Mill Creek Addition

Road Inventory and Assessment Report

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EXECUTIVE SUMMARY

We inventoried all of the known roads within the Mill Creek Addition from 2002 through 2005. Physical parameters of the road surface and road structures such as stream crossings and landings were recorded and entered into Access® databases. Database tables dynamically linked to the GIS allowed us to query data within the databases and against spatial data contained in the GIS.

A range of scoring criteria were assigned to selected physical attributes of road fills, crossing, landing, and mass wasting sites. Selected landscape features such as soils, slope, and relative slope stability were spatially joined to road features to aid in the scoring. Scores were normalized and evaluated individually and grouped by road to objectively quantify the relative risk and threat for each road. Risk describes the relative likelihood a road or site will fail while threat describes the relative volume at risk for delivery to the stream network. Models developed for this analysis may be used to evaluate other threat criteria such as damage to forest stands by landslide run-out or capital loss as road structures fail and require replacement.

Four-hundred and sixty eight kilometers of road and 3,682 sites including 1,451 road-stream crossings, 981 landings, 807 mass wasting sites, and 443 road fills are classified based on their relative risk and threat. Nine-hundred and eight sites are considered high risk with a combined potential sediment delivery of 905,079 cubic meters. Moderate risk sites number 1,813 and represent 1,281,885 cubic meters of potential sediment delivery. Low risk sites account for 398,522 cubic meters of potentially deliverable sediment contained in 961 sites.

ACKNOWLEDGEMENTS

We would like to thank the GIS team at Redwood National and State Parks (RNSP), especially Dave Best, and Daryl Van Dyke, who provided many hours of consultation and technical support to this project. We would also like to thank our geology partners at RNSP, Greg Bundros and Darci Short for their input and technical review of our assessment scoring methods and Joe Seney, who was a valuable resource in providing consultation on the soil survey data used for the slope stability model. Thanks to Patrick Vaughn for his contribution to the geology section. Of course, we are grateful to the dedicated field technicians, especially Davin Peterson and Martha Basham, who spent many long hours in the field, rain or shine, to inventory the roads and to Martha for her countless hours in the office inputting data.

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INTRODUCTION

In June 2002, Save-the-Redwoods League acquired 25,471 acres of private timberland from Stimpson Lumber Company. The acquisition of this land marked the end of an effort that had begun decades before to transfer the property encompassing the Mill Creek watershed into public hands as either a National Park or an addition to the adjacent State Parks. As a commercial property, the acreage was aggressively harvested from the early 1950's to the latter 1990's. Over the course of a few decades, the forest was converted from old growth redwood, Douglas fir, and Sitka spruce to a mosaic of even aged Douglas fir cut units. This ground-based timber operation resulted in the construction of a dense network of haul roads and skid trails to facilitate timber transportation. When the Mill Creek Addition was transferred to the California State Parks (DPR) in 2002, there were approximately 468 km (290 mi) of haul roads and an estimated 650 km (400 mi) of skid trails present.

Although all watersheds have a natural rate of erosion and sedimentation that varies according to their underlying geology, human land management activities such as road building can accelerate the rate of erosion. Several studies have shown forest roads and logging activities are a significant source of excessive sedimentation to streams throughout the western United States. In fact, the road system built for logging more frequently contributes to landslides and accelerated erosion than timber harvesting itself (Rice 1991 and Rice et al. 1972). Road cuts and their drainage features disrupt the natural surface and subsurface drainage patterns through a forested watershed. Roads located in steep terrain can produce large landslides when their sidecast material is saturated from heavy precipitation. Road drainage features such as culverts can become plugged with woody debris during extreme storm events and can cause complete failure of the stream crossing, or divert the stream out of its natural channel and cause gullying down roadways or hillslopes.

Excessive sedimentation is known to adversely impact water quality and aquatic habitat, especially for salmonids. Influx of fine sediment from excessive erosion fills in stream pools necessary for salmonid fry and juvenile survival. After pools are filled, continued influx of sediment creates shallower, wider stream channels, causing lateral migration of the channel, leading to bank erosion, which can lead to loss of vegetative cover. Fine sediment deposits in stream gravels and clog interstitial spaces reducing oxygen levels and nutrient flow within spawning gravels.

The Mill Creek Addition receives on average 60-150 inches of rainfall per year (Stillwater 2002); combined with the high density of roads and stream crossings that traverse steep terrain, the property poses a significant challenge to successful management of the inherited road system. The roads are no longer being used for timber extraction making many of them unnecessary. Without continued maintenance, upgrading, or removal, the risk of road-related erosion and sedimentation will increase over time. The first step in planning for roads on the property was to inventory their status to be able to prioritize them by their relative risk of failure and the threat they pose in terms of sedimentation to the stream network.

Purpose

This report presents the methods and results of our property-wide road inventory conducted from 2002 to 2005. Publication of this report marks the completion of the initial road assessment for the Mill Creek Addition. This report is intended as a starting point for the evaluation of roads within the guiding context of a Mill Creek General Plan Amendment (GPA) and future management planning efforts.

Scope

Our inventory included all known haul roads within the property at the time of acquisition, as well as those discovered during field work. We collected data to determine how each road influences local geomorphic processes, to develop cost estimates for annual maintenance and road reengineering, and to determine the present-day value of roads and facilities.

We did not inventory or assess skid trails. Skid trails are defined as small single-lane tracks that developed as ground-based equipment moved logs across harvest units. Skid trails were not planned as part of the road system, were not constructed using standard cut and fill techniques and typically did not make use of stream crossings. We did not inventory fire breaks developed around harvest units. We classified them as skid trails because they typically followed the existing topography instead of cutting through it.

We used the road inventory data coupled with Geographical Information System (GIS) routing over a digital elevation model (DEM), and a slope stability model (SINMAP) to assign rank and characterize haul roads by their relative risk of failure and threat of potential sediment delivery to streams. Road rankings are not based on the value of roads for use in park operations, resource management, or emergency services. Particular rehabilitation options for each road are not recommended as part of this assessment, instead we will use the risk and threat data presented to evaluate roads for permanent retention or removal consistent with planning guidelines and procedures defined in future management plans.

PREVIOUS ROAD INVESTIGATIONS

Pacific Watershed Associates conducted a property-wide survey of roads between 1995 and 1997 (PWA 1996, 1997, 1998). The purpose of the investigation was to identify existing and potential sources of sediment that could deliver to streams and affect water quality. Approximately 90% of the roads were inventoried across the Mill and Rock Creek basins. The investigation concluded that most of the potential erosion and sediment yield related to roads was likely to come from three sources: 1) failure of the road fillslope, 2) failure of stream crossings, and 3) road surface and ditch erosion (PWA 1997, 1998).

Stimpson Timber Company conducted an investigation of mass wasting and road-related erosion as part of their effort to develop a Habitat Conservation Plan (Stimpson Lumber Company 1998). The investigation relied on aerial surveys coupled with field mapping to identify the location and characteristics of mass wasting features across the landscape. The investigation concluded that roads were the largest contributing source of sediment delivered to streams, and that altered drainage paths contributed significantly to watershed instability.

In 2002, Stillwater Sciences completed Interim Management Recommendations (IMR) under contract with the Save-The-Redwoods-League. The project drew from past investigations to formulate management recommendations for application during the first years of acquisition. We have been implementing road removal projects and maintenance consistent with their preliminary recommendations until State Parks could complete formal planning efforts for the newly acquired park unit.

ROADS, SKID TRAILS, AND ROUTES

Throughout this report, we use the terms roads, skid trails, and routes to describe features that were used by vehicles or equipment to conduct timber extraction and transportation. There are, however, distinctions between these terms that require some definition. Roads, in the common sense, describe passages of all sizes and uses. Roads have a single distinguishing element from other terms, that is, they have a roadbed constructed to be a relatively smooth driving surface for truck or equipment travel.

Skid trails, on the other hand, lack a constructed road bed and often are expressed as lineations of bare mineral soil that follow, rather than cut through the surrounding topography. Timber extraction equipment most often used skid trails for a limited time or for fire breaks during post-harvest burning.

The roads within the Mill Creek Addition can be illustrated with spatial accuracy on maps using GIS software. The term, route, is specifically an ArcGIS® term used to represent the line work (arc framework node to node) that illustrates the roads within the mapping software. Routes provide the fundamental spatial framework for the road assessment. Therefore, routes will be used to describe the inventory, and subsequently derived data, as it pertains to the physical roads on the property.

BACKGROUND INFORMATION

PHYSICAL SETTING

The Mill Creek Addition, now part of Del Norte Coast Redwoods State Park, is a 103 km^2 (40 m^2) parcel located approximately 9 kilometers (6 mi) southeast of Crescent City, Del Norte County, California (Figure 1). The property adjoins Jedediah Smith Redwoods State Park to the north, Del Norte Coast Redwoods State Park to the west, Six Rivers National Recreation Area to the east, and Industrial timber lands (owned by Green Diamond Resources Company) to the south. The property encompasses most of the Mill Creek and Rock Creek watersheds and small areas within the Turwar, Hunter, and Wilson Creek watersheds (Figure 2).

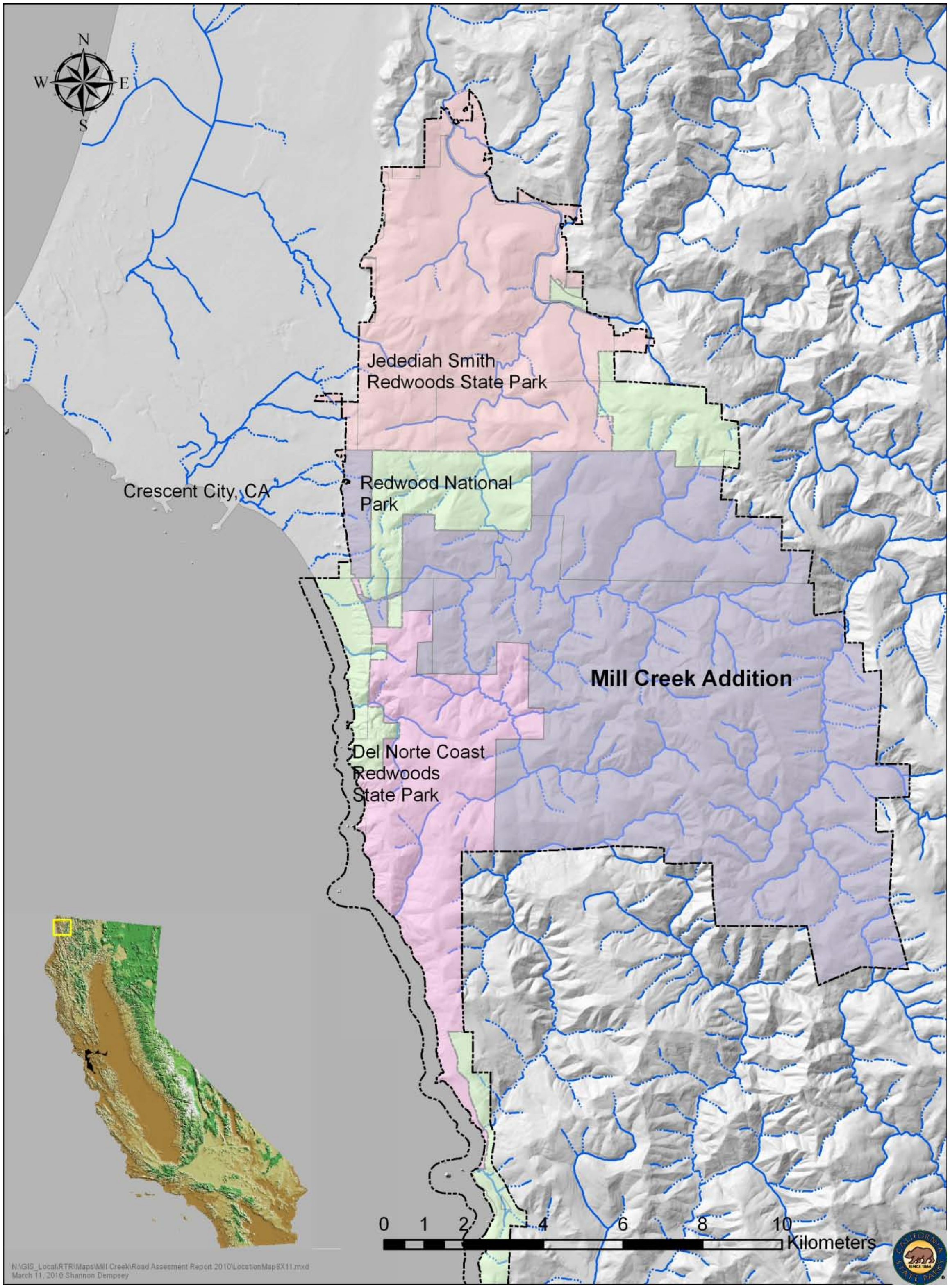

Figure 1. Location of the Mill Creek Addition, Del Norte County, CA.

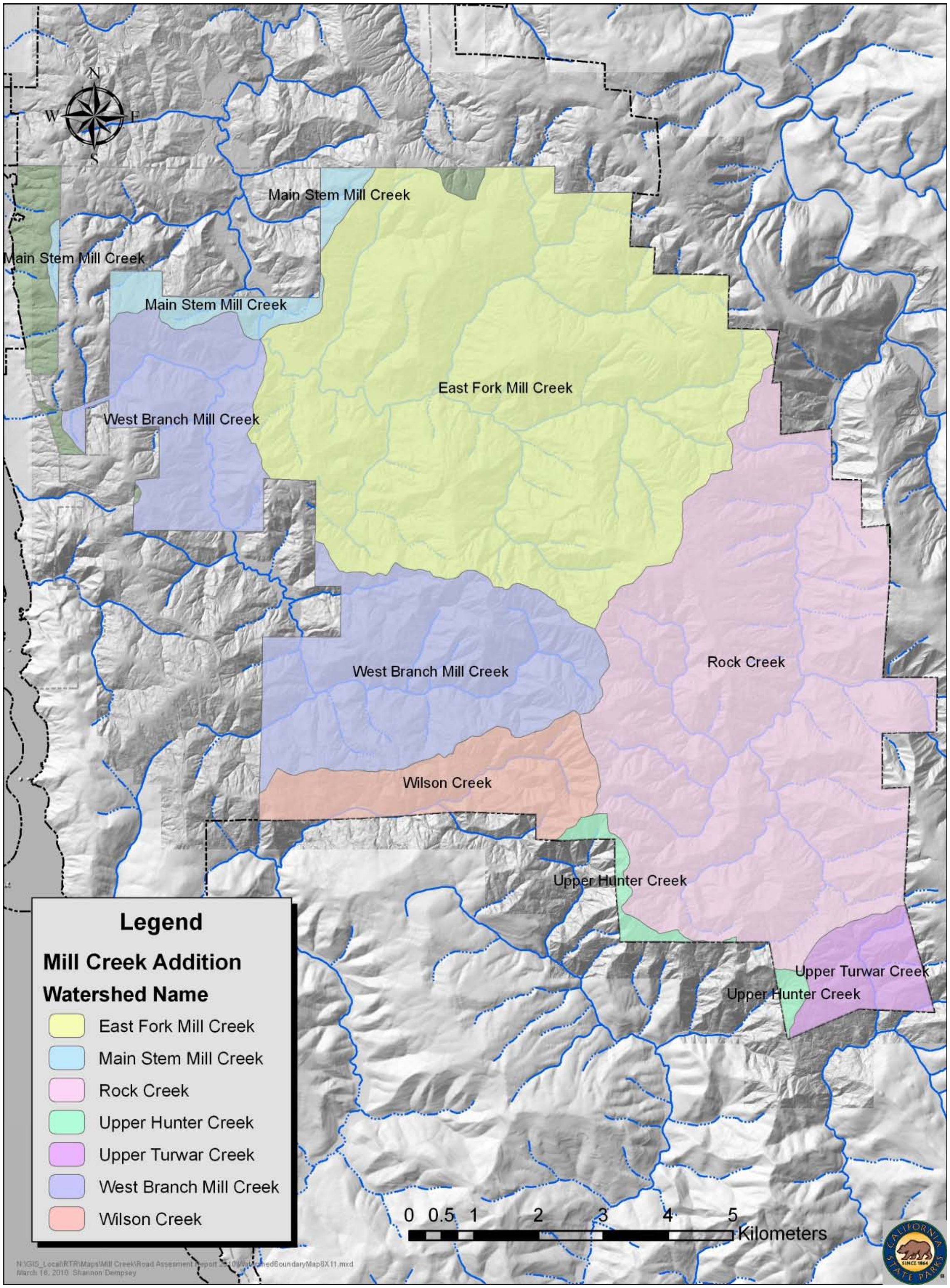

Figure 2. Watershed boundaries within the Mill Creek Addition.

Geology and Soils

Tectonic convergence and relatively hard bedrock control the physiographic expression of the Mill Creek Addition. The Coast Range Thrust Fault, locally known as the South Fork Fault, strikes north-northwest through the Rock Creek watershed and forms the boundary between rocks of the Coast Ranges and the Klamath Mountains (Figure 3). The Coast Range Thrust Fault is a remnant from the early convergence and accretion of marine Franciscan Formation rocks with the North American continent from the mid-late Mesozoic to early Tertiary (beginning approximately 180 million years ago; note: temporal or spatial uncertainty in geologic terms is directly expressed; the symbol (?) may be used to convey uncertainty); the fault extends several hundred miles to the south. The convergence of the Gorda and North American tectonic plates, which meet at the ocean floor approximately 100 km (60 mi) offshore west of the Mill Creek Addition, continues this accretionary process. The Gorda plate dives under the North American plate at a low angle along the southern part of the Cascadia Subduction Zone such that their contact is below the Mill Creek Addition at depth.

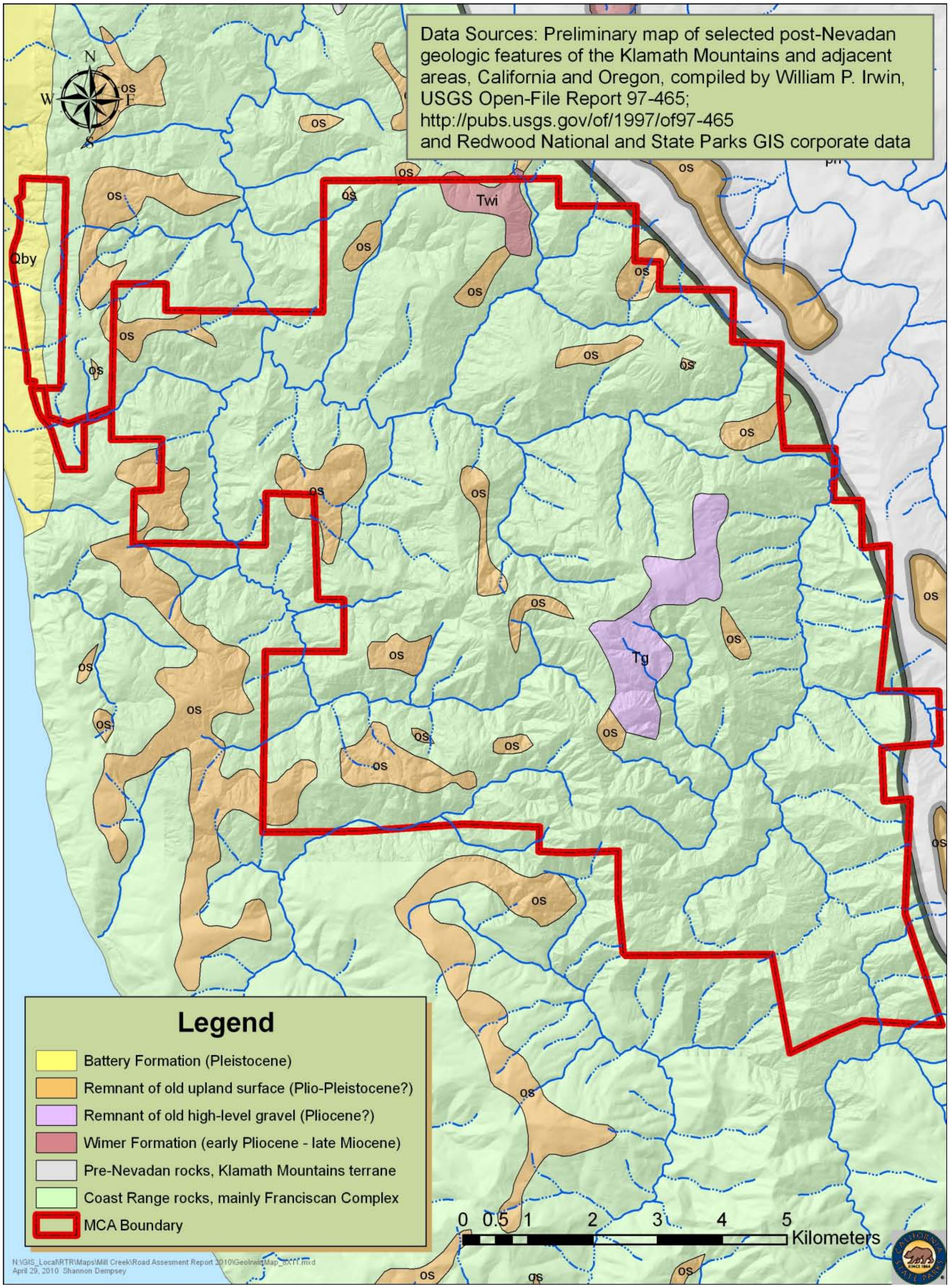

Figure 3. Geology of the Mill Creek Addition.

Other active faults in the vicinity—the Whalehead Fault in southern Oregon and offshore extensions of the Big Lagoon-Bald Mountain and Trinidad faults—could produce strong ground shaking in the Mill Creek Addition but have lesser recurrence and lesser maximum magnitude capability than the Cascadia Subduction Zone. Using average long-term recurrence data, Goldfinger et al. (2008) indicated that rupture along the southern segment of the Cascadia Subduction Zone, estimated to produce earthquakes of Magnitude 8+, is several decades overdue.

Ongoing deformation along the subduction zone continues to contribute to uplift and preserve Pleistocene to Miocene alluvial and marine deposits on ridges. The hard bedrock and uplift also contribute to the development of steep and generally straight to convex slopes that frequently exceed 50% grade (Madej et al. 1986).

Drainages are deeply incised and have dendritic to trellis patterns. LiDAR analysis suggests a propertywide average drainage density for USGS blue line streams of approximately 2.3 km/km^2 (1.4 mi/mi^2), although subwatersheds may have drainage densities of approximately 4.5 to 5.5 km/km^2 (2.7 to 3.3 mi/mi^2).

Bedrock west of the Coast Range Thrust Fault is predominantly the Broken Formation of the Eastern Belt Franciscan Complex. These late Jurassic to early Cretaceous rocks are tectonically fragmented and consist of interbedded greywacke (sandstone), shale, and conglomerate (Aalto and Harper 1982). More coherent, massive sandstone characterized by massive bedding and moderate shearing predominates in the Mill Creek Addition. Fracturing and shearing of the Broken Formation increases from west to east toward the Coast Range Thrust Fault. Immediately west of the fault, highly sheared and foliated metagreywacke, argillite, and semischist predominate (Davenport 1984), indicating slight metamorphism along the fault zone. The bedrock east of the fault is composed of Pre-Nevadan rocks, including highly sheared serpentinite and peridotite, in the western Klamath Mountains terrain (Aalto and Harper 1982). Because the fault encompasses a broad zone, serpentine and peridotite that may bear asbestos minerals are also found in the Mill Creek Addition several hundred meters west of the fault depicted in Figure 3.

Marine, estuarine, and fluvial siltstone, sandstone, and conglomerate of the early Pliocene to late Miocene (?) Wimer Formation, coincident with J.S. Diller's "Klamath Peneplain," cap many of the ridges. A younger Pliocene (?) alluvial deposit also caps the ridge near Childs Hill, on the southeast side of the MILL CREEK ADDITION. Pleistocene to late Miocene remnant upland surfaces thought to be part of the Klamath Peneplain consist of unclassified sedimentary deposits and deeply weathered bedrock and saprolite; Irwin (1997) interpreted their distribution from 1:62,500- and 1:100,000-scale USGS topographic maps (Figure 3). The distinctions among these Pleistocene to early Miocene units, which occupy similar topographic position and have temporal overlap and some temporal uncertainty, appear to be cross-cutting relationships, limited paleontological evidence, and, to some extent, the character of the earth material.

Late Quaternary deposits are located throughout the Mill Creek Addition landscape. A small sliver of property on the northwest side of the Mill Creek Addition overlies the Pleistocene Battery Formation, a marine terrace, sand dune, and alluvial fan deposit consisting of unconsolidated sand, silty clay, and imbricated gravel (Davenport 1982). Holocene to Pleistocene landslides are common throughout the Mill Creek Addition. Holocene to Pleistocene fluvial terraces and floodplain deposits are located in Mill Creek and, to a lesser extent, in Rock Creek. Limited drilling data and some observational data indicate that the terrace deposits are typically cobbly or gravelly, sometimes with a moderately high amount of silt and clay in the gravel matrix. Overbank silts and clays typically cap the coarser deposits, and finer grained alluvial fans are associated with the floodplain deposits at some tributaries. The terrace deposits locally help protect the valley side slopes from stream undercutting and failure (Madej et al.

1986). Colluvium of variable thickness mantles the bedrock. Large fill deposits are locally associated with the extensive logging road network and the old mill site at the confluence of the West Branch and East Fork.

Staff from the NRCS recently completed soil mapping of Redwood National and State Parks, including the Mill Creek Addition, providing a modern soil survey that provides a wealth of soil data (USDA 2008). Fifteen soil associations and soil series of various slopes are identified in this mapping. With respect to surface erosion, approximately 75% of the land base has a severe erosion hazard rating (Figure 4). Only the Bigtree-Mystery Association, on floodplains, has a slight erosion hazard rating. Moderate erosion hazard ratings generally occur on ridgetops for the Trailhead-Wiregrass, Wiregrass-Pittplace-Scaath, and Coppercreek-Tectah-Slidecreek Associations. The Surpur and Childshill soil series also have moderate erosion hazards. The Slidecreek-Lackscreek-Coppercreek, Wiregrass-Rockysaddle, Sasquatch-Siterrocks-Ladybird, Sisterrocks-Ladybird-Footstep, Jayel-Walnett-Oragran, Coppercreek-Slidecreek-Tectah, Wiregrass-Rockysaddle, Sasquatch-Yeti-Footstep, Gasquet-Walnett-Jayel, Oragran-Weitchepec, Coppercreek-Ahpah-Lackscreek, and Scaath-Rockysaddle-Wiregrass Associations have severe erosion hazard ratings, generally on the valley sidewalls.

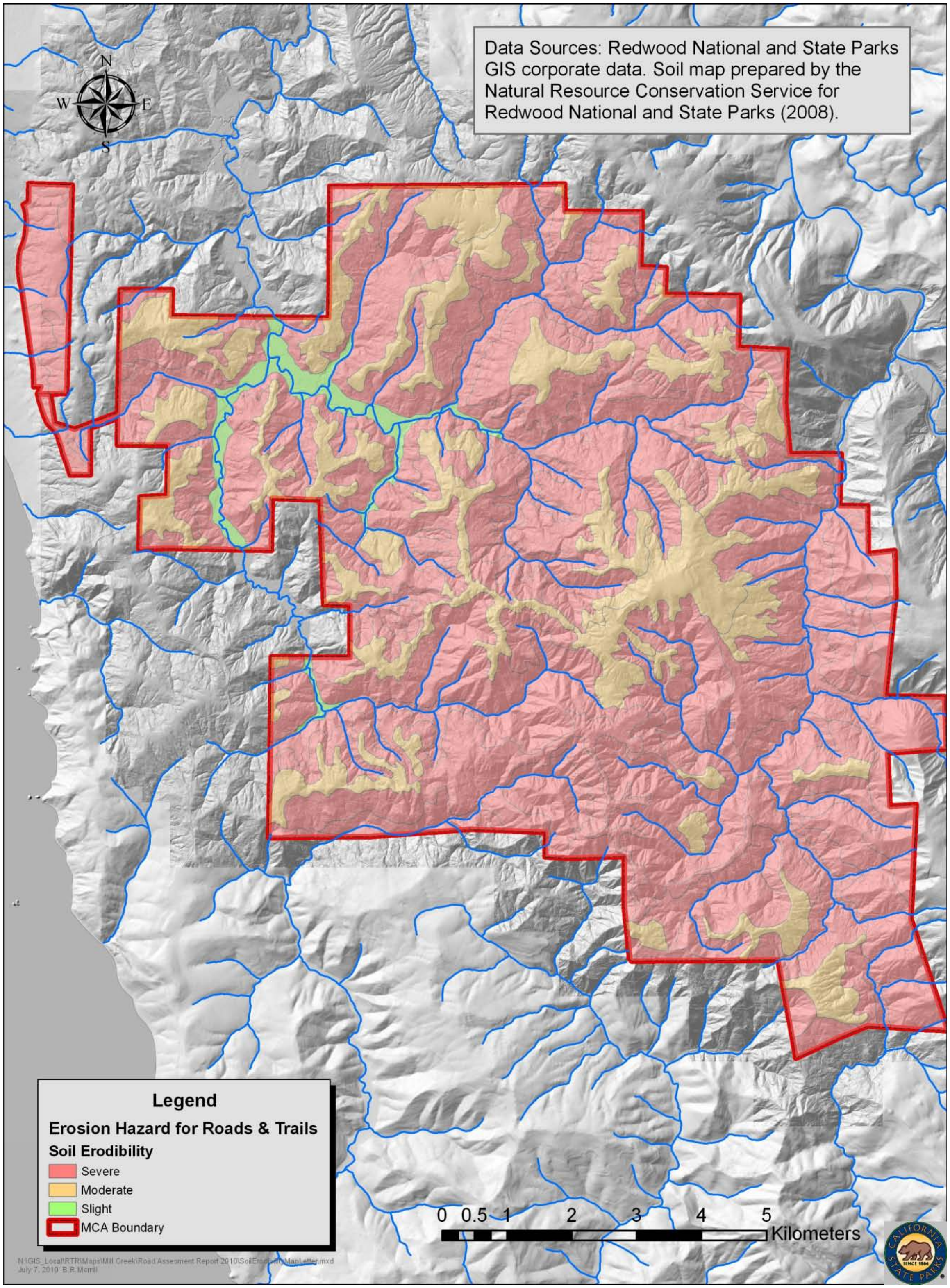

Figure 4. Surface erosion hazard within the Mill Creek Addition.

Prehistory

The Mill Creek Addition encompasses the traditional territory of the Tolowa tribe (Rohde and Roscoe, 2005). The Tolowa established most of their larger villages along the coastal plain in the vicinity of the mouth of the Smith River. There is no evidence of large villages in the acquisition, but the Tolowa did establish two small villages: one for gathering acorns and one fishing village near the confluence of the east fork and west branch of Mill Creek. Numerous seasonal hunting and fishing camps were set up at inland sites, and were connected to coastal villages by trails.

