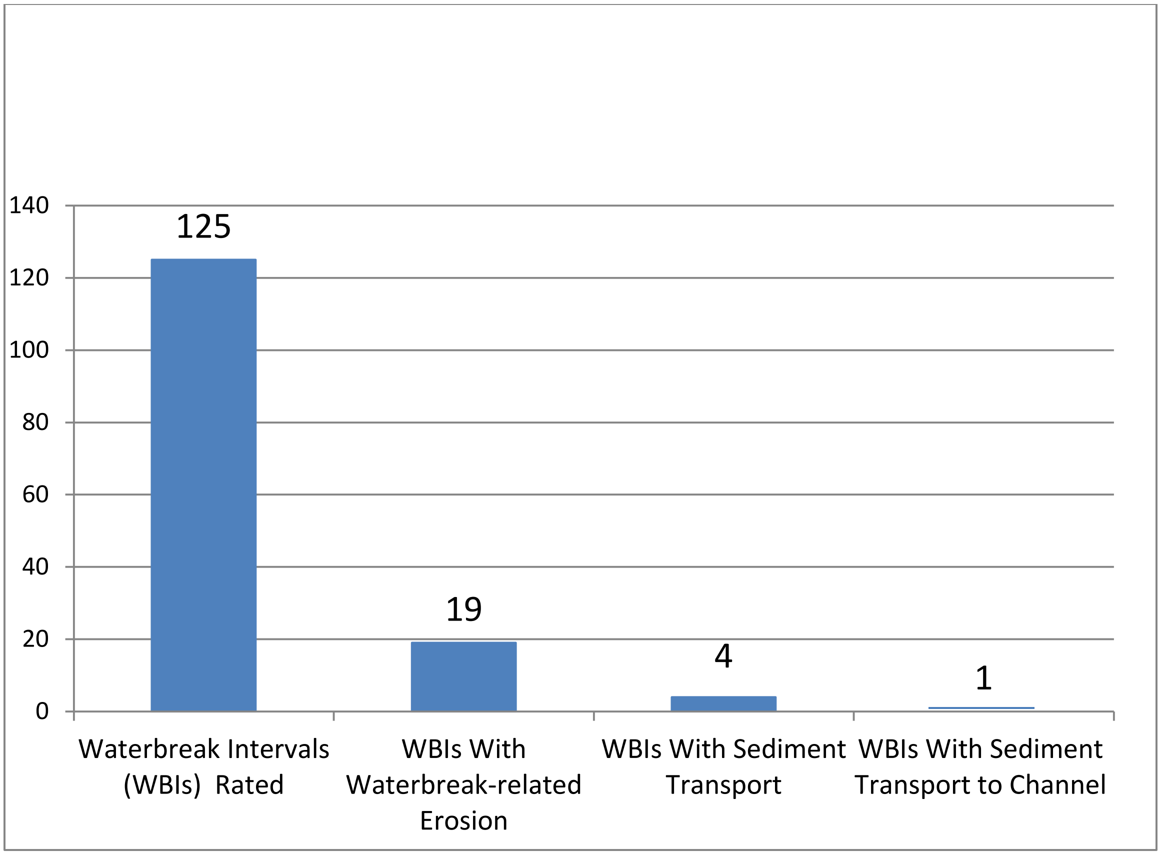

Figure 47. NTMP-NTO road intervals monitored compared to the number with erosion, with sediment transport, and sediment transport to the channel. The WBI with sediment transport to a channel was not related to a problem with waterbreak spacing (Table 11).

Of the NTMP-NTO waterbreak intervals with correct spacing, 90% had no WBI-related erosion and 10% had some waterbreak-related erosion (Figure 48). By comparison, of the NTMP-NTO waterbreak intervals with incorrect spacing, 50% had no WBI-related erosion and 50% had some WBI-related erosion (Figure 49). As with THP road segments, for NTMP-NTOs insufficient waterbreak spacing does not always result in erosion after the first few overwintering periods, and correct waterbreak spacing does always prevent erosion; however, incorrect waterbreak on NTMP-NTO roads was five times as likely to result in erosion as correct waterbreak spacing.

NTMP-NTO roads are often built for lighter traffic at lower speeds than THP roads and they commonly have minimal cuts and fills. Additionally, NTMP-NTO roads are controlled by small nonindustrial landowners with different objectives than roads controlled by larger landowners, frequently resulting in less maintenance. These factors may account for some of the differences in the road erosion results observed, but a larger sample size for NTMP-NTOs is required before firm conclusions can be made.

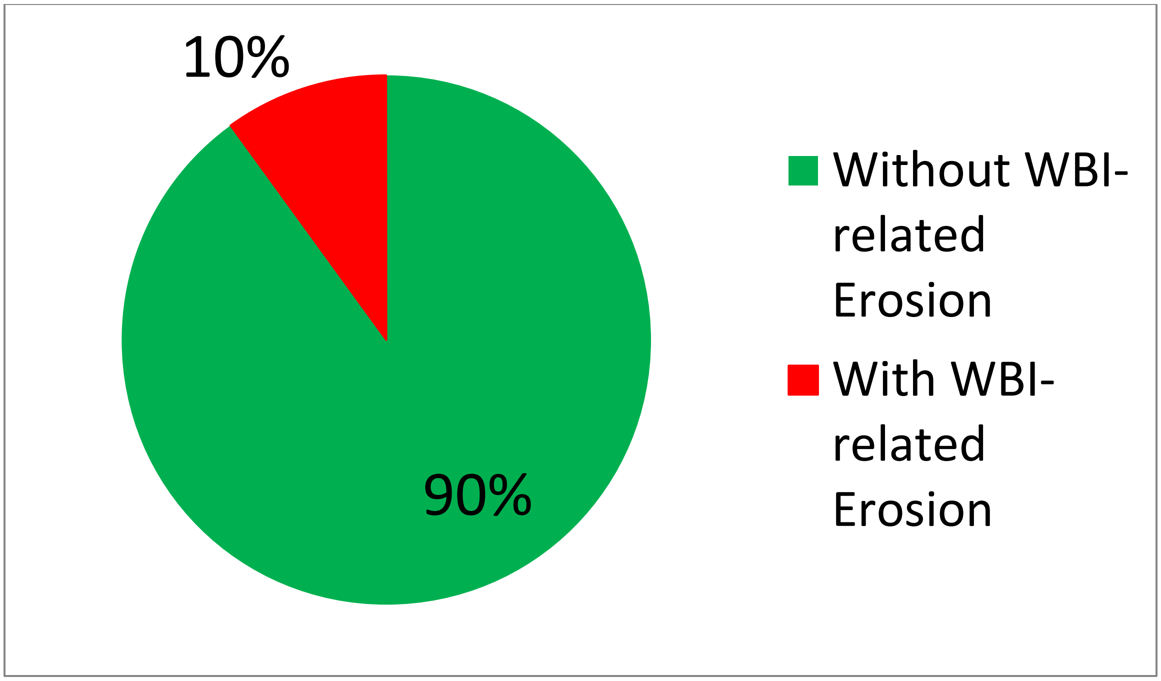

Figure 48. FORPRIEM NTMP-NTO random road segments with correct waterbreak-interval spacing, and resulting percentages of segments with and without erosion features.

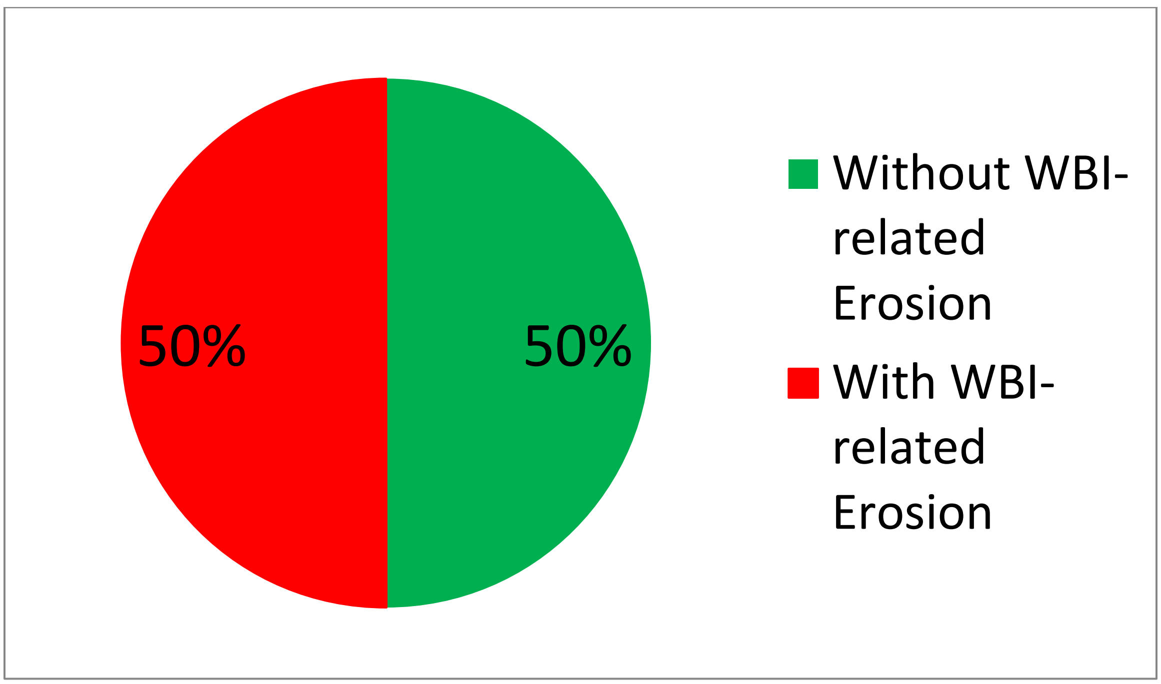

Figure 49. FORPRIEM NTMP-NTO random road segments with incorrect waterbreak-interval spacing, and resulting percentages of segments with and without erosion features.

As with the THP road segments, the incidence of NTMP-NTO road sediment transport and sediment transport to channels are few enough that it is possible to relate each instance to the FPR implementation ratings for waterbreak spacing, waterbreak construction, and discharge into cover at each site (Table 11).

Table 11. Specific incidents of NTMP-NTO road sediment transport and transport to channels found among the 125 waterbreak intervals monitored.

NTMP - NTOs	Waterbreak Spacing	Waterbreak Construction	Discharge into Cover	Evidence of Discharge to Channel	Notes
2-00NTMP-007-5	Acceptable	Acceptable	Acceptable	No	Rilling on road surface.
1-07NTMP-015-1	Departure	Exceeds	Departure	No	Gully on fill slope.
1-06NTMP-026-3	Acceptable	Acceptable	Acceptable	No	Minor surface erosion into grass cover.
1-97NTMP-001-14	N/A	N/A	N/A	Yes	Sinkhole over failed culvert.

IV. Road QA/QC

Field training using the FORPRIEM Procedures and Methods for sampling and monitoring roads was provided to most of the CAL FIRE Forest Practice Inspectors who did the monitoring. Typically the training was done on an actual FORPRIEM sampled road segment on the Inspectors' home units (Figure 50). The data were checked as they were sent to Sacramento for entry in the FORPRIEM database. Sacramento personnel were in communication with the CAL FIRE Audit Foresters and the Inspectors. The data in the database were spot checked to make sure they were entered correctly.

Five FORPRIEM-monitored THPs were picked at random for re-monitoring (Figure 51). All five THPs had monitored road segments. The THPs were revisited during 2013 and the five road segments were re-monitored. The shortest period between the original monitoring and re-monitoring was three months; the longest was two years and 10 months. On one of the re-monitored roads, an additional waterbreak was monitored

Figure 50. Field training for and regular communication with CAL FIRE's Forest Practice Inspectors performing FORPRIEM monitoring was an important part of FORPRIEM QA/QC.

near the end of the segment. This one waterbreak was not included in the following comparisons and was close enough to the end of the segment that it did not significantly affect waterbreak spacing.

For the five road segments, the original ratings for waterbreak construction were: 14 acceptable, two marginally acceptable, and three departures. Re-monitoring produced the following ratings: 15 acceptable, one marginally acceptable, and three departures. One of the waterbreaks rated as marginally acceptable by the Forest Practice Inspector was rated as acceptable when re-monitored by Sacramento watershed staff.

Likewise, the original ratings for waterbreak discharge into cover were: 15 acceptable, two marginally acceptable, and two departures. Re-monitoring produced the following ratings: 17 acceptable, zero marginally acceptable, and two departures. Two of the waterbreaks rated as marginally acceptable by the Forest Practice Inspector were rated as acceptable when re-monitored by watershed staff.

In this small QA/QC re-sample, the monitoring results for waterbreak construction and discharge into cover were largely the same, with the Forest Practice Inspectors grading slightly harder when deciding between ratings of acceptable and marginally acceptable.

One road segment among the five segments re-monitored accounted for all of the rule departure ratings.

When considering waterbreak spacing, re-monitoring of distance and gradient between waterbreaks varied slightly from the original monitoring, but not enough to affect the analysis of waterbreak spacing. Correct versus incorrect waterbreak spacing was the same for both evaluations.

For effectiveness monitoring, waterbreak interval-related erosion was similar for both the originally recorded data and the QA/QC recorded data for the five road segments. Rills were found in the same waterbreak intervals and at the same lengths, with a minor exception of one set of rills which was recorded as 30 feet long the first time and 40 feet long during re-monitoring three months later. Since road surface erosion was recorded in 10-foot increments, this is not a significant difference. Also note that rill patterns grow overtime given intervening storms. One of the resampled road segments had significantly more rutting when it was re-monitored nearly three years after the original monitoring. Most likely this was due to traffic during wet weather road conditions in the period between the original monitoring and re-monitoring.

Figure 51. Seasonal road segment monitored a second time during a QA/QC monitoring inspection in Humboldt County in 2013.

V. Discussion

There are four important things to consider when evaluating the results of the FORPRIEM road monitoring. First, this was a representative random sample of road segments meant to represent average conditions. A random selection of sites provides an overall estimate of Forest Practice Rule implementation and effectiveness. Significant erosion events like major landslides are relatively rare in a population of plan areas, and unlikely to show up in a random sample of plans and random sample sites within those plans. A different approach, such as stratified random sampling, is more appropriate for monitoring these types of features.[21] Second, the FORPRIEM monitoring period (2008-2013) produced few intense storms with high flows in the forested parts of California (Figure 52). Intense storms with high runoff are more likely to create erosion, sediment transport, and transport to channels. Third, FORPRIEM monitoring only looked at logging roads in the plan area and appurtenant roads to the plan. It did not include public roads and legacy roads that have not been used recently for timber harvesting, of which there are many (Figure 53). Finally, documentation of fine sediment delivery to watercourses during strong winter storm events was not undertaken with this program. Non-storm event field observations of sediment delivery can document coarse sediment deposits that reach the high water line of a channel or flood prone area, but they cannot record observations of turbid water reaching the watercourse during winter runoff events.

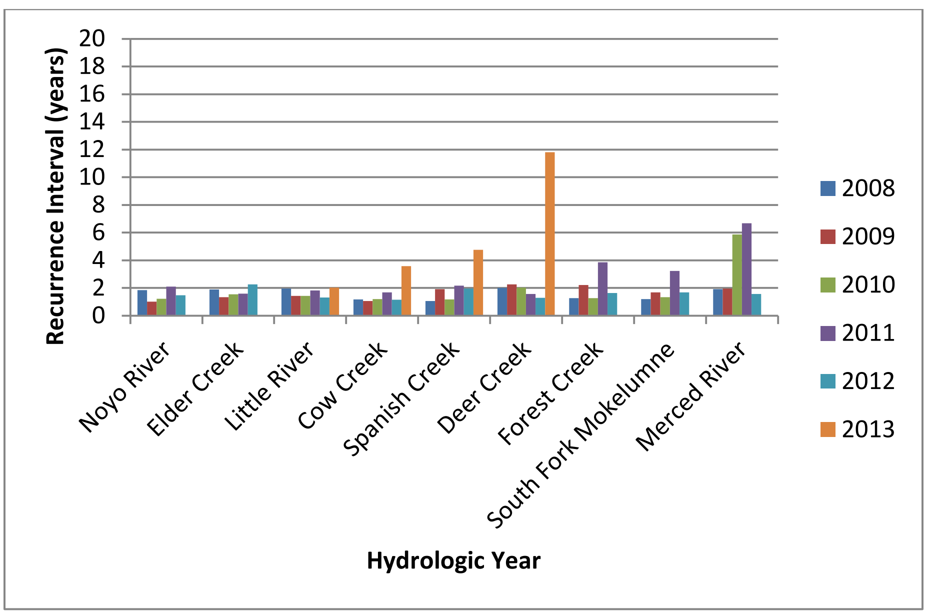

Figure 52. Annual instantaneous peak flows during the FORPRIEM monitoring period were generally low, based on peak flow recurrence intervals for a number of rivers covering the FORPRIEM monitoring area. One exception was the 12-year recurrence interval discharge that occurred on Deer Creek in Tehama County during the 2013 hydrologic year.

[21] Sites to be evaluated could be randomly selected from a subset of sites that have been classified as higher risk because of their location and site conditions (e.g., steeper sites on more unstable terrain).

Figure 53. Public roads, such as this road in Santa Cruz County with a major landslide feature, were not included in the FORPRIEM sample.

Generally, properly implemented Forest Practice Rules work to limit road-related erosion, to prevent sediment transport, and to prevent sediment transport to channels. Waterbreak intervals with correct spacing in compliance with the Forest Practice Rules (14 CCR § 914.6 [934.6, 954.6] (c)) were found to have a lower incidence of erosion, specifically WBI-related erosion. For THPs, it was 14% with erosion for correct spacing versus 37% with erosion for incorrect spacing. For NTMP-NTOs, it was 10% with erosion for correct spacing versus 50% with erosion for incorrect spacing. Put another way, THP roads with waterbreaks at incorrect spacing were found to have WBI-related erosion approximately two and half times as often as roads with waterbreaks with correct spacing. NTMP-NTO roads with waterbreaks at incorrect spacing were found to have WBI-related erosion five times as often as roads with waterbreaks at correct spacing. NTMP-NTO roads are generally built more narrow than THP roads, with minimal cut and fills, for light traffic and slower speeds, and this may account for some of the differences observed in this monitoring program. Additionally, NTMP-NTO roads are controlled by small nonindustrial landowners with different objectives than roads controlled by larger landowners, frequently resulting in less maintenance.

All roads in the FORPRIEM sample were used for timber harvesting one to five years preceding this monitoring, which means they were more likely to have received recent maintenance and upgrading than similar roads that were not involved in recent timber harvest operations.

The FORPRIEM road results compare well with results from earlier monitoring work conducted on non-federal timberlands in California. 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. For the MCR monitoring program, 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 (Brandow et al. 2006).

The State Board of Forestry and Fire Protection approved the Road Rules, 2013, rule package in 2014 and it will be implemented January 1, 2015 for non-federal timberlands in California.[22] These rules require hydrologic disconnection (where feasible) and road erosion site inventories on a statewide basis for the first time. It is anticipated that there will be a substantial effort made to ensure that the rule sections requiring hydrologic disconnection are adequately enforced on the ground. Several Road Rules, 2013 training workshops for state agency personnel and RPFs were held in the fall of 2014 to improve understanding of the rule package. It is expected that further improvements in road drainage and road-related erosion control will occur with the use of these new rules in 2015 and beyond. Effectiveness studies targeted specifically at determining hydrologic disconnection success and other topics are anticipated by the Board of Forestry and Fire Protection's newly formed Effectiveness Monitoring Committee.

[22] This rule package was worked on by various Board committees for 14 years.

FORPRIEM Monitoring:
Watercourse Crossings

I. Methods

<u>Monitoring Timelines and Site Selection</u>

Watercourse crossing selection was based on the random selection of the road segment. The first two permanent or abandoned watercourse crossings on Class I, II, or III watercourses encountered along the randomly located 660-foot road transect (as described in the Road Section of this report) were selected for FORPRIEM monitoring. Forest Practice Inspectors were instructed to sample the first crossing that was available.

If no crossings were noted within the 660-foot road transect, then Inspectors selected the two closest watercourse crossings shown on the THP or NTMP-NTO map relative to the randomly chosen road transect (Figure 23). If there were no watercourse crossings associated with Class I, II, or III watercourses along roads, the nearest skid trail crossings were evaluated. If there were no watercourse crossings within the THP or NTMP-NTO, then "No Watercourse Crossings" was written on the data form.

The watercourse crossing evaluation area included the road approaches which drained towards the crossing from both sides. The evaluation also included the drainage structures on the road approaches immediately upslope from the crossing intended to route water off the road before reaching the crossing (i.e., "cut-off" drainage structure).

The FORPRIEM monitoring procedures and methods document specified that each of the selected crossings was to be rated for implementation and effectiveness as described below:

> "Each watercourse crossing will be rated for FPR implementation and effectiveness. Implementation can be rated on the first visit at the time of the Completion Report inspection. Effectiveness may be rated the same first visit if the watercourse crossing being evaluated has been through at least one winter period. If the watercourse crossing being evaluated has not been through at least one winter period at the time of first visit, a second visit after the winter period to the site will be necessary to evaluate the watercourse crossing for effectiveness."

<u>Watercourse Crossing Site Information</u>

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

- Watercourse class (i.e., I, II, III, or IV)
- Road type (i.e., permanent, seasonal, temporary, or abandoned)
- Crossing type (i.e., culvert, ford, bridge, etc.)
- Date of installation (i.e., prior to the THP or part of the THP)
- Crossing status (i.e., existing or abandoned)
- Culvert diameter (if applicable)
- Multiple culvert information (if applicable)
- Photographs of the crossing/approaches taken (yes or no)
- Recommended follow-up monitoring of the crossing (yes or no)

It was requested that culvert diameters be measured with a pocket tape measure (Figure 54). The watercourse crossing site information and implementation field forms are displayed in the Appendix.

Figure 54. Clay Brandow measuring the pipe diameter on a FORPRIEM THP located in the upper Sacramento River Canyon.