As their populations grew and they established themselves in the area, Euro-Americans occupied and used trails originally established by local Indians. Some trails of special note include: 1) the Kelsey Trail which ran along the Bald Hills and eastward toward Nickerson's Ranch, 2) the Bense Trail which left the Kelsey Trail in the vicinity of the intersection of Cougar Ridge Road and Teran Road and descended toward the main stem of Mill Creek just north of the present mill site, and 3) a coastal trail which follows the ridge north-south near the current alignment of State Route 101.

Private Ownership

Private ownership of the property was a mixed bag of land speculators, cut-and-run logging operations and ranchers prior to 1944 (Ross and Adams, 1983). Hobbs and Wall Company, founded as a spruce and redwood box company in 1871, was the only major land holder in the area and had significant holdings in the west branch of Mill Creek. When Hobbs and Wall closed for business in 1939, Harold Miller had already evaluated the timber on the property and purchased the property in 1944. During the next decade Miller consolidated his holdings through a series of tax forfeiture acquisitions and was ready to begin timber harvest by 1955. That year the Rellim Redwood Company, a newly formed subsidiary of the Stimson Lumber Company hauled the first redwood logs from the property using local gyppo crews. The first logs were removed from the road right-of-ways and sold to regional mills. Miller soon realized the inefficiency of selling and hauling the logs and soon began plans for a lumber mill adjacent to Mill Creek. In May 1955, the first buildings were constructed, an office and equipment shed. Logging operations continued to focus on right-away clearing and site development for the mill. During the early years of the logging operations, Miller's vision included sustainable forestry across the property. However, following a contentious land battle for the Rock Creek tract and the realization that demand was outpacing reforestation, Miller moved away from sustainable forestry and ultimately removed all but 120 acres of the old-growth. By the time of the 2002 State Park acquisition, timber managers expected no approved timber harvest plans for at least 7 years due to the lack of trees advanced enough in age to meet regulatory requirements.

TIMBER HARVEST HISTORY

The timber harvest history of the Mill Creek Addition can be broken into two periods. There are no data presently compiled showing the first-cut history (pre 1955) in detail. The cut history, however, generally mimics the road construction history and can be inferred using those data and aerial photos. Prior to 1955, timber harvesting was limited to the West Branch of Mill Creek and subwatersheds to the west. Preceding 1930, the Hobbs and Wall Company conducted harvest primarily using steam donkeys and rail transportation. Older cut-unit boundaries are visible in the 1958 aerial photos as distinct from the Redwood and Spruce old-growth. In 1955, Harold Miller and E.P. Hamilton began to move into the Mill Creek and Rock Creek watersheds and a new era of industrial timber extraction began.

By 1958, major logging efforts had been made in the upper West Branch, Kelly Creek, Upper Rock Creek, Upper East Fork and upper Bummer Lake Creek subwatersheds. Efforts continued in the upper West Branch with new incursions into the First Gulch and lower Bummer Lake Creek subwatersheds throughout the 1960's. The 1970's brought an intense effort in the entire Rock Creek watershed and lower Bummer Lake Creek and upper Turwar subwatersheds. By the 1980's, much of the Mill Creek Addition had been entered and fragmented with cut units. Large areas along the northern boundary in upper First Gulch and Bummer Lake Creek, however, were still being entered for the first time. The 1990's saw consolidation of the cut units as the timber on the property was nearing exhaustion.

AIR PHOTO ANALYSIS

ROAD CONSTRUCTION HISTORY

We compiled a road construction history for the entire road network to document the chronology of road construction and determine the approximate age of road segments. This history was assembled using all available stereo aerial photographs in the Mill Creek Addition collection (Appendix A), as well as digital orthophoto quadrangles (DOQs) (rectified air photos) subsequent to 1998. We captured the minimum road age directly from the air photo series in which it first appeared, and then entered the data into a geodatabase. We also listed whether the road was constructed as multiple segments or one complete project. For roads that were constructed as multiple segments separated by time, each segment was individually listed to reflect its actual air photo age. Except for 1955 and earlier, the first photo on which the road appears (the minimum age) and the air photo series prior (the maximum age) constrains the actual construction year of the route segments. Due to the close temporal spacing of the available air photo series, it was possible to constrain the road age to within a few years.

Some roads appear isolated by year. That is, they appeared prior to any road connecting them to the rest of the existing road network. This result occurred when an old segment of road was abandoned and either failed or was not routed as part of the GIS data acquisition. Later, a newer piece of road reconnected the abandoned road. A larger more developed road would often later appear where many cut units were entered and skid trails were developed. We only catalogued a road as built, when it was formally constructed as a primary access.

Early Road Building

The earliest road building into the area was probably associated with W. Bayse's early mill operations conducted in the lower main stem of Mill Creek near the Nickerson Ranch (Rhode and Roscoe, 2005). This mill operation is thought to be the namesake for Mill Creek and has a probable association with the name Bense. Following the Bayse mill operations, the Hobbs, Wall & Company extended their operations southward into the West Branch of Mill Creek. Beginning in 1908, the company began construction of the Del Norte & Southern Railroad. The railroad used an extensive series of trestles to cross the valley bottoms near the present-day routes of Hamilton Road and Picnic Road. The railroad extended approximately four kilometers (2.5 miles) upstream along the West Branch where it was fed by three inclined railways that moved large timber from the surrounding ridge-tops to the main line. A segment coincident with what is now known as Upper First Gulch Road was the only other road known to pre-date the aerial photo record (Rhode and Roscoe, 2005).

Industrial Road Building

Prior to 1958, aerial coverage was very limited, and only the western 4.5 kilometers (3 miles) of Hamilton Road was known to exist in 1955 (Table 1 and Figure 5). A large road building surge occurred between 1955 and 1958 but unfortunately that chronology cannot be resolved with available aerial photo resources (Figure 6). Historical accounts indicate that Harold Miller came to an agreement with E.P. "Buck" Hamilton to allow access through Miller's property (Ross and Adams, 1983). Hamilton would pay per thousand feet of timber hauled across Miller's roads. It is unknown when Hamilton's operations ceased in the area but it is clear from aerial imagery that the initial surge of road construction between 1950 and 1958 was the result of two robust timber operations. Those two operations and the roads that supported them were geographically distinct with one expanding into the upper Rock Creek and Child's Hill Area and one into the Lower West Branch and Kelly Creek, a tributary to the East Fork. By 1958, 31 kilometers (19 miles) of road had been built in the East Fork with 28 kilometers (17.4 miles) built in the West Branch and 29 kilometers (18 miles) in Rock Creek (Table 2 and Figure 7). Still, road densities remained below 2km/km^2 as these roads represented main lines into newly opened tracts.

Table 1. Road construction history.

Year	Annual (km)	Cummulative (km)	Period Preceding (years)	Rate (km/year)
1955	4.36	4.36	0	
1958	93.54	97.90	3	31.2
1964	73.54	171.44	6	12.3
1966	24.71	196.15	2	12.4
1969	35.82	231.97	3	11.9
1972	8.94	240.91	3	**
1975	82.03	322.93	3	15.2
1978	14.34	337.28	3	4.8
1980	20.43	357.70	2	10.2
1982	12.90	370.60	2	6.4
1984	10.07	380.67	2	5.0
1986	13.64	394.32	2	6.8
1988	15.52	409.84	2	7.8
1990	22.17	432.00	2	11.1
1993	17.29	449.29	3	5.8
1994	15.22	464.51	1	15.2
1995	1.91	466.42	1	**
1997	10.24	476.65	2	4.0
1998	2.86	479.52	1	2.9
2002	3.32	482.83	4	0.8

** Kilometers per year not shown because flight line coverage of the Mill Creek Addition is incomplete for the air photo series.

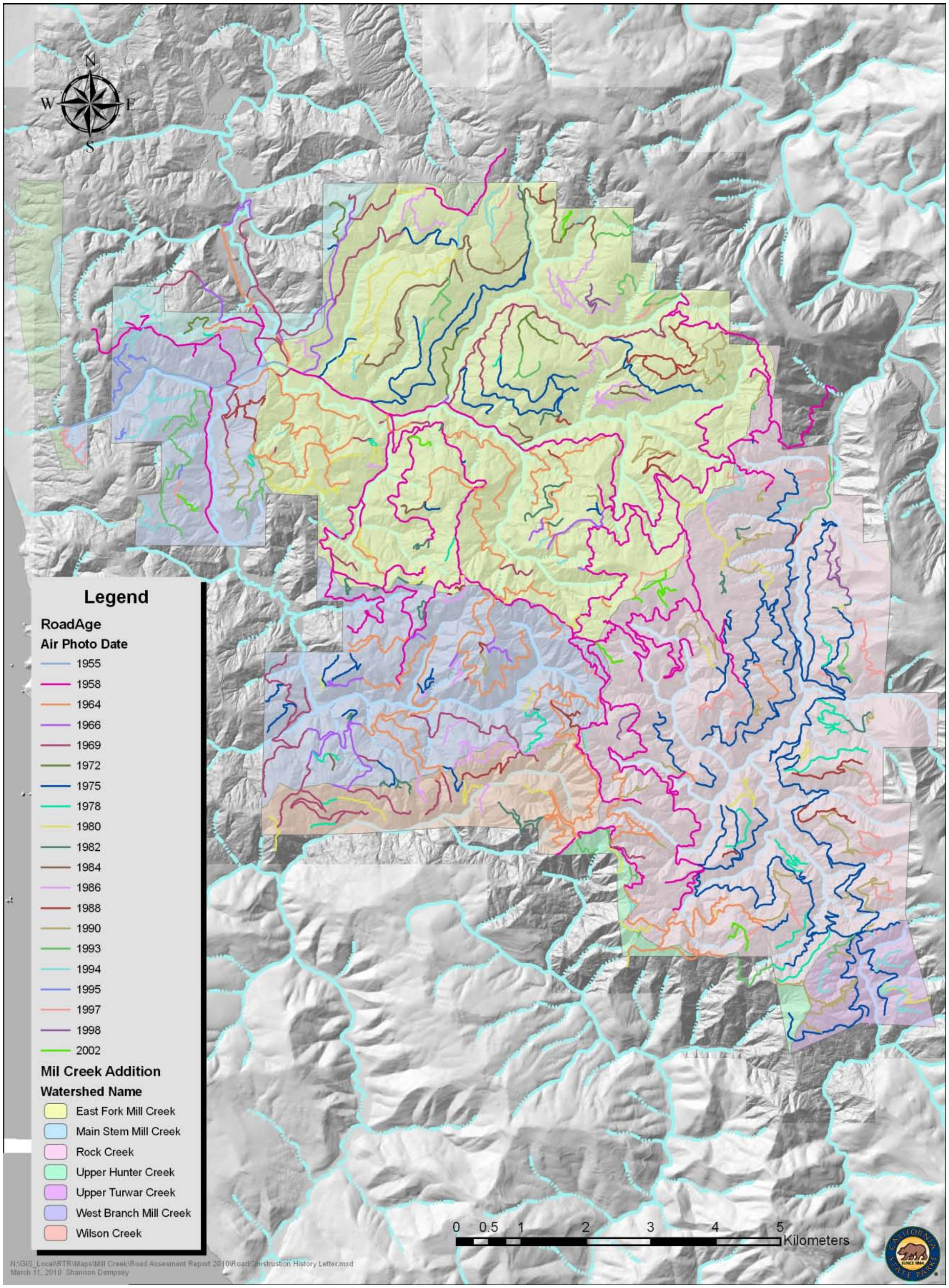

Figure 5. Road construction history.

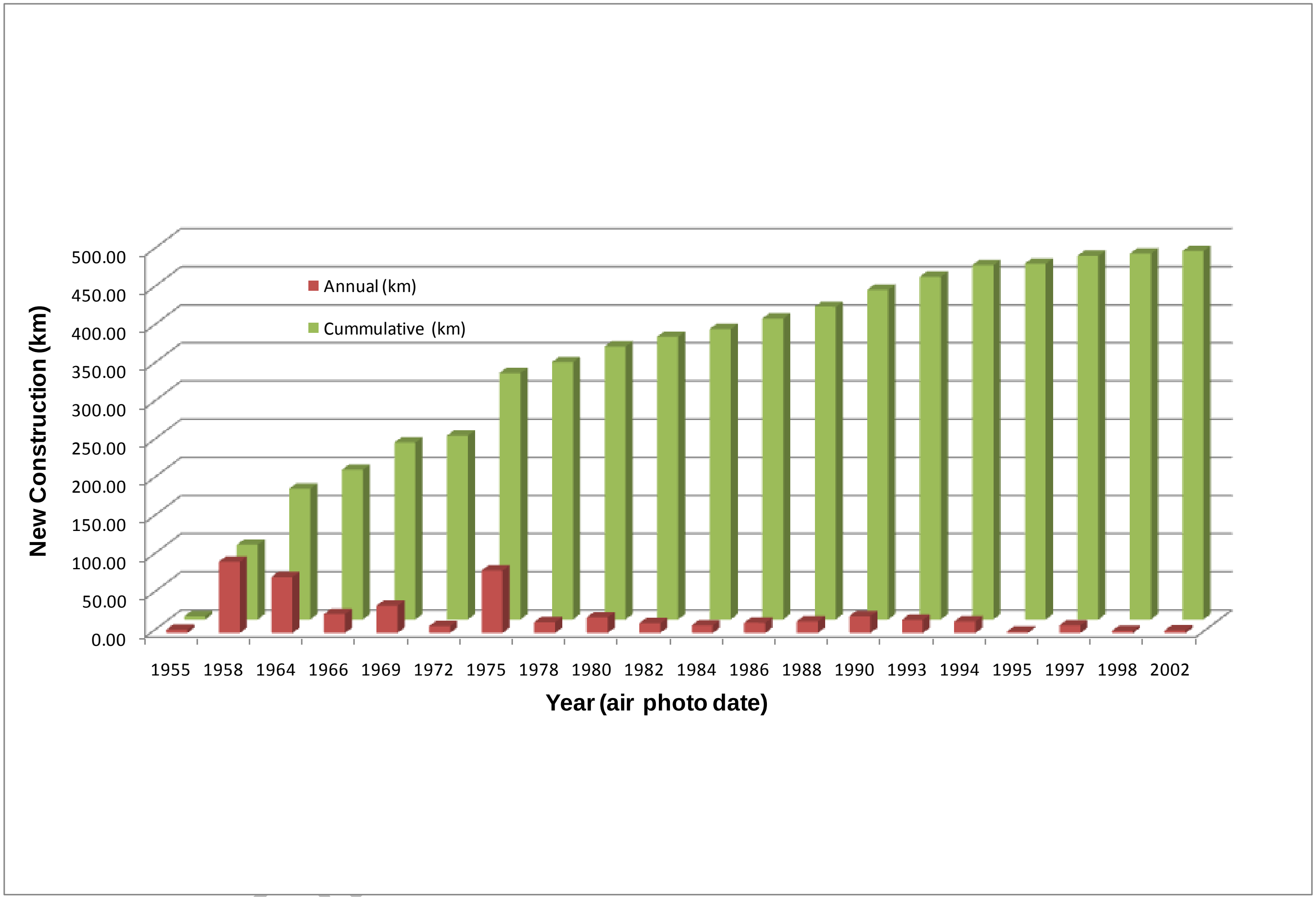

Figure 6. Road construction activity.

Table 2. Road construction length and density by watershed within the Mill Creek Addition.

Road length (km)	Main Stem Mill Creek		East Fork Mill Creek		West Branch Mill Creek		Rock Creek		Upper Hunter Creek		Upper Turwar Creek		Wilson Creek		Other
Air Photo Date	Annual	Cummulative	Annual	Cummulative	Annual	Cummulative	Annual	Cummulative	Annual	Cummulative	Annual	Cummulative	Annual	Cummulative	
1955		0.00	0.15	0.15	4.05	4.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16
1958	4.25	4.25	29.81	29.96	24.35	28.40	29.09	29.09	1.49	1.49	0.00	0.00	3.45	3.45	1.10
1964	4.03	8.29	17.13	47.09	24.66	53.06	17.32	46.41	2.02	3.51	0.00	0.00	7.79	11.24	0.59
1966	3.18	11.46	11.20	58.29	7.63	60.69	0.00	46.41	0.00	3.51	0.00	0.00	2.70	13.94	
1969	3.82	15.28	19.07	77.36	8.04	68.73	0.64	47.04	0.01	3.52	0.00	0.00	4.24	18.19	
1972	1.05	16.33	7.89	85.25	0.00	68.73	0.00	47.04	0.00	3.52	0.00	0.00	0.00	18.19	
1975	0.09	16.42	24.32	109.57	5.00	73.73	45.87	92.91	0.58	4.10	4.67	4.67	1.38	19.57	0.11
1978	0.10	16.52	1.48	111.05	2.69	76.42	7.94	100.84	0.41	4.51	0.69	5.36	1.05	20.62	
1980	0.00	16.52	9.19	120.24	0.48	76.90	6.44	107.29	0.56	5.08	0.74	6.10	2.23	22.84	0.78
1982	0.00	16.52	7.44	127.68	1.06	77.96	2.92	110.21	0.00	5.08	0.00	6.10	1.47	24.32	
1984	0.00	16.52	9.78	137.46	0.18	78.15	0.00	110.21	0.00	5.08	0.00	6.10	0.00	24.32	0.11
1986	0.09	16.60	7.17	144.62	2.98	81.13	0.24	110.45	0.00	5.08	0.70	6.80	2.37	26.68	0.11
1988	0.00	16.60	6.82	151.44	2.40	83.53	5.04	115.49	0.00	5.08	0.00	6.80	1.26	27.94	
1990	0.00	16.60	6.45	157.89	2.04	85.57	10.19	125.68	0.26	5.34	1.99	8.79	0.41	28.35	0.83
1993	0.00	16.60	3.61	161.49	5.48	91.05	4.86	130.53	1.08	6.42	0.99	9.78	1.28	29.63	
1994	0.98	17.58	3.14	164.63	4.97	96.02	2.46	132.99	0.21	6.63	2.49	12.27	0.19	29.82	0.78
1995	0.00	17.58	0.00	164.63	1.91	97.93	0.00	132.99	0.00	6.63	0.00	12.27	0.00	29.82	
1997	0.00	17.58	1.75	166.38	1.16	99.08	7.09	140.09	0.00	6.63	0.05	12.32	0.00	29.82	0.19
1998	0.00	17.58	0.79	167.17	0.00	99.08	2.07	142.16	0.00	6.63	0.00	12.32	0.00	29.82	
2002	0.00	17.58	0.96	168.13	0.31	99.40	1.24	143.39	0.00	6.63	0.00	12.32	0.00	29.82	0.81
Total length (km)	**17.58**		**168.13**		**99.40**		**143.39**		**6.63**		**12.32**		**29.82**		**5.57**

Density (km/km^2)	Main Stem Mill Creek	East Fork Mill Creek	West Branch Mill Creek	Rock Creek	Upper Hunter Creek	Upper Turwar Creek	Wilson Creek
Watershed area (km^2)	**23.75**	**43.14**	**28.82**	**41.84**	**20.06**	**14.80**	**32.75**
Watershed area within unit (km^2)	**2.29**	**38.61**	**19.53**	**31.33**	**1.01**	**2.63**	**5.27**
1955	0.0	0.0	0.2	0.0	0	0	0
1958	1.9	0.8	1.5	0.9	1.5	0	0.7
1964	3.6	1.2	2.7	1.5	3.5	0	2.1
1966	5.0	1.5	3.1	1.5	3.5	0	2.6
1969	6.7	2.0	3.5	1.5	3.5	0	3.4
1972	7.1	2.2	3.5	1.5	3.5	0	3.4
1975	7.2	2.8	3.8	3.0	4.1	1.8	3.7
1978	7.2	2.9	3.9	3.2	4.5	2.0	3.9
1980	7.2	3.1	3.9	3.4	5.0	2.3	4.3
1982	7.2	3.3	4.0	3.5	5.0	2.3	4.6
1984	7.2	3.6	4.0	3.5	5.0	2.3	4.6
1986	7.2	3.7	4.2	3.5	5.0	2.6	5.1
1988	7.2	3.9	4.3	3.7	5.0	2.6	5.3
1990	7.2	4.1	4.4	4.0	5.3	3.3	5.4
1993	7.2	4.2	4.7	4.2	6.4	3.7	5.6
1994	7.7	4.3	4.9	4.2	6.6	4.7	5.7
1995	7.7	4.3	5.0	4.2	6.6	4.7	5.7
1997	7.7	4.3	5.1	4.5	6.6	4.7	5.7
1998	7.7	4.3	5.1	4.5	6.6	4.7	5.7
2002	7.7	4.4	5.1	4.6	6.6	4.7	5.7

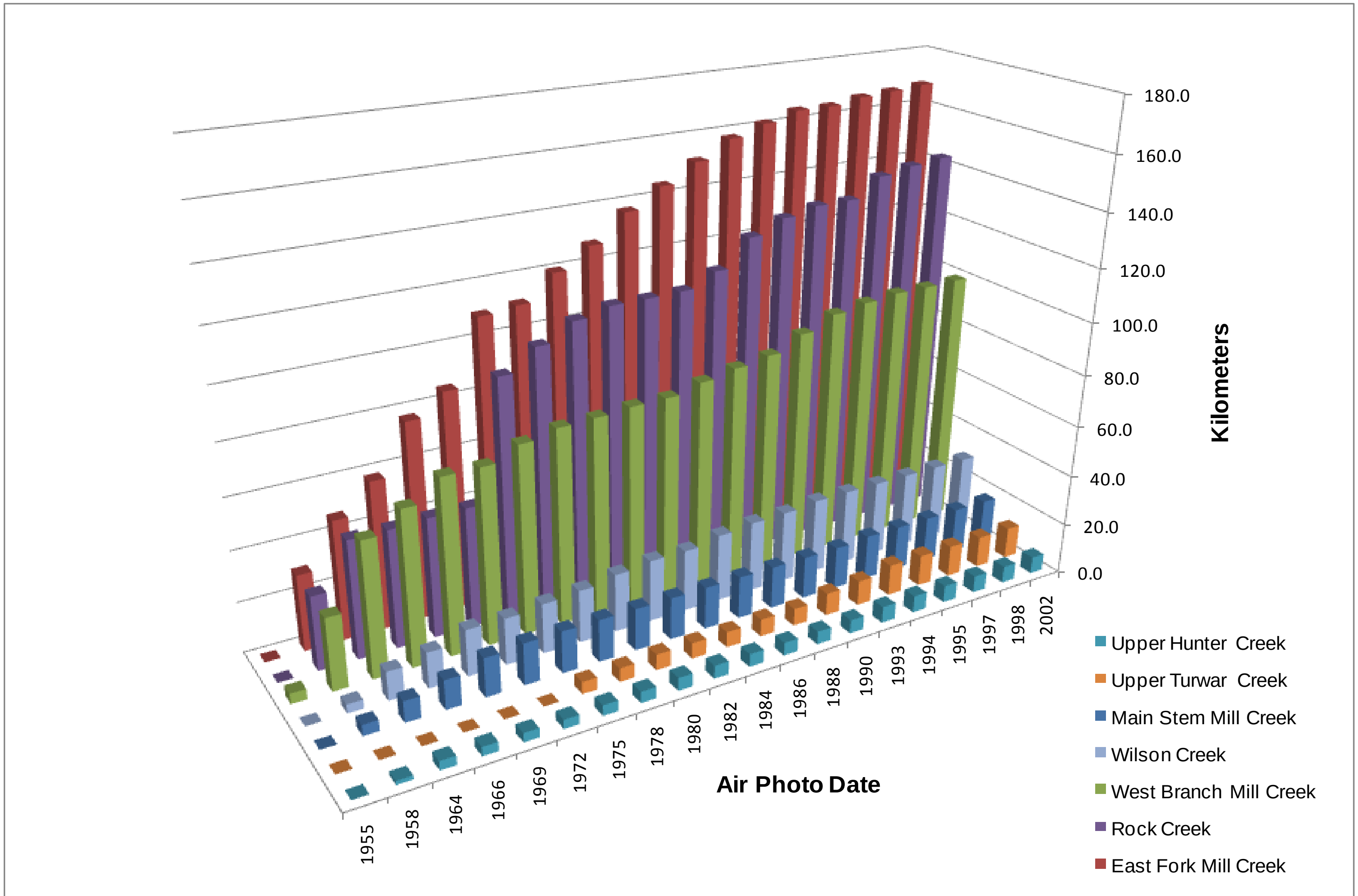

Figure 7. Road length by watershed within Mill Creek Addition.

As timber harvesting became more widespread, road building continued at a fast and relatively steady pace. Main lines were extended, and spur roads enabled access to more timber. One notable expansion was seen in 1975 as operations moved swiftly into large tracts of the lower western slopes of Rock Creek. Road density jumped from 1.5 km/km^2 to 3.0 km/km^2 in a three year period (Table 2 and Figure 8). As the last of the available timber was harvested in the late 1990's, the pace of road building slowed dramatically (Figure 9). Although Stimpson Lumber Company applied some erosion control techniques to selected roads, none of the roads constructed on the property were effectively decommissioned or removed (see Landscape Stabilization and Erosion Prevention Plan section). Road density at the time of acquisition by DPR varied from 4.4 km/km^2 in the East Fork Mill Creek watershed to 7.7 km/km^2 in the Main Stem Mill Creek watershed (Table 2). No new road construction has occurred on the property since 2002.

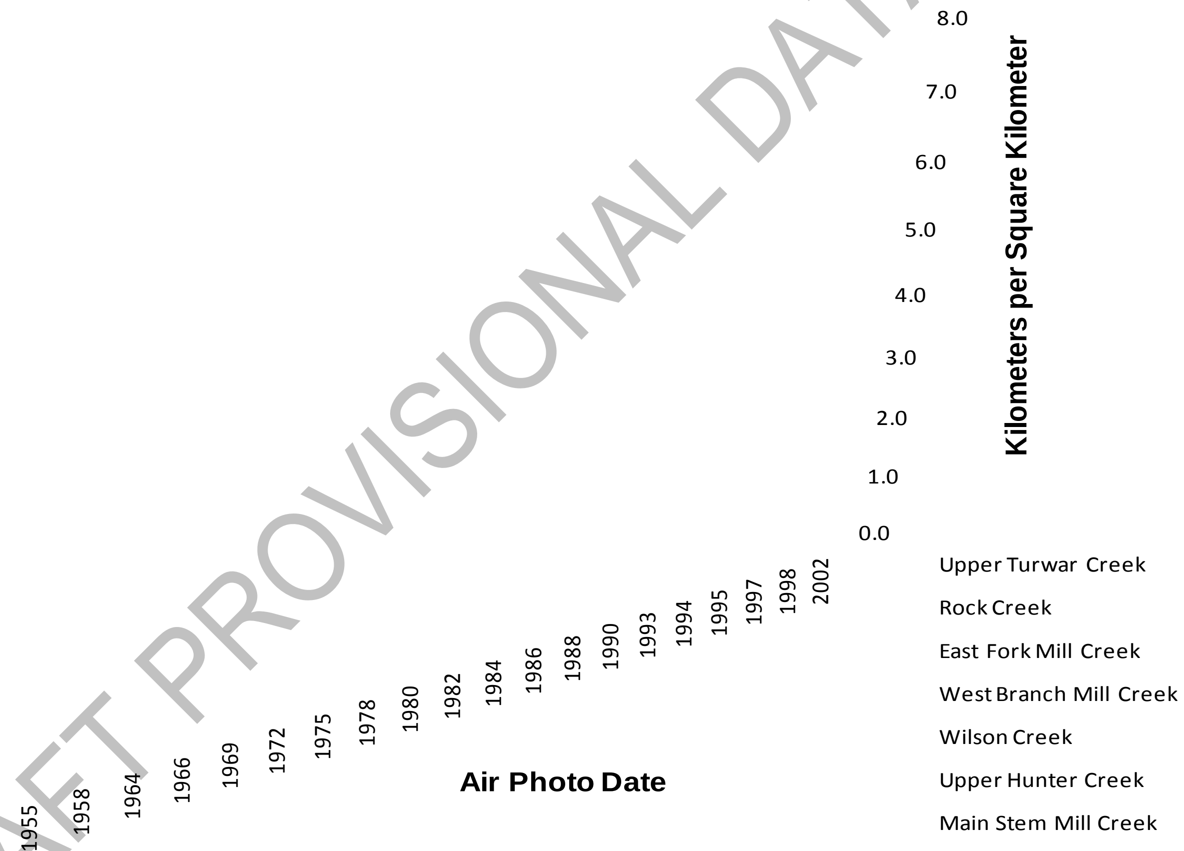

Figure 8. Road density by watershed within Mill Creek Addition.

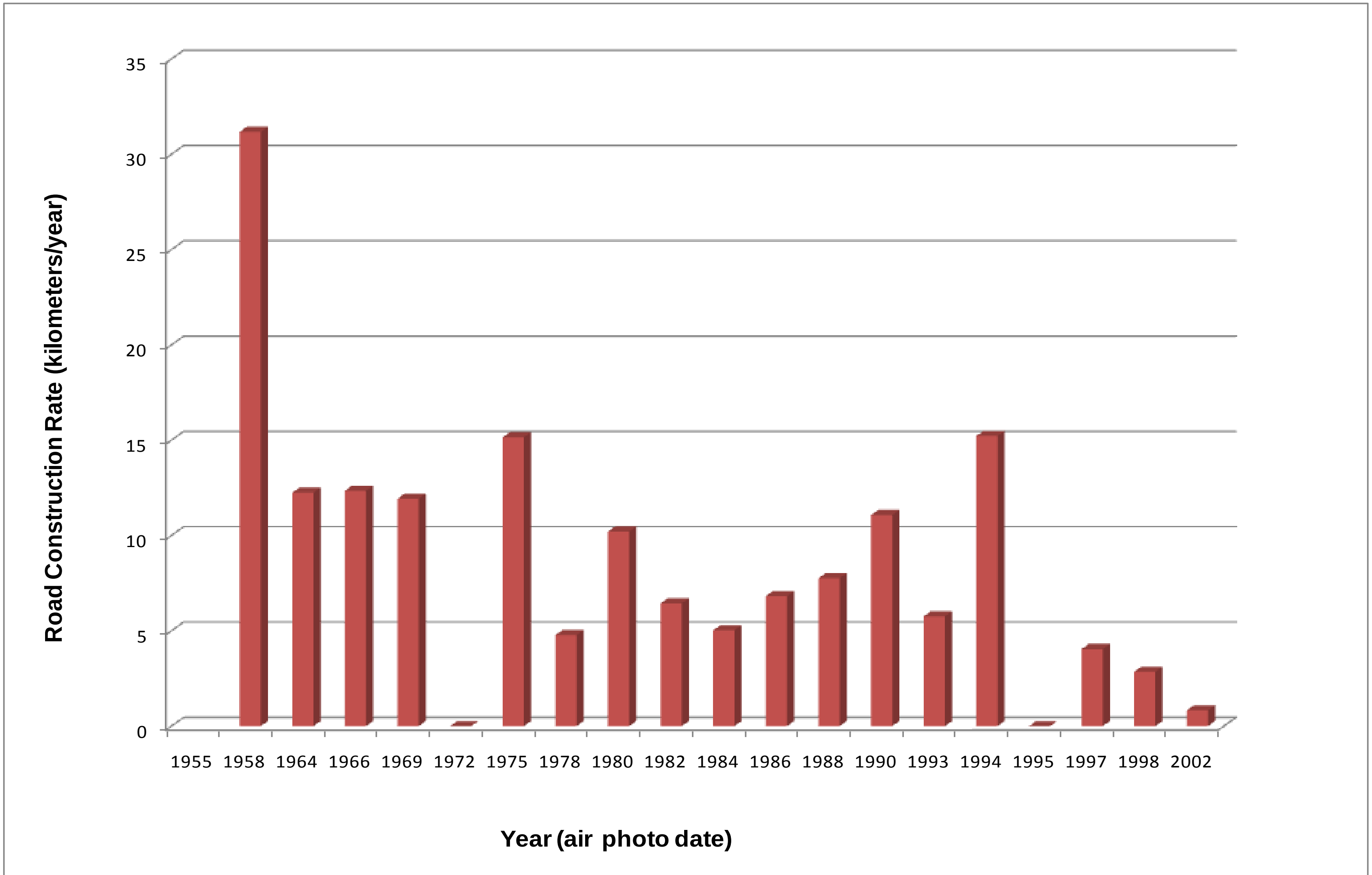

Figure 9. Road construction rate.

Landslide History

We compiled a property-wide landslide history using the same series of photos used for the road construction history (Appendix A). Each series (year) was reviewed using a mirrored stereoscope with magnifier. We reviewed all areas for landslide activity, including uncut areas and areas without roads. We wanted to characterize and quantify between mass wasting occurring in roadless areas compared to road-related instability. We identified and classified landslides using morphologic characteristics expressed in conjunction with bare soil areas. In some cases, where morphologic expression was subtle, plan view shape and bare soil were used to identify mass wasting features. Air photo series 1993 and 1998 were previously scanned, rectified and tiled into a single mosaic. Therefore, we were unable use stereo-pairs for these years making it difficult to identify smaller mass wasting features. For 1993, we used the 1994 stereo-pairs to confirm activity first appearing on the 1993 images. The 1998 mosaic was of poor quality and was not useful for identification of features first appearing in that year. No post-1998 stereo-pairs were available to cross check 1998 imagery. The 2005 NAIP imagery was of sufficient enough quality that we employed it for identification of features occurring between 1998 and 2005. A single geologist captured all air photo visual data by to maintain consistency across the dataset.

We measured feature dimensions directly off of the aerial photographs using a millimeter scale. We then converted it to on-the-ground dimensions using the photo scale. Photo measurements were rounded to the nearest 0.5 mm. We made dimensional adjustments for slope by eye. All dimensions were approximate but served to define a relative size and volume for the feature. We did not capture features with dimensions less than 6 m (0.5mm on air photo). We made measurements of the evacuated area only and did not include depositional areas. In cases where secondary failure appeared to have occurred simultaneously with the primary feature, dimensions were summed to include all material displaced by a mass wasting event. We remeasured and recalculated the entire mass in cases where reactivations occurred at a later date. We subtracted all previous failures at a site from the most current failed mass to determine the reactivated volume.

The sediment delivery ratio (SDR) expressed the percentage of failed material that was delivered to a watercourse. Colluvium was considered “delivered” as part of the SDR if it reached the floodplain or alluvial terraces within a well defined valley floor associated with a blue line stream as characterized from LiDAR analysis or previous USGS mapping. We did not, however, consider broad swales and convergent topography. We compared the relative size of evacuated area with the depositional zone, material visible in watercourses, and position of depositional zone relative to convergent or divergent terrain in order to estimate the sediment delivery ratio. Material that remained within the mass wasting scar and on the slope below were considered the undelivered portion when estimating the SDR.

We entered landslide features into the GIS as point features and attributed them with values listed in Table 3. We chose a point coverage over polygons for several reasons: 1) there were no accurate rectified images which showed all features that could be used to capture the shape of the feature, 2) spatial integrity at scales measured for individual features would have been poor even with rectification, 3) features visible on more than one series would have had different shapes regardless of the quality of the rectification, and 4) most polygons would have been too small to portray on maps. We grouped and summed small coalescing features along road fillslopes and inner gorge areas to account for volume and dimension. GIS points were set at the center of the feature(s).

Table 3. Landslide history attributes.

Field (as labeled in geodatabase)	Description	Possible Values
MWType	Type of mass wasting feature as described by Varnes (1978)	Debris flow, Debris slide, Slump earthflow
AffectedWatercourse	Describes whether a mass wasting feature affected a watercourse. Affects could include deposition of sediment directly into the channel or the active floodplain. Could also include opening of canopy along the riparian corridor. A "Probable" value indicates no visible runout on air photo but topographic characteristcs downslope of failure favor delivery to watercourse.	Yes, No, Probable
CoalescingFeatures	Describes whether the mass wasting feature was part of a larger feature with atypical shape or symetry.	Yes, No
SlopePosition	Describes the location of the mass wasting feature on the slope as measured on the fall line from the ridge to the base of the slope.	Upper Slope, Mid slope, Lower Slope, Inner gorge
LengthAverage	Average length of feature in meters as measured directly from air photos.	Measured value
WidthAverage	Average width of feature in meters as measured direclty from air photos.	Measured value
DepthAverageEstimated	Visual estimate of the average depth in meters of a mass wasting feature. The depth was discernable in stereographic images where shadowing and scarp heights were visible.	Visually estimated value
CalculatedVolume	Volume in cubic meters. Calculated as the product of the LengthAverage,WidthAverage and DepthAverageEstimated.	Calculated value
VolumeCatagory	Catagorical volume range used for broad grouping of feature size.	<500, 500 to 1000, 1000 to 5000, 5000 to 10000, 10000 to 50000
SedimentDeliveryRatio	Visual estimate of the percentage of failed material that reached the stream below the mass wasting feature as seen on the air photo.	0 - 1.0
EstimatedDeliverd Volume	Product of the CalculateVolume and the SedimentDeliveyRatio	Calculated value
Torrent	Describes whether the feature torrented after initiation. Transitional features	Yes, No, Transitional
EnlargementOfPreexisting	Describes whether the feature was an enlargement of a mass wasting feature that had already been identified.	Yes, No
RoadRelationship	Describes how the mass wasting feature is physically related to nearby roads. Road associated indicates a direct physical connection between the road and the mass wasting feature. Road related indicates a likely causal relationship between a nearby road and a mass wasting feature. None indicates no apparent relationship.	None, Road associated, Road related
SourceOfFailure	Describes the physical source of the mass wasting feature. The source was identified as the area where the head of the slide was located.	Hillslope, Crossing fillslope, Inner gorge slope, Landing fillslope, Road cutbank, Road fillslope, Road fillslope-cutbank, Road fillslope-hillslope, Road fillslope-swale headwall, Swale headwall
CutUnitRelationship	Indicates the physical relationship between the mass wasting feature and cut units in the area.	None, Within unit, Within older unit, Below unit, Below older unit, Above unit, Above older unit
AirPhotoDate	Air photo series identified by year flown	As shown on photo
AirPhotoNumber	Air photo number printed on the photo	As shown on photo

We based the classification of slides vs. flows on morphological expression. Slides tended to maintain their width as they propagated downslope. Flows tended to narrow and flow toward topographic depressions. Many debris slides may have transitioned into flows as the failed mass disintegrated. In these situations, we classified the feature as a debris flow. We did not consider failed stream crossings as landslide features.

We did not capture ravel from road construction activities as mass wasting although it was common during construction activities. Ravel typically was confined to a short slope segment immediately below the road and only delivered to water courses as roads descended into inner gorge areas or at crossings. Ravel was expressed in the aerial photos as a wide flat sheet of exposed soil along recently constructed roads and crossings. Small cutbank failures were difficult to differentiate from constructed surface and were only captured if the failure resulted in a clear scarp above the road. We were able to capture small cutbank failures in the field during the road inventory.

Results

We inventoried 482 landslide features across the property. The estimated volume of failed material totaled 575,000 cubic meters with 310,000 m^3 delivered to streams. Of the 482 failures, 394 (82%) affected a watercourse and an additional 8 (1%) features probably affected a watercourse.

We most frequently observed road fillslopes as a failure type, accounting for 46% of all failure events (Table 4). Road fillslopes, due to their frequency, also accounted for the largest aggregate volume of failed material and the largest volume of delivered material. Landing fillslopes showed the largest failed and delivered volume per event with an average of 1,063 m^3 per event delivered to streams. Inner-gorge failures (75%) with landing fillslopes showing a 62% delivery rate exhibited the greatest delivery rate (total volume delivered divided by total volume failed).

Table 4. Landslide size by type.

Landslide Type	n	%	Failed Volume (m^3)			Delivered Volume (m^3)			Delivery Rate
			Average	Maximum	Total	Average	Maximum	Total	
Road fillslope	223	46%	1,327	16,200	296,006	697	11,340	155,398	52%
Hillslope	119	25%	918	20,160	109,272	466	10,080	55,437	51%
Landing fillslope	57	12%	1,722	28,800	98,172	1,063	25,920	60,606	62%
Inner gorge slope	46	10%	856	7,200	39,354	640	5,760	29,455	75%
Road cutbank	34	7%	820	2,592	27,882	224	1,080	7,622	27%
Swale headwall	3	1%	1,488	2,304	4,464	653	1,728	1,958	44%
Totals	482	100%			575,150			310,476	

Roads were either directly or indirectly related to landslide events 71% of the time. We detected direct physical association between roads and slope failures with 317 (66%) of the events, with less clear but probable relationships to roads occurring with 27 (5%) of the failure events. Skid roads did not appear to be a significant factor in triggering mass wasting events. Hillslope landslides did not occur in higher numbers in heavily skidded units than they did in yarded units.

The timing and magnitude of mass wasting appears to be reasonably well correlated to large storm events that have affected the northern coastal California. Storms in 1955, 1964, 1975, 1986 and 1997 all resulted in notable spikes in landslide activity and delivered volume (Figure 10).

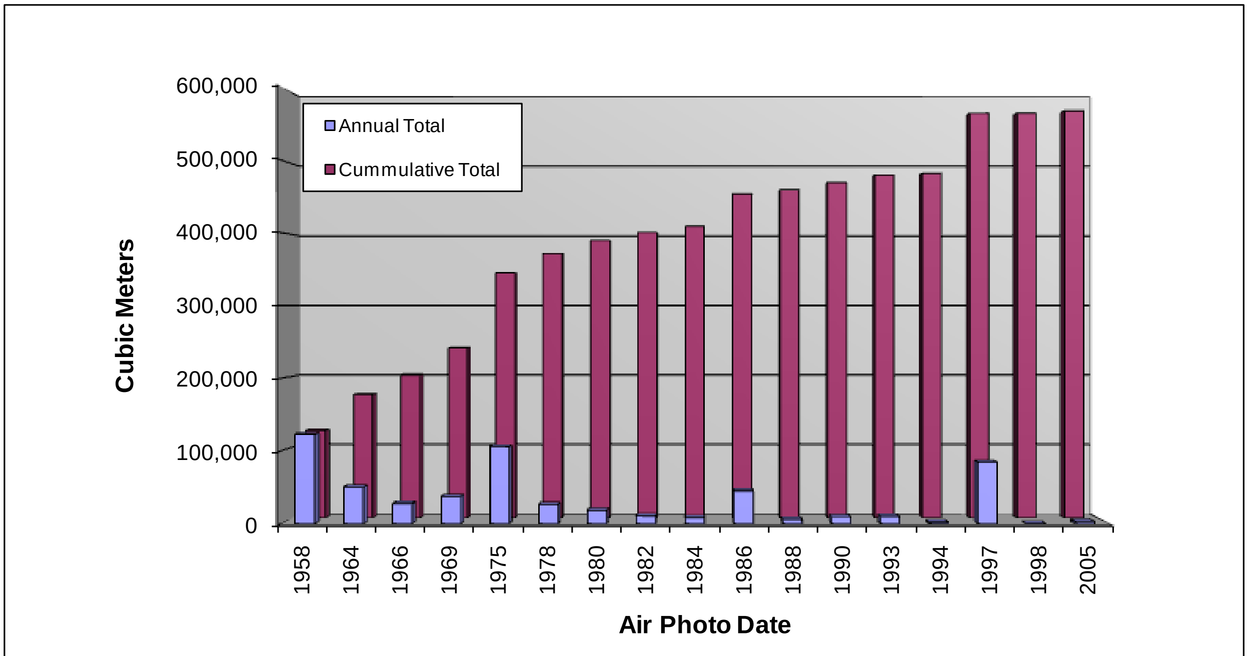

Figure 10. Annual total of failed landslide volume.

The affects of the 1955 storm are well known throughout the region and delivered 13.85 inches of rainfall over a nine-day period beginning December 15, 1955 (Harden, 1995). The 1964 storm did produce a small increase in yield form mass wasting but did not produce the devastating effects seen in adjacent counties. The floods in 1955 and 1964 had respective long term average recurrence intervals of 25-30 years and 45-50 years. Significant storms in March, 1975 and February, 1986 also produced noticeable spikes in sediment yield from mass wasting, likely related to substantial increases in road length on the property.

The 1997 spike in landslide activity was likely the result of a 6-day storm which impacted the west coast from Washington to Southern California. A shift in the weather pattern brought warm storms of tropical origin across the region from December 26, 1996 through January 3, 1997, with the most potent system affecting the region at the turn of the year. This change occurred after a cool winter storm affected the region just before Christmas on December 21 and 22, 1996. This polar system left behind several feet of snow over the mountainous terrain; a snow pack that would contribute to the flooding just over a week later. With the tropical air mass storms, precipitation fell across much of the west coast with a focus of excessive precipitation over the higher terrain from western Washington southward to northern California and western Nevada (Kozlowski and Ekern, n. d).

Results from this historical landslide inventory indicate the majority of landslides on the property are road-related and that large storm events trigger marked increases in landslide activity. We expect to see additional road-related mass wasting as large storms affect the area in the future. Based on recent past events we expect to see significant mass wasting occur where 12 hour precipitation intensities exceed 3 inches and antecedent conditions have left soils nearly saturated. Ongoing treatment of roads, whether by upgrade, conversion, or removal will likely reduce the effect of road-related sediment on downstream aquatic resources.

ROAD INVENTORY

GIS ROUTING

The fundamental spatial framework we used to located road-related features is known as linear referencing (also dynamic segmentation or routing), a method that Environmental Systems Research Institute (ESRI) ArcGIS™ software uses to store attribute data linked to linear features. Linear features, such as roads, are attributed with a measure system along their length, similar to how mileage markers are assigned along a highway. Point and line features along that linear feature can then be created and stored in an external table by only referencing a unique route ID and the starting and ending measures. The location of these features is not fixed, but rather tied to the measure system. At display time, the route is “dynamically segmented” to allow the event features to be located. Updating the geometry of the underlying route will modify the location of the associated events.

The first step was to create routes from spatially accurate line work that represents the road system. Line features were first heads-up digitized from DOQs and stored as an

ESRI coverage. Each line consists of a starting and ending node, and a series of vertices. Sufficient vertices are added to accurately depict the location of the road as viewed on the orthophoto. The arcs are edited so that nodes of adjacent arcs are coincident, and oriented in the same direction (arcs have a direction property based on the “from_node” and “to_node” pair. The “from_node” of one arc is edited to be exactly coincident with the “to_node” of an adjacent arc.

Once the geometry of the underlying arcs is complete, collections of arcs are grouped together to form a new feature known as a “route”. The arcs participating in any given route are usually based on the road name; that is, each different road will form a separate route. To create a route, the starting position of the route and measure units are specified. The resulting route feature has a new property based on distance along the route, similar to an addressing system used for mail delivery. The measure system units used in this road assessment is kilometers.

New point and line features can be located along the route by referencing only a unique identifier for the route and starting and ending address on the measure system. Point features are located with only a start address. Line features are located with both a start and end address. The features located along a route are known as “events”, and are stored in an external table known as an “event table”.

The event table can contain additional attributes and these data can be assigned and updated independent of the underlying arcs (node to node framework) that spatially display the roads. In this way, the event tables can be stored in databases independent of the route framework, and dynamically linked to the routes using addresses. This allows the ability to assign multiple attributes without ever editing or altering the underlying arc/routes framework.

Redwood National and State Park’s GIS staff digitized the road line work prior to our inventory. The assessment area is covered partially by both 1993 and 1998 DOQs. Where both years exist, 1998 data were used because it was determined to be more accurate. 1993 imagery was used where there was no 1998 coverage. About 5.0 km of roads were constructed after 1998 (and prior to park ownership) and were not captured in the initial digitizing. These roads were hand digitized and routed after discovery by field technicians.

We did not use the Stimpson Timber Company line work because it lacked the spatial precision that is standard for RNSP GIS. However, in order to preserve the historical reference of the road network, we chose to use the original road naming that the previous owners had assigned to the individual roads. In most cases, the original road name was used as its corresponding route name. Where roads were not named, we assigned a road name based on its up-line road (road leading to un-named road). For example, the first unnamed road that intersected Child's Hill Road would be labeled Child's Hill-1; the third unnamed road that intersected Child's Hill Road would be labeled Child's Hill-3 and so on. We labeled the first road that branched off from Child's Hill-3 as Child's Hill-3-1 and so on. Some roads began and ended along the same up-line road. Where this occurred, we labeled the road with the up-line road name and the suffix "-loop". In the case of an unnamed route linking two named routes, we used the two named routes and the suffix "-link."

Base Maps

We prepared black and white field maps as 11" x 17" tiles and laminated them for field use. We used 119 to cover the entire park. Field tiles portrayed the routes and route names along with tic marks every 10 meters overlaid onto the 1998 DOQs. In the field, technicians used the tiles to pinpoint their locations when capturing data for a site. A spatial accuracy of approximately plus or minus 10 meters was achievable at sites where no distinct features were visible on the DOQs.

Field Data Collection

Field data was collected by two groups divided into two two-person teams from January, 2002 until June, 2005. The first group collected geomorphic data for all known routes to evaluate how each road and associated sites influence local geomorphic processes. The second group collected data related to road construction, reengineering, and maintenance requirements (Appendix B). The second group only collected data on open drivable roads that had not been made “maintenance-free” by the previous land owner.

For continuous road condition data, field technicians entered data for the following categories at the start of each road (route address 0.00 km): usability, surface material, surface condition, roadbed width, embankment fill volume, road grade, road pitch, inboard ditch status, vegetation load and drainage (Appendix B, Continuous Variable Worksheet). As the field technician progressed down the road, any change in road condition was noted by a route address entry and a corresponding change in road condition value.

Road sites included road-stream crossings, gullies, mass wasting events, seeps and/or springs, and landings. Each site type was first assigned an address. We assigned a start and end address to linear features (gullies, mass wasting events, seeps and/or springs), as opposed to stream crossings that we considered a distinct point where the stream crosses the road and assigned a start address only. We marked each feature with the start address on a yellow aluminum tag for ease of locating in the future.

Data were collected for each site type and recorded on separate data sheets for later entry into the database (Appendix B, Road Assessment Form-Sheet 1). We used the backside of each data sheet for diagramming complicated sites as needed for clarification or later reference (Appendix B, Road Assessment Form-Sheet 2). Distance measurements were typically estimates and were obtained in a variety of ways depending on terrain, vegetation, and number of field crew on-site. Tape measurements or range finders were used when feasible. Otherwise, combinations of visual estimates, pacing off open distances, or measurements taken directly from the rectified map tiles were used when necessary. Field crew personnel regularly calibrated with tape measures and to each other in order to maintain consistency for visual estimates.

Early on in the road assessment, we considered and evaluated two different methods for assessing stream crossing volume. The first method measured the basic crossing dimensions (averaged centerline, up and down stream top widths, channel widths, and estimated fill depths) to calculate crossing volume using a double ended area formula. A second method involved taking additional field measurements including the slope length and angle of fill from the edge of roadbed down to channel on both the upstream and downstream sides of the road. We recorded the slope of the natural stream channel above and below the influence of road, and this additional data was used to draw a scaled cross sectional diagram of each crossing to derive the upstream and downstream depth of fill. Next, we calculated volumes for the center wedge of fill directly beneath the roadbed and the wedges of fill that extended from the edge of roadbed out toward the stream channel on either side. We then added together the separate volumes for a total stream crossing volume. Although the second method is commonly used for estimating stream crossing volumes, it was significantly more time consuming with the collection of additional field data and the requirement of sketching each stream crossing in the office. When we compared the two methods side by side for the same crossings, the first method always resulted in a larger calculated volume.

Uncertainty is inherent when estimating the volume of a stream crossing. Estimating crossing dimensions (for example, depth of fill), interpreting crossing fill footprint, and existence of buried logs, culverts, or tree stumps affect the calculated and actual volumes. Excavated crossing volumes often preclude calculated crossing volumes because site specific design may warrant it. Because of the inherent uncertainty, we chose to use the first method, opting to be conservative with our calculations both in terms of threat to the resource and project planning.

The second group collected information on existing road features and structures and recommended upgrades to improve road construction standards and to minimize annual maintenance requirements. For continuous road features, this team recommended a particular course of action (monitor, clear, remove, replace or install) for each feature (road base, inboard ditch, inboard pitch, or outboard pitch). For site features or structures, they recorded current condition and/or recommended prescriptions for installation, replacement, repair, or monitoring of bridges, retaining walls, culverts, stream crossings, climbing turn/switchbacks and road armoring (Appendix B, Road Assessment Forms-Sheets 3 and 4).

SKID TRAIL INVENTORY

Although we did not inventory or assess skid trails and fire breaks in the scope of this investigation, we conducted a property-wide air photo analysis of the skid trail network concurrent with field data collection. This was done to assist immediate planning and address any possibility of overlooking significant abandoned roads that were not already contained in the GIS line work of known haul roads. The analysis utilized the same series of photos used for the road construction and landslide histories (Appendix A). We reviewed each series (year) using a mirrored stereoscope with magnifier. All skid trails and roads within the property not part of the GIS line work were reviewed. Any roads exhibiting characteristics likely to contribute to future erosion or stream crossing diversion were hand digitized into a separate secondary roads database. Criteria for inclusion of secondary roads were those appearing to have a large cut and fill prism compared to adjacent skid trails, those that cross a stream channel, or those that traverse a steep slope for significant length without possibility of hydrologic disconnection. Secondary roads total 45.8 km (28.5 mi), adding 10% to the overall known haul road mileage. We will continue to address the secondary roads at a project unit planning level as necessary.

DATABASE DEVELOPMENT

We inventoried a total of 468.4 km of routed haul roads (Table 5). Our office technician input the data from all Continuous Variable worksheets and Road Assessments forms We stored road inventory data in two Microsoft Access databases. The databases were developed to contain all features collected during the inventory. We deigned one database (MillCreekAssessment.mdb) to contain discrete point or interval features (road sites). These sites had limited extent and a distinct set of characteristics that we captured regardless of whether it was a single point or a segment of road. Road sites included stream crossings, gullies, mass wasting events, and seeps and/or springs. The second database (MillRoadCondition.mdb) was developed to contain road condition data. These data were continuous along all roads. We captured unit fill volume, width, grade, pitch, and others continuously for all roads.

Table 5. Road inventory summary.

Kilometers (miles) of haul road inventoried:	468 (291)
Kilometer (miles) of secondary roads:	46 (29)
Number of road-stream crossings:	1451
Number of landings:	981
Number of culvert cross drains:	515

ROAD ASSESSMENT

The road assessment is based on inventory data collected during the field surveys from 2002 through 2005. We used the inventory data combined with GIS raster data (DEM and SINMAP) to develop a scoring matrix that would evaluate the road's relative risk of failure and determine which roads pose the greatest threat to resources within the property.

We characterized sites and road segments by assigning score values to the various attributes collected during the road inventory. Once characterized, sites are evaluated individually and cumulated along routes to determine which roads and sites are the most likely to experience failures and how much sediment each route and site could contribute to watercourses.

RISK VS. THREAT

Our approach begins by distinguishing individual sites and road segments by their relative probability or risk of failure. We used physical attributes that are known to affect stability in order to assign a sensitively score to each site and road segment. In addition, we calculate the potential threat posed by the sites and road segments. For this analysis we chose to use delivery of sediment to streams for the threat presented by the road network. Although threat could be characterized by a variety of potential impacts (water quality, aquatic habitat, rare flora, loss of infrastructure), we are confident that episodic and chronic inputs of sediment to the stream network produce negative impacts to aquatic habitat that can persist for decades. Sediment delivery is a commonly used parameter to quantify road impacts, and conversely, the cost effectiveness of road rehabilitation projects.

By evaluating risk and threat independently, we will be able to view roads and sites based on their risk of failure alone, or in combination with a variety of other factors that would constitute threat (sediment delivery, resource impacts, loss of infrastructure). For example, a site may exhibit high risk for failure but not have a large volume associated with it. In a typical second growth forest setting the threat may be interpreted as low compared to a similar site with high volume. However, if the road is immediately above exceptionally sensitive habitat such as a Darlingtonia Fen, even a small volume failure could have a severe impact. As new information is gathered regarding natural, cultural, and capital resources, threat values can be interpreted in the context of new information, as well as the current condition of a site or road segment.

Analysis and Derived Data

This analysis necessitated combining the two databases (road sites database: MillCreek Assessement.mdb and road condition database: MillRoadCondition.mdb). If we wished to examine the road surface condition at the location of springs throughout the network, for example, we needed a method to combine the data and then query the results. We accomplished this task by using the model builder function in ArcGIS®9 (ArcMap™ Version 9.3.1). The model was designed to add the two database event tables to the map and then export them as feature classes. Once converted to feature classes, the model overlaid the data using a spatial join. We set the model to use a one-to-one intersection to join road condition attributes to the road interval features. For point features, we set the model used a one-to-one join for features within the road condition interval. Once combined, the resulting feature class could be queried using common definition queries to obtain the desired information.

SPATIAL DATA (DEM AND SINMAP)

Lidar-based 1m DEM

DPR obtained LiDAR (Light Detection and Ranging) data over the entire Addition property in 2007 (post road inventory completion). The LiDAR data was used to develop a DEM with a resolution of 1 meter pixel size. A grid DEM consists of a matrix data structure with the topographic elevation contained in each pixel. The LiDAR-based DEM was capable of resolving site specific elevations across the landscape to within 0.3 m to 0.5 m (1 to 1.5 ft) in the vertical dimension. The DEM provides a powerful tool for this road assessment permitting us to visualize road alignment and landing features, confirm location of secondary roads, and derive local slope steepness.

Accuracy and limitations of routed network revealed by LiDAR data

The new LiDAR data has been a useful tool for assessment of the routed network, and reveals the inaccuracy of our hand digitized line work. Recall that the original line work for the routed roads was derived from the 1998 and 1993 DOQs, and a small portion of roads constructed after 1998 (5.04 km) not seen in the DOQs were hand digitized by field staff (see GIS Routing). The new LiDAR based DEM allows us to accurately visualize the ground surface and road network quite clearly without the obstruction of vegetation that is present in the DOQs.

It should be noted that the portion of attribute score assigned by the DEM is only as accurate as the routed line work is in relationship to the actual road prism in the DEM. For example, if a route does not accurately line up with the road prism on the DEM, then the slope value (taken 50 m downslope from the designated point on the route) may not actually be the slope 50 m below the road, it would be the slope 50 m downslope from where the line work is drawn. The initial line work derived from the DOQs has been substantiated with the addition of the LiDAR based 1-meter DEM to be accurate; however, the hand digitized routes are not in alignment with the road prism. Because the hand digitized line work represents such a small fraction, 1%, of the overall routed network, we chose not to redraw, reroute, and reassign site addresses to the features on the hand digitized roads. The LiDAR based 1-meter DEM has allowed us to confidently conclude there are no major discrepancies or undetected haul roads that were somehow missed in our original inventory. Additionally the 1-meter DEM will be useful in validating the secondary roads identified through the air photo inventory, and provide a template to redraw secondary roads as needed on a project by project basis.

SINMAP

We used SINMAP 2.0 to produce a slope stability index and map for the Mill Creek Addition. We used the stability index to characterize relative slope stability across the property and as an input to the scoring matrix. Calibration parameters used for the SINMAP model were derived from local soil properties measured as part of a RNSP soil survey (USDA 2008), a study conducted by Gabriel Paulín (2007) within the Mill Creek area, and regionally estimated precipitation values. We validated the SINMAP output using the landslide history obtained through our earlier air photo inventory of the property.

SINMAP 2.0 (Stability INdex MAPping) uses the infinite plane slope stability model and steady-state shallow groundwater hydrology to produce a slope stability index for a study area (Pack, et. al., 2005). Input parameters are assumed to be normally distributed and the upper and lower limits of parameter values are set as model input. Parameter values can be calibrated for geographic regions to reflect varying conditions across the study area. In addition, SINMAP allows for visual calibration by adjusting input parameters to reflect field verified landslide activity.

SINMAP 2.0 is implemented through a plug-in to ArcGIS-ArcMap. The original ArcView SINMAP was developed between Terratech Consulting Ltd, Utah State University and C.N. Goodwin Fluvial System Consulting with the support of Forest Renewal British Columbia, in collaboration with Canadian Forest Products Ltd., Vancouver, British Columbia. The ArcGIS version of SINMAP 2.0 was developed with support from the Rocky Mountain Research Station, Forest Service, U.S. Department of Agriculture under joint venture agreement number 03-jv-11222014-050. The digital elevation model methodology and algorithms have been developed by David Tarboton.

Appendix C contains a complete description of each soil map unit that was characterized as part of the RNSP soil survey. We divided the property into 7 soil regions where soil map units were grouped according to an erodability index (Seney 2010). Each soil region was grouped from 2 to 5 soil map units, with each soil region consisting of one to three major components (Table 6 and Figure 11). The major components of each soil region are divided by horizon and those that fell within 50 cm to 150 cm deep were evaluated to determine values for calibration parameters.

Table 6. Soil Map Units grouped into regions.