Watercourse Crossing Forest Practice Rule Implementation Rating

Following completion of the site information portion of the form, the Inspector rated implementation of 30 Forest Practice Rule 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:

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

<u>Watercourse Crossing Effectiveness Rating for THPs</u>

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; Staab 2004, USFS 2009, USFS 2013), as well as a simplified version of the field forms developed for the Hillslope Monitoring Program (BOF 1999, 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 field form is displayed in the Appendix, and the following is a brief description of the rating criteria used for the 27 different crossing features.

FILL SLOPES

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

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

<u>Slope Failures</u>: Slope failures were defined as movement of soil in blocks, rather than by rills, gullies, or sheet erosion. The Inspector observed whether fill slope failure(s) at the crossing site was present, and if so, estimated the total as between zero and one cubic yard, 1-10 cubic yards, or greater than 10 cubic yards.

ROAD SURFACE DRAINING TO THE CROSSING

<u>Gullies</u>: Gullies on the road surface draining to 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 (Figure 55). The major problem category was selected when all water was allowed to reach 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.[23] 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 over the crossing fill. 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.

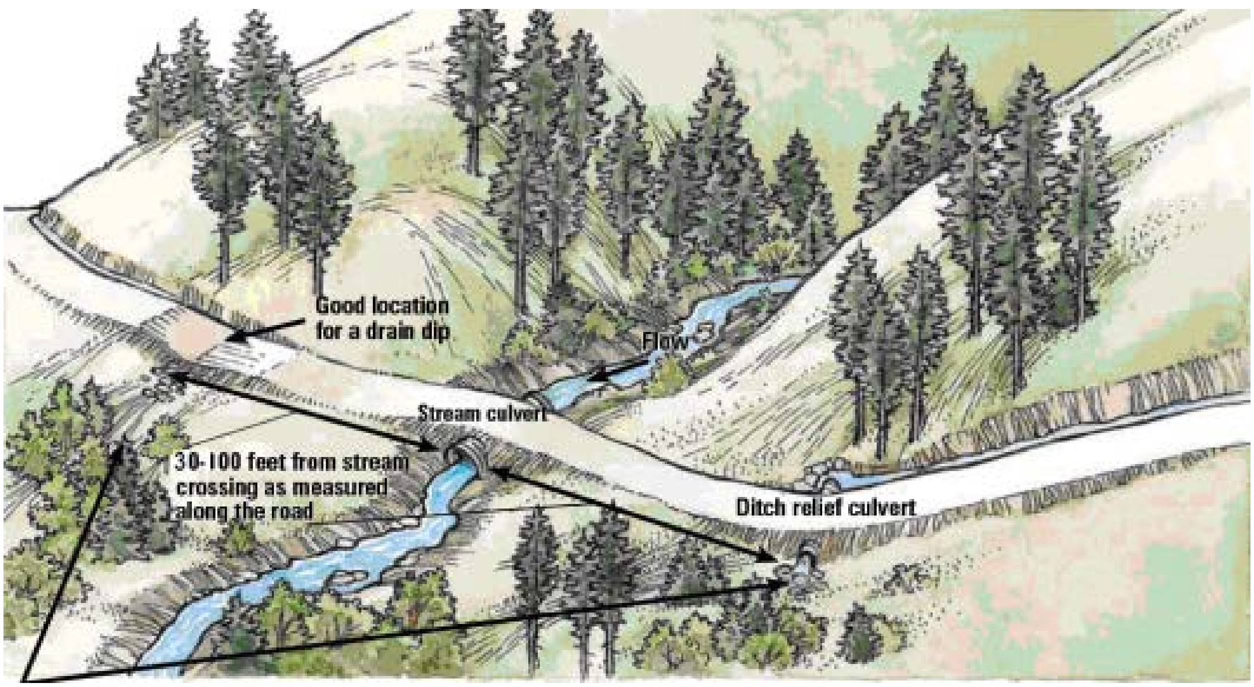

Figure 55. Diagram illustrating functioning cutoff drainage structures preventing water from reaching the watercourse crossing (modified from Oregon Forest Resources Institute 2011, 2nd Ed.).

CULVERT DESIGN/CONFIGURATION

Scour at Inlet: The total amount of scour that had occurred at the inlet of the culvert was observed. The presence of significant scour, which may have undercut the fill material, was used to identify major problems.

[23] Even though the goal is to have hydrologic disconnection along road segments, the area below the last cut-off drainage structure will still deliver water to the culvert inlet (commonly less than 100 feet).

Scour at Outlet: The total amount of scour that had occurred at the outlet of the culvert was observed. The presence of significant scour, which extended for greater than two channel widths or undercut the crossing fill, 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 and/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 between the channel approach and the pipe.

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 by a screwdriver or similar tool.

Crushed Inlet/Outlet: The Inspector determined if the pipe inlet or outlet had been deformed by heavy equipment (e.g., grader or backhoe). Less than 30% blockage by crushing was defined as a minor problem, and greater than 30% was denoted as 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 fill erosion problems.

Gradient: Improper culvert gradient was indicated when the pipe inlet was set too low 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., Rock Ford or Rock Armored Fill Crossing)

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 should the crossing structure fail.

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 or stabilization.

Gullies: Gullies were defined as being greater than six 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 one cubic yard (slight), greater than one cubic yard without channel entry (minor), or greater than one cubic yard and deposition into the stream channel (major).

Channel Configuration: The restored channel configuration was examined at abandoned and removed crossings to determine if it was as wide or 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: Sites where excavated soil was placed were evaluated to determine if they had been sloped back from the channel and stabilized to prevent slumping and minimize sediment input into the channel. A minor problem was defined as having less than one cubic yard of excavated material transported to the channel, and a major problem was identified when greater than one 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 observed.

Watercourse Crossing Effectiveness Rating for NTMP-NTOs

FORPRIEM includes the first comprehensive review of NTMP-NTOs. Only the North Coast Hydrologic Region was sampled in a joint monitoring effort with the NCRWQCB in 2011-2012 (Figure 56), with limited data collected statewide starting in 2013. Due to the heavy emphasis on sampling in the North Coast Hydrologic Region, about 90% of the NTMP-NTOs have come from the CAL FIRE Coast Region (R-1).

CAL FIRE Forest Practice Inspectors evaluated watercourse crossings using the standard FORPRIEM watercourse crossing site information, rule implementation, and effectiveness forms for the most part. For 10 NTMP-NTOs, the modified NCRWQCB crossing effectiveness form was utilized, which added additional categories for evaluation (e.g., road approach and road fill slope surface erosion, road slope failure/perched fill, and both inlet/outlet gradient control). Forest Practice Rule implementation for crossings was not included in the NCRWQCB form. For one NTMP-NTO, only the NCRWQCB form was used, resulting in no information on rule implementation for two crossings.

For both NTMP-NTOs and THPs, approximately 90% of the plans had at least one watercourse crossing available to evaluate.

Figure 56. Joint CAL FIRE and NCRWQCB staff inspection of a watercourse crossing evaluated in August 2011 (1-97NTMP-018 MEN; NTO #6).

II. THP Watercourse Crossing Results

<u>General Descriptive Results</u>

A total of 208 watercourse crossings from THPs were rated for implementation from 2008 through 2013, and 198 of these crossings were rated for effectiveness. Approximately 67% of the crossings were culverts, 21% fords, 9% removed or abandoned, 2% bridges, and 1% other types (e.g., tractor road crossings) (Figure 57).

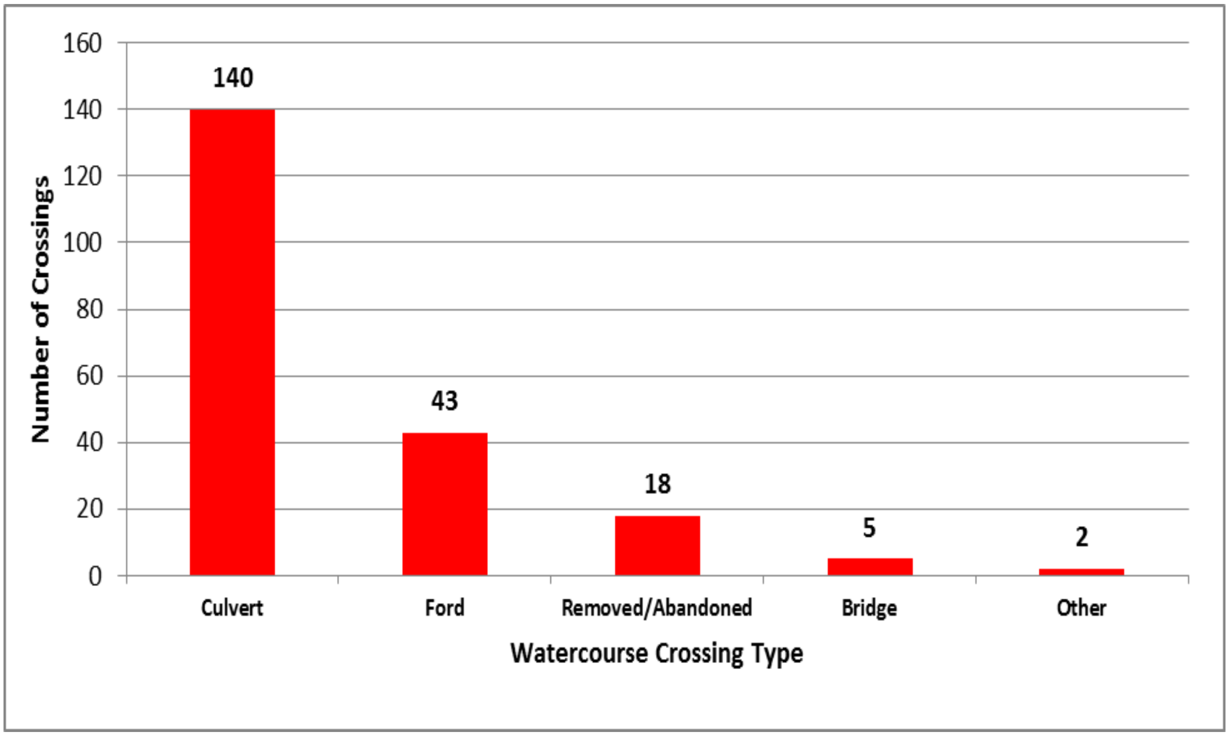

Figure 57. Distribution of watercourse crossing types associated with sampled THPs.

Approximately 48% of the crossings rated for implementation were located in Class III watercourses, 46% were in Class II drainages, and 6% were in Class I channels (Figure 58). The proportion of crossing types varied considerably depending on watercourse class. Approximately 80% of the ford crossings were located in Class III watercourses, with a similar percentage of bridges located in Class I watercourses. Culverts were more broadly distributed, with 55% in Class II, 41% in Class III, and 4% in Class I watercourses.

Roughly 68% of the crossings were found on seasonal roads and one quarter on permanent roads. Temporary, abandoned, and other types (tractor roads) made up the remainder of the road types encountered.

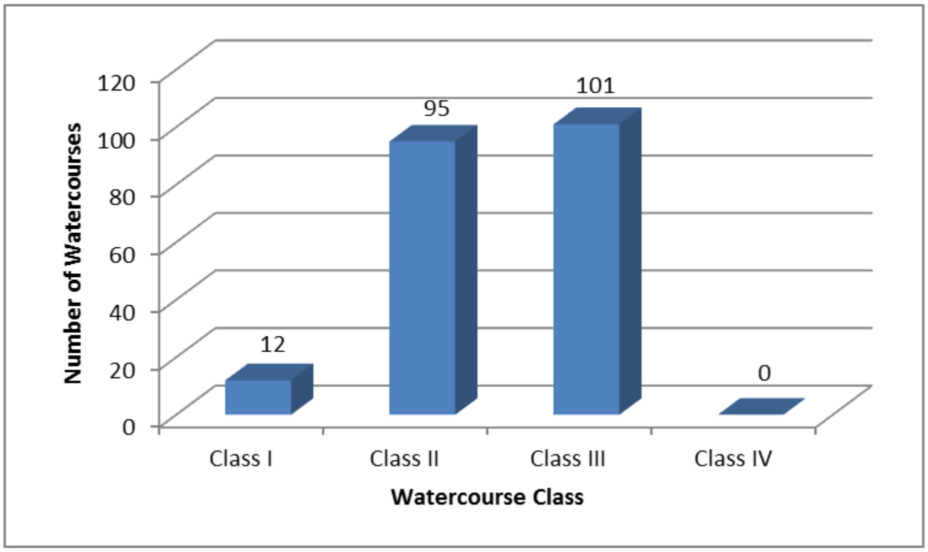

Figure 58. Percentages of sampled watercourse classes with THP watercourse crossings.

The distribution of pipe sizes for crossings with culverts is displayed in Figure 59. This diagram shows that approximately 22% of the pipes were 18 inches in diameter, 29% were 24 inches, and 16% were 36 inches. Approximately 11% of the pipes were 48 inches or larger, and about 22% were other sizes or multiple pipe configurations. Approximately 50% of the culverts were 18 inch or 24 inch diameter pipes, since the majority of the crossings were located in small headwater streams. The majority of the culverts were steel, with a smaller component of plastic pipes (Figures 60 and 61).

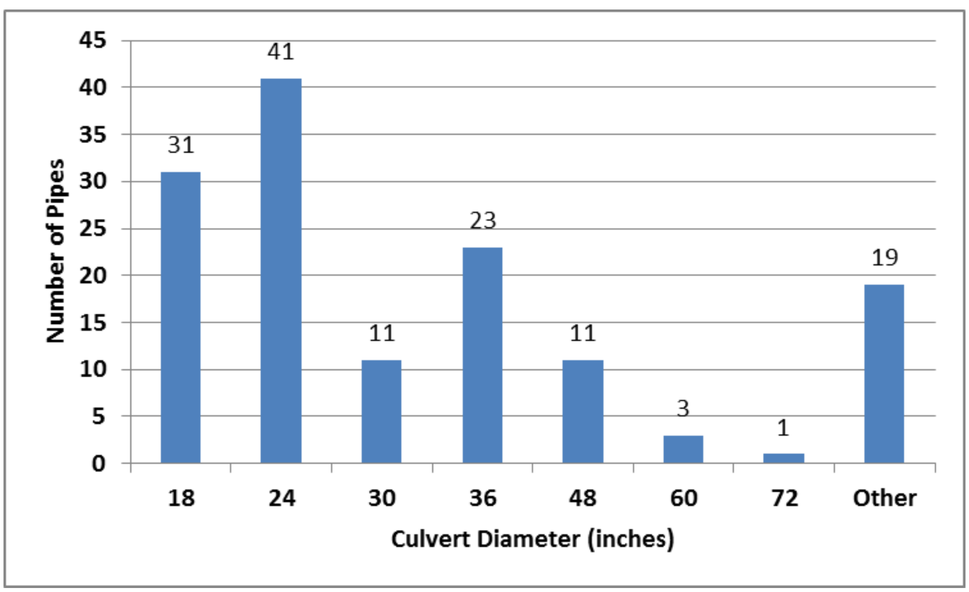

Figure 59. Culvert size distribution for THP watercourse crossings with pipes.

Figure 60. 30-inch corrugated plastic pipe outlet, THP 1-06-107 MEN.

Figure 61. 36-inch galvanized steel culvert, THP 1-09-026 HUM.

For crossings with culverts, 74% had pre-existing pipes and 26% of the crossings had new pipes installed as part of the THP. About 65% of the ford crossings were installed as part of the THP, while 35% were existing structures. Roughly half the removed/abandoned crossings were new, and one-fifth of the evaluated bridges were installed as part of the plan. Overall, approximately 64% of the watercourse crossings were installed prior to the THP and 36% were installed as part of the plan.

THP Watercourse Crossing Implementation Results

As stated in the methods section above, implementation of watercourse crossing requirements included in the California Forest Practice Rules was rated using the following compliance categories: Departure (D), Marginally Acceptable (MA), Acceptable (A), Exceeds Rule/THP Requirements (ER), and Not Applicable (NA). These rating categories were applied to 30 individual rule requirements, including 27 road rules found in 14 CCR § 923 [943, 963] and three rules related to tractor roads found in 14 CCR § 914 [934, 954]. Implementation data are presented in Table 12 for all of the crossing types combined.

The number of observations available for analysis is not the same for each rule requirement, since many of the rules were not applicable (NA) at the crossing sites evaluated. The following discussion of combined crossing types has been limited to those rules with greater than 10 observations (approximately 5% of the possible number of ratings that could have been assigned for the 208 crossings evaluated).

Twenty-seven specific FPR requirements related to watercourse crossings were observed and rated for implementation at more than 10 field sites (Table 12). Six rule requirements had departure percentages that exceeded 3%, led by 14 CCR § 923.4 [943.4, 963.4] (d), which requires trash racks to be installed where needed at culvert inlets (15% departure rate).[24] Second highest in departure percentage (8%) was 14 CCR § 923.4 [943.4, 963.4] (l), requiring drainage structures and trash racks to be maintained and/or repaired to prevent pipe blockage. The rules requiring crossings to be constructed or maintained to prevent diversion potential, 14 CCR §§ 923.3 [943.3, 963.3] (f) and 923.4 [943.4, 963.4] (n), had departure rates of 5% and 4%, respectively. Rule requirements specifying that new permanent crossings be shown on the THP map (14 CCR § 923.3 [943.3, 963.3] (a)) and requiring that the crossing remain open to restricted passage of water (14 CCR § 923.4 [943.4, 963.4] (d)) had departure rates of 4% and 3%, respectively.

When considering rule departures combined with marginally acceptable ratings (D+MA >10% in Table 12), six other rules merit consideration in addition to those listed above. These include three crossing removal or abandonment rules (14 CCR §§ 923.8 [943.8, 963.8] (c), 923.8 [943.8, 963.8] (e), and 923.3 [943.3, 963.3] (d)(2)); waterbreak maintenance (14 CCR § 923.4 [943.4, 963.4] (c)), discharge limitation on unprotected fill (14 CCR § 923.2 [943.2, 963.2] (o)), and a requirement for oversize culverts or trash racks where there is evidence of debris likely to reduce culvert capacity (14 CCR § 923.2 [943.2, 963.2] (i)).

[24] As shown in Table 12, 14 CCR § 923.3 [943.3, 963.3] (c) has a departure rate of 6%, but this rule only applies to Class I watercourses with fish present. Since it was rated 52 times, but only 12 Class I watercourses were included in the sample, it was concluded that spurious data were recorded for this requirement and it is not included in this discussion. Similarly, 14 CCR § 914.8 [934.8, 954.8] (d) applies to tractor road (skid trail) crossings and was rated 14 times. Since only three skid trail crossings were included in the sample, these data were also considered suspect.

Table 12. Forest Practice Rule crossing requirements rated for THP implementation (only Coast District rule numbers are displayed in the left column, but Northern and Southern District rule requirements are included).

FPR No.	Brief Rule Description	Total Rated	Departure (%)	D + MA (%)
923.2(h)	size, #, location of structures sufficient to carry runoff	200	0.0	2.0
923.2(h)	size, #, location of structures minimizes erosion	200	0.0	2.5
923.2(h)	size, #, location of structures-natural drainage pattern	200	0.0	3.5
923.3(a)	new permanent crossings shown on THP map (+pipe diameter(s) if appropriate)	166	3.6	4.8
923.3(c)	unrestricted passage of all life stages of fish allowed	52	5.8	9.6
923.3(f)	crossing/fills built or maintained to prevent diversion	196	5.1	12.8
923.4(c)	waterbreaks maintained as specified in 914.6	176	1.1	15.3
923.4(d)	crossing open to unrestricted passage of water	198	3.0	8.1
923.4(e)	permanent constructed/reconstructed--100-year flood flow + sediment and debris passage	168	1.8	8.3
923.4(m)	Inlet/outlet structures, additional drainage structures, etc. repaired/replaced/installed as needed to protect water	157	0.6	7.0
923.4(n)	crossing/approaches maintained to prevent diversion	194	4.1	13.4
923.2(d) (Coast)	fills across channels built to minimize erosion	134	2.2	7.5
923.2(i)	where evidence of debris likely to significantly reduce culvert capacity below design flow, oversize culverts, trash racks, or similar devices installed in a manner that minimizes culvert blockage	74	0.0	13.5
923.2(o)	no discharge on fill unless energy dissipators used	124	1.6	12.9
923.4(d)	trash racks installed where needed at inlets	34	14.7	23.5
923.4(l)	drainage structure & trash rack maintained/repaired to prevent blockage	64	7.8	21.9
923.3(d)(1)	removed--fills excavated to reform channel	23	0.0	0.0
923.3(d)(2)	removed--cut bank sloped back to prevent slumping	22	0.0	13.6
923.3(d)(2) [required]	removed--where needed, stabilizing treatment applied	23	0.0	0.0
923.8	abandonment--maintenance free drainage	19	0.0	0.0
923.8	abandonment--minimize concentration of runoff	18	0.0	5.6
923.8(b)	abandonment--stabilization of exposed cuts/fills	18	0.0	0.0
923.8(c)	abandonment--grading of road for dispersal of water	18	0.0	16.7
923.8(d)	abandonment--pulling/shaping of fills	17	0.0	5.9
923.8(e)	abandonment--fills excavated to reform channel	18	0.0	0.0
923.8(e)	abandonment--cutbanks sloped back	18	0.0	11.1
923.8(e)	removal not feasible--diversion potential handled	4	25.0	25.0
914.8(b)	structure (bridge, culvert, etc.) used where water present during life of the crossing	0		
914.8(c)	unrestricted fish passage in Class I watercourse	1	100.0	100.0
914.8(d)	tractor road crossing fill removed and banks sloped properly	14	7.1	42.9

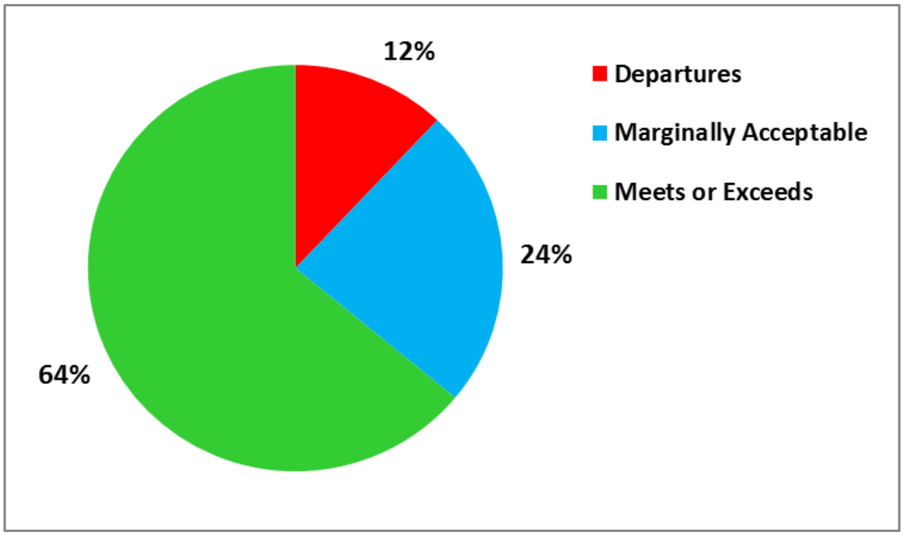

Figure 62. Percentages of THP watercourse crossings rated for Forest Practice Rule implementation falling in three main categories.