Region	Map Units	Major Components	Description
1	590, 591, 592, 594	Sasquatch, Yeti, Footstep, Sisterrocks, Ladybird	very deep, sandstone and some mudstone colluvial and residual soils (150 to 200 cm thick) with fine-loamy to fine textures and angular fragments (forest type moist redwood)
2	580, 581, 582	Cooopercreek, Tectah, Slidecreek, Lackscreek	very deep, sandstone and some mudstone colluvial and residual soils (150 to 200 cm thick) with fine-loamy to fine textures and angular fragments (forest type redwood-Douglas-fir)
3	583, 586	Peacock, Wiregrass	very deep, schist and metasedimentary colluvial and residual soils (150 to 200 cm thick) with fine-loamy to fine textures and angular fragments (forest type Douglas-fir-redwood)
4	534, 538, 549, 584, 585	Coppercreek, Ahpah, Lackscreek, Wiregrass, Pittplace, Scaath, Rockysaddle	very deep, sandstone and some mudstone colluvial and residual soils (150 to 200 cm thick) with fine-loamy to fine textures and angular fragments (forest type tanoak-Douglas-fir)
5	587, 588	Childshill, Surpur	very deep, weakly consolidated siltstone, sandstone and conglomerate colluvial and residual soils (150 to 200 cm thick) fine-loamy to loamy-skeletal and rounded fragments (forest type tanoak-Douglas-fir)
6	756, 759, 760, 761	Oragran, Weitchpec, Jayle, Walnett, Gasquet	shallow to moderately deep, serpentinite and periodite residual soils (50 to 100 centimeters thick) loamy-skeletal and angular cobbles and stones (jeffery pine parkland and Douglas-fir-tanoak forest)
7	171, 172, 174, 177, 595	Bigtree, Mystery	very deep alluvial soils from mixed sources (150 to 200 centimeters thick) coarse to fine loamy and rounded fragments.

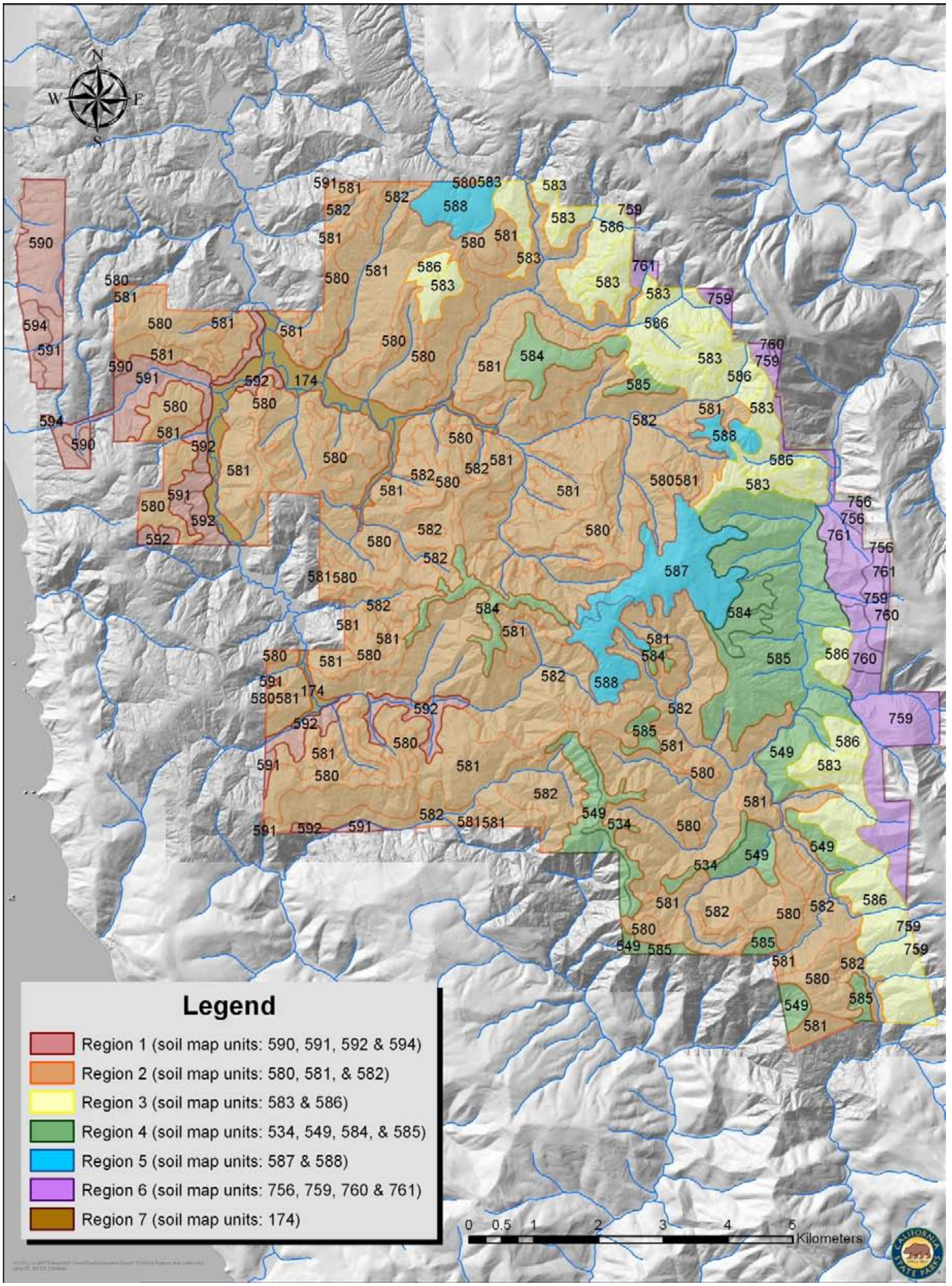

Figure 11. Soil map units grouped by region.

Five calibration parameter values were selected as a starting point for the SINMAP modeling: soil bulk density, internal angle of friction for the soil, dimensionless cohesion, soil transmissivity and the recharge rate within the specific catchment area. The last two parameters are used as a ratio ($^{T}/_{R}$) to define the topographic wetness index. Soil bulk density, internal angle of friction and dimensionless cohesion were taken from *Soil Survey of Redwood and National Parks, California* (2008). Transmissivity values were taken from samples collected by Paulín from 2005 to 2007. The recharge rate was estimated using recent historical observations of landslide activity and the associated rainfall intensity.

Soil Bulk Density

Because soil bulk density contributes to the driving force of a weak soil mass we selected the highest soil bulk density as the input to the model. The soil survey only quantified the non-rock portion of the sample so we had to calculate the density of the horizon including rock fragments. Survey data listed the fraction of the sample that was rock fragments, so we were able to calculate the total bulk density for the horizon by multiplying the measured soil bulk density by its representative percentage in the sample and added that to the percentage of rock fragments multiplied by 2,650 kg/m^3 (the average density of rock fragments).

Angle of Internal Friction (ϕ)

The angle of internal friction is the measure of the ability of a rock or soil to withstand a sheer stress. SINMAP's basis in the infinite slope model requires an estimation of the maximum and minimum values of phi (ϕ). We used values of ϕ taken from the soil survey as calibration parameters for the model.

Cohesion (C)

Cohesion in soils is the result of two primary factors: electro-chemical bonding at the molecular level and root strength. SINMAP's basis in the infinite slope model requires an estimation of the maximum and minimum values of cohesion (C). SINMAP uses a dimensionless cohesion factor derived by combining the soil and root cohesion with soil density and thickness. We used values of C taken from the soil survey as the calibration parameter for the model.

Topographic Wetness Index ($^R/_T$)

The topographic wetness index is the ratio of the recharge to the transmissivity of the soil. Transmissivity values were taken from laboratory results of samples taken by Paulín across the western third of the Mill Creek property. Transmissivity defines the soil's capacity for lateral transmission of water in m^2/hr. Recharge as used for SINMAP refers to effective recharge (in m/hr) over a critical period of rainfall likely to trigger landslides. We assume the effective recharge is imposed over already wet soils with prolonged antecedent precipitation. In our region local observations of rainfall intensity and landslide initiation indicate an effective recharge rate of 3 inches over a 12 hour period with near saturated soils at the start of the period.

Lidar-based DEM 1m verses 10m

SINMAP uses a grid Digital Elevation Model (DEM) to process slope and specific catchment area values. In theory, the better the DEM, the better the model output. Consequently, we began the SINMAP modeling by using the 1-meter DEM developed using 2007 LiDAR data. Unfortunately, for reasons not yet understood, the 1-meter DEM could not be used with the SINMAP modeling software. It is assumed at this point that the problem lies with an unidentified artifact in the data and not with the software. Because of the problems encountered with the 1-meter DEM we chose to use a 10-meter LiDAR derived DEM instead. Using these new data produced satisfactory results but as the problems are resolved with the higher resolution DEM we will return to the model and generate a new stability index.

SINMAP verses Historical Landsliding

Upon finalizing the SINMAP calibration and model runs we compared the distribution of the stability class definitions to the location of landslides inventoried during our historical landslide analysis (See Landslide History). We used the GIS to overlay the two datasets and qualitatively assessed how well the model output fit the observed landsliding (Figure 12).

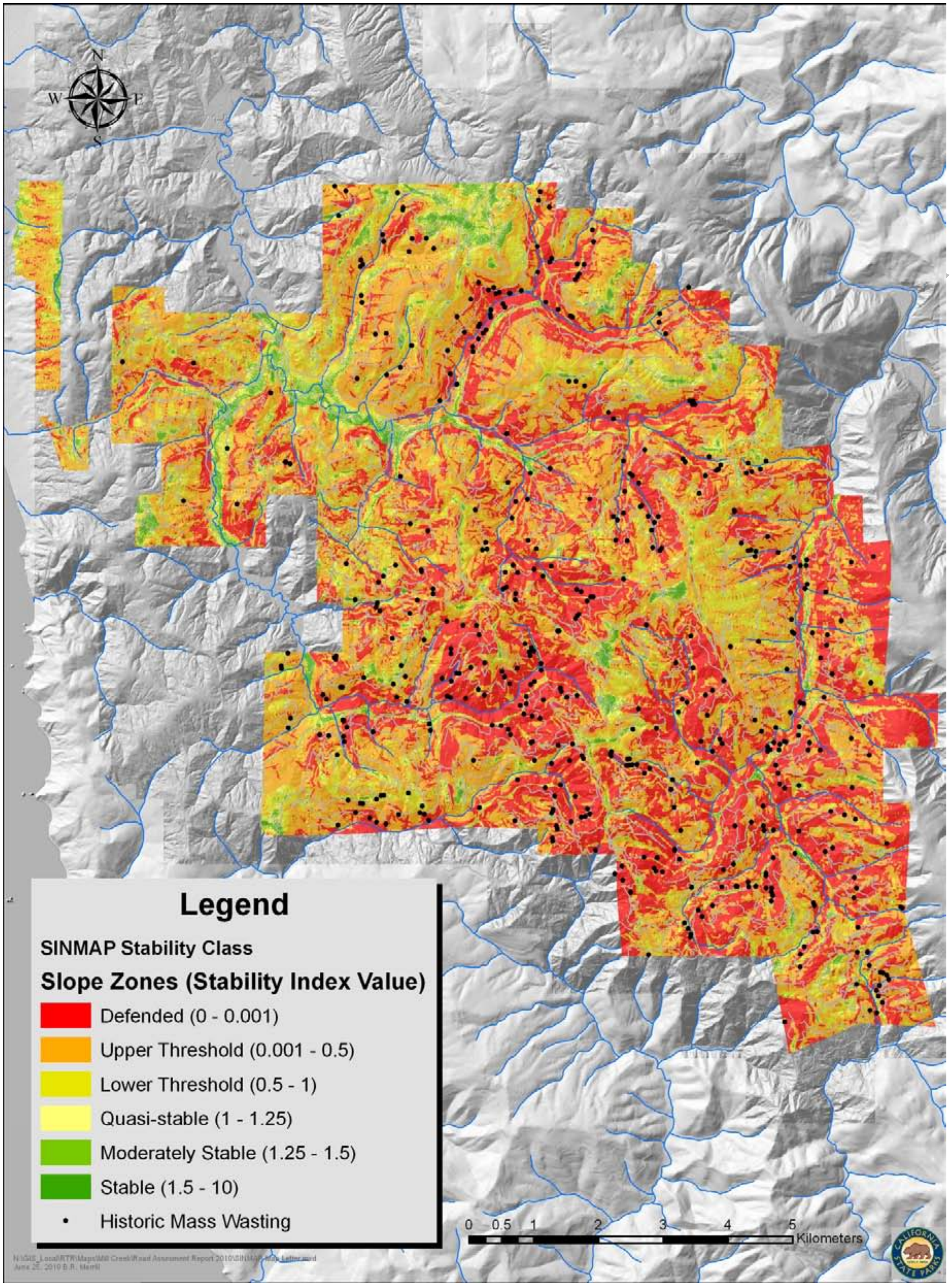

Figure 12. SINMAP slope stability index.

Risk Assessment

We characterized four site types: 1) road-stream crossings, 2) landings, 3) mass wasting events, and 4) road fills (segments) using physical attributes that are known to affect site stability. Sensitivity scores developed for the four site types represent a site's relative potential for failure with the highest score having the highest risk of failure and the lowest score having the lowest risk of failure. It was our goal to rank roads based on their existing physical attributes in a manner that removes as much subjectivity as possible, so that all sites and road segments are compared equally and objectively. A three step process was used to score each site: 1) assigning and summing attribute scores, 2) normalizing the raw site score by the number of attributes, and 3) renormalizing the site score so that all site type scores are equally weighted.

1. Summing Attribute Scores

We used field data contained in the two road inventory databases as well as the LiDAR-based 1-meter DEM and SINMAP to generate the sensitivity scores (Tables 7-10). Because all attributes do not affect the site to the same degree, we scaled the top value of each attribute's score range to reflect the relative importance of that attribute to site stability. For example, when evaluating the stability of a landing site, the maximum score value for local slope (scored 0 to 20) is significantly more important than the proximity of the landing to cross drain culvert (scored 0 to 3). Score values of zero were assigned if the attribute category is not likely to affect site stability.

Table 7. Site scoring values for each attribute of road stream crossings (non-culvert and culvert).

Crossings

Attribute	Category	Score
Crossing feature		
0-10	stream	10
	swale	0
Crossing Diversion		
0-20	Active	20
	Potential	15
	No Potential	0
Crossing type		
0-15	bridge[1]	0
	culvert	6
	Humboldt	15
	fill	12
	other	6
Erosional process		
0-20	undercutting	13
	collapsing	17
	fill failure	20
	gully	9
	streambank	5
	none	0
Condition of fill		
0-15	intact	0
	removed < 50%	6
	removed >50%	14
	washed out > 10%	15
Sediment transport		
0-10	high	10
	medium	5
	low	0
Adjacent instability		
0-10	yes	10
	no	0
Max raw score crossings		100
Max score normalized by number of attributes (n=7)		**14.3**

Culvert Crossings

Attribute	Category	Score
Properly sized culvert		
0-20	yes	0
	no	20
Culvert condition		
0-15	poor	15
	fair	7
	good	0
Plugging potential		
0-20	low	0
	medium	10
	high	20
Culvert drains onto fill		
0-10	yes	10
	no	0
Max raw score culvert crossingss		165
Max score normalized by number of attributes (n=11)		**15.0**

1. If crossing type is bridge, total score defaults to zero

Table 8. Site scoring values for each attribute of landing site types.

Landing Events					
Attribute	**Category**	**Score**	**Attribute**	**Category**	**Score**
Fill unit volume (m/m3)			**Proximity of Landing to springs/seeps**		
0-20	> 50	20	0-8	0 meters (within or touching)	8
	30 - 50	15		1 - 50 meters	7
	10 - 30	10		>50 meters	0
	< 10	2			
			Proximity of Landing to gully		
Water onto landing				0-20 meters	5
0-15	Yes	15		> 20 meters	0
	No	0			
			Proximity of Landing to cross drain culvert		
Local slope (maximum value within 50m downslope)				0-20 meters	3
0-20	>60%	20		> 20 meters	0
	40% - 60%	10			
	0% - 40%	0	**Proximity of Landing to mass wasting[1]**		
			0-10	1 - 50 meters	10
Soil Map units/Underlying geology				>50 meters	0
0-15	Map units 587 or 588	15			
	all other map units	0	**SINMAP (segment overlapping)[1]**		
			0-10	stable	0
				moderately stable	1
				quasi-stable	5
				lower threshold	7
				upper threshold	9
				defended	10
			Max raw score		96
			Max score normalized by number of attributes[2] (n=8)		**12.0**

1. If proximity of landing to mass wasting is from 1 - 50 meters, do not add score value for SINMAP. If proximity of landing to mass wasting is greater than 50 meters, use SINMAP output value.

2. Because categories "proximity to mass wasting" and "SINMAP" are scored either/or to avoid double counting, they count as one category.

Table 9. Site scoring values for each attribute of mass wasting events.

Mass Wasting					
Attribute	**Category**	**Score**			
Extreme erosion potentail[1]			**Future erosion potential[1]**		
0-30	Low	0	5-15	Low	5
	Medium	20		Medium	10
	High	30		High	15
Max raw score		30			
Max score normalized by number of attributes[2] (n=1)		**30.0**			

1. If extreme erosion potential is medium or high, then future erosion potential recieves no score. If extreme erosion potential is low, then use value for future erosion potential.
2. Because categories "future erosion potential" and "extreme erosion potential" are scored either/or to avoid double counting, they count as one category.

Table 10. Site scoring values for each attribute of road fill segments.

Road Fills

Attribute	Category	Score
Fill unit volume (m/m3)		
0-10	> 8	10
	5-8	7
	3-5	4
	0-3	1
Vegetation load		
0-3	high	1
	medium	2
	low	3
Road drainage		
0-6	insloped/ditch	2
	outsloped/none	0
	rill/tire ruts	5
	road gully	6
	tread drainage	3
	water bars	2
Inboard ditch		
0-5	double I/O	3
	filled	5
	gullied	4
	none	0
	open	1
	vegetated	2
	outboard	3
Soil Map units/Underlying geology		
0-15	Map units 587 or 588	15
	all other map units	0

Attribute	Category	Score
Local slope (maximum value in segment)		
0-20	>60%	20
	40% - 60%	10
	0% - 40%	0
Proximity of Road segment (pixel) to springs/seeps		
0-8	0 meters (within or touching)	8
	1 - 50 meters	7
	>50 meters	0
Proximity of Road segment (pixel) to gully		
	0-20 meters	5
	> 20 meters	0
Proximity of Road segment (pixel) to cross drain culvert		
	0-20 meters	3
	> 20 meters	0
Proximity of Road segment (pixel) to mass wasting[1]		
0-10	1 - 50 meters	10
	>50 meters	0
SINMAP (segment overlapping)[1]		
0-10	stable	0
	moderately stable	1
	quasi-stable	5
	lower threshold	7
	upper threshold	9
	defended	10
Max raw score		85
Max score normalized by number of attributes[2] (n=10)		**8.5**

1. If proximity of road segment to mass wasting is from 1 - 50 meters, do not add score value for SINMAP. If proximity of road segment to mass wasting is greater than 50 meters, use SINMAP output value.

2. Because categories "proximity to mass wasting" and "SINMAP" are scored either/or to avoid double counting, they count as one category.

Scores were derived from attributes that were directly related to the site such as fill volume or vegetation load, and from attributes which may affect the site such as proximity to a landslide site or the steepness of the slope below. We used buffering distances along routes within ArcMap™ to assign values to various proximity-based attribute scores. For example, at landing sites values could be scored based on whether a site was 0 meters away (touching or within) (8 points), 1 m to 50 m away (7 points), or greater than 50 m away (0 points) from a spring. Proximity attributes were considered because field observations indicate that road related failures tend to cluster near geomorphic or hydrologic features such as springs or existing mass wasting sites.

Some attribute categories were paired and only one of the two was scored to avoid double counting of related attributes. For example, local slope instability could have been scored based on existing field evidence of mass wasting or probable future events based on the slope stability model. To avoid double scoring a site that was in close proximity to a mass wasting event and also overlapping an area prone to instability according to SINMAP, the site type was first scored according to its proximity to a mass waste event, and if not within 50 m, a score was assigned using the SINMAP output.

2. Normalizing raw site scores by the number of attributes

Once we had assigned a score to each attribute, the scores were summed to yield a raw site score. The raw site scores range from 0-100 for non culvert crossings, 0-165 culvert crossings, 2-96 for landing sites, 5-30 for mass wasting events, and 2-85 for road fill segments (Tables 7-10). The raw site scores, however, are not indicative of the relative risk of failure because each site type is composed of a different number of attributes summed for the total raw score. For example, a site type with 11 attributes will usually generate a raw score higher than a site type with 7 attributes; the maximum raw score achievable by each site type differed. To negate the effect of having differing numbers of scored attributes, we divided each raw site score by the number of attributes summed. This generated the normalized site score.

3. Renormalizing site scores to equally weight site types

We renormalized the site scores using a scaling factor to equalize risk across all site types. We refer to this as a double-normalized site score. By equalizing risk across site types we are able to use the individual site scores to produce summed risk values for whole roads without one site type skewing the total. For example, a road with 5 landing sites and 5 crossing sites scored at the maximum risk value will receive the same total score as a road with 10 crossing sites scored at the maximum risk value.

To calculate the double-normalized site score, we multiplied the normalized site score by a scaling factor to equalize the maximum risk score achievable by all site types.

To calculate the scaling factor for each site type, we divided the maximum achievable normalized site score for each site type by the highest possible normalized site score (which is 15 for culvert crossings). We used each resultant multiplier to increase each normalized site score to equal the weight of the highest scoring site type. This set the maximum scores for the other four site types equal in weight to those of stream crossings with culverts.

Ranking Site Risk

Once we calculated the double-normalized site scores for all sites and road segments, we reviewed the scores for each site type individually. First, we reviewed the range of the values and the maximum and minimum values to determine whether the attribute scoring values produced reasonable sensitivity scores based on our field knowledge of specific sites. This was also an opportunity to identify any outliers and determine their validity.

We chose to group sites and routes into three risk classifications: High, Moderate, and Low. High risk sites represent sites possessing numerous characteristics that indicate failure is probable given the right conditions. Next, we plotted histograms of each of the site type's sensitivity scores and evaluated the distribution. We looked for obvious breakpoints where we could assign risk classifications. We found that the distribution of the data was not as valuable for identifying break points as our own knowledge of the conditions at the sites themselves. We calibrated the break points up and down to produce different map representations and compared those to our first-hand knowledge of individual sites. The scoring was validated as the worst sites known from field observations were appearing as high priority sites.

Ranking Road Fill Risk

We ranked each route's road fills by summing the double-normalized risk scores of all road fill segments that made up a route. By dividing the total road fill score by the length of route, we were able to compare road fill risk scores per length, and in the same manner as sites, determine route risk classifications of High, Moderate, and Low.

Ranking Routes Using Site and Fill Risk Scores

Because stream crossings, landings and mass wasting sites are physically distinct from road fills, we were unable to include the road fills with the other site types to produce a single value that represented the whole route. It is clear that a crossing constitutes a site. The same holds true for landings and mass wasting sites. However, as we tried to define a road fill site in order to assign it a risk score we were unable to answer the question "what is a road fill site?" It became clear that we would have to assign risk scores individually to the sites and collectively to the road fill segments that made up a route. This resulted in two risk scores for each route, one quantifying the road fill failure risk and one quantifying the site failure risk.

Two rankings (fill risk score per length and site risk score per length) can be evaluated independently to determine the relative risk of failure of the road itself and/or the risk of failure of the sites along the road. Evaluating routes as a whole provides us with a first-cut ranking of which routes present the most significant risk to park resources. While this information will help us select which routes deserve the highest consideration for treatment, it doesn't provide information about how the risk is distributed along a route. Knowing which segments of a route constitute the highest risk will allow managers to target the highest scored segments and make decisions about sequencing treatments. Although beyond the scope of this assessment report, segment fill scores and site scores will also be considered at the project planning level.

Threat Assessment

We chose to use sediment delivery to the stream network to characterize the relative threats posed by road segments and sites. Sediment delivery, however, can only be quantified as a potential estimate. It is known that fluvial erosion (stream crossing failures, stream diversions, and gullies) as well as mass movements (fillslope failures, landing failures, and cutbank failures) have the potential to deliver sediment to the stream network. However these erosional processes are episodic in nature and are often triggered by large storm events (DFG 2004). In addition, there are several ways in which a stream crossing has the potential to fail and deliver sediment (a plugged or undersized culvert, flow being diverted down the road, collapse of fill from within, or a gully developing and gradually washing the fill out over time). Each of these failure mechanisms may yield a different quantity of sediment to the streams over an uncertain amount of time. For these reasons, sediment delivery cannot be accurately predicted with an absolute value, but rather as the relative magnitude of an expected outcome if rehabilitation of the roads is not undertaken before the next large storm event.

Stream Crossings

For stream crossing sites, we assume that when crossings fail, they will eventually erode and incise to their original channel depth and width and the side slopes will lie back until they reach an angle of 1:1 (100%). Field observations indicate that crossing failures yield from 60% to 100% of their original fill volume, depending on the failure mechanism involved. Also, the sediment plug upstream of many crossings will deliver to the stream when the crossing fails due to the unconsolidated nature of the material. For this assessment we chose to calculate the potential sediment delivery ratio (SDR) for stream crossings at 80% of the total crossing volume.

Sediment Yield = Sediment Delivery Ratio (%) X Total Crossing Volume (m^3)

Sediment Yield = .80 X (crossing volume + sediment plug volume)

Landslides

For all field documented landslide sites, we ranked the potential for future erosion and the potential for extreme erosion as low, medium, or high (Appendix B, Road Assessment Form Sheet 1). We calculated an estimate of the future deliverable volume and also selected from categorical volumes to quantify an extreme erosion event, if it were to occur. We determined the potential landslide yield volume by using the value taken from a three-step process:

1. If the potential for extreme erosion is high, we use the highest value circled for the associated categorical volume.

2. If the potential for extreme erosion is medium, we use the median value circled for the associated categorical volume.

3. If the potential for extreme erosion is low, we use the volume estimate for future deliverable volume.

Landings

The steepness of slope is a key factor related to the failure of landings. Landing fill slides can only occur when slopes are steep enough for some of the other factors (soil and parent material, root cohesion, and moisture conditions) to combine and produce a stress that exceeds the resistance of the soil or rock material making up the slope. Therefore, we used local slope steepness as a key attribute in the calculation of the SDR for landing fills. We established the SDR by looking at the local slope using the 1m DEM to determine the highest slope value (percent) within 50 meters downslope from a landing. We then chose the SDR based on the following parameters:

1. If the local slope is greater than 60%, the SDR is 150%

2. If the local slope is between 40% and 60%, the SDR is 100%

3. If the local slope is less than 40%, the SDR is 50%

We chose to use a SDR of 150% for landings on slopes greater than 60% because field observations indicate that landing fillslope failures promulgate down steep slopes before delivery to a stream channel. Although this approached is simplified by only using slope values immediately below the landing fills, Bartle (1998) suggests that if hillslope geometry remains constant, fill failures will accumulate volume down a slope greater than 40%.

Road Fills

Road embankment fill is somewhat more difficult to apply a geomorphic rational for calculating SDR. Road fills can be subject to fluvial erosion, mass wasting, or any combination of factors resulting from the road features' interaction with the road network as they fail from lack of maintenance or storm damage. It is not likely that a road will fail in entirety; instead sections will fail over time. For this assessment, we chose to calculate road fill SDR based on a percentage of the road that will eventually fail, and then using a percentage of the failed material that will yield sediment to the creeks. The SDR we used to calculate road fill yield is:

Yield = 20% of total road fill volume (failed) X 40% of failed road volume (delivered)

Road Surface Erosion

Road surface erosion is a chronic low-volume sediment source that can be delivered to streams via drainage ditches, sheet flow, and minor stream flow along road surfaces. Yield from road surfaces can vary widely and is dependent on many factors including road use, road surfacing material, road vegetation cover, and road maintenance activities. A commonly used average rate of road lowering (erosion) is 6mm per year for active, aggregate surfaced roads. Although we did not record a value segment-by-segment we can use the road activity level to estimate a value for road surface erosion.

An accurate estimation of sediment delivery to streams depends on conveyance of the fine sediment off the road to the streams. Within the Mill Creek Addition, most roads were constructed to drain to and inboard ditch so we assume that 100% of fine sediment eroded from active roads will be delivered to the stream network. We calculated the road surface erosion rate for the active road network by multiplying the lowering rate, the average road width, and the road length.

Ranking Site Threat

Similar to site risk, we rank the threat of sediment delivery by grouping sites into categories of high, moderate, and low. Break points for categories of threat remain constant regardless of site type. We chose to group all sites that could deliver up to 300 m^3 as low. Sites that could deliver from 300 m^3 to 1,200 m^3 were categorized as moderate. Any sites capable of delivering over 1,200m^3 were considered a high threat.

We selected these breakpoints based on our observations in the field on the effects of various mass inputs to the streams. Inputs less than 300 m^3 were generally processed quickly by moderate to large streams. The wedge of sediment was quickly attenuated downstream and alluvial deposits were uncommon. Volumes ranging from 300 m^3 to 1,200 m^3 were more resistant to reworking and tended to deposit as small fill terraces for a significant distance downstream. Stream inputs greater than 1,200 m^3 resulted in significant impact to the deposition site as well as distant downstream reaches. At the deposition site sediment often caused the stream to shift course undermining riparian vegetation and scouring additional sediment from adjacent slopes and terraces. In small to moderately sized streams the depositional wedge often remained intact with deeply incised gullies created by stream flow. Downstream deposits extended for long distances and often formed deltaic deposits at stream confluence points. In larger streams much of the sediment was reworked and transported downstream where extensive reworking of the active channel and floodplain often liberated more sediment.

Ranking Route Threat

The threat of sediment delivery for individual road fills was done using a unit-threat value, that is, all potentially deliverable sediment was summed along the route divided by its length in kilometers. This yielded values ranging from 0m^3 to 670 m^3 per kilometer. Because the road fills are distributed along a linear feature it is unlikely that a single segment would yield a significant volume of sediment. Instead, we characterize the whole route with a single unit-value. Breakpoints for high, moderate, and low risk were assigned using even intervals, splitting the range into thirds to show the relative threat between routes.

ROAD ASSESSMENT RESULTS

We ranked 443 roads totaling 468 km by their combined risk of failure and sediment delivery threat (Plate 1). Individual roads ranged in length from 0.02 km to 23.06 km. Of 3,682 sites and fills evaluated, 1,451 are road-stream crossings, 981 are landings, 807 are mass wasting sites, and 443 are road fills (Table 11 and Plate 2). Nine-hundred and eight sites are considered high risk with a combined potential sediment delivery of 905,079 m^3. Moderate risk sites number 1,813 and represent 1,281,885 m^3 of potential sediment delivery. Low risk sites account for 398,522 m^3 of potentially deliverable sediment contained in 961 sites. We estimate chronic road surface erosion and fine sediment transport delivers 14,000 m^3 per year to the stream network within the Mill Creek Addition.

Table 11. Road assessment summary.