For the watercourse crossings rated for rule implementation, 64% of crossings had all the rule requirements rated as meeting or exceeding Forest Practice Rule standards; 24% had one or more marginally acceptable ratings, but no departures; and 12% of the crossings had one or more rule departure ratings (Figure 62).

THP Watercourse Crossing Effectiveness Results

Watercourse crossing effectiveness was evaluated by applying one of the following four ratings to the 27 crossing-related parameters listed in the methods section: (1) not applicable (N/A), (2) not a problem (e.g., none, slight, appropriate), (3) a minor problem, or (4) a major problem.[25] Of the 208 crossings rated for implementation, 198 of these crossings were rated for effectiveness (133 culverts), most often during the same site visit as when the implementation ratings were made. The 10 crossings without effectiveness ratings had yet to overwinter or had other factors associated with them that prohibited data collection.

Major problems were recorded a total of 40 times on 26 of the 198 crossings rated (Figure 63). The most frequently cited effectiveness problems were associated with culvert diversion potential (8) and inadequate road cutoff drainage structure function immediately above the crossing (8), followed by culvert plugging (4), pipe scour at the outlet (3), and non-culvert diversion potential (3). Overall, 13% of the THP crossings evaluated for effectiveness had one or more major problems. Minor effectiveness

[25] For culvert-related piping, the minor category was not provided as an option. For fill slope failures, options available were N/A, none, 0-1 yd^3, 1-10 yd^3, and >10 yd^3.

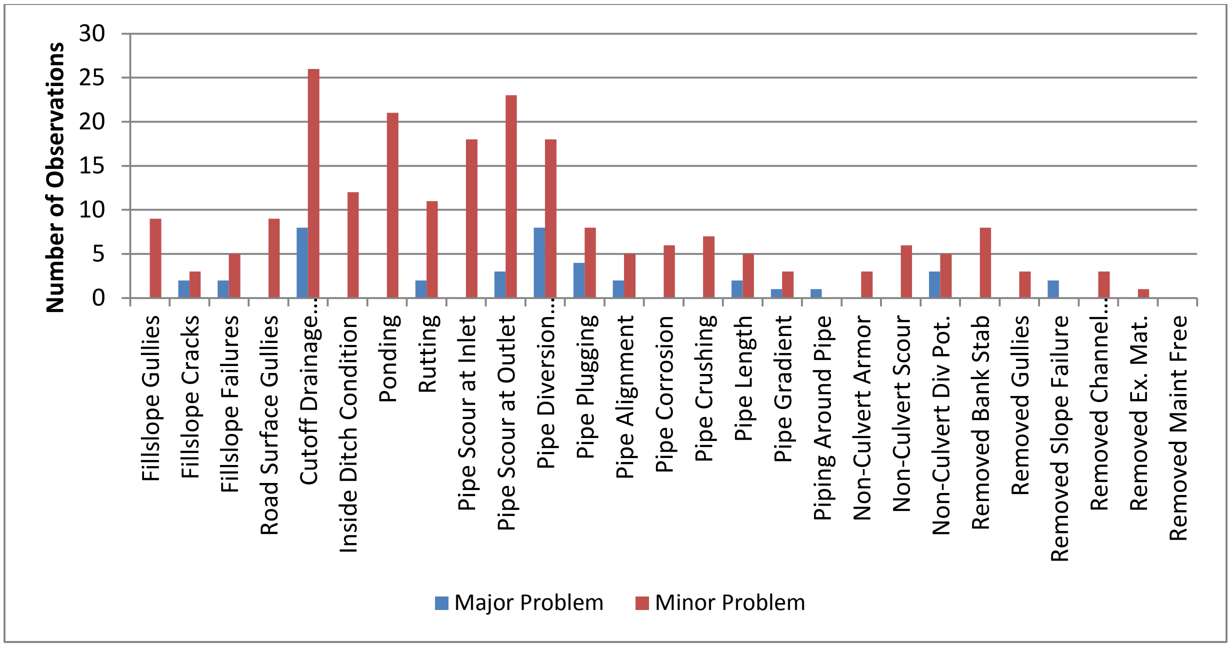

Figure 63. Major and minor effectiveness category problem counts for all crossing types associated with THPs.

problems were noted 218 times on 112 of the 198 crossings rated. The most problematic categories were cutoff drainage structure (26), pipe scour at the outlet (23), road ponding of water (21), pipe scour at the inlet (18), and pipe diversion potential (18). Minor effectiveness problems were recorded for 57% of the crossings rated.

Table 13 shows the percentage of major and minor effectiveness problems for all of the crossing types combined. Diversion potential was found to be a major problem for 6% of both the culvert and non-culvert crossings evaluated. Road cutoff drainage structure was denoted as a major problem for 5% of the road approaches to crossings evaluated. Pipe plugging was found to be a major effectiveness problem on 3% of the culverts observed in the sample (Figure 64). Slope failures were reported as a major problem for a quarter of the removed or abandoned crossings, but the sample size for these types of crossings is small (Figure 65).

When the major and minor problem categories are combined, the highest percentage is for inadequate removed or abandoned crossing bank stabilization (38%). Additionally, gullies associated with removed or abandoned crossings (14%) and inadequate channel configuration (13%) show that these types of crossings often have effectiveness issues.

Diversion potential was a major or minor problem for 20% of culverts rated, while non-culvert (e.g., ford) diversion potential was noted for 17% of the crossings evaluated. Scour at the outlet (20%) or inlet (14%) of culverts was also frequently recorded as a minor problem, as was scour at the outlet of non-culvert crossings (13%). Culvert plugging was noted as a major or minor problem for 9% of the crossings in this category.

Cutoff drainage structure function on road approaches to crossings was a major or minor problem for 21% of the crossings evaluated. Road approaches to crossings had minor problems recorded for inside ditchline condition 17% of the time (where a ditchline was present), while ponding was noted as a minor problem for 12% of the crossings.

Table 13. Watercourse crossing effectiveness ratings for THPs (excludes NA ratings).

Crossing Feature	Problem Type	Total Observations without NA	Major (%)	Minor (%)	Major + Minor Total (%)
Crossing Fill Slopes	Gullies	180	0.0	5.0	5.0
	Cracks	181	1.1	1.7	2.8
	Slope Failure	179	1.1	2.8	3.9
Road Surface Draining to Crossings	Gullies	191	0.0	4.7	4.7
	Cutoff Drainage Structure	160	5.0	16.3	21.3
	Inside Ditch Condition	69	0.0	17.4	17.4
	Ponding	172	0.0	12.2	12.2
	Rutting	192	1.0	5.7	6.8
Culvert Crossings	Scour at Inlet	133	0.0	13.5	13.5
	Scour at Outlet	133	2.3	17.3	19.5
	Diversion Potential	133	6.0	13.5	19.5
	Plugging	133	3.0	6.0	9.0
	Alignment	133	1.5	3.8	5.3
	Corrosion	127	0.0	4.7	4.7
	Crushing	133	0.0	5.3	5.3
	Pipe Length	133	1.5	3.8	5.3
	Gradient	133	0.8	2.3	3.0
	Piping	133	0.8	NA	0.8
Non-Culvert Crossings	Armoring	44	0.0	6.8	6.8
	Scour at Outlet	47	0.0	12.8	12.8
	Diversion Potential	47	6.4	10.6	17.0
Abandoned/Removed Crossings	Bank Stabilization	21	0.0	38.1	38.1
	Gullies	21	0.0	14.3	14.3
	Slope Failure	8	25.0	0.0	25.0
	Channel Configuration	23	0.0	13.0	13.0
	Excavated Material	21	0.0	4.8	4.8
	Maintenance Free Drainage	21	0.0	0.0	0.0

Figure 64. Culvert crossing with sediment and debris blocking more than 30% of the inlet (major problem), THP 1-05-246 HUM, crossing number 1.

Figure 65. Abandoned crossing with significant sediment entering the channel due to slope failure (major problem), THP 1-08-176 MEN, crossing number 2.

III. NTMP-NTO Watercourse Crossing Results

General Descriptive Results

A total of 39 watercourse crossings from NTMP-NTOs were selected for monitoring from 2011 to 2013 (Figure 66). Approximately 61% of the crossings were culverts, 21% fords, 13% temporary tractor road crossings, and 5% other types (e.g., Humboldt crossings) (Figures 67 and 68). Of these crossings, 37 were rated for Forest Practice Rule implementation and 39 were rated for effectiveness.[26]

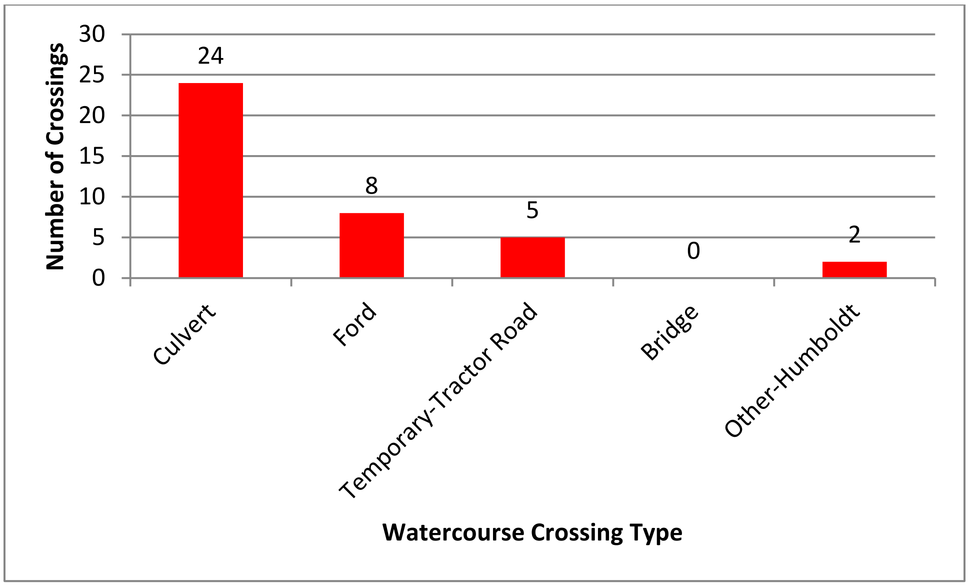

Figure 66. Distribution of watercourse crossing types associated with sampled NTMP-NTOs.

All of the NTMP-NTO crossings evaluated were located in Class II and III watercourses. Approximately 44% of the crossings were located in Class II watercourses and 56% in Class III drainages (Figure 69). The proportion of crossing types did not vary greatly by watercourse class.

Approximately 60% of the crossings were found on seasonal roads and 15% on permanent roads. Temporary, abandoned, and other types (tractor roads) made up the remainder of the road types encountered. The distribution of pipe sizes for crossings with culverts is displayed in Figure 70. This diagram shows that nearly 40% of the pipes were 18 inches in diameter and almost 60% were 24 inches or less in diameter. As with the THP culverts evaluated, pipe sizes were generally small since the majority of the crossings were located in small headwater watercourses.

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[26] Two crossings were not rated for rule implementation because they were only evaluated using forms developed by the North Coast Regional Water Quality Control Board (which did not include rule implementation). See the watercourse crossing methods section for further details.

Figure 67. Typical 18 inch culvert (1-97NTMP-038). The crossing inlet is shown on the left; the outlet is on the right.

Figure 68. Photos of a Humboldt (log-filled) crossing in the sample from an NTMP-NTO in Mendocino County. The crossing inlet is shown on the left; the outlet is on the right.

For crossings with culverts, 71% had pre-existing pipes and 29% of the crossings had new pipes installed as part of the NTMP-NTO. Three quarters of the ford crossings were installed as part of the NTMP-NTO, while 25% were existing structures. Overall, approximately 60% of the watercourse crossings were installed prior to the NTMP-NTO and 40% were installed as part of the NTO.

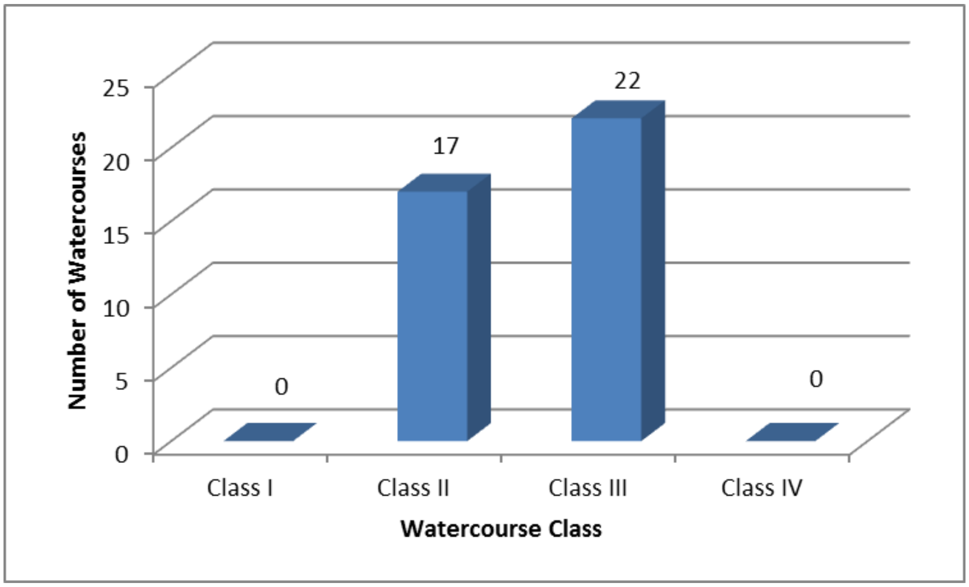

Figure 69. Percentages of sampled watercourse classes with NTMP-NTO watercourse crossings.

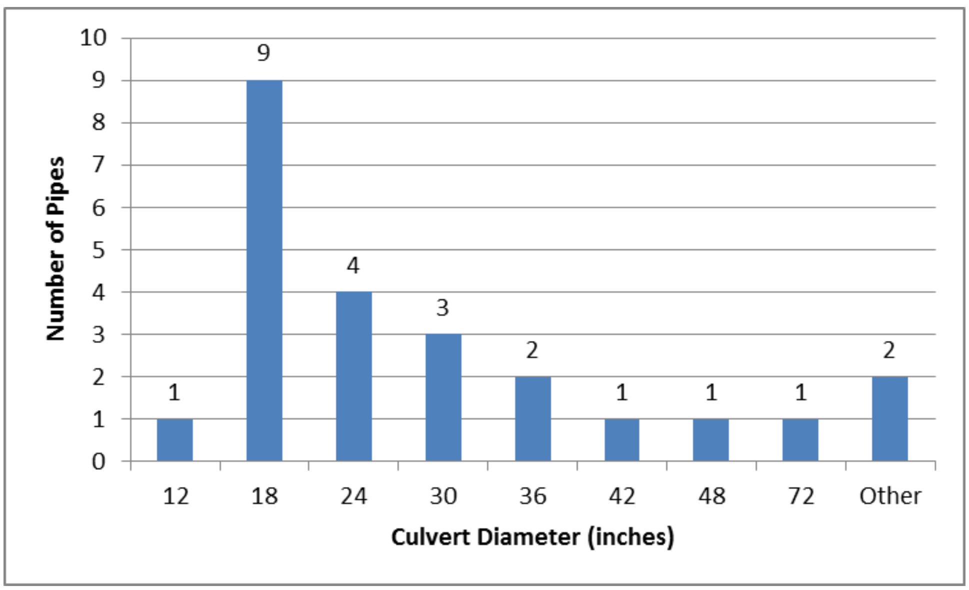

Figure 70. Culvert size distribution for NTMP-NTO watercourse crossings with pipes.

NTMP-NTO Watercourse Crossing Implementation Results

As with THPs, rule requirement implementation ratings were applied to 30 individual rule requirements, including 27 road rules found in 14 CCR § 923 [943, 963] and three rules related to tractor roads found in 14 CCR § 914 [934, 954]. Implementation data are presented in Table 14 for all the NTMP-NTO crossing types combined. The following discussion of combined crossing types has been limited to those rules with greater than 10 observations (approximately 25% of the possible number of ratings that could have been assigned for the 39 crossings evaluated).

Fourteen specific FPR requirements related to watercourse crossings were rated for implementation at more than 10 field sites (Table 14). Ten of these rule requirements had departure percentages that exceeded 3%, led by 14 CCR § 923.4 [943.4, 963.4] (l), requiring drainage structures and trash racks to be maintained and/or repaired to prevent pipe blockage (8%). Second highest in departure percentage was 14 CCR § 923.3 [943.3, 963.3] (a), which requires permanent crossings to be shown on the NTMP-NTO map (7%). The rule specifying that oversize culverts, trash racks, or similar devices be installed where there is evidence of debris (14 CCR § 923.2 [943.2, 963.2] (i)) had a departure rate of 6%, as did the rule mandating permanent crossings be constructed to pass 100-year flood flows and sediment/debris (14 CCR § 923.4 [943.4, 963.4] (e)).

Similarly, the rules requiring crossings to be constructed or maintained to prevent diversion potential, 14 CCR §§ 923.3 [943.3, 963.3] (f) and 923.4 [943.4, 963.4] (n), and remain open to restricted passage of water (14 CCR § 923.4 [943.4, 963.4] (d)) had departure rates of 6%. Forest Practice Rules 14 CCR §§ 923.4 [943.4, 963.4] (c), 923.4 [943.4, 963.4] (m), and 923.2 [943.2, 963.2] (o) had departure rates of approximately 3% to 4%.

When considering both rule departures combined with marginally acceptable ratings (D+MA >10% in Table 14), no additional rules merit consideration in addition to those listed above.

For the NTMP-NTO watercourse crossings rated for rule implementation, 70% of crossings had all the rule requirements rated as meeting or exceeding Forest Practice Rule standards; 11% had one or more marginally acceptable ratings, but no departures; and 19% of the crossings had one or more rule departure ratings (Figure 71).

Table 14. Forest Practice Rule requirements rated for NTMP-NTO implementation (only Coast District rule numbers are displayed in the left column; Northern and Southern District requirements are included).

FPR No.	Brief Rule Description	Total Rated	Departure (%)	D + MA (%)
923.2(h)	size, #, location of structures sufficient to carry runoff	36	0.0	8.3
923.2(h)	size, #, location of structures minimizes erosion	36	2.8	8.3
923.2(h)	size, #, location of structures-natural drainage pattern	36	2.8	2.8
923.3(a)	permanent crossings shown on THP/plan map (+pipe diameter(s) if appropriate)	31	6.5	6.5
923.3(c)	unrestricted passage of all life stages of fish allowed (where applicable)	10	10.0	20.0
923.3(f)	crossing/fills built or maintained to prevent diversion	33	6.1	9.1
923.4(c)	waterbreaks maintained as specified in 914.6	30	3.3	6.7
923.4(d)	crossing open to unrestricted passage of water	35	5.7	11.4
923.4(e)	permanent constructed/reconstructed--100-year flood flow + sediment and debris passage	33	6.1	6.1
923.4(m)	Inlet/outlet structures, additional drainage structures, etc. repaired/replaced/installed as needed to protect water	27	3.7	11.1
923.4(n)	crossing/approaches maintained to prevent diversion	33	6.1	6.1
923.2(d) Coast)	fills across channels built to minimize erosion	24	0.0	4.2
923.2(i)	where evidence of debris likely to significantly reduce culvert capacity below design flow, oversize culverts, trash racks, or similar devices installed in a manner that minimizes culvert blockage	16	6.3	12.5
923.2(o)	no discharge on fill unless energy dissipators used	23	4.3	8.7
923.4(d)	trash racks installed where needed at inlets	7	14.3	14.3
923.4(l)	drainage structure & trash rack maintained/repaired to prevent blockage	12	8.3	25.0
923.3(d)(1)	removed--fills excavated to reform channel	4	0.0	0.0
923.3(d)(2)	removed--cut bank sloped back to prevent slumping	4	0.0	0.0
923.3(d)(2) [required]	removed--where needed, stabilizing treatment applied	4	0.0	0.0
923.8	abandonment--maintenance free drainage	3	0.0	0.0
923.8	abandonment--minimize concentration of runoff	3	0.0	0.0
923.8(b)	abandonment--stabilization of exposed cuts/fills	3	0.0	0.0
923.8(c)	abandonment--grading of road for dispersal of water	3	0.0	0.0
923.8(d)	abandonment--pulling/shaping of fills	3	0.0	0.0
923.8(e)	abandonment--fills excavated to reform channel	3	0.0	0.0
923.8(e)	abandonment--cutbanks sloped back	3	0.0	0.0
923.8(e)	removal not feasible--diversion potential handled	1	100.0	100.0
914.8(b)	structure (bridge, culvert, etc.) used where water present during life of the crossing	4	0.0	0.0
914.8(c)	unrestricted fish passage in Class I watercourse	0		
914.8(d)	tractor road crossing fill removed and banks sloped properly	6	0.0	16.7

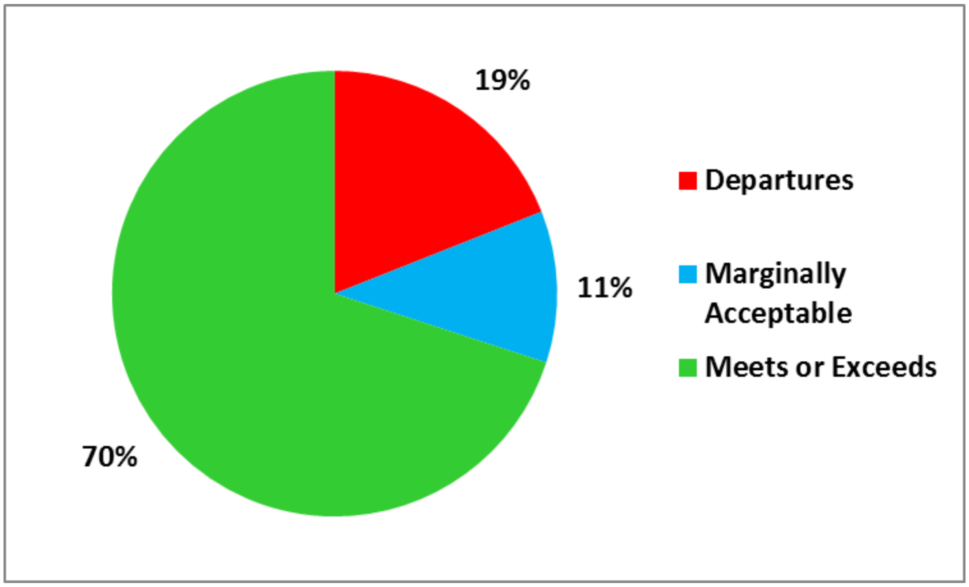

Figure 71. Percentages of NTMP-NTO watercourse crossings rated for Forest Practice Rule implementation falling in three main categories.

NTMP-NTO Watercourse Crossing Effectiveness Results

Watercourse crossings effectiveness was evaluated by applying the same four ratings used for THPs to the 27 crossing-related parameters listed in the methods section, plus four categories added by the NCRWQCB and evaluated at 10 crossings. All 39 crossings were rated for effectiveness, usually at the same time implementation ratings were assigned.

Major problems were recorded a total of nine times on four crossings (Figure 72). The most frequently cited major effectiveness problem was associated with culvert diversion potential, affecting two crossings. Seven additional effectiveness categories had one major problem assigned. Overall, 10% of the NTMP-NTO crossings evaluated for effectiveness had one or more major problems. Minor effectiveness problems were noted 66 times on 26 of the 39 crossings rated. The most problematic minor categories were pipe scour at the outlet (9) and cutoff drainage structure function (7). Minor effectiveness problems were recorded for 67% of the crossings rated.

Table 15 shows the percentage of major and minor effectiveness problems for all of the crossing types combined. Diversion potential was found to be a major problem for 8% of the culvert crossings evaluated. Scour at the inlet and outlet of culverts was denoted as a major problem for 4% of the crossings evaluated (Figure 73). Similarly, culvert plugging and piping were found to be a major effectiveness problem on 4% of the culverts evaluated.

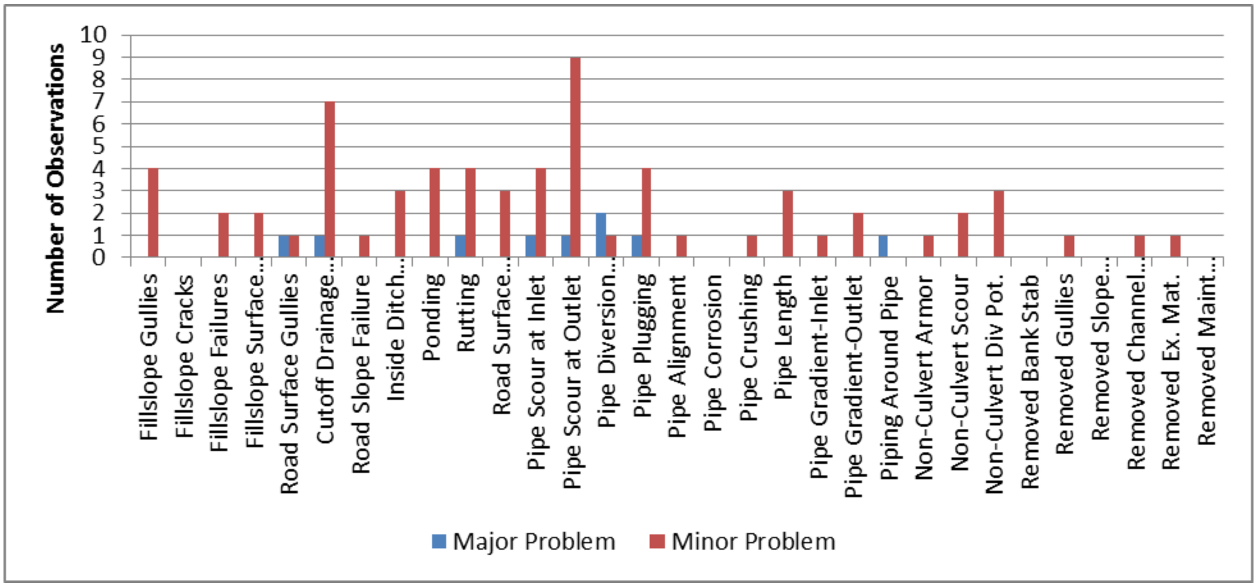

Figure 72. Major and minor effectiveness category problem counts for all crossing types associated with NTMP-NTOs.

Figure 73. Steel culvert with significant scour at the outlet (shown), as well as diversion potential (not shown) (1-97NTMP-018 MEN).

Table 15. Watercourse crossing effectiveness ratings for NTMP-NTOs (excludes NA ratings). [* indicates a category added on the NCRWQCB crossing effectiveness monitoring forms].

Crossing Feature	Problem Type	Total Observations without NA	Major (%)	Minor (%)	Major + Minor Total (%)
Fill Slopes	Gullies	38	0	10.5	10.5
	Cracks	38	0	0.0	0.0
	Slope Failure	39	0	5.1	5.1
	Surface Erosion*	10	0	20.0	20.0
Road Surface Draining to Crossing	Gullies	39	2.6	2.6	5.1
	Cutoff Drainage Structure	39	2.6	17.9	20.5
	Inside Ditch Condition	12	0.0	25.0	25.0
	Ponding	34	0.0	11.8	11.8
	Rutting	36	2.8	11.1	13.9
	Road Slope Failure*	10	0.0	10.0	10.0
	Road Surface Erosion*	10	0.0	30.0	30.0
Culvert Crossing	Scour at Inlet	24	4.2	16.7	20.8
	Scour at Outlet	24	4.2	37.5	41.7
	Diversion Potential	24	8.3	4.2	12.5
	Plugging	24	4.2	16.7	20.8
	Alignment	24	0.0	4.2	4.2
	Corrosion	16	0.0	0.0	0.0
	Crushing	24	0.0	4.2	4.2
	Pipe Length	24	0.0	12.5	12.5
	Gradient (Inlet and Outlet)*	24	0.0	12.5	12.5
	Piping	24	4.2	NA	4.2
Non-Culvert Crossing	Armoring	9	0.0	11.1	11.1
	Scour at Outlet	11	0.0	18.2	18.2
	Diversion Potential	12	0.0	25.0	25.0
Abandoned/ Removed	Bank Stabilization	7	0.0	0.0	0.0
	Gullies	7	0.0	14.3	14.3
	Slope Failure	6	0.0	0.0	0.0
	Channel Configuration	7	0.0	14.3	14.3
	Excavated Material	7	0.0	14.3	14.3
	Maintenance Free Drainage	7	0.0	0.0	0.0

When the major and minor problem categories are combined, the highest percentage is for scour at the outlet of culverts (42%). Inside ditch condition and non-culvert diversion potential ratings had minor problem ratings assigned to 25% of the crossings evaluated. Culvert plugging and scour at the inlet had major and minor problem ratings of 21%, as did road cutoff drainage structure function (Table 15).

Road surface erosion on approaches to crossings was rated 10 times using the modified effectiveness forms developed by the NCRWQCB and found to be a minor problem 30% of the time it was evaluated. Similarly, surface erosion on fill slopes was rated 10 times with the NCRWQCB form and found to be a minor problem for 20% of these crossings.

IV. Watercourse Crossing QA/QC

The five randomly selected THPs utilized for WLPZ canopy and road QA/QC evaluations were also resampled for watercourse crossing QA/QC (Figure 74). Four of the five THPs had crossings to evaluate. Each of these four plans had two culvert crossings, so a total of eight culvert crossings were evaluated twice.

There was good agreement for type of crossing, culvert size, and watercourse class. While the sample size was small, there was a higher rate of poor implementation and effectiveness ratings assigned during the first visit, both for implementation and

Figure 74. Clay Brandow and Gabe Schultz of CAL FIRE completing a QA/QC evaluation on a large culvert in the upper Sacramento River canyon during August 2013.

Table 16. FORPRIEM watercourse crossing QA/QC comparison for eight culvert crossings.

Criteria	First Evaluation	QA/QC Evaluation
# of Major Effectiveness Problems	3	1
# of Minor Effectiveness Problems	13	6
# of Crossings with Major Problems	2	1
# of Crossings with Minor Problems	6	3
# of Crossings with FPR Departures or Marginally Acceptable Ratings	3	2

effectiveness categories (Table 16). Three major effectiveness problems were recorded the first visit for two culvert crossings from a THP located in Humboldt County—two for cutoff drainage structure function and one for diversion potential. During the QA/QC evaluation, only the diversion potential problem was noted for the same crossing. It is possible that road upgrading/improvement work was conducted at these two crossings during the six months between the two evaluations, accounting for the differences in observations. Minor effectiveness problems are likely to be more subjective than major problem assignment.

Overall, due to subjectivity associated with effectiveness ratings and possible road maintenance operations at crossing approaches, we conclude that the crossing evaluation process is less repeatable than that developed for WLPZ total canopy and road drainage facility spacing measurements.

V. Discussion

Watercourse crossing ratings recorded with the FORPRIEM program suggest that there may be improvement when compared to ratings reported earlier with the Hillslope Monitoring Program (Cafferata and Munn 2002) and Modified Completion Report Monitoring Program (Brandow et al. 2006). Data from the three monitoring programs suggest that crossing performance may be improving over time both for rule implementation and for effectiveness ratings, as shown in Figure 75.

Specifically, 13% of the FORPRIEM THP watercourse crossings rated for effectiveness had one or more major problems, compared to 18% with the Modified Completion Report (MCR) monitoring work and 36% with the Hillslope Monitoring Program (HMP).[27] While a direct comparison must be qualified for the HMP data since the monitoring

[27] The 36% figure is not reported in Cafferata and Munn (2002). This value was determined from the data stored in the Hillslope Monitoring Program database for this report. Statistical tests comparing these values have not been conducted.

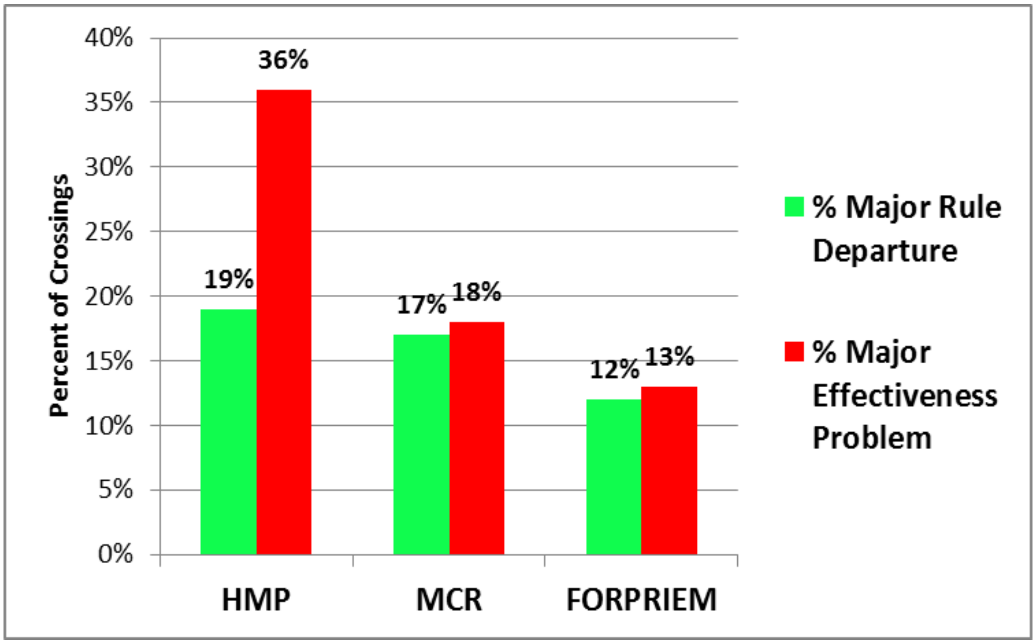

Figure 75. Comparison of THP watercourse crossing Forest Practice Rule implementation and effectiveness ratings for three monitoring programs spanning 1996 to 2013.

data were collected by contractors (i.e., R.J. Poff and Associates), not CAL FIRE Forest Practice Inspectors; 33 effectiveness categories were rated (not 27); and the January 1997 flood event occurred during the study [28], sufficient similarities exist to merit its inclusion in this comparison. In terms of Forest Practice Rule implementation ratings, 26 out of 208 THP crossings for FORPRIEM had one or more rule departures (12%), compared to 17% for the MCR program, and 19% for the HMP.[29]

Looking at specific THP effectiveness categories provides insight into where further improvement is needed for watercourse crossings and road approaches to crossings in the future. Culvert diversion potential has decreased from 9-11% with major problems documented with the HMP and MCR programs to 6% with FORPRIEM, and culvert plugging has dropped from approximately 9% to 3% (Figure 76). Road cutoff drainage structure function problems dropped from 8% with the HMP to 4% with MCR, but then increased to 5% with the FORPRIEM data. Statistical tests have yet to be run to determine if there are significant differences, but these data suggest that improvement is needed for hydrologic disconnection and cutoff drainage structure function. The new Road Rules, 2013, rule package being implemented January 1, 2015 for non-federal

[28] This rain-on-snow event produced flood flows with recurrence intervals greater than 100 years at 32 of 292 streamflow gaging stations evaluated in northern and central California; peak flows were the largest on record at 106 of these stations (Hunrichs et al. 1998). No similar flood events occurred during the life of the FORPRIEM program (see Figure 52).

[29] For the HMP, only major Forest Practice Rule implementation departures were considered (i.e., minor rule departures were excluded). The rule departure rate for NTMP-NTOs is similar to that for the MCR program, but the sample size was small.

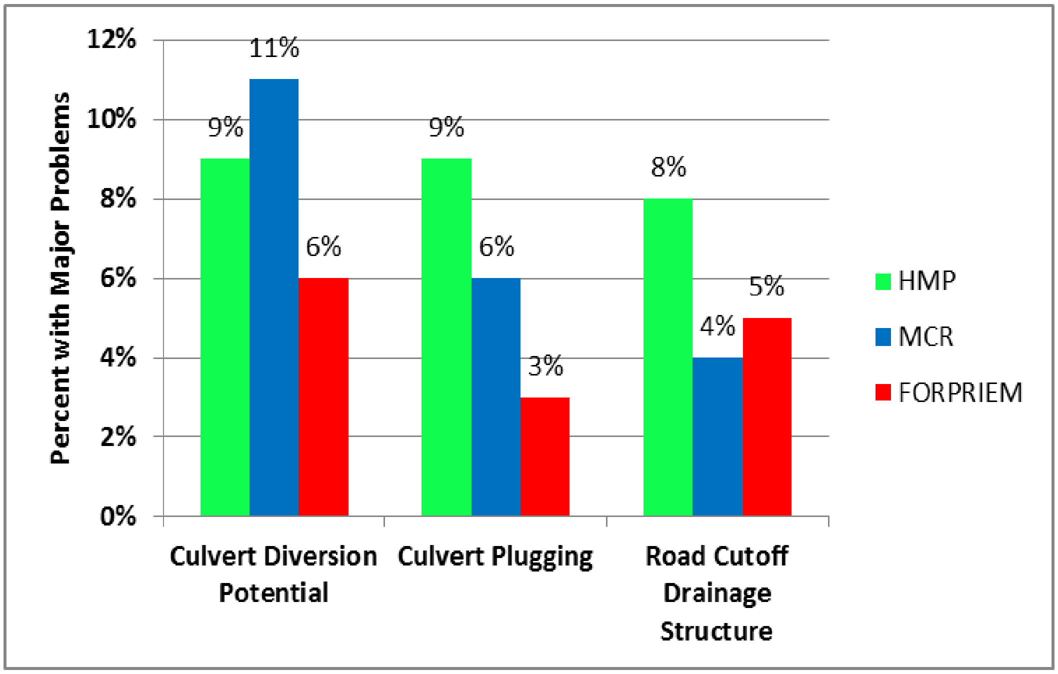

Figure 76. Comparison of three effectiveness categories evaluated with three different monitoring programs spanning 1996 to 2013.

timberlands in California requires hydrologic disconnection (where feasible) on a statewide basis and there will be a substantial effort made to ensure that the rule section requiring hydrologic disconnection is adequately implemented on the ground.[30]

The FORPRIEM THP data suggest that culvert diversion potential is decreasing over time, but it is still a relatively frequent problem for existing forest road crossing structures that requires further improvement. While diversion potential has been addressed by the FPRs since 1991, the new Road Rules, 2013 rule package specifically states that critical dips are to be incorporated into the construction or reconstruction of watercourse crossings utilizing culverts to address diversion potential, except where diversion of overflow is addressed by other methods stated in the plan [14 CCR § 923.9 [943.9, 963.9] (j)].

Additionally, further improvement is needed for existing crossing Forest Practice Rule implementation related to (1) adequate crossing abandonment, since inadequate bank stabilization and slope failures had relatively high rates of major and minor effectiveness problems recorded for the THPs evaluated with FORPRIEM, (2) scour at the inlet and outlet of culvert crossings, and (3) culvert plugging. Reduced culvert plugging is

[30] The Road Rules, 2013 rule package requires hydrologic disconnection in 14 CCR § 923 [943, 963] under these subsections: 14 CCR §§ 923.2 [943.2, 963.2] (a)(5); 923.4 [943.4, 963.4] (a); 923.5 [943.5, 963.5] (a); 923.7 [943.7, 963.7] (a); and 923.9 [943.9, 963.9] (m)(1).

anticipated in the future with use of the new Road Rules, 2013 rule package, which requires monitoring during the erosion control maintenance period a sufficient number of times during the extended wet weather period, particularly after large winter storm events and at least once annually, to evaluate the function of drainage facilities and structures [14 CCR § 923.7 [943.7, 963.7] (k)].

NTMP-NTO watercourse crossings appear to be generally comparable to THPs from a water quality standpoint, but the sample size is small. Future water quality-related monitoring conducted on non-federal timberlands should continue to include NTMP-NTOs so that a more robust dataset can be developed for comparison to that which has been collected to date for THPs.

Conclusions

FORPRIEM monitoring has found a generally high rate of compliance with the California Forest Practice Rules (Title 14, California Code of Regulations) designed to protect water quality and aquatic habitat. When properly implemented, the FPRs evaluated in this study appear to be effective in preventing erosion, sediment transport, and sediment transport to watercourse channels.[31]

The California Forest Practice Rules change every year, with FPR revisions and additions adopted by the California State Board of Forestry and Fire Protection. THPs are subject to the FPRs that were in effect when the plan was approved by CAL FIRE, as well as newly adopted operational rules (see PRC § 4583). The THPs in this FORPRIEM sample were approved between 2002 and 2012. The NTMPs to which the NTOs were attached were approved between 1993 and 2010.

In recent years, the FPRs affecting the three areas studied with FORPRIEM have been updated and improved, starting in 2009 with the adoption of the Anadromous Salmonid Protection (ASP) rule package (implemented January 1, 2010). These rules are permanent regulations and replaced the interim Threatened or Impaired Watershed Rules (T/I rules) which were originally adopted in July 2000 and readopted six times. Goals associated with the ASP rules included providing a high level of protection for listed fish species, and instituting rules that contribute to salmonid habitat restoration. These rules modified WLPZ canopy requirements in the ASP area. In addition, in 2014, the Board adopted the Road Rules, 2013 rule package, affecting both roads and watercourse crossings. Goals for this rule package included modifying the road-related rules to prevent adverse impacts to the beneficial uses of water, and organizing all the road rules into a logical, consistent order in one section of the Forest Practice Rulebook.[32] Therefore, all the THPs sampled with FORPRIEM in areas with listed anadromous salmonids were subject to either the T/I rules or the ASP rules—both requiring significantly higher levels of protection in riparian zones than the standard FPRs required elsewhere in California. None of the plans sampled were affected by the new Road Rules, 2013 rule package requirements.

The next iteration of implementation and effectiveness monitoring conducted on non-federal timberlands in California will have to be updated to accommodate these changes in the FPRs. If the rates of proper implementation remain high for the newer, more challenging and protective rules, then the effectiveness outcomes for WLPZ

[31] Note that FPRs addressing landslide features associated with increased pore water pressures and decreased root strength and occurring with clearcutting 5-15 years after logging were not part of this study. Similarly, rules addressing increased channel incision, gullying, and channel headcutting associated with increased peak flows were not addressed. Additionally, FPRs addressing erosion associated with tractor roads (skid trails), landings, site preparation, and post-fire salvage logging were not considered. Only short-term effectiveness was evaluated in this study.

[32] Improved rules for assessing cumulative impacts, including cumulative watershed effects (CWEs), are currently being addressed by the Board, and are the “third leg of the stool” for improved salmonid protection, originally outlined by the Board in 2007.

canopy retention and the prevention of erosion, sediment transport, and sediment transport to watercourse channels, would also be expected to improve.