	Total Sites	Total Volume	High Risk	High Risk Volume	Moderate Risk	Moderate Risk Volume	Low Risk	Low Risk Volume
	#		#	cubic meters	#	cubic meters	#	cubic meters
Crossings	1,451	833,391	454	395,474	690	349,428	307	88,489
Landings	981	1,445,285	205	374,229	506	809,370	270	261,686
Mass Wasting Sites	807	183,999	153	127,500	376	39,115	278	17,384
Road Fills	443	122,811	96	7,876	241	83,972	106	30,963
Total	3,682	2,585,486	908	905,079	1,813	1,281,885	961	398,522

Individual road ranks ranged from 1 to 12 with 12 representing the most critically unstable roads and 1 representing the least unstable roads (Table 12). The final road rank is a sum of 4 scores ranging from 1 to 3, route risk rank, route threat rank, site risk rank, and site threat rank. Roads with higher rankings have a greater risk of failure combined with a larger potential sediment yield as failures occur. Sites with lower scores represent either less risk of failure, less potential sediment delivery, or both. The final road ranking is gradational rather than categorical because we could not identify any criteria which could define categorical boundaries. We believe this is an advantage because this assessment is intended to be a tool to compare the relative risk and threat of roads in the context of integrated resource management planning and policy decisions.

Table 12. Road and site ranking.

Road/Route	Route Length (km)	Final Road Rank (1 - 12)	Route Risk Rank (1 - 3)	Route Threat Rank (1 - 3)	Site Risk Rank (1 - 3)	Site Threat Rank (1 - 3)	Total Number of Sites (#)	Total Crossings (#)	Total Landings (#)	Total Mass Wasting (#)	Road Fills		Crossings						Landings						Mass Wasting Sites					
											Risk 1-3	Volume cubic meters	High Risk #	High Risk Volume cubic meters	Moderate Risk #	Moderate Risk Volume cubic meters	Low Risk #	Low Risk Volume cubic meters	High Risk #	High Risk Volume cubic meters	Moderate Risk #	Moderate Risk Volume cubic meters	Low Risk #	Low Risk Volume cubic meters	High Risk #	High Risk Volume cubic meters	Moderate Risk #	Moderate Risk Volume cubic meters	Low Risk #	Low Risk Volume cubic meters
Hunter Fire-4	0.08	12	3	3	3	3	1	0	1	0	3	31	0	0	0	0	0	0	0	0	1	1,200	0	0	0	0	0	0	0	0
Ray Smith-1	0.11	12	3	3	3	3	2	0	2	0	3	52	0	0	0	0	0	0	0	0	1	1,440	1	1,080	0	0	0	0	0	0
Visser Spur-1	0.09	11	3	3	2	3	1	0	1	0	3	44	0	0	0	0	0	0	0	0	1	1,500	0	0	0	0	0	0	0	0
Ear Spur-1	0.07	11	3	2	3	3	1	0	1	0	3	17	0	0	0	0	0	0	0	0	1	2,400	0	0	0	0	0	0	0	0
Smoke House Rd-1A	0.25	11	3	2	3	3	6	3	0	3	3	73	3	3,554	0	0	0	0	0	0	0	0	0	0	2	2,750	0	0	1	0
Rocky Point-2	0.16	11	3	2	3	3	3	1	2	0	3	55	0	0	1	147	0	0	0	0	2	2,340	0	0	0	0	0	0	0	0
Camp Spur-1-1	0.14	11	2	3	3	3	3	1	2	0	2	54	0	0	1	317	0	0	1	1,200	0	0	1	2,250	0	0	0	0	0	0
Childs Hill-5	0.77	11	3	2	3	3	11	2	2	7	3	144	2	3,792	0	0	0	0	1	2,800	1	3,990	0	0	3	6,500	2	0	2	0
1st Switchback-2-2	0.07	11	2	3	3	3	2	0	2	0	2	33	0	0	0	0	0	0	0	0	0	0	2	1,500	0	0	0	0	0	0
Rock Creek Road-8	0.08	11	3	3	2	3	1	0	1	0	3	51	0	0	0	0	0	0	0	0	1	7,200	0	0	0	0	0	0	0	0
Windfall	1.53	10	3	2	3	2	17	6	3	8	3	469	3	5,086	2	439	1	104	3	5,475	0	0	0	0	2	750	3	75	3	1
Timberline-Jeep Road Link-1	0.32	10	3	3	2	2	5	2	1	2	3	171	0	0	0	0	2	417	0	0	1	1,200	0	0	0	0	2	80	0	0
Mussel-1-A-1	0.06	10	2	3	2	3	1	0	1	0	2	38	0	0	0	0	0	0	0	0	0	0	1	1,000	0	0	0	0	0	0
Smoke House-3	0.41	10	3	2	3	2	5	0	1	4	3	123	0	0	0	0	0	0	0	0	1	975	0	0	2	1,000	0	0	2	30
Dry Lake-1A	0.23	10	2	3	3	2	4	1	1	2	2	99	0	0	1	362	0	0	0	0	1	800	0	0	0	0	2	0	0	0
No Name-2	0.2	10	3	2	2	3	2	0	2	0	3	46	0	0	0	0	0	0	0	0	2	4,350	0	0	0	0	0	0	0	0
Cougar Ridge-4	0.44	10	3	2	3	2	6	0	3	3	3	93	0	0	0	0	0	0	3	4,100	0	0	0	0	0	0	3	0	0	0
Mussel-3	0.07	10	3	1	3	3	1	0	1	0	3	11	0	0	0	0	0	0	0	0	1	2,025	0	0	0	0	0	0	0	0
Porcupine-2	0.18	10	3	3	2	2	3	1	0	2	3	65	0	0	0	0	1	511	0	0	0	0	0	0	0	0	2	225	0	0
P-Line Spur-1-1	0.84	10	2	3	2	3	6	1	1	4	2	327	0	0	1	3,401	0	0	0	0	1	2,250	0	0	2	2,500	0	0	2	300
A-J-2-2	0.12	10	3	2	3	2	2	0	1	1	3	34	0	0	0	0	0	0	1	800	0	0	0	0	0	0	1	0	0	0
Heat Spur-1	0.12	10	2	3	2	3	1	0	1	0	2	48	0	0	0	0	0	0	0	0	1	2,250	0	0	0	0	0	0	0	0
Demonstration Forest Spur-1	0.29	10	3	2	3	2	5	2	0	3	3	84	2	1,144	0	0	0	0	0	0	0	0	0	0	0	0	2	115	1	35
J-T No. 1 Loop-1-2	0.07	10	3	1	3	3	1	0	1	0	3	6	0	0	0	0	0	0	0	0	1	1,125	0	0	0	0	0	0	0	0
West Branch Road-Park Spur Link-1-1	0.16	10	3	1	3	3	2	0	1	1	3	18	0	0	0	0	0	0	1	1,890	0	0	0	0	0	0	1	35	0	0
Howards Spur-1	0.18	10	3	2	2	3	3	0	1	2	3	59	0	0	0	0	0	0	0	0	1	1,688	0	0	0	0	0	0	2	600
A-J Loop-1	1.45	10	3	3	2	2	15	8	4	3	3	584	0	0	8	2,751	0	0	0	0	2	2,100	2	1,160	0	0	3	300	0	0
Flashlite	2.01	10	2	2	3	3	22	5	5	12	2	546	3	2,526	1	1,672	1	630	2	6,475	3	4,500	0	0	5	6,500	3	500	4	50
Sec.5-1B	0.2	10	3	2	3	2	2	1	1	0	3	48	1	524	0	0	0	0	1	900	0	0	0	0	0	0	0	0	0	0
Park Spur-1	0.56	10	2	2	3	3	10	5	4	1	2	172	3	5,530	2	3,702	0	0	0	0	3	5,326	1	2,100	1	250	0	0	0	0
Wilson Creek-2	0.4	10	3	2	3	2	5	1	0	4	3	123	1	853	0	0	0	0	0	0	0	0	0	0	2	2,250	1	50	1	120
Sec. 5-1	0.32	10	2	2	3	3	5	0	3	2	2	60	0	0	0	0	0	0	2	1,980	1	1,215	0	0	0	0	3	445	0	0
Elkhorn-1	0.18	10	3	2	2	3	2	1	1	0	3	40	1	1,490	0	0	0	0	0	0	0	0	1	1,320	0	0	0	0	0	0
Head Hunter-6	0.35	10	3	2	3	2	5	0	1	4	3	88	0	0	0	0	0	0	0	0	1	1,800	0	0	3	750	1	50	0	0
Childs Hill-2	0.32	10	2	2	3	3	6	0	2	4	2	79	0	0	0	0	0	0	1	1,800	1	1,800	0	0	0	0	4	0	0	0
Dry Lake-1	0.62	10	3	2	3	2	8	4	1	3	3	145	3	629	1	128	0	0	0	0	1	480	0	0	1	750	1	60	1	0
Paragon-1	0.15	10	3	2	3	2	2	0	1	1	3	39	0	0	0	0	0	0	1	1,080	0	0	0	0	1	250	0	0	0	0
Low Divide-4	0.53	10	2	2	3	3	8	3	1	4	2	165	2	959	1	174	0	0	0	0	1	1,000	0	0	1	5,000	2	80	1	0
Hilton Spur-2	0.14	9	2	1	3	3	4	2	2	0	2	12	0	0	0	0	2	447	0	0	1	540	1	840	0	0	0	0	0	0
Crossover-1	0.26	9	3	3	2	1	4	0	0	4	3	115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	50	3	40
Elkhorn Road	2.51	9	2	3	2	2	14	9	1	4	2	893	5	4,142	2	367	1	261	1	1,350	0	0	0	0	3	2,000	1	200	0	0
Rock Creek Road-11	0.74	9	2	2	2	3	8	4	4	0	2	208	1	368	1	196	2	410	0	0	2	3,900	2	3,950	0	0	0	0	0	0
Rock Creek Road-10	1.22	9	3	2	2	2	15	8	2	5	3	302	5	1,164	2	892	1	105	1	2,000	1	1,875	0	0	0	0	1	200	4	600
1st Switchback-2	1.58	9	1	3	2	3	21	4	6	11	1	594	0	0	3	1,640	1	353	2	3,375	2	2,710	2	2,420	3	6,500	5	1,800	2	160
Airport Spur-3	0.12	9	3	2	1	3	1	0	1	0	3	41	0	0	0	0	0	0	0	0	0	0	1	2,500	0	0	0	0	0	0
Reservoir-1	0.11	9	2	2	3	2	2	1	0	1	2	26	1	600	0	0	0	0	0	0	0	0	0	0	1	250	0	0	0	0
Boulder Ave	3.41	9	2	3	2	2	27	12	7	8	2	1287	5	2,559	5	1,954	2	709	2	7,110	5	7,995	0	0	1	250	5	470	2	45
Prospect-1	0.21	9	2	2	2	3	4	2	2	0	2	52	0	0	1	670	1	295	0	0	2	3,300	0	0	0	0	0	0	0	0
Sec. 36-2	1.11	9	2	2	3	2	15	8	5	2	2	385	6	2,887	2	843	0	0	0	0	2	2,055	3	2,700	0	0	2	20	0	0
12Pct Spur	1.7	9	2	3	2	2	11	6	1	4	2	665	0	0	5	1,354	1	134	0	0	1	2,250	0	0	4	2,250	0	0	0	0
Bear-1	0.12	9	2	2	2	3	1	0	1	0	2	32	0	0	0	0	0	0	0	0	1	6,750	0	0	0	0	0	0	0	0
Sec. 31 Road	3.968	9	2	3	2	2	33	14	13	6	2	1674	1	275	8	5,077	3	2,215	4	8,850	8	12,300	1	2,400	4	1,500	2	0	0	0
Head Hunter-5	0.08	9	3	3	2	1	1	0	0	1	3	36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	20	0	0
Westside Spur	3.7	9	1	3	2	3	32	14	13	5	1	1374	10	11,557	4	3,010	0	0	1	3,000	12	19,350	0	0	2	4,250	4	425	0	0
Wilbur Spur-5	0.13	9	3	2	1	3	1	0	1	0	3	33	0	0	0	0	0	0	0	0	1	2,000	0	0	0	0	0	0	0	0
Sec. 36-5	0.18	9	2	2	2	3	2	0	1	1	2	61	0	0	0	0	0	0	0	0	1	1,800	0	0	0	0	1	0	0	0
4th Switchback	4.07	9	2	3	2	2	36	13	8	15	2	1640	8	7,875	4	1,822	1	1,408	3	4,650	5	4,795	0	0	4	6,500	8	960	3	10
Porcupine-3	0.1	9	3	2	3	1	2	0	0	2	3	27	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	25	0	0
12Pct Spur Loop	0.58	9	3	2	2	2	6	0	2	4	3	123	0	0	0	0	0	0	1	1,800	1	2,625	0	0	0	0	3	0	1	0
Childs Hill-5-1	0.11	9	2	1	3	3	2	0	1	1	2	10	0	0	0	0	0	0	1	3,375	0	0	0	0	0	0	0	0	1	0
Wilson Creek-1	0.1	9	3	1	3	2	1	0	1	0	3	14	0	0	0	0	0	0	1	750	0	0	0	0	0	0	0	0	0	0
J-T No. 1 Inner Loop	0.85	9	2	3	1	3	5	0	5	0	2	344	0	0	0	0	0	0	0	0	4	10,500	1	2,750	0	0	0	0	0	0
Childs Hill-1	0.72	9	3	2	2	2	5	1	1	3	3	196	0	0	0	0	1	360	1	4,050	0	0	0	0	1	250	1	0	1	0
B&B Spur	3	9	1	2	3	3	33	13	13	7	1	893	6	7,391	4	2,702	3	1,786	3	5,340	5	5,655	5	4,000	3	10,250	3	2,000	1	
Low Divide-3	0.07	9	2	1	3	3	1	0	1	0	2	3	0	0	0	0	0	0	0	0	1	1,912	0	0	0	0	0	0	0	0
Timberline	4.31	9	2	3	2	2	37	10	7	20	2	1720	5	1,093	3	458	2	291	0	0	5	5,318	2	1,140	18	5,750	2	20	0	0
Yellow Jacket-1	0.11	9	2	3	1	3	1	0	1	0	2	51	0	0	0	0	0	0	0	0	0	0	1	1,275	0	0	0	0	0	0
Mussel-1	0.43	9	2	3	2	2	4	0	0	4	2	169	0	0	0	0	0	0	0	0	0	0	0	0	1	1,500	0	0	3	850
Hunter Fire-3	0.07	9	2	1	3	3	1	0	1	0	2	12	0	0	0	0	0	0	0	0	1	1,200	0	0	0	0	0	0	0	0
Moratorium-3-1	0.06	9	2	2	3	2	1	0	1	0	2	14	0	0	0	0	0	0	1	540	0	0	0	0	0	0	0	0	0	0
Zone 15-2	0.29	9	3	2	2	2	2	0	1	1	3	72	0	0	0	0	0	0	0	0	1	1,100	0	0	0	0	1	0	0	0
Bucket Spur-3	0.71	9	3	2	2	2	9	5	1	3	3	198	1	119	4	2,024	0	0	0	0	1	1,200	0	0	0	0	2	80	1	25
Smokehouse Road Loop	0.21	9	3	2	1	3	1	0	1	0	3	38	0	0	0	0	0	0	0	0	1	2,100	0	0	0	0	0	0	0	0
Mussel-2	0.13	9	2	2	2	3	2	0	1	1	2	39	0	0	0	0	0	0	0	0	1	1,500	0	0	0	0	0	0	1	400
Maple South	1.33	9	2	2	2	3	10	0	6	4	2	381	0	0	0	0	0	0	3	6,795	2	4,545	1	1,280	3	2,000	1	0	0	0
Wilbur-Head Hunter-1	0.59	9	3	3	2	1	4	1	1	2	3	226	0	0	0	0	1	360	1	525	0	0	0	0	1	250	1	50	0	0
Paragon	2.78	9	2	3	2	2	23	7	8	8	2	1114	1	194	5	1,706	1	636	4	5,415	4	5,595	0	0	0	0	7	50	1	0
Maple Spur-2	0.07	9	2	1	3	3	2	0	1	1	2	7	0	0	0	0	0	0	0	0	1	1,575	0	0	0	0	1	100	0	0
Smoke House Road	10.24	9	2	2	2	3	121	51	37	33	2	3168	18	18,134	28	26,037	5	3,205	5	13,080	22	37,050	9	7,798	6	2,000	17	1,250	10	0
Cougar Ridge-2	0.92	9	2	3	2	2	8	3	2	3	2	352	1	2,310	2	924	0	0	0	0	1	2,400	1	2,500	1	500	0	0	2	30
Bummer Lake Road-1	0.42	9	3	3	1	2	2	0	2	0	3	159	0	0	0	0	0	0	0	0	2	2,950	0	0	0	0	0	0	0	0
Low Divide-6	0.29	9	2	1	3	3	3	0	1	2	2	40	0	0	0	0	0	0	0	0	1	1,050	0	0	1	3,500	1	150	0	0

Table 12. cont.

Road/Route	Route Length (km)	Final Road Rank (1 - 12)	Route Risk Rank (1 - 3)	Route Threat Rank (1 - 3)	Site Risk Rank (1 - 3)	Site Threat Rank (1 - 3)	Total Number of Sites (#)	Total Crossings (#)	Total Landings (#)	Total Mass Wasting (#)	Road Fills: Risk 1-3	Road Fills: Volume cubic meters	Crossings: High Risk #	Crossings: High Risk Volume cubic meters	Crossings: Moderate Risk #	Crossings: Moderate Risk Volume cubic meters	Crossings: Low Risk #	Crossings: Low Risk Volume cubic meters	Landings: High Risk #	Landings: High Risk Volume cubic meters	Landings: Moderate Risk #	Landings: Moderate Risk Volume cubic meters	Landings: Low Risk #	Landings: Low Risk Volume cubic meters	Mass Wasting Sites: High Risk #	Mass Wasting Sites: High Risk Volume cubic meters	Mass Wasting Sites: Moderate Risk #	Mass Wasting Sites: Moderate Risk Volume cubic meters	Mass Wasting Sites: Low Risk #	Mass Wasting Sites: Low Risk Volume cubic meters
Sheepshed-4-1	0.23	9	2	2	2	3	3	1	1	1	2	43	0	0	1	820	0	0	0	0	1	1,500	0	0	0	0	0	0	1	0
Zone 15-1	0.31	9	3	3	1	2	1	0	1	0	3	113	0	0	0	0	0	0	0	0	0	0	1	1,200	0	0	0	0	0	0
Westside Spur-1	0.14	9	1	2	3	3	2	0	2	0	1	33	0	0	0	0	0	0	1	3,120	0	0	1	800	0	0	0	0	0	0
Rock Creek Road	20.76	8	2	3	1	2	144	96	34	14	2	8096	44	45,149	25	17,906	22	4,974	6	11,062	20	33,110	8	11,000	5	1,250	7	300	2	0
J-T No. 1 Loop-2	0.16	8	2	2	1	3	1	0	1	0	2	48	0	0	0	0	0	0	0	0	1	1,688	0	0	0	0	0	0	0	0
Ramp Spur	1.36	8	2	2	2	2	10	6	4	0	2	303	3	2,040	3	3,112	0	0	0	0	4	3,660	0	0	0	0	0	0	0	0
Martin Spur-2	0.28	8	1	2	2	3	3	1	1	1	1	73	0	0	0	0	1	194	1	3,300	0	0	0	0	0	0	0	0	1	0
Low Divide-7	0.26	8	2	3	1	2	1	0	1	0	2	98	0	0	0	0	0	0	0	0	1	1,350	0	0	0	0	0	0	0	0
Rock Creek - Crossover Link	0.42	8	3	2	2	1	3	2	0	1	3	134	1	621	1	365	0	0	0	0	0	0	0	0	0	0	1	150	0	0
2nd Switchback	1.2	8	1	2	2	3	15	9	6	0	1	357	1	434	6	6,543	2	584	0	0	3	4,575	3	4,410	0	0	0	0	0	0
2nd Switchback-1	1.92	8	2	3	1	2	18	13	5	0	2	684	1	400	11	5,589	1	260	0	0	2	3,172	3	2,940	0	0	0	0	0	0
Porcupine-1	0.21	8	2	2	1	3	2	0	2	0	2	52	0	0	0	0	0	0	1	2,250	0	0	1	0	0	0	0	0	0	0
4th Switchback-2	0.21	8	2	2	2	2	3	1	1	1	2	55	0	0	0	0	1	272	0	0	1	800	0	0	0	0	1	600	0	0
Hound Dog Left	1.57	8	1	2	2	3	16	7	4	5	1	440	4	10,208	1	621	2	848	0	0	4	7,805	0	0	0	0	3	1,625	1	40
Hound Dog	0.85	8	2	2	2	2	6	2	2	2	2	232	2	2,841	0	0	0	0	0	0	2	2,790	0	0	1	250	1	5	0	0
Hilton Spur-3	0.08	8	3	1	3	1	1	1	0	0	3	8	1	107	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bear	1.59	8	2	2	1	3	12	7	5	0	2	315	2	2,680	4	1,946	1	418	1	2,700	2	4,800	2	3,500	0	0	0	0	0	0
Powder House Right	2.34	8	1	2	2	3	30	14	12	4	1	766	4	5,806	6	3,885	3	1,152	4	5,535	6	13,424	2	1,910	0	0	2	100	2	0
No Name-1	0.5	8	3	3	1	1	5	3	0	2	3	180	0	0	1	375	2	362	0	0	0	0	0	0	0	0	2	50	0	0
Airport Spur Loop-1-1	0.17	8	3	2	1	2	1	0	1	0	3	33	0	0	0	0	0	0	0	0	1	1,400	0	0	0	0	0	0	0	0
48 Spur	1.34	8	2	2	2	2	13	8	1	4	2	416	5	3,019	3	1,396	0	0	0	0	1	480	0	0	0	0	2	20	2	145
Howards Spur	4.93	8	2	2	2	2	56	29	4	23	2	1286	10	7,553	16	4,679	2	341	0	0	4	5,970	0	0	4	1,500	11	1,190	8	900
Idiot Knob-1	0.24	8	2	1	2	3	2	0	2	0	2	29	0	0	0	0	0	0	0	0	2	2,700	0	0	0	0	0	0	0	0
Jane Creek Road	1.7	8	2	1	2	3	20	9	7	4	2	278	3	2,985	3	795	3	508	4	6,800	2	5,025	1	600	1	500	2	200	1	0
Head Hunter-4	0.32	8	2	2	2	2	3	0	2	1	2	103	0	0	0	0	0	0	0	0	2	2,888	0	0	0	0	1	0	0	0
J-T No. 1	2.46	8	2	3	1	2	9	3	6	0	2	1259	0	0	2	1,810	1	207	0	0	5	10,815	1	600	0	0	0	0	0	0
Ordie	1.5	8	2	2	2	2	11	1	7	3	2	385	0	0	1	307	0	0	4	9,098	2	3,150	1	1,200	0	0	1	375	2	600
Upper Visser-1	0.69	8	1	2	2	3	8	5	3	0	1	149	0	0	3	794	2	370	1	2,400	1	2,000	1	1,350	0	0	0	0	0	0
Sec. 36-6	0.14	8	2	1	2	3	1	0	1	0	2	24	0	0	0	0	0	0	1	1,500	0	0	0	0	0	0	0	0	0	0
Sec. 5 Loop-1	0.54	8	2	2	1	3	4	0	4	0	2	172	0	0	0	0	0	0	1	2,160	1	2,550	2	2,525	0	0	0	0	0	0
Bucket Spur	3.31	8	2	2	2	2	30	15	4	11	2	1066	9	1,726	4	2,633	2	218	1	1,800	3	3,800	0	0	0	0	5	370	6	95
Crossover-2	0.15	8	3	1	2	2	2	0	1	1	3	21	0	0	0	0	0	0	0	0	0	0	1	960	0	0	1	0	0	0
Sec. 5-2	0.23	8	2	3	1	2	1	0	1	0	2	88	0	0	0	0	0	0	0	0	0	0	1	1,200	0	0	0	0	0	0
Wilbur Spur Loop	1.1	8	2	2	2	2	11	5	3	3	2	268	2	1,443	2	502	1	77	1	1,500	2	2,700	0	0	1	500	1	10	1	0
Childs Hill Loop	1.01	8	3	2	1	2	6	2	2	2	3	336	1	880	0	0	1	442	2	3,750	0	0	0	0	0	0	2	125	0	0
Sheepshed-2	0.22	8	2	2	2	2	3	0	1	2	2	44	0	0	0	0	0	0	1	1,200	0	0	0	0	0	0	0	0	2	0
Sheepshed-3	0.91	8	2	2	2	2	10	5	3	2	2	218	1	407	4	1,249	0	0	0	0	0	0	3	2,880	1	0	0	0	1	50
Dry Lake-3	0.6	8	3	3	1	1	4	0	2	2	3	210	0	0	0	0	0	0	1	488	1	270	0	0	0	0	0	0	2	0
Violated Spur	3.16	8	2	2	2	2	34	17	12	5	2	904	1	156	10	2,524	6	975	0	0	11	16,570	1	910	1	750	5	270	0	0
Sec. 5 Road	3.98	8	2	2	2	2	43	22	6	15	2	949	8	3,808	9	3,042	3	496	1	3,150	4	5,910	1	720	1	250	6	340	9	225
Sheepshed-6-1	0.22	8	2	2	1	3	2	1	1	0	2	72	0	0	0	0	1	156	0	0	1	2,100	0	0	0	0	0	0	0	0
Upper First Gulch-2	0.38	8	1	2	2	3	4	0	3	1	1	81	0	0	0	0	0	0	0	0	1	2,250	2	1,450	0	0	1	175	0	0
Bucket Spur-2	0.17	8	3	2	1	2	2	0	1	1	3	43	0	0	0	0	0	0	0	0	0	0	1	1,600	0	0	0	0	1	0
Chipmunk Road	0.99	8	2	2	2	2	14	7	1	6	2	318	0	0	4	3,007	2	830	0	0	1	1,155	0	0	1	250	5	409	0	0
West Branch-Porcupine Link	0.3	8	2	2	2	2	4	1	1	2	2	76	0	0	1	305	0	0	0	0	1	1,800	0	0	0	0	2	90	0	0
Childs Hill-6	0.23	8	2	2	1	3	1	0	1	0	2	48	0	0	0	0	0	0	0	0	1	4,000	0	0	0	0	0	0	0	0
Teran	5.62	8	2	2	2	2	54	24	17	13	2	1449	7	12,398	16	11,354	1	584	2	3,480	9	12,285	6	4,895	0	0	6	210	7	95
Zone 15	2.21	8	2	2	2	2	19	5	7	7	2	428	0	0	4	1,197	0	0	6	8,588	1	1,500	0	0	3	1,500	4	65	0	0
Bucket Spur-3-1	0.5	8	2	2	2	2	6	4	1	1	2	112	1	284	3	1,690	0	0	0	0	0	0	1	1,200	0	0	1	40	0	0
Sheepshed-4	1.62	8	2	2	2	2	15	7	5	3	2	420	1	381	6	3,608	0	0	0	0	3	4,650	2	2,295	0	0	2	25	1	50
1st Switchback	1.005	8	2	2	2	2	11	4	4	3	2	277	1	356	3	1,352	0	0	0	0	2	1,500	2	600	0	0	2	35	1	50
Fish Hook	1	8	1	3	2	2	7	0	3	4	1	370	0	0	0	0	0	0	1	2,025	2	3,453	0	0	3	3,750	0	0	1	0
Cedar	1.933	8	2	2	2	2	22	8	7	7	2	413	6	4,974	1	558	1	331	3	4,530	3	3,172	1	405	0	0	2	10	5	20
Visser Spur	4.9	8	1	3	2	2	46	24	13	9	1	1824	6	2,777	9	4,990	9	2,486	3	6,150	9	16,035	1	2,000	3	6,000	6	770	0	0
Blowdown East-1-1	0.03	8	2	0	3	3	1	0	1	0	2	0	0	0	0	0	0	0	1	2,400	0	0	0	0	0	0	0	0	0	0
Cabin Spur	2.76	8	2	2	2	2	25	11	9	5	2	706	3	2,458	7	4,098	1	84	4	7,350	4	6,450	1	1,100	0	0	1	0	4	70
Camp Spur	1.34	8	2	2	1	3	13	9	4	0	2	412	0	0	5	2,214	4	1,498	0	0	4	12,712	0	0	0	0	0	0	0	0
Sec. 1 Loop	0.66	8	2	2	1	3	4	0	4	0	2	180	0	0	0	0	0	0	1	2,400	2	2,900	1	1,300	0	0	0	0	0	0
Camp Spur-1	0.26	8	2	2	2	2	3	2	1	0	2	60	0	0	1	236	1	206	0	0	1	1,200	0	0	0	0	0	0	0	0
Mule Trail-2	0.18	8	2	2	1	3	1	0	1	0	2	40	0	0	0	0	0	0	0	0	1	2,000	0	0	0	0	0	0	0	0
Rock Creek Road-9	0.92	8	2	2	2	2	9	3	4	2	2	199	0	0	2	822	0	0	2	4,050	2	3,525	0	0	0	0	1	250	1	350
Rock Creek Road-7	1.23	8	2	2	2	2	12	6	2	4	2	364	4	2,802	1	510	0	0	0	0	1	1,350	1	650	1	750	3	405	0	0
East Side	0.95	8	1	2	2	3	6	3	1	2	1	306	2	7,493	1	258	0	0	0	0	0	0	1	690	1	3,500	1	0	0	0
Flashlite-1	0.25	8	2	2	2	2	3	0	1	2	2	72	0	0	0	0	0	0	0	0	1	1,980	0	0	0	0	2	85	0	0
Sec. 31-2	0.42	8	3	2	1	2	1	0	1	0	3	102	0	0	0	0	0	0	1	1,500	0	0	0	0	0	0	0	0	0	0
Blowdown East-1	0.15	8	2	1	2	3	1	0	1	0	2	16	0	0	0	0	0	0	1	3,000	0	0	0	0	0	0	0	0	0	0
Visser Spur-1A	1.05	8	2	2	2	2	8	2	2	4	2	209	2	908	0	0	0	0	1	1,800	1	1,500	0	0	3	3,000	1	175	0	0
West Branch Road-2	0.82	8	2	2	2	2	6	4	0	2	2	262	4	2,239	0	0	0	0	0	0	0	0	0	0	1	250	1	50	0	0
Jane Creek Road-1-1	0.13	7	2	2	1	2	1	0	1	0	2	35	0	0	0	0	0	0	0	0	1	1,238	0	0	0	0	0	0	0	0
Wilbur Spur-6 Inner Loop	0.16	7	3	1	1	2	1	0	1	0	3	4	0	0	0	0	0	0	0	0	1	1,500	0	0	0	0	0	0	0	0
Childs Hill-3	1.52	7	2	2	1	2	8	3	4	1	2	526	0	0	0	0	3	502	2	2,300	2	2,650	0	0	0	0	0	0	1	50
Madrone-1	0.17	7	2	2	1	2	1	0	1	0	2	47	0	0	0	0	0	0	0	0	0	0	1	960	0	0	0	0	0	0
Madrone	0.7	7	1	2	2	2	7	1	6	0	1	196	0	0	1	288	0	0	0	0	3	4,000	3	2,670	0	0	0	0	0	0
J-T No. 1 Loop	1.6	7	2	2	1	2	7	1	3	3	2	549	1	297	0	0	0	0	0	0	2	3,430	1	1,200	0	0	3	40	0	0
Childs Hill Road	23.06	7	2	2	1	2	141	86	25	30	2	7121	37	36,909	38	18,238	6	1,170	11	21,462	11	22,075	3	3,100	3	2,000	14	375	13	20
J-T No. 1 Loop-1	0.26	7	2	2	1	2	1	0	1	0	2	52	0	0	0	0	0	0	1	1,688	0	0	0	0	0	0	0	0	0	0
A-J Loop-1-2	0.31	7	3	2	1	1	2	1	1	0	3	66	0	0	1	51	0	0	0	0	0	0	1	800	0	0	0	0	0	0
A-J Loop	1.46	7	1	2	1	3	11	5	5	1	1	323	1	974	3	6,466	1	480	1	1,287	1	750	3	4,164	0	0	0	0	1	550
Bummer Lake Road	7.402	7	2	1	2	2	63	30	20	13	2	1295	9	7,042	19	18,618	2	857	11	19,576	7	15,122	2	1,480	6	1,750	6	2,595	2	1,230
J-T No. 1-1	0.14	7	2	1	2	2	1	0	1	0	2	18	0	0	0	0	0	0	1	1,200	0	0	0	0	0	0	0	0	0	0
Low Divide	3.64	7	2	2	1	2	30	15	7	8	2	949	0	0	11	4,792	3	954	1	2,250	5	7,200	1	600	0	0	3	200	6	230
Childs Hill-3-1-1-1	0.45	7	2	3	1	1	1	0	0	1	2	175	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	25	0	0

Table 12. cont.

Road/Route	Route Length (km)	Final Road Rank (1 - 12)	Route Risk Rank (1 - 3)	Route Threat Rank (1 - 3)	Site Risk Rank (1 - 3)	Site Threat Rank (1 - 3)	Total Number of Sites (#)	Total Crossings (#)	Total Landings (#)	Total Mass Wasting (#)	Road Fills Risk 1-3	Road Fills Volume cubic meters	Crossings High Risk #	Crossings High Risk Volume cubic meters	Crossings Moderate Risk #	Crossings Moderate Risk Volume cubic meters	Crossings Low Risk #	Crossings Low Risk Volume cubic meters	Landings High Risk #	Landings High Risk Volume cubic meters	Landings Moderate Risk #	Landings Moderate Risk Volume cubic meters	Landings Low Risk #	Landings Low Risk Volume cubic meters	Mass Wasting Sites High Risk #	Mass Wasting Sites High Risk Volume cubic meters	Mass Wasting Sites Moderate Risk #	Mass Wasting Sites Moderate Risk Volume cubic meters	Mass Wasting Sites Low Risk #	Mass Wasting Sites Low Risk Volume cubic meters
Cougar Ridge-1	0.18	7	2	1	1	3	2	1	1	0	2	20	0	0	1	171	0	0	0	0	0	0	1	1,950	0	0	0	0	0	0
Low Divide-1	0.24	7	3	3	1	0	1	0	0	1	3	96	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Low Divide-2	1.32	7	2	2	1	2	11	3	4	4	2	368	0	0	3	1,402	0	0	3	4,830	1	1,800	0	0	0	0	2	350	2	0
A-J	1.68	7	2	2	1	2	14	9	2	3	2	523	0	0	8	4,692	1	146	1	840	0	0	1	660	0	0	2	900	1	250
Cushing Spur	0.99	7	2	2	1	2	5	3	2	0	2	232	0	0	0	0	3	603	0	0	2	3,000	0	0	0	0	0	0	0	0
Go Back-1	0.38	7	3	2	1	1	2	0	2	0	3	88	0	0	0	0	0	0	1	810	0	0	1	300	0	0	0	0	0	0
Biltmore Spur-1	0.16	7	2	1	2	2	2	0	1	1	2	8	0	0	0	0	0	0	0	0	1	500	0	0	0	0	1	1,000	0	0
Export Spur-3	0.15	7	2	1	2	2	2	1	1	0	2	26	0	0	0	0	1	50	0	0	1	1,400	0	0	0	0	0	0	0	0
Biltmore Spur	1.62	7	2	2	1	2	13	2	7	4	2	449	0	0	1	195	1	121	0	0	1	500	6	2,724	0	0	3	1,040	1	350
Bense Trail-2	0.32	7	2	2	1	2	2	0	2	0	2	91	0	0	0	0	0	0	0	0	0	0	2	1,425	0	0	0	0	0	0
Bense Trail-1	0.22	7	2	2	1	2	1	0	1	0	2	72	0	0	0	0	0	0	0	0	1	1,395	0	0	0	0	0	0	0	0
Head Hunter-2	0.56	7	2	2	1	2	4	1	2	1	2	145	0	0	0	0	1	86	1	2,625	0	0	1	960	1	750	0	0	0	0
Head Hunter-3	0.95	7	2	2	1	2	6	4	1	1	2	234	0	0	3	1,163	1	97	0	0	1	2,100	0	0	1	250	0	0	0	0
End Haul-2	0.27	7	3	1	2	1	2	1	0	1	3	32	0	0	0	0	1	160	0	0	0	0	0	0	1	250	0	0	0	0
Ear Spur	1.39	7	1	2	2	2	10	2	3	5	1	334	2	466	0	0	0	0	1	1,080	1	1,462	1	1,200	1	250	3	0	1	0
Dry Lake-4	0.08	7	2	2	1	2	1	0	1	0	2	16	0	0	0	0	0	0	0	0	0	0	1	450	0	0	0	0	0	0
Dry Lake-2-1	0.18	7	2	2	1	2	1	0	1	0	2	36	0	0	0	0	0	0	0	0	1	1,210	0	0	0	0	0	0	0	0
Chipmunk Spur-1	0.65	7	2	3	1	1	5	2	1	2	2	239	0	0	1	347	1	394	0	0	0	0	1	800	0	0	2	195	0	0
Cushing-1	0.18	7	2	2	1	2	1	0	1	0	2	38	0	0	0	0	0	0	0	0	0	0	1	1,000	0	0	0	0	0	0
Idiot Knob	0.46	7	2	2	1	2	2	0	2	0	2	98	0	0	0	0	0	0	1	1,950	1	1,350	0	0	0	0	0	0	0	0
Cull Spur-1	0.34	7	2	2	1	2	1	0	1	0	2	66	0	0	0	0	0	0	0	0	1	2,250	0	0	0	0	0	0	0	0
Hound Dog Right	1.01	7	2	2	1	2	5	0	3	2	2	182	0	0	0	0	0	0	1	1,540	2	3,840	0	0	0	0	0	0	2	450
Howards Spur-Childs Hill Loop-1	0.15	7	2	2	1	2	1	0	1	0	2	31	0	0	0	0	0	0	0	0	1	800	0	0	0	0	0	0	0	0
Cougar Ridge-3	0.55	7	2	3	1	1	3	1	1	1	2	209	1	448	0	0	0	0	0	0	1	540	0	0	0	0	0	0	1	
Blowdown	2.67	7	2	2	1	2	16	7	4	5	2	898	3	4,485	1	197	3	1,092	1	1,500	3	4,500	0	0	2	5,000	1	150	2	200
Cougar Ridge Road	5.98	7	2	2	1	2	34	15	10	9	2	1177	2	1,698	11	3,051	2	3,731	3	8,300	5	8,700	2	2,200	0	0	4	45	5	180
First Gulch	2.56	7	1	2	2	2	26	15	7	4	1	597	5	5,222	9	4,658	1	201	0	0	3	5,800	4	5,260	1	250	1	100	2	0
Bucket Spur-1-1	0.29	7	2	1	2	2	5	2	2	1	2	46	1	134	1	263	0	0	0	0	0	0	2	1,800	0	0	0	0	1	0
A-J-2-1	0.12	7	3	1	1	2	1	0	1	0	3	19	0	0	0	0	0	0	0	0	0	0	1	450	0	0	0	0	0	0
A-J-2	0.38	7	3	2	1	1	2	2	0	0	3	90	0	0	1	720	1	80	0	0	0	0	0	0	0	0	0	0	0	0
Childs Hill-A-J Link	0.44	7	3	2	1	1	1	0	0	1	3	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	100
Hunter Fire-2	0.46	7	1	2	2	2	5	2	1	2	1	93	0	0	2	427	0	0	1	1,800	0	0	0	0	0	0	0	0	2	800
Childs Hill-4-1	0.27	7	2	1	2	2	2	1	0	1	2	27	0	0	1	504	0	0	0	0	0	0	0	0	1	1,500	0	0	0	0
BoyScout	1.69	7	2	2	1	2	13	5	4	4	2	400	0	0	1	668	4	1,646	1	2,250	3	5,655	0	0	0	0	3	200	1	0
Ray Smith Road	2.75	7	2	2	1	2	24	11	8	5	2	795	1	872	6	1,818	4	1,210	1	2,100	2	2,610	5	4,015	0	0	3	165	2	25
Wilbur Spur-5-1	0.21	7	3	1	1	2	2	0	1	1	3	23	0	0	0	0	0	0	0	0	1	1,800	0	0	0	0	0	0	1	0
1/2 Mile Spur	0.95	7	2	2	1	2	3	1	2	0	2	234	0	0	1	180	0	0	0	0	1	1,500	1	1,600	0	0	0	0	0	0
1st Switchback-1	0.56	7	2	2	1	2	4	1	1	2	2	176	0	0	1	108	0	0	0	0	1	2,700	0	0	0	0	2	400	0	0
Sec. 1-1E03 Road	0.49	7	3	2	1	1	3	3	0	0	3	96	1	211	2	530	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sec. 1-1	1.85	7	2	2	1	2	15	11	3	1	2	520	0	0	3	1,900	8	1,892	0	0	2	2,700	1	1,200	0	0	1	30	0	0
Sec. 1 Road	7.566	7	2	2	1	2	59	42	7	10	2	2159	6	3,914	14	8,071	22	7,176	0	0	3	3,660	4	4,305	5	2,250	4	225	1	0
Rocky Point Road	2.58	7	2	2	1	2	21	16	4	1	2	705	0	0	5	2,678	11	3,872	0	0	2	2,925	2	1,360	0	0	1	30	0	0
P-J Spur	3.88	7	2	2	1	2	33	13	13	7	2	706	4	1,581	4	1,153	5	1,038	5	12,450	5	11,425	3	5,250	0	0	1	0	6	50
1st Switchback-2-1	0.3	7	2	2	1	2	2	0	2	0	2	61	0	0	0	0	0	0	0	0	1	1,800	1	600	0	0	0	0	0	0
Sec. 5 Road-Extension Link	1.41	7	2	2	1	2	7	4	3	0	2	321	1	600	3	794	0	0	1	1,800	1	1,000	1	880	0	0	0	0	0	0
Rattlesnake	0.83	7	1	2	2	2	11	6	3	2	1	217	0	0	5	927	1	102	0	0	2	2,200	1	750	0	0	1	50	1	1,000
Prospect	0.7	7	3	2	1	1	2	1	0	1	3	235	0	0	1	808	0	0	0	0	0	0	0	0	0	0	1	90	0	0
3rd Switchback	0.87	7	1	2	2	2	12	6	2	4	1	158	2	1,196	2	601	1	250	0	0	2	4,748	0	0	1	250	0	0	2	1,450
P-Line-Martin Spur Link	1.48	7	2	2	1	2	9	4	4	1	2	268	1	274	2	3,153	1	60	0	0	4	6,300	0	0	0	0	0	0	1	0
P-Line	3.96	7	2	2	1	2	25	13	9	3	2	1157	2	6,251	10	6,706	1	20	1	1,800	6	12,300	2	2,625	0	0	1	2,000	2	10
P-J-B&B Spur Link	0.34	7	3	2	1	1	1	1	0	0	3	70	1	102	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P-J Spur-1	0.25	7	3	1	1	2	2	1	1	0	3	40	0	0	1	231	0	0	0	0	0	0	1	1,000	0	0	0	0	0	0
Rock Creek Road-6	0.64	7	1	2	2	2	7	4	2	1	1	195	1	1,116	2	308	1	325	1	1,200	0	0	1	750	0	0	1	300	0	0
Yellow Jacket	1.4	7	2	2	1	2	11	7	3	1	2	447	1	243	3	1,414	3	598	1	1,950	0	0	2	1,400	0	0	1	25	0	0
West Branch Road-5	0.24	7	2	2	1	2	3	1	1	1	2	50	0	0	1	104	0	0	0	0	0	0	1	1,200	0	0	0	0	1	0
Wilbur Spur-7-1	0.1	7	2	1	1	3	1	0	1	0	2	4	0	0	0	0	0	0	0	0	0	0	1	1,100	0	0	0	0	0	0
West Branch Road-3	0.82	7	1	1	2	3	8	4	4	0	1	140	1	482	1	120	2	270	2	2,580	2	5,100	0	0	0	0	0	0	0	0
Wilson Creek Road	4.02	7	2	2	1	2	22	11	4	7	2	1206	6	7,774	4	3,142	1	359	2	3,000	0	0	2	2,300	1	750	3	850	3	400
Violated Spur-1	0.16	7	2	1	1	3	1	0	1	0	2	26	0	0	0	0	0	0	0	0	1	1,620	0	0	0	0	0	0	0	0
Upper Visser	1.76	7	2	2	1	2	6	0	4	2	2	386	0	0	0	0	0	0	1	1,012	2	3,150	1	1,080	0	0	2	175	0	0
Upper First Gulch	5.223	7	2	2	1	2	32	10	12	10	2	1310	7	5,686	2	829	1	425	1	1,170	8	11,635	3	3,690	1	0	8	465	1	50
Wilbur Spur-3	0.33	7	2	2	1	2	3	0	3	0	2	84	0	0	0	0	0	0	0	0	1	1,170	2	1,200	0	0	0	0	0	0
Timberline-Jeep Road Link	1.29	7	3	2	1	1	6	4	1	1	3	409	4	380	0	0	0	0	0	0	1	900	0	0	1	250	0	0	0	0
Sec. 5 Extension-1-1	0.29	7	2	2	2	1	3	0	1	2	2	70	0	0	0	0	0	0	0	0	1	600	0	0	0	0	1		1	0
SW-40	0.79	7	2	3	1	1	3	0	1	2	2	350	0	0	0	0	0	0	0	0	0	0	1	800	0	0	1	0	1	0
Stringer Gap	1.31	7	2	2	1	2	8	3	3	2	2	293	1	374	1	112	1	205	3	8,550	0	0	0	0	0	0	1	200	1	0
Smoke House-4	0.29	7	2	2	1	2	4	2	1	1	2	91	0	0	0	0	2	431	0	0	1	650	0	0	0	0	0	0	1	100
Smoke House-1	0.26	7	2	2	1	2	2	0	1	1	2	64	0	0	0	0	0	0	0	0	1	1,950	0	0	0	0	0	0	1	0
Wilbur Spur	4.99	7	2	2	1	2	27	21	6	0	2	984	3	2,618	9	2,305	9	783	2	3,000	3	5,550	1	750	0	0	0	0	0	0
Wilbur Spur-2	0.63	7	2	2	1	2	6	3	3	0	2	176	0	0	2	586	1	155	0	0	1	900	2	2,000	0	0	0	0	0	0
Sec. 5 Road-Extension Link-2	0.32	7	2	2	1	2	2	1	1	0	2	96	0	0	0	0	1	594	0	0	0	0	1	990	0	0	0	0	0	0
Rock Creek Loop	0.4	7	2	2	1	2	4	2	1	1	2	104	0	0	1	630	1	250	0	0	1	1,650	0	0	0	0	1	25	0	0
Turwar	2.38	7	1	2	2	2	19	9	4	6	1	479	4	3,002	5	2,374	0	0	1	1,200	3	3,240	0	0	1	1,500	2	1,000	3	600
Martin Spur-1A	0.62	7	2	2	1	2	2	0	2	0	2	168	0	0	0	0	0	0	0	0	2	3,300	0	0	0	0	0	0	0	0
Mule Trail	1.79	7	2	2	1	2	12	6	3	3	2	395	0	0	4	2,647	2	898	2	6,300	0	0	0	0	1	750	1	0	1	0
Mountain Lion	1.04	7	2	2	1	2	5	3	2	0	2	310	0	0	2	1,010	1	524	0	0	0	0	2	2,400	0	0	0	0	0	0
Moratorium-3	0.55	7	2	2	1	2	4	1	2	1	2	107	0	0	1	714	0	0	0	0	0	0	2	1,300	0	0	0	0	1	40
Mule Trail-1A	0.27	7	2	1	2	2	3	0	1	2	2	40	0	0	0	0	0	0	0	0	0	0	1	1,275	0	0	2	35	0	0
Martin Spur-1	1.78	7	2	2	1	2	11	4	4	3	2	468	2	630	2	772	0	0	0	0	3	4,500	1	0	0	0	1	0	2	0
Bucket Spur-5	0.31	7	2	2	1	2	2	0	1	1	2	92	0	0	0	0	0	0	0	0	1	3,000	0	0	0	0	0	0	1	0
Mule Trail-1A-1	0.27	7	2	2	1	2	1	0	1	0	2	64	0	0	0	0	0	0	0	0	1	2,100	0	0	0	0	0	0	0	0
Martin Spur	2.79	7	2	2	1	2	16	8	6	2	2	597	3	9,297	4	3,540	1	1,917	0	0	5	9,030	1	1,365	0	0	2	0	0	0

Table 12. cont.

											Road Fills		Crossings						Landings						Mass Wasting Sites					
Road/Route	Route Length (km)	Final Road Rank (1 - 12)	Route Risk Rank (1 - 3)	Route Threat Rank (1 - 3)	Site Risk Rank (1 - 3)	Site Threat Rank (1 - 3)	Total Number of Sites (#)	Total Crossings (#)	Total Landings (#)	Total Mass Wasting (#)	Risk 1-3	Volume cubic meters	High Risk #	High Risk Volume cubic meters	Moderate Risk #	Moderate Risk Volume cubic meters	Low Risk #	Low Risk Volume cubic meters	High Risk #	High Risk Volume cubic meters	Moderate Risk #	Moderate Risk Volume cubic meters	Low Risk #	Low Risk Volume cubic meters	High Risk #	High Risk Volume cubic meters	Moderate Risk #	Moderate Risk Volume cubic meters	Low Risk #	Low Risk Volume cubic meters
Maple Spur-1	0.09	7	2	1	1	3	1	0	1	0	2	16	0	0	0	0	0	0	0	0	0	0	1	1,360	0	0	0	0	0	0
Old Lady	1.68	7	2	1	2	2	17	8	4	5	2	280	1	342	6	2,551	1	278	0	0	3	3,675	1	945	0	0	3	80	2	35
Park Spur	4.89	7	2	2	1	2	36	23	7	6	2	1075	8	10,245	10	6,522	5	1,816	0	0	5	8,985	2	2,210	1	250	2	0	3	25
Cougar Ridge-1A	0.62	6	3	1	1	1	4	1	2	1	3	84	0	0	1	225	0	0	0	0	2	1,420	0	0	0	0	0	0	2	0
Crossover	4.7	6	2	2	1	1	29	24	0	5	2	929	5	4,786	13	7,258	5	873	0	0	0	0	0	0	1	250	2	25	2	15
Cull Spur	1.96	6	1	2	1	2	12	3	4	5	1	486	1	476	2	1,207	0	0	0	0	2	3,300	2	2,640	0	0	3	25	2	0
Lower Spur Road	2.51	6	1	2	1	2	20	10	7	3	1	746	2	4,820	5	4,665	3	1,780	0	0	6	7,230	1	500	0	0	1	50	2	75
Sec. 5 Road-Extension Link-2-A	0.16	6	1	1	1	3	2	0	2	0	1	25	0	0	0	0	0	0	0	0	0	0	2	1,650	0	0	0	0	0	0
Madrone-2	0.09	6	2	1	1	2	1	0	1	0	2	14	0	0	0	0	0	0	0	0	0	0	1	770	0	0	0	0	0	0
Moratorium-1	0.18	6	3	1	2	0	3	0	0	3	3	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Mountain Lion-1	0.29	6	2	2	1	1	2	2	0	0	2	73	0	0	1	377	1	94	0	0	0	0	0	0	0	0	0	0	0	0
Smoke House-3A	0.51	6	2	2	1	1	2	0	1	1	2	102	0	0	0	0	0	0	0	0	1	900	0	0	0	0	0	0	1	4
Sec. 5 Loop	1.58	6	2	2	1	1	6	5	1	0	2	414	1	549	2	1,272	2	771	0	0	0	0	1	1,530	0	0	0	0	0	0
Wilbur Spur-7	0.72	6	2	1	1	2	3	0	2	1	2	76	0	0	0	0	0	0	0	0	1	2,400	1	1,200	0	0	1	0	0	0
Sec. 5 Extension-1	0.56	6	2	2	1	1	4	2	1	1	2	126	0	0	2	234	0	0	0	0	0	0	1	450	0	0	0	0	1	0
Dry Lake-2.5	0.11	6	2	2	2	0	1	0	0	1	2	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Sec. 5 Extension	1.844	6	1	2	1	2	9	5	4	0	1	349	0	0	2	279	3	453	0	0	3	6,975	1	1,000	0	0	0	0	0	0
Rock Creek Road-4	0.42	6	1	2	1	2	4	2	1	1	1	97	0	0	0	0	2	494	0	0	1	1,800	0	0	0	0	1		0	0
Wilbur Spur-4	0.66	6	2	2	1	1	2	1	0	1	2	129	0	0	0	0	1	60	0	0	0	0	0	0	1	250		0	0	0
Sec. 5 Road-Extension Link-1	0.55	6	1	2	1	2	3	1	2	0	1	129	0	0	1	256	0	0	1	900	0	0	1	720	0	0	0	0	0	0
West Branch Road	14.49	6	1	2	1	2	92	47	15	30	1	5039	31	25,550	11	8,461	1	432	5	11,025	10	18,600	0	0	0	0	19	1,463	12	423
Upper First Gulch-1	0.55	6	1	2	1	2	3	0	2	1	1	151	0	0	0	0	0	0	0	0	0	0	2	2,900	0	0	0	0	1	25
Martin Ext.	1.088	6	2	2	1	1	7	2	0	5	2	197	2	1,414	0	0	0	0	0	0	0	0	0	0	1	250	3	35	1	25
Turwar West	1.62	6	2	1	1	2	15	10	3	2	2	253	1	69	5	1,207	4	1,486	1	1,200	1	1,100	1	800	0	0	0	0	2	800
Low Divide-5	0.32	6	2	1	1	2	2	0	1	1	2	35	0	0	0	0	0	0	0	0	1	1,350	0	0	0	0	0	0	1	0
Martin Ext.-1	0.37	6	2	1	1	2	1	0	1	0	2	58	0	0	0	0	0	0	1	2,625	0	0	0	0	0	0	0	0	0	0
Wilson Creek Spur	1.21	6	1	2	1	2	9	5	1	3	1	377	1	365	2	458	2	455	0	0	1	1,500	0	0	1	1,500	1	50	1	5
West-East Link-1	0.16	6	2	2	1	1	1	1	0	0	2	51	0	0	1	240	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Teran-1-1	0.63	6	1	1	2	2	9	4	4	1	1	98	0	0	3	316	1	163	0	0	1	600	3	1,250	0	0	0	0	1	5
West Branch Road-Westside Spur Link	1.05	6	2	2	1	1	5	3	0	2	2	315	2	790	1	168	0	0	0	0	0	0	0	0	0	0	2	320	0	0
Dry Lake-5	0.14	6	2	1	2	1	1	0	1	0	2	17	0	0	0	0	0	0	1	375	0	0	0	0	0	0	0	0	0	0
Main Road	0.75	6	2	1	1	2	5	2	2	1	2	121	0	0	3	1,150	0	0	0	0	0	0	2	1,388	0	0	1	0	0	0
Park Spur-1-A	0.65	6	2	2	1	1	3	2	0	1	2	139	0	0	2	337	0	0	0	0	0	0	0	0	0	0	1	60	0	0
Moratorium	1.92	6	2	2	1	1	15	3	2	10	2	353	1	244	1	924	1	305	1	2,025	0	0	1	180	0	0	5	625	5	115
Smoke House-3A-1	0.16	6	2	1	1	2	1	0	1	0	2	16	0	0	0	0	0	0	0	0	1	680	0	0	0	0	0	0	0	0
Maple Spur	1.38	6	2	2	1	1	3	0	3	0	2	407	0	0	0	0	0	0	0	0	1	900	2	2,000	0	0	0	0	0	0
Smoke House-2	0.29	6	2	2	1	1	1	1	0	0	2	58	1	216	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Childs Hill-4	1	6	2	1	1	2	6	2	2	2	2	176	0	0	1	932	1	211	0	0	0	0	2	2,655	0	0	1	1,000	1	300
Bear Grass Road	0.67	6	1	2	1	2	6	4	2	0	1	156	0	0	4	502	0	0	0	0	2	2,550	0	0	0	0	0	0	0	0
Sec. 36	3.8	6	1	2	1	2	23	11	10	2	1	1122	7	4,781	3	356	1	160	2	1,800	4	4,140	4	2,840	0	0	2	0	0	0
Airport Spur-2	0.71	6	2	2	1	1	6	3	0	3	2	201	1	897	1	403	1	146	0	0	0	0	0	0	0	0	1	50	2	40
Head Hunter Loop-1	0.13	6	2	1	1	2	1	0	1	0	2	10	0	0	0	0	0	0	0	0	1	800	0	0	0	0	0	0	0	0
Bense Trail	2.88	6	1	2	1	2	9	1	8	0	1	527	0	0	1	58	0	0	0	0	1	3,218	7	7,212	0	0	0	0	0	0
Rattlesnake-1	0.42	6	2	2	1	1	4	3	0	1	2	140	0	0	3	650	0	0	0	0	0	0	0	0	0	0	0	0	1	600
Powder House Left	1.7	6	1	2	1	2	12	3	7	2	1	574	0	0	1	0	2	704	0	0	5	6,578	2	1,435	0	0	0	0	2	45
Porcupine	0.59	6	2	2	1	1	2	0	1	1	2	184	0	0	0	0	0	0	1	1,500	0	0	0	0	0	0	0	0	1	5
Blowdown East	1.69	6	1	2	1	2	9	3	4	2	1	410	1	602	1	438	1	934	0	0	1	1,500	3	1,748	0	0	2	18	0	0
Heat Spur-2	0.4	6	2	1	1	2	1	0	1	0	2	13	0	0	0	0	0	0	1	1,755	0	0	0	0	0	0	0	0	0	0
A-J-1	0.31	6	2	2	1	1	3	2	1	0	2	68	0	0	2	288	0	0	0	0	0	0	1	500	0	0	0	0	0	0
4th Switchback Loop	3.31	6	2	2	1	1	16	11	0	5	2	644	1	13	10	2,738	0	0	0	0	0	0	0	0	0	0	5	135	0	0
Mussel-1-A	0.16	6	2	1	1	2	1	0	1	0	2	1	0	0	0	0	0	0	0	0	0	0	1	1,000	0	0	0	0	0	0
No Name	2.32	6	2	2	1	1	9	8	1	0	2	647	1	458	4	1,766	3	1,006	0	0	1	2,400	0	0	0	0	0	0	0	0
P-J Spur-3	0.35	6	2	2	1	1	1	0	1	0	2	63	0	0	0	0	0	0	0	0	0	0	1	750	0	0	0	0	0	0
B&B Spur-1-1	0.39	6	2	1	1	2	1	0	1	0	2	62	0	0	0	0	0	0	0	0	1	2,700	0	0	0	0	0	0	0	0
Airport Road	3.04	6	2	2	1	1	9	5	2	2	2	925	1	1,072	3	2,044	1	179	0	0	2	2,850	0	0	2	1,000	0	0	0	0
Howards Spur-Childs Hill Loop	0.53	6	1	2	1	2	3	0	2	1	1	128	0	0	0	0	0	0	0	0	2	2,875	0	0	0	0	0	0	1	0
Park Spur-2	0.19	6	3	3	0	0	0	0	0	0	3	82	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Airport Road-1	0.34	6	2	2	1	1	1	0	1	0	2	95	0	0	0	0	0	0	0	0	0	0	1	960	0	0	0	0	0	0
Jane Creek Road-1-2	0.19	6	1	2	1	2	1	0	1	0	1	47	0	0	0	0	0	0	0	0	1	1,800	0	0	0	0	0	0	0	0
Mud Spur-2	0.14	6	1	2	1	2	1	0	1	0	1	32	0	0	0	0	0	0	0	0	1	780	0	0	0	0	0	0	0	0
Sec. 31-1	0.441	6	3	3	0	0	0	0	0	0	3	155	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
West Branch Road-Park Spur Link-1-2	0.53	6	1	2	1	2	1	0	1	0	1	142	0	0	0	0	0	0	1	2,100	0	0	0	0	0	0	0	0	0	0
Sec. 1-4	0.5	6	1	2	1	2	3	1	2	0	1	113	0	0	1	102	0	0	0	0	2	3,712	0	0	0	0	0	0	0	0
End Haul-1	0.46	6	1	2	1	2	4	0	2	2	1	122	0	0	0	0	0	0	1	760	0	0	1	1,000	0	0	1	250	1	100
Blowdown-1	0.25	6	2	1	1	2	1	0	1	0	2	40	0	0	0	0	0	0	0	0	1	1,800	0	0	0	0	0	0	0	0
Jeep Road	2.43	6	2	1	1	2	15	6	7	2	2	275	0	0	3	538	3	547	2	1,950	4	3,798	1	1,000	0	0	0	0	2	
2nd Switchback-1-1	0.16	6	2	1	1	2	1	0	1	0	2	3	0	0	0	0	0	0	0	0	1	1,200	0	0	0	0	0	0	0	0
Rocky Point-1	0.53	6	2	2	1	1	2	2	0	0	2	149	0	0	1	255	1	768	0	0	0	0	0	0	0	0	0	0	0	0
Rock Creek-Jeep North Link-1	0.61	6	3	1	1	1	1	0	1	0	3	27	0	0	0	0	0	0	1	750	0	0	0	0	0	0	0	0	0	0
Rock Creek Road-5	0.13	6	3	3	0	0	0	0	0	0	3	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Airport Spur	4.11	6	2	1	1	2	18	9	6	3	2	444	1	310	5	4,543	3	498	0	0	2	3,570	4	4,140	0	0	1	50	2	0
Airport Spur Loop-1	0.65	5	2	1	1	1	3	1	2	0	2	111	0	0	1	110	0	0	0	0	2	1,800	0	0	0	0	0	0	0	0
B&B Spur-1	0.81	5	1	2	1	1	5	3	2	0	1	219	1	410	2	368	0	0	0	0	0	0	2	900	0	0	0	0	0	0
West-East Link-1-1	0.05	5	3	2	0	0	0	0	0	0	3	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Airport Spur Loop-1-2	0.33	5	2	3	0	0	0	0	0	0	2	137	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Airport Road-1-1	0.15	5	3	2	0	0	0	0	0	0	3	36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Airport Spur Loop-2	0.39	5	2	1	1	1	1	1	0	0	2	26	0	0	0	0	1	130	0	0	0	0	0	0	0	0	0	0	0	0
4th Switchback-1	0.16	5	1	1	2	1	1	1	0	0	1	19	1	168	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bucket Spur-1	1.07	5	1	2	1	1	2	0	1	1	1	213	0	0	0	0	0	0	0	0	1	1,800	0	0	0	0	0	0	1	35
Wilbur Spur Loop-1	0.19	5	2	1	1	1	1	0	1	0	2	11	0	0	0	0	0	0	1	450	0	0	0	0	0	0	0	0	0	0
Airport Spur Loop	1.15	5	2	1	1	1	8	6	2	0	2	154	0	0	1	50	5	410	0	0	1	1,400	1	1,000	0	0	0	0	0	0
2nd Switchback-2	0.21	5	1	2	1	1	1	1	0	0	1	58	0	0	1	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 12. cont.