More stringent rules will generally not improve effectiveness in cases where the rules are not being properly implemented. Improvement in implementation requires iterative learning through self-monitoring, agency inspections, timely corrective actions, and enforcement actions when necessary. Fortunately, FORPRIEM monitoring found high rates of proper implementation for most of the FPRs evaluated. Maintaining high rates of implementation or, when low, improving rates of proper implementation, is at least as important as improving the rules. If the rules are found to be ineffective even when properly implemented, focus should be placed on the cause-and-effect linkage between the implemented Rule and the desired resource outcome (e.g., clean water) to determine if the conceptual basis of the Rule is sound. Once a presumably more effective Rule is developed, the focus should return to proper Rule implementation.

WLPZs

Watercourse and Lake Protection Zone (WLPZ) percent total canopy averages are generally high and appear to meet the FPR requirements.[33] The distribution of monitored values that comprise the averages are skewed toward the high end, with very few monitored values at the low end which did not meet the FPRs. WLPZ percent total canopy averages are higher on average inside the ASP rules area than outside these areas. In the ASP rules area, WLPZ percent total canopy is slightly higher on average for NTMP-NTOs than for THPs.

THP WLPZ percent total canopy for Class I watercourses appears to be improving over time based on a comparison of results from three studies conducted between 1999 and the present (Figure 21). Generally, the Forest Practice Rules appear to be working to retain high levels of post-harvest WLPZ canopy, particularly in the Coast and Inland South Regions of the state, and to prevent erosion in the WLPZ.

FORPRIEM, as well as earlier MCR and HMP results, indicate that the FPR standards are generally being met for percent WLPZ canopy. 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 (using the Robards (1999) enforcement procedure).

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[33] Class I WLPZs currently require between 50% and 80% post-harvest overstory canopy, depending on geographic location (ASP area on non-ASP area, Forest Practice District) and the band of the WLPZ being considered (i.e., inner zone vs outer zone). Class II standard WLPZs require 50% post-harvest total canopy; Class II large watercourses in the ASP rules area require 70% or 80% overstory canopy, depending which Forest Practice District the plan is located within. Only total canopy was measured in this study due to difficulty in measuring overstory canopy with a vertical sighting tube.

FORPRIEM 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. As with WLPZ canopy, similar findings on groundcover were reported for the HMP and MCR monitoring programs.

The advent of the ASP rules now requires breaking affected WLPZs into subzones. Each sub zone has a different proximity to the watercourse and different WLPZ canopy retention requirements. FORPRIEM monitoring was designed to evaluate WLPZs as a single zone without subzones. New procedures and methods will need to be developed to monitor and evaluate WLPZs with multiple subzones. These methods and procedures will need to be field tested to ensure repeatable results.

Roads

FORPRIEM monitoring work has shown that individual practices required by the California FPRs are generally effective in preventing hillslope erosion features.
The rules evaluated, where properly implemented, appear to work to limit road-related erosion, to prevent sediment transport, and to prevent transported sediment from discharging into watercourses. Proper implementation rates are high for waterbreak spacing, waterbreak construction and discharge into cover. Compliance with the waterbreak construction rule (14 CCR § 914.6 [934.6, 954.6] (g)) and general construction standards for rolling dips (14 CCR § 923.2 [943.2, 963.2] (h)) was 97% for THPs and 99% for NTMP-NTOs. Compliance with the road drainage facilities and structures requirements for discharge into cover (14 CCR §§ 914.6 [934.6, 954.6] (f) and 923.2 [943.2, 963.2] (o)) was 98% for THPs and 98% for NTMP-NTOs.

Compliance with the waterbreak spacing rule (14 CCR § 914.6 [934.6, 954.6] (c)) [also used for rolling dips] was 88% for THPs and 90% for NTMP-NTOs. Waterbreak intervals with correct spacing in compliance with the FPRs had a lower incidence of erosion, specifically erosion on the road surface (excluding rutting) and on the fill slope. For THPs, it was 14% with erosion for correct spacing versus 37% with erosion for incorrect spacing. For NTMP-NTOs, it was 10% with erosion for correct spacing versus 50% with erosion for incorrect spacing. Put another way, THP waterbreaks with incorrect spacing were found to have erosion approximately two and half times as often as waterbreaks with correct spacing. NTMP-NTO waterbreaks with incorrect spacing were found to have erosion five times as often as waterbreaks with correct spacing. NTMP-NTO roads are generally built to narrow standards with minimal cuts and fills, as well as for light traffic and slower speeds. Additionally, NTMP-NTO roads are controlled by small nonindustrial landowners with different objectives than roads controlled by larger landowners, frequently resulting in less maintenance. These factors may account for some of the differences observed, but a larger sample size for NTMP-NTOs is required before firm conclusions can be made.

Since proper waterbreak spacing (including waterbars, rolling dips, natural lows, natural highs and other waterbreak features features) is important for reducing road surface erosion and erosion on the fill slope and there is room for improvement, CAL FIRE watershed staff recommends devising a plan to increase road drainage facility and structure spacing compliance from the current 88% and 90% to 95% or greater. This likely will require an educational component for RPFs and Licensed Timber Operators (LTOs), as well as increased enforcement of the new Road Rules, 2013 rule package requirements.

Incidences of forensically observed sediment transport were very low during this monitoring period (2008-2013). One contributing factor was that the FORPRIEM monitoring period had few large stressing winter storm events (Figure 52). There were some local exceptions, such as the December 2012 (HY 2013) event in northeastern California. The McCloud River watershed, including the area burned by the 2012 Bagley Fire, had a particularly intense storm event that severely impacted the road infrastructure in this area (Figure 77).[34] The U.S. Forest Service documented the impacts of this event in a detailed post-event erosion and sedimentation report (USFS 2013). CAL FIRE watershed staff recommends performing monitoring specifically targeted at roads and watercourse crossings after large hydrologic events (see for example Furniss et al. 1998). The information generated is valuable in evaluating FPR effectiveness in the face of large events (i.e., a post-mortem monitoring approach). This kind of information is not normally generated in broad-scale, random sample monitoring, such as FORPRIEM.

All roads in the FORPRIEM sample were associated with timber harvesting conducted one to five years prior to monitoring, which means they were more likely to have received recent maintenance and upgrading than similar roads that were not involved in recent timber harvesting. While FORPRIEM focuses on evaluating the implementation and effectiveness of the FPRs in protecting water quality from roads recently used in timber harvesting and under the control of the landowner, this is a small portion of the much larger picture of road impacts on water quality. To put the water quality impacts of active timber harvesting roads in proper perspective will require a larger study than FORPRIEM.

Watercourse Crossings

Compared to post-harvest Class I and II WLPZ canopy and implementation of FPRs related to construction and maintenance of road drainage facilities and structures, watercourse crossings and their immediate road approaches remain more problematic. In this monitoring effort, 13% of the THP crossings rated for effectiveness had one or more major problems and 12% had FPR implementation departures. Major problem

[34] Storms impacting the fire area were estimated to have return intervals of 25-50 years based on a four day storm (11/29-12/02/2012) with totals ranging from 15 to 22 inches. Many of the stream crossing culverts failed in high severity burn areas. Additionally, many road segments were buried by small sediment fans up to three feet thick. Roads also diverted flows in many locations, resulting in gullies downslope of where the water exited the road (USFS 2013).

Figure 77. Road fill failure in the Hawkins Creek watershed resulting from the December 2012 storm event (photo from USFS 2013, provided by Juan de la Fuente, Shasta-Trinity National Forest).

areas included culvert diversion potential and inadequate road cutoff drainage structure function immediately above the crossing. For NTMP-NTOs, approximately 19% of the crossings sampled had FPR departures and 10% had one or more major effectiveness problems (with a much smaller sample size than that available for THPs). Effectiveness categories with higher rates of denoted problems included culvert diversion potential, scour at the inlet and outlet of pipes, and culvert plugging.

Even though implementation and effectiveness problem rates were higher for crossings than for WLPZ canopy and road drainage, the FORPRIEM crossing data suggest that there may be improvement when compared to ratings reported earlier with the Hillslope Monitoring Program (Cafferata and Munn 2002) and Modified Completion Report Monitoring Program (Brandow et al. 2006). Data from the three monitoring programs suggest that crossing performance may be improving over time both for rule implementation and for effectiveness ratings (Figure 75).

It is possible that watercourse crossing results have improved over the past 18 years due to several efforts made in the last 15 years to make RPFs and landowners aware of needed improvements for watercourse crossing design, construction, and maintenance. These efforts have included (1) production of a crossing design guidance document for RPFs and agency personnel (Cafferata et al. 2004), (2) watercourse crossing training workshops developed for RPFs and agency personnel that were conducted from 2006 to 2008 and held throughout the state, (3) dissemination of crossing monitoring information at numerous professional conferences and meetings, and (4) production of agency reports (BOF 1999, Cafferata and Munn 2002, Brandow et al. 2006, Longstreth et al. 2008, BCTF 2011) and published papers (e.g., Ice et al. 2004, CWSF 2007, Cafferata et al. 2007, Harris et al. 2008) documenting monitoring results for watercourse crossings. Higher confidence in this preliminary conclusion will be possible when similar data are available after higher recurrence interval stressing storm events have occurred to test more recently installed and upgraded watercourse crossings.

Further improvement for watercourse crossing performance can be expected with use of the improved Road Rules, 2013 rule package and higher state agency staffing to ensure proper implementation of the new rules on the ground. For example, the new rules require (1) RPFs to include in plans the method(s) used to determine permanent culvert diameter (allowing for better agency review), (2) alignment of culverts to the channel and setting the pipe to natural grade, (3) hydrologically disconnected approaches to crossings, and (4) monitoring of crossings during operations and through the erosion control maintenance period. While training workshops on the Road Rules, 2013 rule package were held throughout the state in the fall of 2014, CAL FIRE recommends continued training for both LTOs and RPFs to ensure that these rules are properly understood by the personnel who will be implementing them in the field. In addition, excellent guidance material is available with the revised and improved Handbook of Forest, Ranch, and Rural Roads produced by Pacific Watershed Associates (Weaver et al. 2014).

It is anticipated that improved effectiveness monitoring will be developed by the Board of Forestry and Fire Protection's newly formed Effectiveness Monitoring Committee (EMC), including evaluation of hydrologic disconnection near watercourse crossings. This work will likely provide information on crossing-related effectiveness, and needed improvements to be made over time through adaptive management. An earlier review of existing monitoring programs in California did not provide evidence of a consistently effective feedback loop between monitoring data and decision-making in California (Coe 2009), and it is expected that the EMC will fill this void.

In summary, (1) data collected over the past 18 years for THP watercourse crossing and road approach rule implementation and effectiveness suggest possible improvement over time; (2) NTMP-NTO watercourse crossings appear to be generally comparable to THPs from a water quality standpoint, but the sample size is small; (3) crossing diversion potential and cutoff drainage structure function/hydrologic disconnection on road approaches to crossings remain high priority items for training and enforcement efforts; (4) further improvement is needed, and education for LTOs and RPFs, and enforcement will continue to be emphasized with the implementation of the Road Rules, 2013 rule package; and (5) continued effectiveness monitoring is needed to provide a feedback loop to determine if additional improvements are required in the future.

Recommendations

Based on the results compiled from FORPRIEM data collected from 2008 through 2013, we recommend the following items:

TRAINING AND ENFORCEMENT

1. Develop a Licensed Timber Operator training program for roads and watercourse crossings that can be used at logging conferences and posted on the CAL FIRE/BOF websites.

2. Continue to provide training to CAL FIRE Forest Practice Inspectors, RPFs, and LTOs on (1) the Road Rules, 2013 rule package; (2) watercourse crossing design, construction, maintenance, and abandonment; and (3) proper design and construction of road drainage structures and facilities (e.g., waterbars, rolling dips, and ditch relief culverts).

3. Stress increased enforcement of the new Road Rules, 2013 rule package requirements, including hydrologic disconnection of roads at watercourse crossing approaches.

4. Promote the use of the *Handbook of Forest, Ranch, and Rural Roads* (Weaver et al. 2014) and similar guidance documents as excellent sources of information regarding forest roads and watercourse crossings.

MODIFICATIONS FOR THE FORPRIEM PROGRAM

5. Modify the FORPRIEM methods to accommodate changes to the Forest Practice Rules, including the ASP rules that were implemented in 2010, and the Road Rules, 2013 rule package, adopted in 2014 and effective January 2015. In particular, new methods are needed to monitor and evaluate WLPZs with ASP-required multiple zones. Both new WLPZ and road related monitoring procedures will need to be field tested to ensure repeatable results, and a new set of field training workshops for CAL FIRE Forest Practice Inspectors will be required.

6. Continue to sample NTMP-NTOs to build a more robust sample for future monitoring reports.

7. Arrange for CAL FIRE's Forest Practice Inspectors to enter their revised FORPRIEM monitoring measurements and observations into field personal digital devices that can be downloaded directly into a revised FORPRIEM database. Newly entered data should be flagged until it is quality checked.

8. Update the FORPRIEM database to accommodate the changes made in the FORPRIEM field forms.

9. Gather input from the BOF's Effectiveness Monitoring Committee on revisions to FORPRIEM and attempt to better utilize the other Review Team agencies to collect field data.

10. Investigate using a stratified random sampling approach for the next iteration of FORPRIEM to better test the effectiveness of the Forest Practice Rules on a larger percentage of higher risk sites.

WORK NEEDED TO COMPLEMENT THE FORPRIEM PROGRAM

11. Continue to support the implementation and funding of cooperative instream monitoring projects to complement future revised FORPRIEM results. Ideally, FORPRIEM methodologies should be used within the monitored watersheds to link BMP implementation and effectiveness to downstream response.

12. Work with and encourage the Board's Effectiveness Monitoring Committee to undertake specific projects to determine the effectiveness of FPRs related to WLPZ, road, and watercourse crossing requirements. The goal is to have more rigorous and scientifically defensible tests of individual practice effectiveness.

13. Perform post-mortem monitoring specifically for roads and watercourse crossings after large hydrologic events (e.g., storm recurrence intervals exceeding 20 years covering a large hydrologic basin).

14. Complete the production of a revised, updated watercourse crossing design guidance document for RPFs and agency personnel (the original version is Cafferata et al. 2004).

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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). As defined in the Road Rules, 2013 rule package, abandonment means implementing measures to effectively remove an existing logging road, landing, or logging road watercourse crossing from the permanent road network.

Alternative practice – Alternative prescriptions for the protection of watercourses and lakes may be developed by the RPF or proposed by the Director of CAL FIRE on a site-specific basis, as specified in 14 CCR § 916.6 (936.6, 956.6), 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)]. 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 cold water 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. As defined in the Road Rules, 2013 rule package, a constructed dip or low point across a logging road surface down grade from, or over, a logging road watercourse crossing that functions to prevent crossing overflow from draining down the road and minimizes fill erosion.

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 [934.2, 954.2] (f)(3).

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

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 planned 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. 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. As defined in the Road Rules, 2013 rule package, permanent road means a logging road that is part of the permanent road network and is designed for year-round use. These roads have a surface that is suitable for maintaining a stable operating surface throughout the year.

Process - The procedures through which the FPRs/BMPs are administered and implemented, including: (a) plan preparation, review, and approval by RPFs, Review Team agencies, and CAL FIRE decision-makers; and (b) the timber operations completion, oversight, and inspection by LTOs, RPFs, and CAL FIRE 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, and 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.

Road interval – A unit of road length at which monitoring data is collected. FORPRIEM recorded road data at 10-foot intervals, or 66 intervals per 660-foot (1/8 mile) segment.

Road segment – A specified length of road. A 660-foot (1/8 mile) long road segment was randomly selected for FORPRIEM monitoring from each of the randomly selected THP and NTMP–NTO with logging roads suitable for monitoring.

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. The Road Rules, 2013 rule package defines a seasonal road as a logging road that is part of the permanent road network that is not designed for year-round use. These roads have a surface that is suitable for maintaining a stable operating surface during the period of use.

Standard practice - A practice prescribed or proscribed by the Forest Practice 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). The Road Rules, 2013 rule package defines a temporary road as a logging road that is to be used only during timber operations and that will be deactivated or abandoned upon completion of use.

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).

Waterbreak interval – Road distance between waterbreaks.

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 on characteristics or key indicators of beneficial uses as described in 14 CCR § 916.5 [936.5, 956.5]. Anadromous Salmonid Protection rules affecting watercourse classification are found in 14 CCR § 916.9 [936.9, 956.9].

- 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 within1000 feet downstream and/or (2) Aquatic habitat for non-fish 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: Man-made watercourses, usually downstream, established domestic, agricultural, hydroelectric supply, or other beneficial uses.

In Anadromous Salmonid Protection rule planning watersheds, Class II-L (large) watercourses have either (1) a contributing drainage area of ≥ 100 acres in the Coast Forest Practice District or ≥ 150 acres for the Northern or Southern Forest Districts, or (2) an average active channel width of five feet or greater near the confluence with the receiving Class I watercourse.

Appendix

FORPRIEM Monitoring Procedures and Methods

FORPRIEM

Forest Practice Rules Implementation & Effectiveness Monitoring

(Formerly known as Modified Completion Report (MCR) Monitoring)

Monitoring Procedures and Methods

Revised September 14, 2007

Overview

The objective of the Forest Practice Rules Implementation & Effectiveness Monitoring (FORPRIEM) Program is to provide abundant data on the adequacy of the implementation and effectiveness of those Forest Practice Rules (FPRs) specifically designed to protect water quality and riparian/aquatic habitat. FORPRIEM (pronounced "for-prime") uses information collected during completion inspections for Timber Harvesting Plans (THPs). FORPRIEM is a continuation of monitoring that was previously completed under the Modified Completion Report (MCR) Monitoring Program (Brandow, Cafferata and Munn 2006). The results from the MCR Monitoring Program conducted from 2001 to 2004 are available on-line in report published by CAL FIRE in 2006 at:

http://www.bof.fire.ca.gov/pdfs/MCRFinal_Report_2006_07_7B.pdf

Following are the FORPRIEM Methods and Procedures, which are an updated revision of the MCR Methods and Procedures. USE THESE METHODS AND PROCEDURES FOR FORPRIEM MONITORING. DO NOT USE THE MCR METHODS AND PROCEDURES. FORPRIEM includes three sampling protocols:

1) **WLPZ Canopy/Surface Cover Sampling Method**
2) **Road Sampling Method**
3) **Watercourse Crossing Sampling Method**

These methods will be applied to a random selection of approximately 10% of THPs with filing dates between 2002 and 2011, as the selected plans are completed. Lists of THP numbers randomly selected for FORPRIEM monitoring are included Appendix A-1.

On each listed THP, the following four randomly selected sample sites will be evaluated: 1) a 200-foot segment of Class I or II WLPZ, 2) a 660-foot (1/8th mile) segment of road, and 3) two Class I, II or III watercourse crossings. In the event a suitable sample site is not available on a listed THP, the method form should be turned in with a notation: "Not applicable to this THP."

The selected monitoring sites will be evaluated at the time of the final Completion Report inspection(s). The sample road and the two sample watercourse crossings can be monitored for both implementation and effective on this first evaluation if each has gone through at least one winter season. In the event the selected road segment and/or the two sample watercourse crossings have not yet been through at least one winter season, a return visit (maintenance inspection) to those sites will be necessary to monitor for effectiveness in preventing erosion, sediment transport, and sediment transport to stream channels.

The FORPRIEM monitoring forms are attached to these instructions in Appendices A-2, A-3 and A-4 and are suitable for photocopying. Copies of the completed forms along with a photocopy of the THP map showing the location of the sample sites shall be sent to the Audit Forester for the Forest Practice Area where the THP is filed.

Field instruction on selecting the sample sites, evaluating the sites and completing the forms is available by contacting Clay Brandow at clay.brandow@fire.ca.gov or (916) 653-0719. If you have questions regarding FORPRIEM please contact Clay Brandow, Pete Cafferata, John Munn or your Audit Forester at their respective email addresses and phone numbers listed in CAL FIRE Outlook.

List of Items to take to the Field

- FORPRIEM Methods and Procedures for reference
- FORPRIEM Forms: WLPZ (1), Road (1), and Watercourse Crossings (2)
- THP file for reference
- THP WLPZ Map(s) with WLPZs segmented and sample segment randomly selected
- THP Road Map(s) with roads segmented and sample segment randomly selected
- Erosion Hazard Rating (EHR) from THP for randomly selected road segment
- Map scale or ruler, plus dividers (optional)
- Pencil, clipboard, and extra paper or notebook
- White flagging and marking pen
- Sighting tube
- Clinometer
- Hip-chain (String Box) with extra string
- Pocket tape measure or logger's tape
- Digital camera

Random Selection of THPs

FORPRIEM evaluations will be conducted at the time of the completion inspections on an approximately 10% random sample of THPs that have been or will be filed with CAL FIRE between the year 2002 and the year 2011. The middle number in a typical THP number indicates the year it was filed. For example, for the hypothetical THP number 1-04-999, the filing year would be 2004. Appendix A-1 contains randomly selected lists of FORPRIEM THPs for each filing year up to 2011.

THP numbers on the lists that will not go through an inspection report in the future for one reason or another should be crossed-off. Examples are THPs that have been withdrawn, administratively closed or that have already gone through a final completion inspection. Also, for years prior to the current calendar-year, cross-off hypothetical THPs numbers that were never assigned to a THP. Crossing-off these numbers does not affect the sample size of approximately 10% of the THP going through completion report inspections.

Theses lists were generated using a Monte Carlo type method, which is basically a roll of the dice on each hypothetical THP number that was run through the program. This method eliminates the need to know how many plans will be filed by Region in future years. It also eliminates the need to know in advance which plans will not receive a completion inspection is the future. The program for generating these lists was written by Tim Robards in collaboration with Clay Brandow.

1) WLPZ Canopy/Surface Cover Sampling Method

Figure 1. Pete Cafferata making WLPZ canopy cover measurements using a sighting tube.