											Road Fills		Crossings						Landings						Mass Wasting Sites					
Road/Route	Route Length (km)	Final Road Rank (1 - 12)	Route Risk Rank (1 - 3)	Route Threat Rank (1 - 3)	Site Risk Rank (1 - 3)	Site Threat Rank (1 - 3)	Total Number of Sites (#)	Total Crossings (#)	Total Landings (#)	Total Mass Wasting (#)	Risk 1-3	Volume cubic meters	High Risk #	High Risk Volume cubic meters	Moderate Risk #	Moderate Risk Volume cubic meters	Low Risk #	Low Risk Volume cubic meters	High Risk #	High Risk Volume cubic meters	Moderate Risk #	Moderate Risk Volume cubic meters	Low Risk #	Low Risk Volume cubic meters	High Risk #	High Risk Volume cubic meters	Moderate Risk #	Moderate Risk Volume cubic meters	Low Risk #	Low Risk Volume cubic meters
A-J North-1	0.27	5	1	2	1	1	1	0	1	0	1	73	0	0	0	0	0	0	0	0	0	0	1	480	0	0	0	0	0	0
Bense Trail-1.1	0.23	5	1	2	1	1	1	0	1	0	1	44	0	0	0	0	0	0	0	0	0	0	1	532	0	0	0	0	0	0
West Side	0.25	5	1	2	1	1	1	1	0	0	1	49	0	0	1	243	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Westside Spur-1A	0.53	5	2	1	1	1	2	0	1	1	2	90	0	0	0	0	0	0	0	0	0	0	1	500	0	0	1	0	0	0
Jeep Road North-2	0.91	5	2	1	1	1	5	3	2	0	2	152	0	0	3	626	0	0	0	0	1	900	1	1,000	0	0	0	0	0	0
Wilbur Spur-1	0.08	5	3	2	0	0	0	0	0	0	3	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A-J North	1.42	5	1	2	1	1	12	5	1	6	1	398	1	450	3	1,726	1	298	1	700	0	0	0	0	0	0	5	455	1	150
Mud Spur-1	0.7	5	1	2	1	1	4	1	3	0	1	140	0	0	0	0	0	0	0	0	1	325	2	1,640	0	0	0	0	0	0
Hunter Fire-1	0.15	5	1	1	1	2	1	0	1	0	1	18	0	0	0	0	0	0	0	0	1	1,100	0	0	0	0	0	0	0	0
Rock Creek - Jeep North Link	0.96	5	1	2	1	1	5	5	0	0	1	194	1	103	4	337	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reservoir Road	1.35	5	1	2	1	1	5	5	0	0	1	384	0	0	4	2,083	1	336	0	0	0	0	0	0	0	0	0	0	0	0
Powderhouse Left-1	0.46	5	1	2	1	1	1	0	1	0	1	116	0	0	0	0	0	0	0	0	0	0	1	715	0	0	0	0	0	0
Powder House	0.7	5	1	2	1	1	3	3	0	0	1	214	1	698	2	699	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sec. 36-1	0.33	5	2	1	1	1	1	0	1	0	2	35	0	0	0	0	0	0	0	0	1	900	0	0	0	0	0	0	0	0
Mussel	1.02	5	1	2	1	1	2	1	1	0	1	224	0	0	0	0	1	308	0	0	1	1,688	0	0	0	0	0	0	0	0
Sec. 36-4	0.7	5	1	1	1	2	6	2	1	3	1	105	0	0	0	0	2	187	0	0	1	2,438	0	0	0	0	0	0	3	50
Mud Spur	1.66	5	1	2	1	1	4	2	2	0	1	345	1	694	1	242	0	0	0	0	0	0	2	1,350	0	0	0	0	0	0
Main Road-1	0.45	5	2	1	1	1	1	1	0	0	2	33	0	0	0	0	1	59	0	0	0	0	0	0	0	0	0	0	0	0
Madrone-1A	0.23	5	3	2	0	0	0	0	0	0	3	77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Madrone-1-1	0.08	5	3	2	0	0	0	0	0	0	3	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jeep Road North	2.08	5	2	1	1	1	6	4	2	0	2	246	0	0	4	400	0	0	0	0	2	2,000	0	0	0	0	0	0	0	0
Jane Creek Road-1	0.99	5	1	1	1	2	4	1	3	0	1	158	0	0	0	0	1	162	1	2,250	1	1,950	1	720	0	0	0	0	0	0
Picnic Road	2.43	5	2	1	1	1	17	11	0	6	2	184	1	77	8	1,909	1	34	0	0	0	0	0	0	3	1,750	3	360	0	0
Tanoak Saddle-1	0.2	5	3	2	0	0	0	0	0	0	3	56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
West Branch Road-Park Spur Link-1	0.87	5	1	2	1	1	2	1	0	1	1	221	0	0	0	0	1	466	0	0	0	0	0	0	0	0	0	0	1	0
West Branch Road Loop	0.59	5	1	2	1	1	2	2	0	0	1	131	0	0	1	160	1	170	0	0	0	0	0	0	0	0	0	0	0	0
Violated Spur-3	0.16	5	1	1	1	2	2	1	1	0	1	28	0	0	0	0	1	196	0	0	0	0	1	1,350	0	0	0	0	0	0
Turwar Spur-1	1.19	5	2	1	1	1	4	2	1	1	2	133	0	0	2	150	0	0	0	0	1	800	0	0	1	250	0	0	0	0
Timberline-1	0.29	5	3	2	0	0	0	0	0	0	3	68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sec. 1-A-J Link	0.61	5	2	1	1	1	2	0	1	1	2	61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	20	0	0
Teran-1	1.73	5	2	1	1	1	3	2	1	0	2	218	0	0	2	270	0	0	0	0	0	0	1	800	0	0	0	0	0	0
Mussel-1-1	0.05	5	3	2	0	0	0	0	0	0	3	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tanoak Saddle	1.61	5	1	2	1	1	7	0	5	2	1	508	0	0	0	0	0	0	0	0	1	900	4	3,570	0	0	2	180	0	0
Smoke House-5	1.24	5	2	1	1	1	9	4	3	2	2	200	3	1,316	0	0	1	82	0	0	1	720	2	1,065	0	0	1	0	1	0
Smoke House-1-1	0.08	5	3	2	0	0	0	0	0	0	3	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sheepshed-Reservoir Link	0.48	5	2	1	1	1	1	1	0	0	2	35	0	0	0	0	1	144	0	0	0	0	0	0	0	0	0	0	0	0
Sheepshed-6	1.2	5	1	2	1	1	1	1	0	0	1	289	0	0	1	230	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sheepshed-5	0.57	5	2	1	1	1	4	1	1	2	2	83	0	0	1	101	0	0	0	0	1	1,000	0	0	0	0	1	75	1	0
Teran-1-2	0.8	5	2	1	1	1	6	5	1	0	2	100	1	73	4	437	0	0	0	0	0	0	1	750	0	0	0	0	0	0
End Haul	1.36	5	1	2	1	1	9	4	2	3	1	319	0	0	1	392	0	0	0	0	1	700	1	600	0	0	2	580	1	16
Heat Spur	2.4	5	2	1	1	1	10	3	6	1	2	404	0	0	0	0	3	478	1	1,800	3	2,705	2	1,950	0	0	1	0	0	0
Go Back-2	0.2	5	1	1	1	2	1	0	1	0	1	33	0	0	0	0	0	0	0	0	0	0	1	770	0	0	0	0	0	0
Head Hunter Loop	0.47	5	3	2	0	0	0	0	0	0	3	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hamilton Road	5.85	5	1	2	1	1	22	21	0	1	1	1610	12	10,128	4	1,139	1	231	0	0	0	0	0	0	0	0	0	0	1	0
Export Spur	1.43	5	1	2	1	1	5	1	2	2	1	356	0	0	0	0	1	0	1	540	1	1,000	0	0	0	0	2	700	0	0
Dry Lake-2	1.58	5	1	2	1	1	3	2	1	0	1	460	0	0	2	720	0	0	0	0	1	350	0	0	0	0	0	0	0	0
Dry Lake	3.65	5	1	2	1	1	16	8	5	3	1	1036	3	1,858	5	1,789	0	0	3	3,908	0	0	2	2,025	0	0	0	0	3	0
Demonstration Forest Spur	1.02	5	2	1	1	1	3	1	0	2	2	108	0	0	0	0	1	105	0	0	0	0	0	0	0	0	0	0	1	40
Head Hunter	2.74	5	2	1	1	1	8	0	4	4	2	478	0	0	0	0	0	0	0	0	3	3,135	1	1,750	0	0	1	0	3	0
Chipmunk Spur 1-1	0.37	5	1	2	1	1	1	0	1	0	1	105	0	0	0	0	0	0	0	0	1	1,000	0	0	0	0	0	0	0	0
Hunter Fire Road	3.15	5	1	2	1	1	13	8	0	5	1	719	1	113	6	1,079	0	0	0	0	0	0	0	0	1	1,500	2	800	2	250
Childs Hill-3-1-1	0.54	5	2	1	1	1	3	1	2	0	2	66	1	120	0	0	0	0	1	825	0	0	1	280	0	0	0	0	0	0
Sheepshed-4-2	0.07	4	3	1	0	0	0	0	0	0	3	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock Creek-12Pct Spur Link	0.08	4	3	1	0	0	0	0	0	0	3	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sec. 1-3	0.12	4	3	1	0	0	0	0	0	0	3	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sec. 1-5	0.19	4	3	1	0	0	0	0	0	0	3	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wilbur Spur-6	0.39	4	3	1	0	0	0	0	0	0	3	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bense Trail-3	0.06	4	1	0	1	2	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	250	0	0	0	0	0	0
Bense Trail-4	0.55	4	1	1	1	1	1	0	1	0	1	10	0	0	0	0	0	0	0	0	1	1,050	0	0	0	0	0	0	0	0
Sec. 36-3	0.28	4	3	1	0	0	0	0	0	0	3	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ray Smith-Violated Spur Link	0.92	4	1	1	1	1	4	2	1	1	1	141	0	0	1	170	1	30	0	0	0	0	1	225	0	0	0	0	1	0
Sheepshed	1.57	4	1	1	1	1	2	0	0	2	1	224	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	30
Sec. 1-2	0.07	4	3	1	0	0	0	0	0	0	3	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Go Back Loop	0.07	4	3	1	0	0	0	0	0	0	3	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Go Back	0.83	4	1	1	1	1	4	2	1	1	1	84	1	170	0	0	1	148	0	0	0	0	1	540	0	0	0	0	1	0
Smoke House-6	0.09	4	3	1	0	0	0	0	0	0	3	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bucket Spur-1-2	0.25	4	1	1	1	1	1	1	0	0	1	38	0	0	0	0	1	64	0	0	0	0	0	0	0	0	0	0	0	0
West Branch Road-1	1.14	4	1	1	1	1	6	5	0	1	1	177	1	304	2	486	2	350	0	0	0	0	0	0	0	0	0	0	1	0
Sec. 5-1A	0.05	4	3	1	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jeep Road North-1	0.26	4	3	1	0	0	0	0	0	0	3	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Moratorium-2	0.23	4	2	2	0	0	0	0	0	0	2	55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mountain Lion-2	0.1	4	2	2	0	0	0	0	0	0	2	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P-Line Spur-1	0.698	4	1	1	1	1	2	0	2	0	1	72	0	0	0	0	0	0	0	0	0	0	2	2,000	0	0	0	0	0	0
A-J Loop-2	0.26	4	2	2	0	0	0	0	0	0	2	76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sec. 1-3-1	0.21	4	3	1	0	0	0	0	0	0	3	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4th Switchback Loop-1	0.14	4	2	2	0	0	0	0	0	0	2	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J-T No. 1 Loop-1-1	0.02	4	3	1	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hunter Fire Loop	0.7	4	2	0	1	1	1	0	1	0	2	0	0	0	0	0	0	0	0	0	1	750	0	0	0	0	0	0	0	0
Mule Trail-1	0.47	4	1	1	1	1	4	3	1	0	1	71	0	0	1	581	2	254	0	0	1	525	0	0	0	0	0	0	0	0
Head Hunter-1	0.59	4	1	1	1	1	4	2	0	2	1	98	1	144	1	142	0	0	0	0	0	0	0	0	0	0	1	20	1	50
Airport Spur-1	0.57	4	1	1	1	1	1	0	1	0	1	74	0	0	0	0	0	0	0	0	1	1,000	0	0	0	0	0	0	0	0
Bucket Spur-4	0.08	4	2	2	0	0	0	0	0	0	2	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 12. cont.

Road/Route	Route Length (km)	Final Road Rank (1 - 12)	Route Risk Rank (1 - 3)	Route Threat Rank (1 - 3)	Site Risk Rank (1 - 3)	Site Threat Rank (1 - 3)	Total Number of Sites (#)	Total Crossings (#)	Total Landings (#)	Total Mass Wasting (#)	Road Fills Risk 1-3	Road Fills Volume cubic meters	Crossings High Risk #	Crossings High Risk Volume cubic meters	Crossings Moderate Risk #	Crossings Moderate Risk Volume cubic meters	Crossings Low Risk #	Crossings Low Risk Volume cubic meters	Landings High Risk #	Landings High Risk Volume cubic meters	Landings Moderate Risk #	Landings Moderate Risk Volume cubic meters	Landings Low Risk #	Landings Low Risk Volume cubic meters	Mass Wasting Sites High Risk #	Mass Wasting Sites High Risk Volume cubic meters	Mass Wasting Sites Moderate Risk #	Mass Wasting Sites Moderate Risk Volume cubic meters	Mass Wasting Sites Low Risk #	Mass Wasting Sites Low Risk Volume cubic meters
Go Back Link	0.25	3	1	2	0	0	0	0	0	0	1	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hilton Spur-1	0.17	3	2	1	0	0	0	0	0	0	2	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hound Dog Left-1	0.41	3	2	1	0	0	0	0	0	0	2	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Airport Spur Loop-1-3	0.2	3	2	1	0	0	0	0	0	0	2	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Timberline-Jeep Road Link-2	0.14	3	2	1	0	0	0	0	0	0	2	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper First Gulch-3	0.87	3	2	1	0	0	0	0	0	0	2	85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hunter Fire Road Loop Connector-1	0.03	3	3	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Childs Hill-3-1	0.57	3	2	1	0	0	0	0	0	0	2	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Export Spur-1	0.14	3	1	2	0	0	0	0	0	0	1	44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ray Smith-Violated Spur Loop Link	0.05	3	3	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sec. 5 Road-Extension Link-3	0.17	3	2	1	0	0	0	0	0	0	2	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Powder House Left-1-1	0.22	3	2	1	0	0	0	0	0	0	2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bense Trail-4-1	0.63	3	2	1	0	0	0	0	0	0	2	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock Creek Road-2	0.14	3	2	1	0	0	0	0	0	0	2	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hamilton-Elkhorn Link	0.57	3	1	0	1	1	1	1	0	0	1	0	1	283	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Low Water Crossing	0.31	2	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
West Branch Road-4	0.48	2	1	1	0	0	0	0	0	0	1	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jane Creek Road-1-3	0.15	2	1	1	0	0	0	0	0	0	1	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hunter Fire Road Loop Connector-2	0.1	2	1	1	0	0	0	0	0	0	1	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P-J Spur-2	0.27	2	1	1	0	0	0	0	0	0	1	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chipmunk Spur 1-1-1	0.05	2	1	1	0	0	0	0	0	0	1	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sheepshed-1	0.2	2	1	1	0	0	0	0	0	0	1	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Low Divide-Crossover Link	0.81	2	1	1	0	0	0	0	0	0	1	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Airport Spur-5	0.1	2	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Substation Road	0.53	2	1	1	0	0	2	2	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Picnic - Hamilton Link	0.04	2	1	1	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/2 Mile Spur-1	0.29	2	1	1	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sec. 31-Turwar West Link	0.28	2	1	1	0	0	0	0	0	0	1	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hilton Spur	0.79	2	1	1	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sheepshed Link	0.51	2	1	1	0	0	0	0	0	0	1	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock Creek Road-3	0.07	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
West-East Link	0.69	1	1	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Low Water Crossing-1	0.15	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	468.418						3,278	1,451	981	807		122,811	454	395,474	690	349,428	307	88,489	205	374,229	506	809,370	270	261,686	153	127,500	376	39,115	278	17,384

Table 12 also lists the total number of sites per road and the number of each site type as well as the number and volume of road-streams crossings, landings, and mass wasting sites grouped by risk level. Road fill risk, although scored as small segments along each route, are collapsed to a single risk value and the corresponding volume shown represents the sum of all fill segments within a given route.

Road stream crossings represent the largest number of sites across all three risk categories with landings and mass wasting sites numbering fewer respectively. High risk road stream crossings number 454 and represent 395,474 m^3 of potential delivery. Less than half the number of high risk landing sites (205) represent 374,229 m^3 of potential sediment delivery to local streams. The high delivery rate for landing sites is a result of larger fill volumes coupled with the ability for failed landing fills to accumulate soil as they propagate down steep slopes. Mass wasting and road fill sites represent significantly smaller volumes of potential sediment delivery. This is due to the relatively small amount of potentially unstable fill that remains in most mass wasting sites and in the road fills.

We compared the final route ranking with our first hand knowledge of the road network within the Mill Creek Addition. We looked at the ranking score for roads which over the past eight years have demonstrated chronic or catastrophic problems. We expect to see those roads near the top of the ranking while we expect relatively trouble-free roads to be near the bottom. Our model output reflects known conditions quite well. Two of the most problematic roads are ranked 11 out of a possible 12, and 10 routes known to be problematic are ranked 9 and higher. Conversely, no known problematic roads appear in the lowest ranking routes.

Our results did illustrate one unanticipated result. Because the overall route risk and threat were calculated per unit length, short routes with any significant risk or threat were ranked high. Although unanticipated, this result is consistent with the results as a whole and serves to highlight the threat associated with short roads.

EXISTING CONDITIONS AND PROJECTS

ROAD MAINTENANCE

Currently, DPR maintains approximately 80 miles of critical circulation routes throughout the unit. Each year approximately 5% of those routes are brushed and regraded. Road maintenance crews patrol accessible roads during the winter season to correct drainage failures before they cause severe damage to the roadway. Drain and culvert cleaning are performed on a year-around basis and many sites are cleared more than once per year.

BRIDGES

Eleven bridges exist on the property (Plate 3). Ten bridges are dual railcar bridges resting on log crib abutments. The railcar bridges typically consist of two flatbed railcars welded together lengthwise. One bridge, we built in 2009, is an Akrow pre-fabricated truss bridge on loan from Redwood National Park. The bridge was installed to provide a detour around two railcar bridges that received exceptionally low capacity ratings from California Department of Transportation (Cal Trans) inspections in 2008.

All of the bridges within the Mill Creek Addition require routine inspections conducted by Cal Trans to comply with Federal Highway Safety standards. Since 2004, all of the bridges have been inspected by the Cal Trans, and 6 have been identified as “scour critical” bridges. This designation required the development of a Plan of Action (POA) which spells out the steps and timeline to be implemented to resolve the scour issues. Six Plans of Action were developed in 2009 for the scour critical bridges (Appendix D). The Plans call for replacement of the bridges, interim repairs to the rock slope protection beneath the bridges, and routine monitoring until the bridges can be rebuilt. The remaining 5 bridges have been designated “scour unknown,” which requires development of a Work Plan (WP). A Work Plan outlines the steps and timeline required to inspect the bridge and to conduct scour surveys. Results of scour surveys will determine whether the bridges are scour critical requiring Plans of Action. Work

Plans are now under development at the DPR Northern Service Center and are expected to be complete by fall 2010.

Landscape Stabilization and Erosion Prevention Plan

Immediately prior to the State's acquisition of the property, Stimpson Timber Company representatives conducted several orientations to acquaint State Park resource managers with the property and the road system. During these orientations, we became familiar with a group of roads collectively referred to as "maintenance-free." These roads had been partially decommissioned and were no longer part of the transportation network. Stimpson representatives told us that approximately 60 miles of maintenance-free roads were distributed across the ownership.

As part of our orientation, we were shown the treatment these roads had received and maps depicting their location on the property. Treatments were generally uniform on all the roads and consisted of partial removal of stream crossing fill and large cross drains (tank traps) that segmented road and ditch drainage.

During the first winter following the acquisition (2002/2003), we observed higher rates of failure on the maintenance-free roads than on roads that were open and monitored. Further investigation revealed numerous critical erosion sites and pointed to several flaws in the treatment method that had been used to treat the maintenance-free roads. As a result, we developed the Landscape Stabilization and Erosion Prevention Plan (LSEP) to immediately address and stabilize the maintenance-free roads.

Maintenance-Free Stream crossings

The Stimpson Timber Company had conducted treatment of stream crossings by removing a portion of the crossing fill, usually down to within a meter or less of the culvert and leaving the culvert in place. Many crossings did not have a culvert, and at those sites, Stimpson had removed fill down to an arbitrary depth. With a few exceptions, none of the crossings had been excavated down to natural stream grade. The timber company had pushed fill excavated from the crossings into large piles on one or both sides of the treatment site. In some cases where there was limited space, fill piles had been perched directly above the crossing site. The rationale for the treatment, according to Stimpson representatives, had been to reduce the risk of diversion and reduce the volume of erodible fill should the crossing have failed in the future. By leaving culverts in place, they had hoped to be able to reestablish the road with limited permitting requirements. What Stimpson did not understand at the time was that this treatment would accelerate the failure rate of the sites yielding significant quantities of sediment to the affected streams.

To date, these crossings continue to erode at an accelerated rate compared to the non-maintenance-free roads. Erosion occurs as chronic scour of the fill where flow overtops the fill, and as headcuts migrate upstream from the downstream end of the crossing (Figure 13).

Figure 13. Chronic erosion of stream crossing fill on a partially removed (maintenance-free) crossing.

At several sites, catastrophic failure has occurred as high flow overwhelmed the culvert and scoured large volumes of fill from the sites (Figure 14). By removing the crossing fill to a level that increases the likelihood of overtopping, the crossings have proven to be far less stable than if they had been left intact. In addition, the rationale to leave the culverts in place for future re-entry was flawed; by definition, these maintenance-free roads were to remain decommissioned for several decades and by then, the culverts would have either failed or replacement would likely be required under future THP review.

Figure 14. This partially removed stream crossing has subsequently failed and delivered sediment to the stream channel because of the ineffective method used to convert the crossing to maintenance-free status.

Maintenance-Free Cross Drains

The Stimpson Timber Company had installed large cross drains placed at regular intervals on most maintenance-free roads. Some segments with very low grades had not been drained or were drained less frequently. The cross drains are large “tank trap” type features that extend from the inboard ditch to the outboard hinge of the road. These features had served to eliminate vehicle access and to segment road and ditch drainage. The cross drains, in theory, trap runoff from the roadbed, the hillslope and shallow groundwater and deliver it to the slope below.

Because the cross drains had been placed at regularly spaced intervals, as opposed to with the natural drainage topography, they most often drained onto hillslope areas that had never received stream flow. These areas can experience gullying and mass wasting as concentrated runoff is directed downslope. Segmentation of road drainage can reduce large accumulations of runoff but measurements taken at several locations have noted discharges of up to 20 gallons per minute from a single cross drain during a moderate storm. The result of high flow and unnatural placement of cross drains can be detrimental to the stability of the landscape. B&B Spur, for example, experienced a large landslide in January 2003 where a cross drain directed inboard ditch runoff and spring flow onto the slope below.

Maintenance-Free Road Monitoring

The generally good performance of the road network within the Mill Creek Addition is due in large part to the level of monitoring and pro-active maintenance that has occurred under prior ownerships. When the treatment was applied to the maintenance-free roads, it eliminated the ability to monitor the condition of the road and its structures. This has lead to failure of numerous sites that may have been averted had the sites received monitoring and necessary maintenance. The lack of monitoring coupled with poor decommissioning treatment has resulted in a group of roads that are critically unstable and in need of immediate additional treatment.

Assessment of LSEP Roads

We conducted the road assessment of maintenance-free roads as part of the property-wide road assessment. Geomorphic data collected on maintenance-free roads was the same as for other roads within the acquisition. The second team did not assess the maintenance-free roads for upgrade and maintenance requirements because they had already been partially decommissioned and were not going to be redeveloped into usable roads.

We assessed 175 km (109 mi) of maintenance-free roads as part of our inventory, more than twice the number originally estimated by Stimpson Timber Company. The under-estimation on their part was probably a result of work that had occurred in the field and was never reported back to their GIS or property management staff. Based on our early conversations with Stimpson representatives, it was common for road crews to initiate work on roads that were known to be "surplus."

LSEP Project Grouping

We developed the LSEP Plan to treat the 175 km (109 mi) of maintenance-free roads ahead of any other road removal work within the Addition (Plate 3). This was done for two reasons: 1) as a group, the LSEP roads were failing at a much higher rate than the open road network and could not be monitored or repaired to reduce the failure rate, and 2) roads to be removed within the open road network (non-LSEP) would have had to be identified through a comprehensive planning process that includes a transportation element. LSEP roads are grouped at the project planning level to minimize the distance between and cluster treatment roads. When grouping the roads, we consider the location on the property, logistics for treatment, and the potential for cumulative effects. By grouping the LSEP roads into project units, the geographic scope of each project group is confined, reducing the cost for project-level environmental surveys and equipment operations. Additionally, implementing project groups across the property within separate subwatersheds minimizes potential cumulative effects over time.

LSEP Roads removed to date

The LSEP Plan was begun in summer 2004 and work has continued each season with the amount of road removal fluctuating based on available funding. At the end of the 2009 summer season, 66 km (41 mi) of road had been removed with grant funding from California Department of Fish and Game, DPR, Save-the-Redwoods-League, State Water Resources Control Board and the California Wildlife Conservation Board (Plate 3). It is our intent to amend this Road Assessment Report at regular intervals to include current road removal status under the LSEP Plan and any other significant project work or information pertaining to the road system at the Mill Creek Addition.

High Risk Culvert Upgrades

The 2002 to 2005 road inventory identified 811 culvert stream crossings throughout the Mill Creek Addition. Recommendations in the IMR (2002) called for "all road-stream crossings with high and very high erosion risk to be treated prior to the next large storm event to minimize the potential for significant impacts to aquatic resources." Therefore, we developed a culvert upgrade project to address a subset (phased projects) of 169 culverts in need of upgrading as soon as possible.

In addition to preventing chronic erosion and possible catastrophic failure and sediment delivery to streams, properly engineered road-stream crossings will reduce the amount of maintenance required over time. Replacement culverts are sized to convey discharge greater than the 100-year flow and to pass associated wood and bedload material. The approach roads to the crossings are reengineered to disconnect road drainage from the steam, and fail-safe dips are installed where necessary to prevent stream diversion.

To date, 9 critically undersized or failed culverts have been replaced since 2002 with grant funding from the State Coastal Conservancy and FEMA. A recently failed culvert on Rock Creek Road is scheduled to be replaced with a structural pipe arch in 2011 with grant funds from Redwood National Park.

Serpentinitic Soil Areas

Serpentinitic soils affect about 21 km (13 mi) of roads; 14 km (9 mi) traverse serpentinitic terrain and 7 km (4 mi) have base rock excavated from serpentinite quarries but are otherwise built outside of serpentinitic terrain. The serpentinitic soils are restricted to the east side of the Mill Creek Addition, near the Coast Range Thrust Fault (Figure 15). Asbestos bearing serpentinic soil presents a unique health hazard as inhalation of related air borne dust can cause lung cancer. Road restoration in serptentinitic terrain and/or driving at excessive speeds on roads surfaced with serpentinitic rock can generate this dust. Operational methods to minimize exposure to restoration workers are in place. Methods for informing the public and addressing worker safety will be evaluated in future planning efforts including a roads and trail management plan.

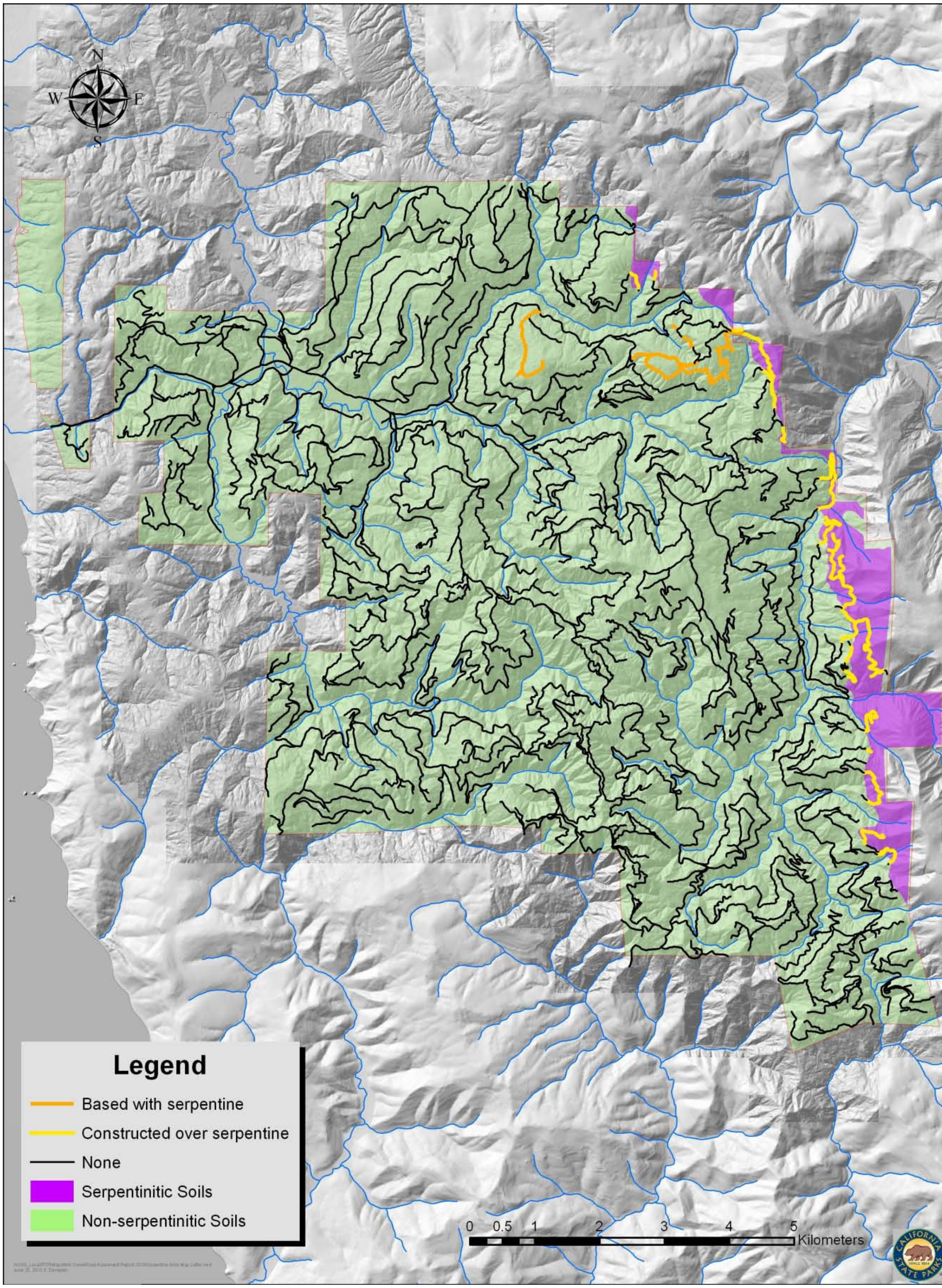

Figure 15. Distribution of serpentinitic soils.