The WLPZ canopy/surface cover sampling procedure is to be completed once at the time of the Completion Report inspection. This FORPRIEM method is a modified version of Procedure 1 of the PHI and potential enforcement actions method developed by Robards (1999). The number of sighting tube observations is 50, as compared to 100 for the enforcement procedure. The inspector will also record the average WLPZ width based on pacing within the segment sampled for canopy cover and will record erosion features in the sample segment (i.e., gullies, rills, mass failures, or areas of sediment deposition).

Using a similar procedure for FORRIEM WLPZ canopy/surface cover sampling, pre-harvest inspections (PHIs), and enforcement has several advantages, including simplicity, continuity, and reducing the need for additional training. In addition, the data will be comparable. The enforcement data represents the worst-case post-harvest WLPZ conditions, while FORPRIEM represents the average WLPZ conditions. FORPRIEM data also allows us to look at trends in average post-harvest WLPZ conditions.

Selecting a WLPZ segment. The FORPRIEM method differs from Procedure 1 in the way the sample WLPZ segment is selected. Rather than selecting the least stocked reach for sampling, as in the enforcement method, in the FORPRIEM method the Class I and II watercourses on the THP are divided into 200-foot long, numbered segments on the THP map. Then using a random number table or calculator with a random number generator function, the inspector will generate a random number between the highest and lowest road number segment on the THP map. The segment that matches this number is the WLPZ segment to be evaluated, with two possible exceptions: 1) the WLPZ segment contains a road, watercourse crossing, cable yarding corridor or some other permitted large opening in the canopy, or 2) the WLPZ is deemed to be too dangerous to monitor due to extreme terrain or some other reason. In the case of these two exceptions, randomly select an alternate WLPZ segment to evaluate. (Note that when using a random number table, cross off numbers as they are used, so they will not be used a second time.)

Figure 2 shows a typical THP map with 200-foot WLPZ segments marked off and numbered. The randomly selected segment is circled. A copy of the marked-up map used for selecting the WLPZ segment shall be submitted with the completed FORPRIEM WLPZ monitoring form.

Note that in many situations, like the one presented in Figure 2, more then one map will be needed. All segments shall be consecutively numbered for any given THP regardless of the number of maps. These maps often overlap, so care must be used to assign only one number to each 200-foot WLPZ segment.

Where only one side of the creek was harvested along the WLPZ segment to be evaluated, measure the side of the creek where this harvesting took place. Where both sides of the creek were harvested along the WLPZ segment to be evaluated, a flip of a coin shall be used to determine whether to measure the right or the left bank of the WLPZ.

WLPZ Canopy Sampling Procedure. Regardless of the size of the area, 50 points will be the target sample size. The following formula calculates the distance (D) between points. Width and length refer to the width and length of the WLPZ section to be sample.

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

Since for FORPRIEM the sample length is a standard 200 feet, this equation can be simplified, as follows:

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

Using this formula for standard WLPZ widths of 50, 75, 100, 150 and 200 feet, D is 14, 17, 20, 24 and 28 feet, respectively. For other WLPZ widths, the inspector will need to calculate D using the above formula.

The WLPZ width to utilize when calculating D is the width stated in the THP. **Once the field sampling begins, continue to use the calculated D, even if the actual WLPZ width flagged on the ground is considerably wider than that stated in the plan. If the WLPZ width varies due to slope and the flagging results in a narrower WLPZ than was anticipated, do not take a sample point above the flag line.** Simply turn 90 degrees and begin a new line going in the downhill direction. Stop when 50 points are achieved, regardless of whether this results in a line being completed.

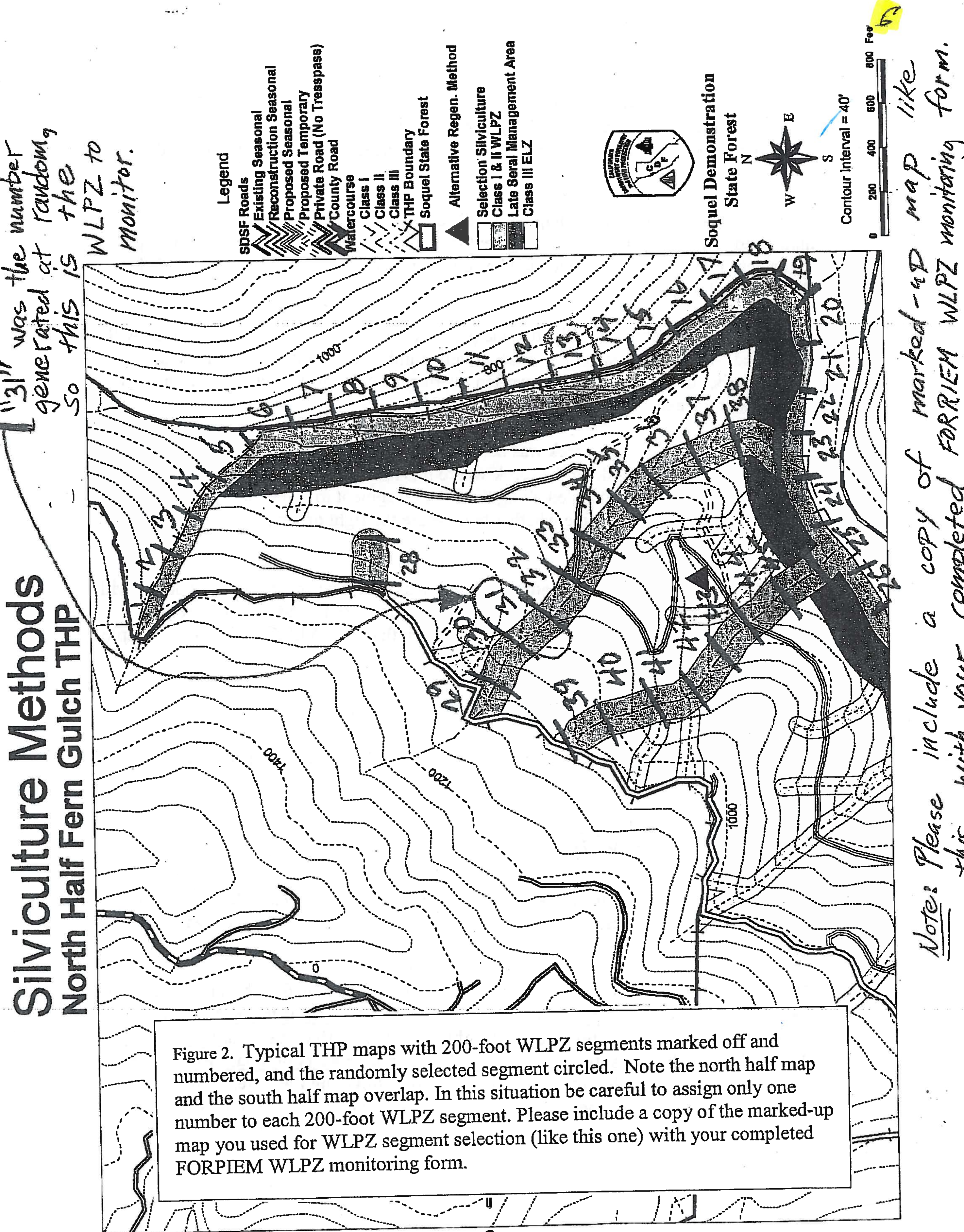
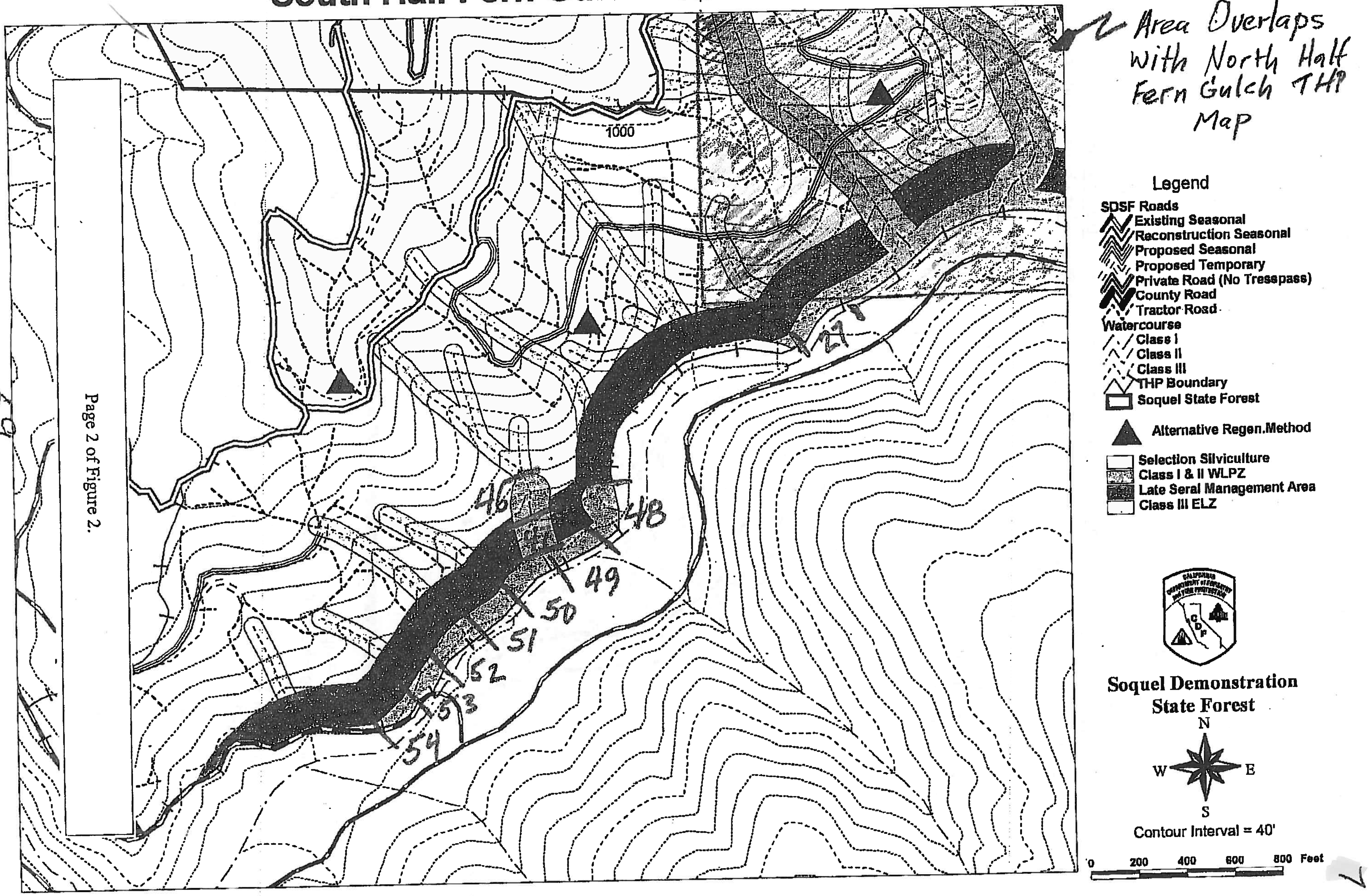


Figure 2. Typical THP maps with 200-foot WLPZ segments marked off and numbered, and the randomly selected segment circled. Note the north half map and the south half map overlap. In this situation be careful to assign only one number to each 200-foot WLPZ segment. Please include a copy of the marked-up map you used for WLPZ segment selection (like this one) with your completed FORPIEM WLPZ monitoring form.

Silviculture Methods
South Half Fern Gulch THP



Start in the corner of WLPZ segment at the watercourse transition line. The first measurement needs to be randomized. To randomize the first point, generate a random number between 0 and 1 using a random number table or random number generator. Then multiply this random number times D to calculate to distance to the first measurement point. For example, if D is 17 feet and the random number generated is 0.3, then the distance to the first measurement point from the watercourse transition line is 17 feet x 0.3 = 5.1 ≈ 5 feet. Pace 5 feet away from and perpendicular to the watercourse transition line. This is your first point. Collect **total canopy** data for this point using a vertical sighting tube **(i.e., do not try to differentiate between overstory and understory vegetation).** After the first sighting tube point, the distance to the next measurement point will always be D. From the first sighting tube measurement point, pace D feet to the next point away from and perpendicular to the watercourse. Continue to collect points on the line until the next point will exit the WLPZ. Then change direction 90º, pace D feet, and start a new line, this time heading towards the watercourse. The resulting pattern will look something like Figure 3.

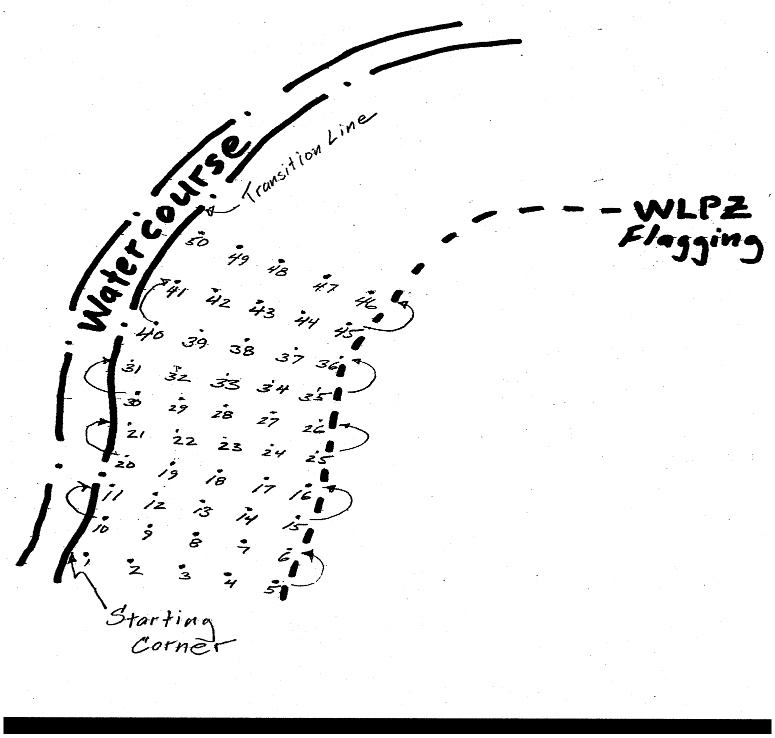


Figure 3. Typical pattern of canopy sighting and groundcover observation points within a typical randomly sampled WLPZ segment.

When using the vertical sighting tube at each point, first level it using the horizontal and vertical bubbles. Align the dot center by holding the tube steady and moving your head to put your eye in the correct position. The dot is then evaluated as to whether it intercepts canopy. Figure 4 shows a typical sighting tube. Hits are recorded as "+" in the hit column and misses are recorded as "-" in the miss column on the form provided. A blank form, suitable for photocopying, is included in Appendix A-2. If deciduous trees are encountered in the winter without leaves, it is permissible to assume that leaf cover would be present in the summer. However, if hardwoods are present, it is best to attempt to do this work prior to winter.

On the bottom of the first page, there are a series eight (8) questions requiring ocular estimates with the WLPZ sample segment. Carefully observe the conditions within the WLPZ sample segment and circle the appropriate answer to each question based on what was observed.

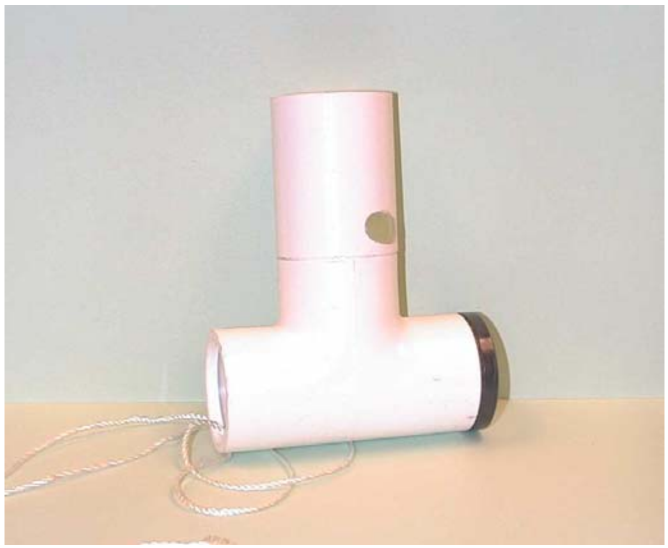


Figure 4. Example of a sighting tube used for making WLPZ canopy measurements.

Additionally, note and record fresh erosion features in the sample segment on the second page of the WLPZ form. A copy of this form that is suitable for photocopying is provided in Appendix A-2. A check box for “No erosion features observed in the sample WLPZ segment” is included on this form. In the event there are erosion features present, at each point in the sample WPLZ segment where erosion or deposition is observed, note the nearest canopy sample point by number, the type of erosion feature (i.e., gully, rilling, mass failure, or areas of sediment deposition), whether the feature is related to the current logging or not (yes or no), and the feature’s approximate size (width, depth, and length) in feet. Record dimensions to the nearest half foot (0.5 feet). Record each erosion feature (e.g., gully, rill) only one time, even though if may be crossed or observed at several sample points. In the comments column, note the cause of the problem and if any sediment was transported to the channel.

Figure 5 is a completed WLPZ sample form. The first page records WLPZ canopy and the second page records erosion features. It is important to fill the forms out completely to assure good quality data. It is also very important to record the THP number, observer(s) and date on each page of the form in case the pages get separated.

FORPRIEM

Forest Practice Rules Implementation & Effectiveness Monitoring
(formerly known as Modified Completion Report (MCR) Monitoring)

WLPZ Canopy Sampling Form

Revised 9/14/07

THP No. 1-04-XXX
Observer(s) C. Brandow, P. Cafferata, J. Munn
Date 2-29-07

Estimated total length of Class I stream in this THP 5 600 feet.
Estimated total length of Class II stream in this THP 4 800 feet.
(Estimate by counting the number of segments delineated on the THP map for the random selection of sample a 200 foot WLPZ segment and multiply by 200.)

CALWATER Planning Watershed No. 3304.13010
Watercourse Class I or (II) (Circle the class that applies to the sampled segment.)

Target sample length is 200 feet.
Actual WLPZ sample length 200 feet.

Prescribed WLPZ width (from THP) 75 feet.
Actual WLPZ width (based on flagging) 75 feet.
Sampled WLPZ width 75 feet.

D = Distance between sample points.
(For standard WLPZ widths of 50, 75, 100, 150 and 200 feet, D is 14, 17, 20, 24 and 28 feet, respectively.)

$D = 2\sqrt{\text{width}}$ = 17 feet.

100 x (Hits) / (Hits + Misses) = 88 % Canopy Cover.

Ocular Estimates
within the WLPZ sample segment (circle one per question):

1. Harvesting in WLPZ segment this entry? (YES) NO
2. Percent Canopy removed this entry? 0-10% (10-30%) 30-50% ≥ 50%
3. Understory canopy remaining ≥ 50%? (YES) NO
4. Overstory canopy remaining ≥ 50%? (YES) NO
5. Class I watercourse in a T&I watershed? (YES) NO
6. Overstory meets T&I standards? N/A (YES) NO
7. WPLZ Groundcover (live&dead) ≥75 %? (YES) NO
8. Untreated patches of bare mineral soil in WLPZ ≥ 800 sq.ft. or as specified in THP? (ABSENT) PRESENT

Points	Hit (+)	Miss (-)
1.	+	
2.	+	
3.	+	
4.	+	
5.	+	
6.	+	
7.	+	
8.	+	
9.	+	
10.	+	
11.	+	
12.	+	
13.	+	
14.	+	
15.		−
16.		−
17.	+	
18.	+	
19.	+	
20.	+	
21.	+	
22.	+	
23.	+	
24.	+	
25.	+	
26.	+	
27.	+	
28.	+	
29.		−
30.		−
31.		−
32.	+	
33.	+	
34.	+	
35.	+	
36.	+	
37.	+	
38.	+	
39.	+	
40.	+	
41.	+	
42.	+	
43.	+	
44.	+	
45.	+	
46.	+	
47.	+	
48.	+	
49.		−
50.	+	
Totals	44	6

Figure 5. Example of a completed FORPRIEM WLPZ form for purposes of demonstration. Note that both pages of the form are completed and that the THP number, the names of the observers and the date have been filled in on each page.

FORPRIEM

Forest Practice Rules Implementation & Effectiveness Monitoring
(formerly known as Modified Completion Report (MCR) Monitoring)

WLPZ Erosion Features Form

Revised 9/14/07

THP No. 1-04-XXX
Observer(s) C. Brandow P. Cafferata, J. Munn
Date 2-29-07

1. Were erosion features observed in the sample WLPZ segment (circle one)?

(YES, circled) NO

2. If the answer to the above question is YES, please complete one row in the table below for each erosion feature observed. Use additional sheets if necessary.

Point Number (Nearest WLPZ canopy measurement point.)	Erosion Feature Type (rills, gully, or sediment deposition.)	Related to the Current Entry (circle one)	Width (feet)	Depth (feet)	Length (feet)	Comments (Please note the cause of the problem and if any sediment was transported to the channel.)
45	Gully	Yes (circled) No	2	1.5	16	Originated at skid trail just outside WLPZ. Deposition in Channel
		Yes No				
		Yes No				
		Yes No				

Figure 5.
Page 2 of 2.

2) Road Sampling Method

Figure 6. Pete Cafferata 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 the sample segment.

One 660-foot (1/8 mile) road segment will be sampled on each selected THP if available. To randomly select a road segment, make a copy of the THP map(s) showing the roads. Using a scale or dividers and a pencil, divide the THP roads into 660-foot segments. Then number the segments. Do not include roads, such as county roads, where the landowner does not control road use and maintenance. Using a calculator with a random number generator or a random number table (see Appendix A-5), generate a random number between the lowest and highest numbered road segment. Circle the road segment that corresponds to this number. This is the segment to be evaluated. Please include a copy of the segmented THP map(s) with the completed FORPRIEM road evaluation forms. Figure 7 shows a typical set of THP maps with the roads divided into approximately 660-foot segments, the segments numbered, and the randomly selected road segment circled.

The selected road segment will be rated for implementation and effectiveness. Implementation can be rated at the time of the Completion Report inspection. Effectiveness may be rated during the same visit if the selected road segment has been through at least one winter period. If the selected road segment has not been through at least one winter period at the Completion inspection, another visit after the winter period to the site will be necessary to evaluate the road segment for effectiveness.

The road form has six (6) pages. The first page records site information, pages 2, 3 and 4 record implementation, and pages 5 and 6 record effectiveness. With exception of the space provided for comments at the end of page 6, pages 5 and 6 should not be completed until the watercourse crossing being evaluated has been through at least one winter period. A blank road form suitable for photo copying is included in Appendix A-3.

Road Construction and Reconstruction

North Half Fern Gulch THP

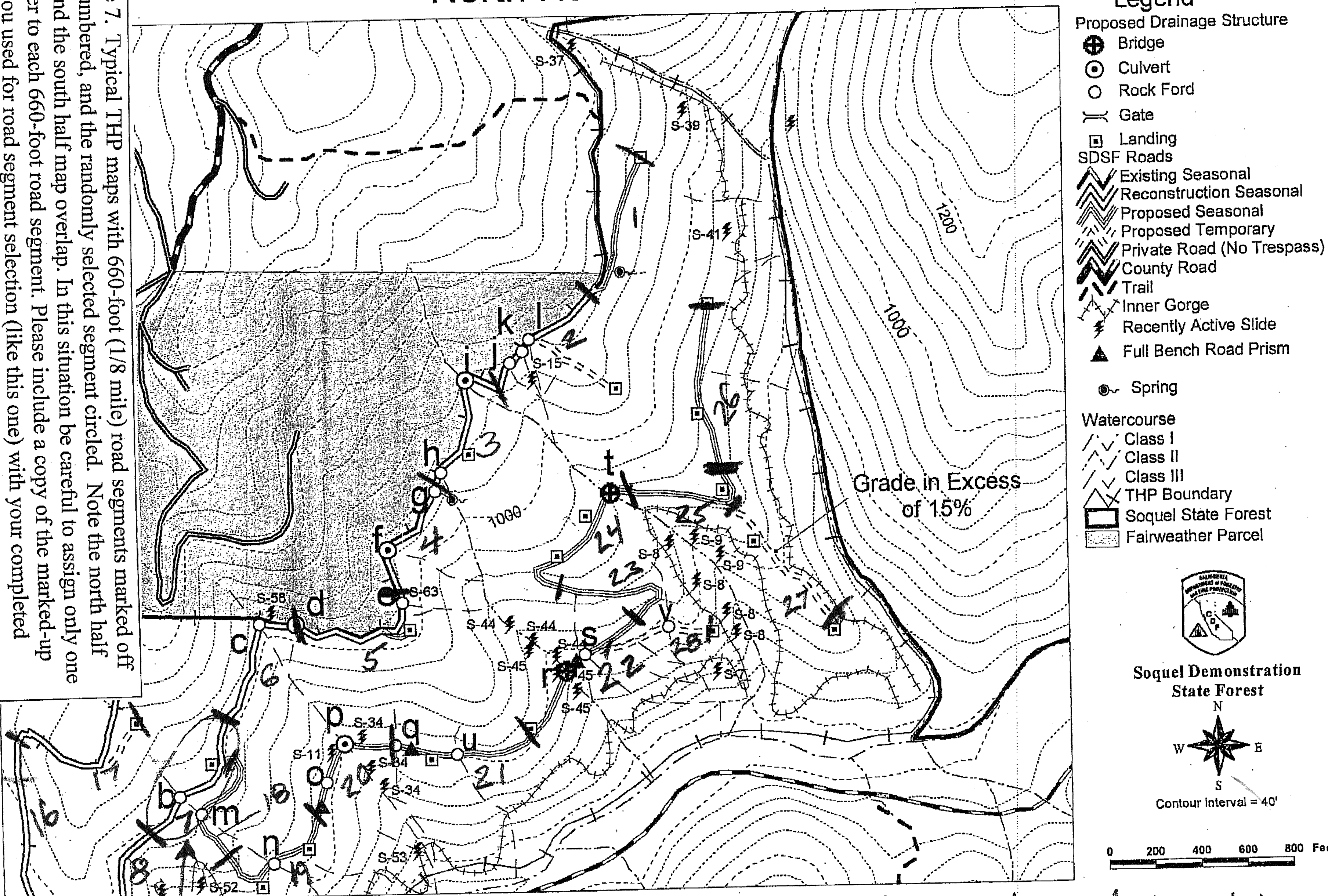


Figure 7. Typical THP maps with 660-foot (1/8 mile) road segments marked off and numbered, and the randomly selected segment circled. Note the north half map and the south half map overlap. In this situation be careful to assign only one number to each 660-foot road segment. Please include a copy of the marked-up map you used for road segment selection (like this one) with your completed FORPRIEM road monitoring form.

"7" was the number generated at random, so this is the road segment to evaluate.

Road Construction and Reconstruction

South Half Fern Gulch THP

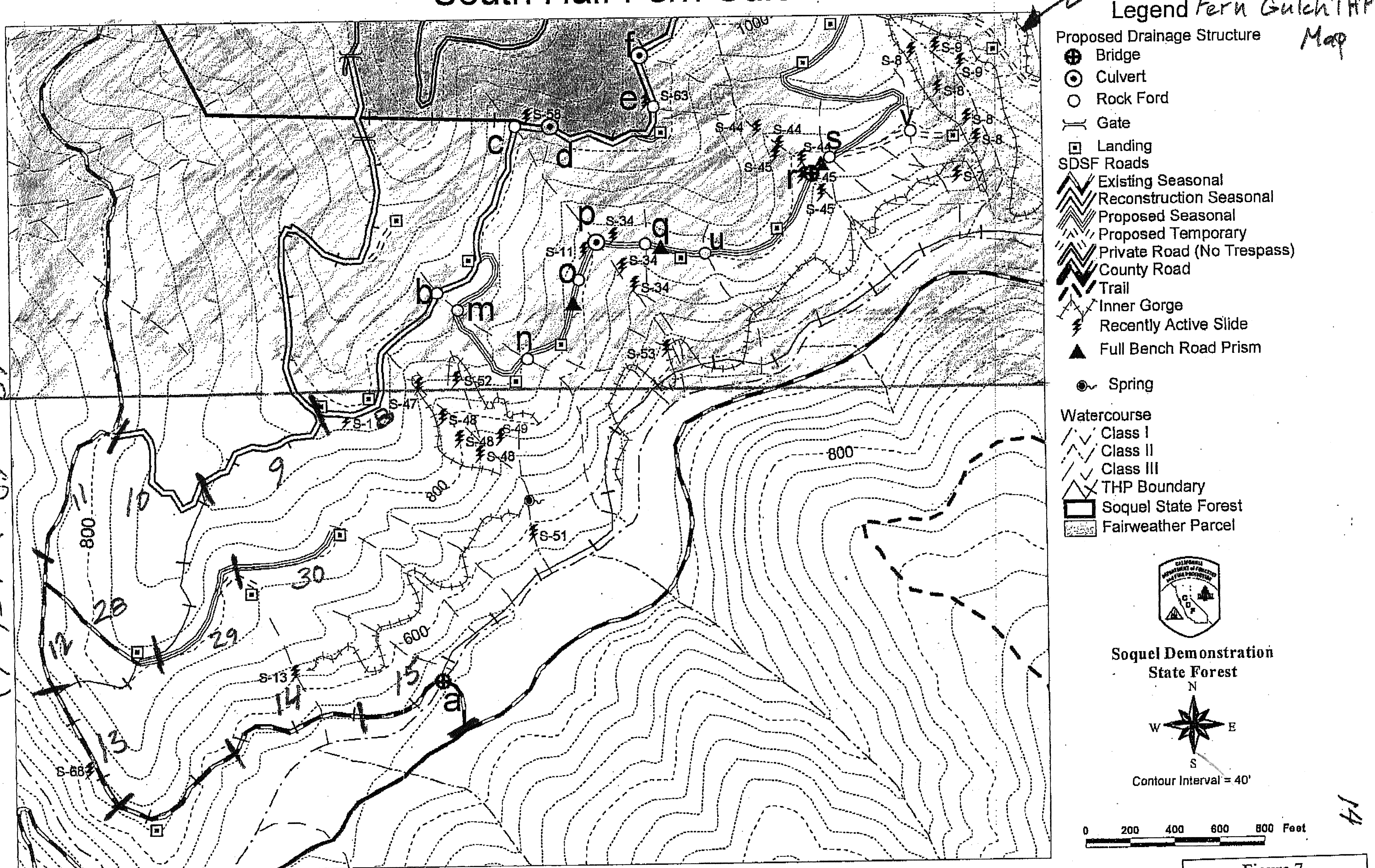


Figure 7.
Page 2 of 2.

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(Revised 5/25/04)

14

Find the starting point of the selected road segment and flag it with the following information "THP# X-XX-XXX start FORPRIEM road segment." Complete the site information on the first page of the road form. You will need to look-up the Erosion Hazard Rating (EHR) for the selected road segment in the THP. The last question on the first page is "Recommend follow-up monitoring of this site based on problems found?" If significant erosion or any sediment transport to channels is found, circle "yes" in response to this question. Follow-up monitoring may be recommended for other reasons as well, such as failure of an adequately implemented FPR or mitigation measure to adequately control erosion.

Complete pages 2, 3 and 4 of the road form based on your observations of the road segment and drainage system. The form segments the road into sixty-six (66) 10-foot increments, starting on page 2 and ending on page 4. On the line labeled "Road Construction", choose the appropriate letters for each increment from the following: "CF" for cut & fill, "TC" for through-cut, "TF" for through-fill, or "FB" for full-bench cut. Indicate the location of each watercourse crossing in the road segment by inserting the appropriate following letter symbol in the corresponding box:

B = bridge	C = culvert	P-A = pipe-arch	OBA = open-bottom arch
Ford = Ford	A = abandoned	O = other	

On the line labeled "Road Surface," choose the appropriate letters for each increment from the following: "OS" for out-slope, "IS" for in-slope, "FL" for flat, or CR "crowned road surface" (i.e., road drains away from the highpoint in the middle towards both edges). Mark the appropriate boxes where there is an outside berm with a break. Mark the appropriate boxes where there is an inside ditch and indicate the location of ditch relief features with either a "C" for culvert, a "D" for dip, or an "O" for other. Rate the maintenance of each inside ditch and by circling "E" for exceeds rule, "A" for acceptable, "MA" for marginally acceptable, or "D" for departure.

Mark the location of waterbreaks and other road drainage structures with a "WB" for waterbar, an "RD" for rolling dip, "NL" natural low point, or "O" for other. Using a clinometer, measure the gradient between waterbreaks and record it on the next line about mid-way between waterbreaks indicated on the line above. Indicate whether it is upgrade (+) or downgrade (-) to the next waterbreak by using a plus (+) or minus (-) symbol or a minus in front of the percent road gradient. On the next line directly below each measurement of road gradient, record the estimated side slope of the natural terrain. Rate each waterbreak/drainage structure for implementation by circling the appropriate letter (E for exceeds rule, A for acceptable, MA for marginally-acceptable, or D for departure). Rate each waterbreak/drainage structure on whether it discharges into cover and not on to erodible fills by circling the appropriate letter (E, A, MA or D). Note any other implementation problems by making X-marks in the appropriate boxes on the line labeled "Other implementation problems explained in comments section." Briefly explain each of these problem in the comments section or additional sheets of paper. Refer to each problem by the road increment it affects. For example, if you observe an implementation problem at 175 feet from the staring point, mark the box “170-180” and refer to it in the your comments as problem 170-180.

After the road segment has been through at least one winter, complete page 5 and 6 of the road form based on your observations of erosion, sediment transport beyond the road prism (e.g., toe of the fill), and sediment transport to watercourse channels. The form uses the same 10-foot increments as used for the implementation evaluation starting on page 5 and ending on page 6. Using the erosion symbols listed (both below and on the form), record erosion observed on the cut slope, the road surface, and the fill slope. Use the comment section at the end of page 6 to record the location and the estimated dimensions (length, width and depth) of gully, mass wasting, and sloughing erosion with a volume of approximately 3 cubic yards or more.

RT = ruts
R = rills (< 6” deep)
G = gullies (≥ 6” deep)
M = mass wasting
S = cutbank or sidecast sloughing
O = other erosion

Where evidence of sediment transport beyond the road prism (e.g., toe of the fill) is found in the selected road segment, write “ST” in the appropriate “Sediment Transport” box to indicate its location. Likewise, where evidence of sediment transport to a channel from the road is found, write “STC” in the appropriate box to indicate the point along road from which the sediment originated. **<u>This step is extremely important – you must determine if sediment reached the stream channel.</u>** Sediment transport beyond the road prism and sediment transport to the transition line of a channel can usually be detected by observing deposition of small amounts of fine sediment left along the margins of the path where sediment was transported (i.e., sediment plumes).

Figure 8 shows a completed road form. If possible, document significant erosion features with annotated digital photos and attach them to the completed road form. Also send labeled digital photos to the appropriate audit/monitoring forester for cataloging.

FORPRIEM

Forest Practice Rules Implementation & Effectiveness Monitoring

(formerly known as Modified Completion Report (MCR) Monitoring)

ROAD FORM

Revised 9/14/07

Site Information

THP No. 1 - 04 - XXX **Observer(s)** C. Brandow, P. Cafferata, J. Munn **Date** 2-29-07

Erosion Hazard Rating (EHR from THP)(circle one): extreme high (moderate) low

Type of road (circle one): permanent (seasonal) temporary abandoned other______

Type of road surface (circle one): (native-surface) oiled gravel/rocked paved other______

Position of road segment on slope (circle one): road in WLPZ road adjacent to WLPZ (mid-slope road) upper-slope road ridge-road

Date of construction (circle one): (prior to THP) part of THP

Current status (circle one): (existing) abandoned

Photos of this road segment were taken, annotated and attached to this monitoring form? Yes (No)

Recommend follow-up monitoring of this site based on problems found? (Yes) No

Figure 8. Example of a completed FORPRIEM road form for purposes of demonstration. Note that all three pages of the form are completed and that the THP number, the names of the observers and the date have been filled in on each page.

ROAD IMPLEMENTATION FORM

THP No. 1 - 04 - XXX **Observer(s)** C. Brandow, P. Cafferata, J. Munn **Date** 2-29-07

Revised 9/14/07

Distance from the Starting Point in 10-Foot Increments

	000 010	010 020	020 030	030 040	040 050	050 060	060 070	070 080	080 090	090 100	100 110	110 120	120 130	130 140	140 150	150 160	160 170	170 180	180 190	190 200	200 210	210 220
Road Construction CF=Cut & Fill, TC=Thru-Cut TF=Thru-Fill FB= Full Bench Cut	TF	—	—	—	—	—	TF	CF	—	—	—	—	—	—	—	—	—	—	—	—	—	CF
Watercourse Xing B, C, P-A, OBA, F, A, O			C																			
Road Surface 0S=Out-Sloped IS=In-Sloped FL= Flat CR=Crowned	FL	—	—	—	—	—	FL	OS	—	—	—	—	—	—	—	—	—	—	—	—	—	OS
Outside Berm																						
Inside Ditch & Ditch Relief Culvert, Dip or Other	—	C			D	—	—	—														
Rate Maintenance of Inside Ditch & Ditch Relief: (Circle E, A, MA or D)	E (A) MA D	E (A) MA D	E A MA D	E A MA D	E (A) MA D	E (A) MA D	E (A) MA D	E (A) MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D
Waterbreaks WB, RD, NL					NL				RD								RD					
Percent Road Gradient between Waterbreaks		-3%				+5%							+3%							+4%		
Percent Side Slope between Waterbreaks		6%				10%							25%							30%		
Rate Waterbreaks constructed with a depth ≥6" into firm roadbed: (circle E, A, MA or D)	E A MA D	E A MA D	E A MA D	E A MA D	E (A) MA D	E A MA D	E A MA D	E A MA D	E (A) MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E (A) MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D
Rate Waterbreaks discharge into cover and not onto erodible fills: (circle E, A, MA or D)	E A MA D	E A MA D	E A MA D	E A MA D	E A MA (D)	E A MA D	E A MA D	E A MA D	E (A) MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A (MA) D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D
Other implementation problems explained in comments section.					X																	

* **E** (Exceeds Rule), **A** (Acceptable), **MA** (Marginally Acceptable), **D** (Departure)

Figure 8.
Page 2 of 6.

ROAD IMPLEMENTATION FORM
THP No. 1 - 04 - XXX

Observer(s) C. Brandow, P. Cafferata, [illegible] Munn

Date 2-29-07

Appendix A-3

Revised9/14/07

Distance from the Starting Point in 10-Foot Increments

	220 230	230 240	240 250	250 260	260 270	270 280	280 290	290 300	300 310	310 320	320 330	330 340	340 350	350 360	360 370	370 380	380 390	390 400	400 410	410 420	420 430	430 440
Road Construction CF=Cut & Fill, TC=Thru-Cut TF=Thru-Fill FB= Full Bench Cut	CF	—	—	—	—	—	—	—	—	—	—	CF	TC	—	—	—	—	—	—	—	TC	CF
Watercourse Xing B, C, P-A, OBA, F, O																						
Road Surface 0S=Out-Sloped IS=In-Sloped FL= Flat CR=Crowned	OS	—	—	—	—	—	—	—	—	—	—	OS	FL	—	—	—	—	—	—	—	FL	OS
Outside Berm																						
Inside Ditch & Ditch Relief Culvert, Dip or Other																						
Rate Maintenance of Inside Ditch & Ditch Relief: E, A, MA or D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D
Waterbreaks WB, RD, NL, NH				RD								RD										RD
Percent Road Gradient between Waterbreaks									+6%									+2%				
Percent Side Slope between Waterbreaks									35%									40%				
Rate Waterbreaks constructed with a depth ≥6" into firm roadbed: (circle E, A, MA or D)	E A MA D	E A MA D	E A MA D	E (A) MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	(E) A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E (A) MA D
Rate Waterbreaks discharge into cover and not onto erodible fills: (circle E, A, MA or D)	E A MA D	E A MA D	E A MA D	E (A) MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E (A) MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E (A) MA D
Other implementation problems explained in comments section.																						

* **E** (Exceeds Rule), **A** (Acceptable), **MA** (Marginally Acceptable), **D** (Departure)

Figure 8.

ROAD IMPLEMENTATION FORM
THP No. 1 - 04 - XXX **Observer(s)** C. Brandow, P. Cafferata, J. Munn **Date** 2-29-07

Appendix A-3
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Revised 9/14/07

Distance from the Starting Point in 10-Foot Increments

	440 450	450 460	460 470	470 480	480 490	490 500	500 510	510 520	520 530	530 540	540 550	550 560	560 570	570 580	580 590	590 600	600 610	610 620	620 630	630 640	640 650	650 660
Road Construction CF=Cut & Fill, TC=Thru-Cut TF=Thru-Fill FB= Full Bench Cut	CF												CF	TF								TF
Watercourse Xing B, C, P-A, OBA, F, O																						
Road Surface 0S=Out-Sloped IS=In-Sloped FL= Flat CR=Crowned	OS												OS	CR								CR
Outside Berm																						
Inside Ditch & Ditch Relief Culvert, Dip or Other															C					O		
Rate Maintenance of Inside Ditch & Ditch Relief: E, A, MA or D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E (A) MA D	E (A) MA D	E (A) MA D	E (A) MA D	E (A) MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D
Waterbreaks WB, RD, NL													RD							NL		
Percent Road Gradient between Waterbreaks					+7%												-3%				14%	
Percent Side Slope between Waterbreaks					30%												10%				20%	
Rate Waterbreaks constructed with a depth ≥6" into firm roadbed: (circle E, A, MA or D)	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E (A) MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E (A) MA D	E A MA D	E A MA D
Rate Waterbreaks discharge into cover and not onto erodible fills: (circle E, A, MA or D)	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E (A) MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E A MA D	E (A) MA D	E A MA D	E A MA D
Other implementation problems explained in comments section.																						

* **E** (Exceeds Rule), **A** (Acceptable), **MA** (Marginally Acceptable), **D** (Departure)

Figure 8.
Page 4 of 6.

ROAD EFFECTIVENESS FORM

THP No. 1 - 04 - XXX **Observer(s)** C. Brandow, P. Cafferata, T. Munn **Date** 2-29-07

Evidence erosion features associated with this road segment (circle one): **present** **absent**

Erosion Codes: RT=Ruts R=Rills G=Gullies M=Mass Wasting S=Cutbank or Sidecast Sloughing O=Other Erosion

Distance from the Starting Point in 10-Foot Increments

	000 010	010 020	020 030	030 040	040 050	050 060	060 070	070 080	080 090	090 100	100 110	110 120	120 130	130 140	140 150	150 160	160 170	170 180	180 190	190 200	200 210	210 220
Erosion on Cut Slope (insert erosion code)											R							R				
Erosion on Road Surface (insert erosion code)																						
Erosion on Fill Slope (insert erosion code)	RT					RT																
Erosion downslope of Fill (insert erosion code)			G																			
Sediment Transport beyond road prism (toe of fill) (insert "ST" in appropriate boxes)			ST																			
Sediment Transport to Channel Transition Line (insert "STC" in appropriate boxes)			STC																			
Other problems (explain in the comments section)																						

Distance from the Starting Point in 10-Foot Increments

	220 230	230 240	240 250	250 260	260 270	270 280	280 290	290 300	300 310	310 320	320 330	330 340	340 350	350 360	360 370	370 380	380 390	390 400	400 410	410 420	420 430	430 440
Erosion on Cut Slope (insert erosion code)		R						R														
Erosion on Road Surface (insert erosion code)												RT						RT				
Erosion on Fill Slope (insert erosion code)																						
Erosion downslope of Fill (insert erosion code)																						
Sediment Transport beyond road prism (toe of fill) (insert "ST" in appropriate boxes)																						
Sediment Transport to Channel Transition Line (insert "STC" in appropriate boxes)																						
Other problems (explain in the comments section)												X						X				

Figure 8.
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ROAD EFFECTIVENESS FORM

THP No. 1-04-XXX **Observer(s)** C. Brandow, P. Cafferata, J. Munn **Date** 2-29-07

Erosion Codes: RT=Ruts R=Rills G=Gullies M=Mass Wasting S=Cutbank or Sidecast Sloughing O=Other Erosion

Distance from the Starting Point in 10-Foot Increments

	440 450	450 460	460 470	470 480	480 490	490 500	500 510	510 520	520 530	530 540	540 550	550 560	560 570	570 580	580 590	590 600	600 610	610 620	620 630	630 640	640 650	650 660
Erosion on Cut Slope (insert erosion code)																						
Erosion on Road Surface (insert erosion code)																						
Erosion on Fill Slope (insert erosion code)																				R	—	R
Erosion downslope of Fill (insert erosion code)																						
Sediment Transport beyond road prism (toe of fill) (insert "ST" in appropriate boxes)																						
Sediment Transport to Channel Transition Line (insert "STC" in appropriate boxes)																						
Other problems																						

Comments (use additional sheets if needed)

Distance from Starting Point (10-Foot Increments)	Brief Description or Explanation of the feature. (Use additional pages if necessary. Annotated photos may also be attached.)	If applicable: Average Dimensions (Length x Width x Depth to the nearest foot)
000-060	Soil Stabilization needed on loose sidecast materials near watercourse (923.4 (i))	—
020-050	Gully near Crossing.	L x W x D 20' x 2' x 3'
340-390	Rutting on Road Surface in Thru-Cut due to traffic when road was wet. Needs Maintenance.	—

Figure 8.
Page 6 of 6.

3) Watercourse Crossing Sampling Method

Figure 9. Clay Brandow rating implementation and effectiveness of water quality related FPRs at a watercourse crossing.

Two (2) watercourse crossings will be sampled on each selected THP, if available. Each watercourse crossing will be rated for FPR implementation and effectiveness. Implementation can be rated on the first visit at the time of the Completion Report inspection. Effectiveness may be rated the same first visit if the watercourse crossing being evaluated has been through at least one winter period. If the watercourse crossing being evaluated has not been through at least one winter period at the time of first visit, a second visit after the winter period to the site will be necessary to evaluate the watercourse crossing for effectiveness. The watercourse crossing form has three (3) pages. The first page records site information, the second page records implementation and, the third page records effectiveness. The third page should not be completed until the watercourse crossing being evaluated has been through at least one winter period. A blank watercourse crossing form suitable for photo copying is included in Appendix A-4. You need to make two (2) copies of the form for each THP.

Selecting the two (2) Class I, II or III watercourse crossings for FORPRIEM monitoring. Step through the following process until two (2) watercourse crossings (Class I, II or III) are selected (include crossings abandoned as part of the current THP):

1. Select the first Class I, II or III watercourse crossing encountered within the 660-foot randomly selected road segment, if any. (Do not include cross-drain culverts. These are typically used for inside-ditch relief.)
2. Select the second Class I, II or III watercourse crossing encountered within the 660-foot randomly selected road segment, if any.
3. Select the Class I, II or III watercourse crossing that is closest to the 660-foot randomly selected road segment, if any.
4. Select the next closest Class I, II or III watercourse crossing to the 660-foot randomly selected road segment, if any.
5. If steps 1 through 4 did not yield two (2) watercourse crossings for monitoring, repeat steps 1 through 4, this time looking for Class IV watercourse crossings.
6. If steps 1 through 4 did not yield two (2) watercourse crossings for monitoring, crossings on a nearby skid road may be selected for monitoring.
7. If the THP includes no watercourse crossing, fill-out a watercourse crossing form with the THP number, the observer(s) and date. Then write on the form "Not applicable to this THP."

Instructions for Watercourse Crossings.
After selecting the two (2) Class I, II or III watercourse crossings for FORPRIEM monitoring using the stepwise process above, go to the first of the two watercourses. Flag the crossing with the following information "THP# X-XX-XXX FORPRIEM X-ing #1 month-day-year." Mark the location of the crossing on the copy of the THP map to be stapled to the FORPRIEM monitoring forms, and label it either "x-ing #1" or "x-ing #2," as appropriate.

From the watercourse crossing, walk the road in both directions. The length of road to be evaluated is determined by the points where drainage from the road surface, cuts, and fills no longer carries to the watercourse crossing. The evaluation includes the cut-off drainage structure that should route water away from the crossing.

Complete the first page of the watercourse crossing with information about the crossing site. Be sure to include the THP number, crossing number, observer's name(s) and the date.

Complete the second page by rating each of the applicable FPRs for implementation. For all crossings, rate each FPR under the section titled "All Watercourse Crossings" by circling the appropriate rating symbol on each line. If the crossing is a culver/pipe arch, is abandoned/removed, or is a tractor road crossing, then circle one of following titles as appropriate for this crossing: "Culvert/Pipe Arch Crossings," "Abandoned/Removed" or "Tractor Road Crossings." Rate each FPR under the title circled by selecting the appropriate rating symbol on each line. Do <u>not</u> rate the FPRs under the two titles not circled. Be sure to include the THP number, crossing number, observer's name(s) and the date at the top of this page of the form. The rating symbols stand for the following:

ER (Exceeds Rule/THP requirements)
A (Acceptable)
MA (Marginally Acceptable)
D (Departure)
N/A (Not Applicable)

Complete the third page by evaluating effectiveness after the crossing has gone through at least one winter. For all crossings, rate effectiveness on the fill slopes (lines 1-3) and road surfaces draining the crossing (lines 1-5) by checking the appropriate box. If this crossing is a bridge, stop here. If the crossing is not a bridge, circle one of following titles as appropriate for this crossing: "Culvert Design/Configuration," "Non-Culvert Crossing", or "Removed/Abandoned Crossings." Under the circled title, rate each line item by checking the appropriate box. Do not rate the line items under the two titles not circled. Be sure to include the THP number, crossing number, observer's name(s) and the date at the top of this page of the form.

Repeat the above process for the second selected watercourse crossing.

Figure 10 is a completed watercourse crossing sample form, including the first page recording general information, the second page rating the implementation and third page rating effectiveness. It is important to fill the forms out completely to assure good quality data. It is also very important to record the THP number, observer(s) and date on each page of the form in case the pages get separated.

An expanded description of each line item (parameters) to be rated for effectiveness is provided below.

FILL SLOPES

Gullies: Gullies are greater than 6" deep. Determine as best as possible if the gullies appear to be enlarging and whether there is deposition into watercourse channels.

Cracks: As you survey the fillslopes, also note any evidence of cracks on the slope. Often these are present at the upper edge of the fillslope. Cracks are common as fill settles. Assess whether the cracks appear to be stabilized or widening (active). Look for signs of vegetation, litter or rounded edges to identify older features, and for sharp edges that indicate recent cracking.

Slope Failures: While surveying the fillslope, note instances of slope failure. Slope failures are indicated by movement of soil in blocks or slumps, rather than by rills, gullies or sheet erosion. Estimate whether the failures total between 0 and 1 cubic yard, 1 to 10 cubic yards, or greater than 10 cubic yards.

ROAD SURFACE DRAINING TO THE CROSSING

Gullies: Determine if gullies are present on the road surface draining towards the crossing. Determine if the gullies appear to be enlarging and whether there is deposition into watercourse channels.

Cutoff Drainage Structure: Evaluate the cutoff drainage structures to determine if they are preventing the passage of water down to the crossing location.

Inside Ditch Condition: If an inside ditch is present, evaluate its condition and how functional it is in routing water down to the inlet of the culvert.

Ponding: Observe the road surface for evidence of ponding of surface runoff. Normally, ponds form at the low points of the surface, where a berm or other feature prevents drainage. Minor ponding is to be expected, so examine the fillslope below areas where ponding is evident, to determine if the ponding has resulted or could result in slippage or failure of the fill.

Rutting (from vehicles): Determine if ruts from vehicles are present, and whether the ruts impair road drainage.

CULVERT DESIGN/CONFIGURATION

Crossing Failure: Note whether the crossing catastrophically failed.

Scour at Inlet and Outlet: Observe the stream channel at both the inlet and outlet of the culvert. If scour is evident, rate as minor or major scour. Major scour extends more than 2 channel widths below outlet, or undercuts crossing fill at either the inlet or the outlet.

Diversion Potential: Examine the grade of the roadway at the crossing. If the crossing fails (plugs up or fails to carry all of the flow), will the stream be diverted out of its channel and down the roadway, or will flow continue across the road and down the channel?

Plugging: Examine the inlet of the culvert and determine the presence and degree of blocking of the capacity of the culvert by debris (woody debris, soil, or rock).

Alignment: Observe the channel as it enters the culvert inlet and determine if there is basically a straight shot for water and debris to enter the pipe, or if there is a considerable angle between the channel and crossing center lines.

Degree of Corrosion: Use a screwdriver or similar tool and test the competency of the metal for steel pipes.

Crushed Inlet/Outlet: Determine if machinery or other impacts have deformed the pipe inlet or outlet.

Pipe Length: Determine if the pipe length is appropriate for the fill placed at the crossing, or if the pipe length is causing erosion problems.

Gradient: Determine if the gradient is appropriate or inappropriate. Improper gradient is evident when the pipe inlet or outlet is set too low in the channel or too high in the fill.

Piping: Examine the crossing fill and determine if piping of water around the culvert is occurring, whereby water is passing through the fill without going through the culvert.

NON-CULVERT CROSSINGS (e.g., Rocked Class III crossings)

Armoring: Evaluate the armoring present and determine if it is preventing downcutting at the crossing location.

Scour at Outlet: Observe the stream channel at the outlet of the crossing. Estimate the total amount of scour that has occurred and is likely to occur in the next 2 years, and rate accordingly.

Diversion of Flow: Examine the watercourse crossing and approaches to determine if they have been maintained to prevent diversion of stream overflow down the road should the crossing structure become plugged.

REMOVED OR ABANDONED CROSSINGS

Bank Stabilization: Determine if exposed soil on bank cuts have been stabilized to prevent transport of deleterious quantities of eroded soils to a watercourse.

Gullies: Gullies are greater than 6" deep. Determine if the gullies appear to be enlarging and whether there is deposition into watercourse channels.

Slope Failure: Slope failures are evidenced by movement of soil in blocks or slumps, rather than by rills, gullies or sheet erosion. Estimate whether the failures total less than 1 cubic yard, greater than one cubic yard without channel entry, or greater than 1 cubic yard with channel entry.

Channel Configuration: Examine restored channel configuration to determine if it is as wide or wider than the natural channel and as close as feasible to the natural watercourse grade and orientation.

Excavated Material: Examine sites where excavated soil material has been placed to determine if they are sloped back from the channel and stabilized to prevent slumping and minimize input into the channel.

Maintenance Free Drainage: Determine if the abandonment procedure does, and will continue to, provide permanent, maintenance free drainage.

Figure 10. Example of a completed FORPRIEM watercourse crossing form for purposes of demonstration. Note that all three pages of the form are completed and that the THP number, the names of the observers and the date have been filled in on each page.

FORPRIEM

Forest Practice Rules Implementation & Effectiveness Monitoring
(formerly known as Modified Completion Report (MCR) Monitoring)

WATERCOURSE CROSSING FORM

Revised 9/14/07

1. Site Information

THP No. 1 - 04 - XXX **Crossing No.** 1 **Observer(s)** C. Brandow, P. Cafferata, J. Munn **Date** 2-29-07

Watercourse Class (circle one): I (II) III IV

Type of road (circle one): (permanent) seasonal temporary abandoned other______

Type of crossing (circle one): bridge (culvert) pipe-arch open-bottom-arch ford other______

Date of the Installation was (circle one): (prior to THP) part of THP

Current status (circle one): (existing) abandoned

Culvert diameter (circle one): N/A 12" 18" 24" 30" (36") 42" 48" 60" 72" Other______"

Multiple Culverts: (N/A) number of pipes ______ sizes __", __", __", __", __", __" Other ______

Photos of this crossing/approaches taken, annotated and attached to this monitoring form? Yes (No)

Recommend follow-up monitoring of this site based on problems found? Yes (No)

2. Rate this crossing for implementation by circling **ER** (Exceeds Rule), **A** (Acceptable), **MA** (Marginally Acceptable), **D** (Departure), or **N/A** (Not Applicable) for each Forest Practice Rule on the following implementation rating page (pg. 2).

3. Rate this crossing for effectiveness by checking the appropriate box on each line of the effectiveness page, which follows the implementation page. Make sure that the crossing has been through at least one winter season prior to rating for effectiveness (pg. 3).

4. Make sure the THP Map showing the watercourse crossings sampled is attached.

THP No. 1 -- 04 -- XXX Crossing No. 1 Observer(s) C. Brandow, P. Cafferata, J. Munn Date 2-29-07

Type of Crossing/Rule No.	Brief Rule Description	Implementation Rating (circle one for each rule)					Comments
All Watercourse Crossings							
923.2(h)	size, #, location of structures sufficient to carry runoff	ER	(A)	MA	D	N/A	
923.2(h)	size, #, location of structures minimizes erosion	ER	(A)	MA	D	N/A	
923.2(h)	size, #, location of structures-natural drainage pattern	ER	(A)	MA	D	N/A	
923.3(a)	permanent xings shown on THP map (+pipe diameter(s) if appropriate)	ER	(A)	MA	D	N/A	
923.3(c)	unrestricted passage of all life stages of fish allowed (where applicable)	ER	A	MA	D	(N/A)	
923.3(f)	crossing/fills built or maintained to prevent diversion	ER	A	(MA)	D	N/A	
923.4(c)	waterbreaks maintained as specified in 914.6	ER	(A)	MA	D	N/A	
923.4(d)	crossing open to unrestricted passage of water	ER	(A)	MA	D	N/A	
923.4(e)	permanent constructed/reconstructed--100-year flood flow + sediment and debris passage	ER	(A)	MA	D	N/A	
923.4(m)	Inlet/outlet structures, additional drainage structures, etc. repaired/replaced/installed as needed to protect water	ER	(A)	MA	D	N/A	
923.4(n)	crossing/approaches maintained to prevent diversion	ER	A	MA	(D)	N/A	Cut-off WB needed.
Culvert/Pipe Arch							
923.2(d)(Coast)	fills across channels built to minimize erosion	ER	(A)	MA	D	N/A	
923.2(i)	where evidence of debris likely to significantly reduce culvert capacity below design flow, oversize culverts, trash racks, or similar devices installed in a manner that minimizes culvert blockage	ER	A	MA	D	(N/A)	
923.2(o)	no discharge on fill unless energy dissipators used	ER	A	(MA)	D	N/A	
923.4(d)	trash racks installed where needed at inlets	ER	A	MA	D	(N/A)	
923.4(l)	drainage structure & trash rack maintained/repaired to prevent blockage	ER	A	MA	D	(N/A)	
Abandoned/Removed							
923.3(d)(1)	removed--fills excavated to reform channel	ER	A	MA	D	N/A	
923.3(d)(2)	removed--cut bank sloped back to prevent slumping	ER	A	MA	D	N/A	
923.3(d)(2) [required]	removed--where needed, stabilizing treatment applied	ER	A	MA	D	N/A	
923.8	abandonment--maintenance free drainage	ER	A	MA	D	N/A	
923.8	Abandonment--minimize concentration of runoff	ER	A	MA	D	N/A	
923.8(b)	abandonment--stabilization of exposed cuts/fills	ER	A	MA	D	N/A	
923.8(c)	abandonment--grading of road for dispersal of water	ER	A	MA	D	N/A	
923.8(d)	abandonment--pulling/shaping of fills	ER	A	MA	D	N/A	
923.8(e)	abandonment--fills excavated to reform channel	ER	A	MA	D	N/A	
923.8(e)	abandonment--cutbanks sloped back	ER	A	MA	D	N/A	
923.8(e)	removal not feasible--diversion potential handled	ER		MA	D	N/A	
Tractor Road Crossing							
914.8(b)	structure (bridge, culvert, etc.) used where water present during life of the crossing	ER	A	MA	D	N/A	
914.8(c)	unrestricted fish passage in Class I watercourse	ER	A	MA	D	N/A	
914.8(d)	skid crossing fill removed and banks sloped properly	ER	A	MA	D	N/A	

Figure 10.
Page 2 of 3.

THP No. 1 - 04 - XXX **Crossing No.** 1 **Observer(s)** C. Brandow, P. Cafferata, J. Munn **Date** 2-29-07

WATERCOURSE CROSSING EFFECTIVENESS

[ALL] Fill Slopes (Check appropriate box on each line for all crossings.)

1) Gullies (>6" in deep)	☐ N/A	☐ None	☑ Small gullies, but not enlarging	☐ Large gullies or enlarging	
2) Cracks	☐ N/A	☑ None	☐ cracks present but stabilized	☐ cracks threaten stability of fill	
3) Slope Failure	☐ N/A	☑ None	☐ 0-1 cubic yard	☐ 1-10 cubic yard	☐ >10cubic yard

[ALL] Road Surface Draining to Crossing (Check appropriate box on each line for all crossings.)

1) Gullies (>6 in deep)	☐ N/A	☐ None	☑ Small gullies, but not enlarging	☐ Large gullies and enlarging
2) Cutoff Drainage Structure	☐ N/A	☐ Functional	☑ Allows some water to reach crossing	☐ Allows all water to reach crossing
3) Inside Ditch Condition	☑ N/A	☐ Open	☐ Some sediment/debris accumulation	☐ Blocked with sediment and debris
4) Ponding	☐ N/A	☑ None	☐ Ponding present but does not threaten stability of fill material	☐ Ponding present and threatens the stability of the fill material
5) Rutting	☐ N/A	☑ None	☐ Some ruts but drainage not impaired	☐ Rutting impairs road drainage

[X] Culvert Design/Configuration (For culvert crossings, check box and check appropriate box on each line below, 1 thru 10.)

1) Scour at Inlet	☐ N/A	☑ None	☐ Minor scour—not undercutting fill	☐ Major scour, may be undercutting fill
2) Scour at Outlet	☐ N/A	☐ No evidence of scour	☑ Minor scour—extends < 2 channel widths and no undercut of crossing fill	☐ Major scour, extends > 2 channel widths or scour undercuts crossing fill
3) Diversion Potential	☐ N/A	☐ Not possible	☑ Road slopes downward in one direction with drainage structure	☐ If culvert fails, overflow will be diverted out of channel and down road
4) Plugging	☐ N/A	☑ None	☐ Sediment/debris blocking <30%	☐ Sediment/debris blocking >30% of inlet/outlet
5) Alignment	☐ N/A	☑ Appropriate	☐ Low angle channel approach	☐ High angle channel approach
6) Degree of Corrosion	☐ N/A	☑ None/minor	☐ Moderate—some metal missing	☐ Severe—pipe easily punctured
7) Crushing Inlet/Outlet	☐ N/A	☑ None	☐ Pipe deformed but <30% blocked	☐ Pipe deformed and >30% blocked
8) Pipe Length	☐ N/A	☑ Appropriate	☐ Length causing minor fill erosion	☐ Length related to major erosion around pipe
9) Gradient	☐ N/A	☑ Appropriate	☐ Inlet slightly too low or high in fill	☐ Inlet too high or low—causing debris to collect
10) Piping	☐ N/A	☑ None		☐ Flow passes beneath or around culvert

[ ] Non-Culverted Crossing (For non-culverted crossings, check box and check appropriate box on each line below, 1 thru 3.)

1) Armoring	☐ N/A	☐ Appropriate	☐ Minor downcutting evident	☐ Major downcutting evident
2) Scour at Outlet	☐ N/A	☐ None	☐ Minor scour—not undercutting fill	☐ Major scour, maybe undercutting fill
3) Diversion	☐ N/A	☐ Not possible	☐ Road slopes downward in one direction but unlikely to divert flow	☐ Overflow will be diverted down road

[ ] Removed/Abandoned Crossings (For removed/abandoned crossings, check box and check appropriate box on each line below.)

1) Bank Stabilization	☐ N/A	☐ Dense cover or stabilized	☐ >50% of banks covered and/or stabilized	☐ <50% of banks have effective cover or or stabilized
2) Gullies (>6 in deep)	☐ N/A	☐ None	☐ Small gullies, not enlarging	☐ Large gullies or enlarging
3) Slope Failure	☐ N/A	☐ <1 cu yd	☐ >1 cu yd but does not enter stream	☐ >1 cu yd and enters channel
4) Channel Configuration	☐ N/A	☐ Near natural	☐ Minor difference from natural channel	☐ Major difference from natural channel
5) Excavated Material	☐ N/A	☐ Sloped to min. erosion	☐ <1 cubic yard transported to channel	☐ >1 cubic yard transported to channel
6) Maintenance Free Drainage	☐ N/A	☐ Sufficient	☐ Minor problem(s) noted	☐ Major problem(s) noted

REFERENCES

Brandow, C. A., Cafferata, P.H. and Munn, J.R. 2006. Modified Completion Report Monitoring Program, Implementation and Effectiveness of the forest Practice rules related to Water Quality Protection, Monitoring results from 2001 through 2004. California Department of Forestry and Fire Protection. Sacramento, 80p. http://www.bof.fire.ca.gov/board/msg_supportedreports.asp

Cafferata, P.H. and Munn, J.R. December 2002. Hillslope Monitoring Program: Monitoring results from 1996 through 2001. California Department of Forestry and Fire Protection. Sacramento, CA. 114 p. http://www.bof.fire.ca.gov/board/msg_supportedreports.asp

Robards, T. 1999. Instructions for WLPZ Canopy /Surface Cover Sampling (Canopy Enforcement Protocol). California Department of Forestry and Fire Protection –Forest Practice. Sacramento, CA. 9 p. http://cdfweb/Forestry/tools_trade/InstructionsforWLPZSampling.pdf

FORPRIEM

Forest Practice Rules Implementation & Effectiveness Monitoring

(formerly known as Modified Completion Report (MCR) Monitoring)

Appendices

(Note: Provided for convenience. Any random number table or random number generating calculator may be used to randomly select WLPZ reaches and road segments.)