TREATMENT OPTIONS FOR ROADS

Current and future planning efforts will determine what treatments will be considered for the roads remaining on the property following the LSEP program. The roads will generally fall into two categories: nonessential roads that will be removed and essential roads that will be upgraded and maintained as part of the permanent park infrastructure. Roads identified for removal may be completely removed or converted to trail. Some roads may receive a combination of removal treatments: converting some portions to trail while removing other portions completely and building a new trail to reroute unsustainable sections. Roads identified for upgrades (re-engineering, storm proofing) will receive a variety of treatments including reshaping the roadbed, eliminating the inboard ditch, hardening the driving surface, upgrading culvert crossing sites and rerouting where necessary. Road abandonment may be considered for some roads where current and future conditions along the road are certain to remain stable and no significant threat exists.

ECONOMIC ANALYSIS

A seasonal storm patrol crew will continue to operate on a seasonal basis to clear culverts, ditches and other drainage structures. Seasonal storm patrols are an essential, cost effective way to prevent road related sedimentation from the existing road network prior to upgrade. Currently, a four person crew with heavy equipment operates from November 1st though April 30th each year. Annual support costs for the storm patrol crew are $80,000.

It is estimated that approximately 128 km [80 mi] of road will remain operational on the property for public access and administrative purposes in the long-term. Most of these roads are poorly designed, with problematic drainage, inboard ditches and undersized culvert road crossings and cross drains. Road upgrades will improve conveyance at road stream crossings, improve road surface drainage, reduce connectivity between roads and streams and stabilize road fills. Costs for road upgrades are estimated to be $15 million in 2008 dollars. Annual maintenance costs for 128 km [80 mi] of retained road are estimated to be $900,000 in their present condition. Once upgraded, maintenance costs will be reduced to an estimated $673,000 annually, which includes costs for annual grading, roadside brushing, and cyclic replacement of drainage structures.

The property contains a surplus road network estimated to be 320 km [199 mi]. Over the next several decades road rehabilitation will take the form of road removal or conversion to trail. Costs associated with removing or converting roads to trails are estimated to be $25 to $35 million depending primarily on the price of fuel which has the greatest effect on the cost of road work. Although road removal and conversion can be costly to implement, over a relatively short term, removing roads will save money. We have tracked road removal project costs since 2004 and have compared those costs with maintenance costs for the same roads if left in place. On average annual maintenance costs required to keep the road stable will exceed the cost to remove the road in 9 years using constant dollars. Using a 3% inflation rate the cost recovery period drops to 7 years.

FUTURE PLANNING EFFORTS

Any future road or trail development will be evaluated as part of the Roads and Trail Management Plan for the Addition. Road and trail planning provides an opportunity for public involvement to help define the vision for a road and trail system. In the Mill Creek Addition a dense road network already exists so it is unlikely that an extensive road construction effort will occur. However, no single track trails exist within the park and many opportunities exist for access and circulation. Although a few public circulation routes have been established by various user groups, none are currently classified as recreational trails. The routes follow abandoned or active road beds, some of which have become overgrown making them appear as single-track trails. The routes are currently maintained as trails by various user groups and may be incorporated into a park-wide trail system when the Roads and Trail Management Plan is developed.

DISCUSSION

Our road inventory and assessment represents eight years of road data collection, management, and analysis. During this time we developed techniques for storing and cataloguing road data that enabled us to quickly and accurately query the large dataset. When we set out to design our inventory and assessment protocol we had three primary goals in mind: objectivity, repeatability, and it had to be dynamic and updateable over time. We knew that our initial inventory would be the first look at a road system that will likely be changing dramatically over the next several decades. With those changes, we concluded, there would be a need to continuously update the inventory and perhaps reassess the road system. We believed that over time many different managers and technicians would be collecting and managing the data, so objectivity was a cornerstone of the data collection effort and the subsequent analysis. Repeatability also played an important role as we set up our protocols. We aimed to reduce the inefficiency associated with "reinventing the wheel" so we structured the data collection and modeling to be simple and repeatable with little need for extensive training. Lastly, we knew that the road system would be changing over time. Deterioration and catastrophic failure of the roads and sites, upgrading and routine maintenance of roads, and removal or conversion would result in changes to the road characteristics and the data that describe them. Also, the questions we might ask of the data could change over time so the protocols had to allow for change without starting from scratch. We believe we have succeeded in accomplishing our design goals, making this inventory and assessment program usable by other land managers.

As the on-the-ground road management program took shape on the newly acquired property, our GIS-based road inventory was continuously updated and our assessment techniques were refined. As data gaps were discovered we were able to deploy additional field staff to collect missing or inaccurate data. Between 2005 and 2007 a property-wide LiDAR acquisition project was implemented, providing us with a much improved resource for our assessment. With the acquisition of the LiDAR digital elevation model in 2007, we made the last major revision to our data structure and began developing models for analysis and prioritization of the roads and road related sites within the Mill Creek Addition.

Developing analytic techniques that produced meaningful and appropriate results was challenging. Output from raster-based processing had to be integrated with point and line event tables. Our assessment often related the relative proximity of specific features of interest where physical processes operate in a topographic context. In addition, we used numerous parameters from 4 different site types to assign scores used to rank sites and roads. Scores were then normalized on two different scales to equally weight the components of the roads. Rankings were produced using the final scores compared to known field conditions and adjusted as necessary to reflect actual conditions on the ground. Lastly, we automated the process as much as possible to make updates manageable and repeatable. Now complete, the entire analysis can be re-run in 24 automated steps as data is updated.

Needless to say, modeling and process development involved a lot of trial and error. Output from model runs at each step had to be carefully reviewed to look for inconsistencies and errors. An error not detected in one of the early steps often would propagate and compound as it moved through the process. Fortunately, reviewing the data at each step allowed us to evaluate the accuracy and validity of the output along the way making us confident that the end results are equally accurate and valid.

Our inventory and assessment results provide a tool for evaluating the roads within the Mill Creek Addition across a variety of applications. Prioritization of road treatments, whether road upgrading, conversion to trail, or road removal will enable us to make informed decisions in future management planning and project development. Individual site assessment will guide annual maintenance cycles and improve the sustainability of permanent roads within the Addition. As additional resource data such as vegetation series or wildlife habitat become available they can be integrated into our process to produce a comprehensive road management tool.

CRITICAL REVIEW

Looking back on our effort, we have identified some issues that we would improve were we to apply this to another road system. We provide this critical review so anyone wishing to develop a similar process will have the benefit of our hindsight.

As we collected the inventory data between 2002 and 2005 we found that some of the routes were incomplete or spatially inaccurate. In those cases we continued to collect data and used a Rola-tape to measure distance rather than revising the map tile in the GIS and remaining consistent with the existing measuring method. We did this to save time because revisions would require time in the office to add or adjust the linework, reroute the line, reproduce the mapping tile, and revisit the field and repeat the road inventory. Looking back we would now agree that revising the GIS would have been a better choice. Although it represents only 1% of the total road network, the lack of spatial accuracy does have an effect on the route score.

When we set up the initial data collection field sheets, we endeavored to include all anticipated characteristic and configurations. Unfortunately we encountered some unanticipated scenarios and had to "shoehorn" them into our existing data scheme. For example, some crossing sites had two culvert pipes so when we input the data the database created two sites rather than one site with two pipes. While not inaccurate, small inconsistencies in the data did result in many hours of tedious data sleuthing to find the source of miscounts in the model output. Again, these sites represent a small fraction (35 sites out of 3,682) of the total so the effort was manageable. Although it is not possible to predict all scenarios or configurations at the start of such an effort, once they are identified an evaluation of how they might affect modeling should be considered early on.

Although the LiDAR-based DEM represents a notable improvement in our understanding of the geomorphic setting within the Mill Creek Addition the underlying data has demonstrated significant shortcomings. The problems have so far limited our ability to use the 1-meter resolution DEM to run some tools and models through ARCMAP such as the watershed tool and the SINMAP model. The source of the problems with the data are numerous and too complex to discuss here but appears to be a combination of poor data acquisition and delivery of a "cleaned" dataset to the clients. As future data acquisition projects are planned, it will be essential to specify the content and form of the data to be provided by the vendor.

ADAPTIVE MANAGEMENT

Monitoring the success of road rehabilitation projects is key to identifying mistakes and avoiding them in the future, as well as learning what techniques worked well. We employ site specific monitoring including permanent photo points and qualitative surveys. We visit project sites during the winter/spring following treatment to evaluate individual sites for post-treatment erosion. If significant erosion exists, we determine the likely cause and evaluate whether it could have been avoided through use of a better technique or site design. We also monitor revegetation efforts for three years post-planting to determine success rates of our nursery plants.

Backcountry road management remains an evolving practice and future projects will be implemented using the most current techniques through a comprehensive adaptive management program. The North Coast Redwoods District continues to be a leader in development of cost effective techniques for road removal, conversion and upgrade. Lessons learned from our own activities and information gathered from other practitioners will be incorporated into our program as we move forward.

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GLOSSARY

ABANDONED ROAD

Road lacks obvious maintenance. Ditches may lack cleaning and vegetation may be encroaching the road and road surface. Culverts may be partially or completely plugged, badly rusted or crushed. The road is typically not drivable without improvements.

ABUTMENT

Foundation at either extreme end of a bridge that supports the stringers.

ACTIVE DIVERSION

A condition originating at a stream crossing, where stream flow overtops the road and flows down a road, inboard ditch, or skid trail instead of re-entering its natural watercourse. Stream diversions can cause significant gully and landslide erosion.

ALIGNMENT

The area affected by a road or trail including the fill slopes, road bench, and cut bank. Also a linear representation of features on a map such as a stream channel.

AGGRADE

Refers to the filling of a stream channel with sediment. This usually happens when the supply of sediment is greater than the stream is transporting. Compare to “degrade” and “graded stream”.

ARMORED

A feature that is covered with coarse rock to reduce surface erosion. Some armored structures may also include geotextile fabric as a baking for the coarse rock. Armored features can sustain flow across their surface without experiencing significant erosion or incision.

ATTRIBUTES

The various physical characteristics of a site. Attributes are the basic physical elements that define the site and are used to generate site scores.

BERM

A general term used to describe a constructed mound of earth typically long and narrow in shape. Berms can form a barrier along the edges of roads and can confine runoff along a road.

BARRIER BERM

A large earth or rock berm pushed up across a road to inhibit vehicular traffic. Barrier berms are often referred to as "tank traps".

BREAK-IN-SLOPE

At the convex break in slope. The slope above is gentler than the slopes below.

BRIDGE

A structure, including supports, erected over a depression or stream, and having a deck for carrying traffic. May have railings.

CLIMBING TURN

A turn that is constructed on a slope of 30 per cent or less when measured between the exterior boundaries of the turn and changes the direction of the road 120 - 180 degrees.

COST-EFFECTIVENESS

The cost per unit volume of sediment to prevent it from entering a stream, commonly expressed as cost per cubic yard "saved".

CRITICAL DIP

A broad rolling dip located at a stream crossing that returns streamflow to its natural watercourse if the crossing culvert plugs and streamflow overtops the road. It is a broad, gentle, permanent dip (low spot) across the road surface that allows passage of vehicles, logging trucks and standard logging equipment. They are generally maintenance-free.

CROSS DRAIN CULVERT

A culvert installed just below road grade that intercepts and conveys water from the inboard ditch to the outside embankment edge of the road. Typically placed at frequent intervals (150-300 feet) to disconnect and drain ditch flow. Compare to open cross drain.

CULVERT

A metal, plastic or concrete pipe set below the road surface. Is used to pass streamflow from upslope of the road to downslope of the road. Culverts can also be placed to drain springs and inboard ditch flow from the inside to the outside of the road, beyond the outer edge of the road fill, or fillslope.

CUTBANK

The portion of the hillslope on the upslope side of the roadbed that has been cut into bedrock or native soil.

CUTBENCH

The portion of a roadbed that has been cut into bedrock or native soil. Compare with embankment.

DECOMMISSION

See road decommissioning.

DEGRADE

Refers to the erosion of a stream channel. This usually happens when the supply of sediment is less than the amount the stream is transporting. Compare to "aggrade" and "graded stream".

DELIVERY

The amount, expressed as a percentage or ratio of material (sediment) that is delivered to a stream from a site. Also labeled as Sediment Delivery Ratio (SDR). The percentage is an objective estimation based on site conditions including but not limited to slope steepness, ground water emergence, road drainage, fill materials, adjacent instability, and vegetative cover.

DIVERSION POTENTIAL

Normally associated with stream crossings that have continuous road grades through the crossing which allow a stream to flow down a road if the crossing culvert plugs and streamflow overtops the road. The crossing is not the low point of the road as the road passes over the stream channel. Existing diversion potentials can be corrected by installing well-constructed critical dips at the crossing so that streamflow returns immediately to its stream channel if diversion occurs. Proper crossing construction (grade-breaks, critical dips, minimum fill, properly sized culverts) can prevent diversions.

DOWN DRAIN

Normally culvert material bolted and secured to the culvert outlet that conveys water down a fillslope to undisturbed ground to prevent surface erosion. Downspouts may be either full-round or half-round.

DRAIN LENS

A sub-grade drain structure composed of coarse rock extending from the inboard edge of the road to the outboard edge. The coarse rock is covered by geotextile fabric and then covered by road base aggregate. Drain lenses are often used to drain seeps or springs under a road without the need for a culvert cross drain.

DRAIN SWALE

Topographic dip in the road that is matched to a minor natural swale upslope of the road. Drain swales are designed to carry only minor flows during runoff events.

DUFF

A layer of decaying organic plant material deposited on the surface of the ground principally comprised of leaves, needles, woody debris, and humus.

EMBANKMENT

Fill excavated from the cutbench and used to construct the outboard road bench. This is often referred to as the fill slope, outboard fill material, or sidecast material.

ENDHAULING

Transportation of excavated material to a stable storage location using a dump truck.

ENTRENCHED

Describes a road or trail that is below the grade of the surrounding ground surface. Roadbed is lower in center than on both sides. Rilling or gullies can occur if a long section of road is entrenched with no outlet. Because ground level is higher on both sides, drainage flows down the road or trail or inside ditch.

ENERGY DISSIPATER

Material such as rock riprap or a structure made of logs, metal pipe, or poured concrete that is used to reduce the energy of flowing water below culvert outlets or dips.

EROSION VOLUME

The amount of material that could erode from a site. It is expressed in cubic meters. It is used with delivery to calculate yield.

EXTREME EROSION POTENTIAL

A relative ranking of the capability of a site to erode significantly more volume than is estimated in the feature's dimensions alone (erosion volume). Expressed as "high", "medium" or "low." A high potential for extreme erosion is a worst case scenario that identifies the capability of an unusually large magnitude failure during the next major storm. An example might be a stream diversion that would end up draining onto a landing that may catastrophically fail, scouring hillslopes or channels below. Compare to future erosion potential.

FALL-LINE

An imaginary line on a sloped surface that follows the steepest angle. You can think of the fall-line as the line that would be made by a marble rolling down the slope.

FILL

Material used to construct roads and related structure. Fill can include soil, rock, large organic debris, and man-made objects such as cars, etc..

FILLSLOPE

Area of excavated material cast on the downslope side of road cut (also called embankment).

FORD

A road-stream crossing that requires a vehicle to drive across and through a stream channel bed. There is no fill or drainage structure in a ford crossing and can be armored to stabilize the roadbed through the stream.

FUTURE DELIVERABLE VOLUME

This volume represents total future sediment that will likely be delivered to a stream channel from the site during the next major storm. It is calculated by multiplying the erosion volume at a site by the delivery percentage (e.g. 800 m^3 erosion volume x 80% delivery = 640 m^3 future deliverable volume). Also called "site potential yield".

FUTURE EROSION POTENTIAL

The subjective ranking of the likelihood of erosion at a site during the next major storm. Expressed as "high", "medium" or "low." Compare to extreme erosion potential.

GEOMORPHOLOGY

The study of the earth's surface and the processes that shape it. Geomorphology is closely related to geology.

GEOMORPHOLOGIST

A person who studies geomorphology.

GRADE

The natural, proposed, or planned ground surface. Usually grade is set to match the surrounding topography.

GRADED STREAM

A stream that over a long period of time can move as much sediment as is supplied to it. Compare to "aggrade" and "degrade".

GRADIENT

The measurement of the angle along the length of a road or a stream. This term is often confused with grade (see definition).

GULLY

A steeply sided channel caused by erosion from surface runoff or a diverted stream channel. Gullies can usually be identified by their location away from natural stream valleys. Gullies are at least 1 square foot in cross-sectional area. Compare with rill.

HEADWALL

A steep slope or precipice rising at the head of a valley or swale, characterized by broad steep converging slopes. They are generally unchannelized.

HUMBOLDT CROSSING

A stream crossing constructed with logs set parallel to the stream channel and covered with fill. Stream flow passes through the logs under the fill.

HYDROLOGY

The science of water found on the surface of the earth and in the atmosphere. This term is often confused with hydrogeology, which is the science of groundwater.

INBOARD

The side of a road or other slope feature that is on the inside or close to the slope - toward the upslope direction.

INBOARD DITCH

a drainage ditch cut along the inboard edge of the road that collects and conveys road surface runoff, slope runoff, small streams and spring discharge. Inboard ditches convey runoff to the next cross drain culvert or stream crossing down the road.

INSLOPE

Where the road bed is sloped downward toward the inboard side.

LANDING

A location where logs are collected and loaded onto trucks for transport. Landings are typically located along haul roads and are seen as a “wide spot” in the road. Landings are most often constructed with typical cut/fill techniques but have a large embankment fill volume due to their size, and typically contain a higher concentration of large woody debris (LWD) than regular road embankment fill because tree limbs and discarded pieces from logging operations were typically pushed over the outboard edge for removal from the work area.

LARGE WOODY DEBRIS (LWD)

Also known as large organic debris (LOD), refers to logs and stumps found in stream channels, road fills, etc. The term “large” can refer to anything from a 4” tree trunk to a 200” redwood log.

MASS WASTING

A general term that includes many types of mass earth movements. These include rockslides, debris slides, debris flows, and earthflows, etc.

OPEN CROSS DRAIN

A deep, abrupt ditch constructed across a road to drain water from the road surface and/or inboard ditch. Generally, not drivable and placed at frequent intervals (approx. every 50 - 100 feet) on permanently closed roads. Compare to rolling dip and water bar.

OPEN ROAD

Road is passable to a standard four-wheel drive vehicle during dry weather without clearing brush or making other improvements. Road typically shows evidence of recent maintenance including clearing culvert inlets and inboard ditches, grading, rolling dip or waterbar reconstruction, and or brushing

OUTBOARD

The side of a road or other slope feature that is on the outside or away from the slope - toward the downslope direction.

OUTSLOPE

A road surface that is shaped to slant toward the outboard edge of a road. The slanted surface naturally disperses surface runoff. A road that is outsloped may or may not be drivable depending on the intent of treatment. Outsloped road may or may not have an inboard ditch.

OUTSLOPING

the act of changing a flat or insloped road to an outsloped road. For erosion control treatments, substantial fill is removed from the outer edge of the road prism, and spread and shaped along the inside edge of the road, typically against the cutbank. For surface drainage on active roads, the road surface has a mild outslope that is drivable by logging trucks and forms a relatively maintenance-free road surface that disperses road surface runoff.

PERMEABILITY

A measure of the rate at which water can pass through soil.

RAVEL

The rolling, bouncing, and sliding of individual particles down a slope and the dominate hillslope process in steep, arid, and semiarid landscapes. Ravel is commonly referred to as dry ravel and operates in the absence of water.

RILL

A small erosional feature similar to a gully in morphology but less than 1 square foot in cross-sectional area. Rills often form on soft bare soil or road surfaces. Compare with gully.

REMOVED ROAD

Road that has been physically removed from the landscape and is no longer accessible to vehicles (see road removal).

ROADBED

The surface of the road where driving takes place.

ROADWAY

The corridor of the road within the limits of excavation and embankment, including the cutbank, the inboard ditch, the roadbed, and the outboard fill.

ROAD DECOMMISSIONING (DECOMMISSION)

The treatment of a road to eliminate stream diversions and minimize erosion and sedimentation typically during periods of non-use. A decommissioned road has all culverts removed, all road fill at stream crossings fully excavated and road surface drainage provided by a combination of outsloping, rolling dips or cross road drains. A road is typically decommissioned when a road will not be used for a period of time but will be used at some time in the future, however a road may be permanently decommissioned.

ROAD OUTSLOPING

The treatment of a road to eliminate collection or diversion of water along the roadbed and provide uniform sheet drainage. Outsloping can be prescribed for roads still in use or roads that are no longer used. See outsloping.

ROAD REENGINEERING (ROAD UPGRADE)

Improving a road to current road building standards with the intent of reducing erosion from roads and minimizing annual maintenance required. Reengineering includes; replacing rusted, plugged and undersized culverts, installing culverts on the natural stream grade to facilitate sediment and runoff conveyance, reshaping roads for proper drainage (road outsloping), constructing critical dips at crossings to prevent stream diversions, pulling back steeply perched road or landing fill that can enter a stream, reducing road fill volumes at stream crossings and others.

ROAD REMOVAL

The treatment of a road that completely recovers unstable side-cast fill and stabilizes the fill within the original cutbench. Stream crossing fill is excavated, and all excavated materials are placed in stable locations along the cutbank. This type of treatment is also referred to as road recontouring or road obliteration. Sometimes called road obliteration.

ROAD SURFACE

The material, native or placed, that comprises the top layer of the roadbed (see surfacing).

ROLLING DIP

A broad, shallow, gentle dip (low point) in the road surface that collects road surface runoff and conveys it to the outer edge of the road. It can also drain an inboard ditch. Drivable

RUNOFF

Rainwater flowing on the surface of the ground. Runoff can be generated by rain falling on saturated ground or from heavy rain that cannot soak in fast enough.

SEDIMENT

Silt, sand, clay, and gravel that is moved by water and deposited at some location.

SEDIMENT PLUG

Depositional sediment upstream of a crossing. Early road building included stream crossings with drainage features installed at a lower gradient than the natural stream channel. As stream flow approaches the lower gradient reach, it loses energy and deposits the sediment upstream of the drainage feature.

SLOPE ANGLE

The angle of the hillslope measured in percent along the fall-line.

SKID TRAIL

Small single-lane tracks that develop as ground-based equipment moved logs across harvest units. Skid trails are not constructed like haul roads; they lack a constructed road bed and follow, rather than cut through the surrounding topography.

SOIL

The uppermost layer of decayed organic matter, clay, silt, sand, air, water, and weathered rock mixed in various proportions. Soil consists of horizons or layers that display different amounts of weathering and fertility.

SPOILS

Soil and organic material that is excavated from stream crossings or road embankments that is used for recontouring or can be end-hauled to a stable storage location.

STREAM CROSSING

A constructed road section across a natural stream. There are many types of crossings such as bridges, culverts, Humboldt (see definition), and fill crossings. A stream crossing includes all locations where a road crosses a channel, whether or not water is flowing, and whether or not a drainage structure has been provided.

STREAM DIVERSION

A condition where streamflow has been diverted from its natural watercourse (see active diversion).

STRINGER

Log or timber that rests on bridge abutments, spans the watercourse, and supports the tread surface of bridge.

SURFACING

Rock aggregate or paving that is placed on the road surface to reduce erosion and weatherproof a road for winter use.

SWALE

A concave or spoon shaped hollow on the hillslope lacking channelized flow and does not exhibit stream banks separate from stream channel. It is the headwaters to the stream channel forming some distance downslope.

SWALE CROSSING

A constructed feature where a road crosses a topographic swale. The crossing may be composed of road fill without a drainage structure or may be composed of buried logs (Humboldt crossing), a culvert, a ford, or in some rare cases, a bridge.

SWITCHBACK

A turn that is constructed on a slope of more than 30 per cent when measured between the exterior boundaries of the trail 120 to 180 degrees. The landing is the turning portion of the switchback. The approaches are the road sections upgrade and downgrade from the landing.

THROUGH-CUT

A portion of a road that has cutbanks on both sides with drainage flowing down the road or inside ditch.

TOPOGRAPHY

The natural shape of the land's surface.

TURNPIKE

A section of road built by elevating the constructed roadbed above wet, boggy areas by importing soil.

WATER BAR

A shallow ditch or berm constructed across a road or skid trail that drains the road surface and/or inboard ditch. It is not a permanent structure as they tend to break down with any type of use, including wildlife tramping. They are insufficient to prevent stream diversions at crossings.

WINTERIZED ROAD

A road that has received a particular method of partial road decommissioning employed by Stimpson Timber company in the late 1990's prior to DPR ownership. The method consisted of partial removal of stream crossing fill and large cross drain waterbars that segmented road and ditch drainage. See discussion of "maintenance free" roads under LSEP section in main report.

YIELD

The amount of sediment that reaches a stream channel after eroding from a site. It is expressed in cubic meters and calculated by multiplying the erosion volume and delivery ratio.

APPENDIX A

AIR PHOTO TABLES

Series	Flight Line	Full Collection Photo Numbers	Indexed Photo Numbers	Missing Photo Numbers	Duplicate Photo Numbers	Non-Indexed Photo Numbers
1988 C - HUM - 88	B1	1-5	1-5			
	B2	1-7	1-7			
	B4	1-6	1-6			
	B7	11-20	11-20			
	B11	12-22	12-22			
	14	26-39	26-39			
	16	30-45	30-45			
	18	30-42	30-42			
	B20B	16-29	16-29			
	23	36-43	36-43			
1986 Mill Creek	1	1-5	1-5			
	2	1-7	1-7			7 "Smith River"
	3	1-6	1-6			
	4	1-11	1-2,4-11	3		
	5	1-11	1-11		3	
	6	1-11	1-11			
	7	1-10	1-3,5-10		4	
	7A	1				1
	8	1-10	1-10			
	8A	1				1
	9	1-11	1-11			
	10	1-10	1-10			
1984 MR - 84	01	1-14	1-14			
	02	1-7	1-7			
	03	1-8	1-8			
	04	1-14	1-14			
	05	1-14	1-14			
	06	1-14	1-14			
	07	1-10	1-10			
1982 RRU - 82	101	1-5	1-5			
	102	1-6	1-6			
	103	1-6	1-6			
	104	1-10	1-10			
	105	1-10	1-10			
	106	1-10	1-10			
	107	1-12	1-12			
	108	1-11	1-11		2	
	109	1-9	1-9		2	
	110	1-7	1-7		2	

Series	Flight Line	Full Collection Photo Numbers	Indexed Photo Numbers	Missing Photo Numbers	Duplicate Photo Numbers	Non-Indexed Photo Numbers
1980 RRU - 80	102	1-9	1-9			
	103	1-9	1-9			
	104	1-13	1-13			
	5	1-14	1-14			
	106	1-15	1-15			
	107	1-18	1-18			
	108	1-17	1-17			
	109	1-14	1-14			
	110	1-10	1-10			
1978 DNC 8-6-78	17	1-5	1-5			
	18	1-7	1-7			
	19	1-11	1-11			
	20	1-9	1-9			
	21	1-9	1-9		1	
	22	1-10	1-10			
	23	1-12	1-12			
	24	1-13	1-13			
1978 DNC 9-1-78	18	0				0
	23	13-16	13-16			
	24	14-16	14-16			
	25	5-11	5-11			
1975 DNC - 75	6A	31-36	31-36			
	7	40-43	40-43			
	8	40-45	40-45			
	9	43-54	43-54			
	10A	8-17	8-17			
	11	35-46	35-46			
	12A	9-23	9-21,23	22		
	13A	8-21	8-21		10-21	
	14	25-37	25-37		25-37	
1972 DNC 822 - 72	11-8	15,16				15,16
	11-9	25,26				25,26
	12-11	29				29

Series	Flight Line	Full Collection Photo Numbers	Indexed Photo Numbers	Missing Photo Numbers	Duplicate Photo Numbers	Non-Indexed Photo Numbers
1969 DNC - 69	50-6	10-14	10-14			
	50-7	13-17	13-17			
	82-8	17-19	17-19			
	82-9	20-31	20-31	30		
	82-10	27-38	27-38			
	78-11B	9-19	9-19			
	78-12B	12-23	12-23			
	83-13	16-36	16-18,25-36			
	78-14A	26-38	26-38		32-34	
	78-15A	25-36	25-36			
1966 AV - 712	01	01-07	01-07			
	02	01-13	01-13			
	03	01-14	01-14	04,05		
	04	01-14	01-14	03-05		
	05	01-11	01-11			
	06	01-11	01-11			
1964 DNC - 3	7	8-12	8-12			
	8	11-17	11-17			
	9	14-24	14-24			
	10	23-29	23-29			
	11	25-35	25-35			
	12B	22-33	22-33			
	13	23-35	23-35			
	14	23-33	23-33			
1958 DN	6	6-10	6-10			
	7	5-33	5-15	16-25, 27,28, 31		26,29,30,32,33
	8	10-37	10-17	18,20,22-31		19,21,32-37
	9	16-28	16-28			
	10	21-33	21-33			
	11	22-35	22-35			
	12	23-35	23-35			
	13	22-33	22-33			

APPENDIX B

MILL CREEK ADDITION ROAD ASSESSMENT FORMS

DEFINITION OF TERMS

These road assessment forms and accompanying definitions were developed by State Parks specifically for inventories in the Mill Creek Addition to Del Norte Coast Redwoods State Park beginning in winter, 2002.

ROAD CONDITION DATA – CONTINUOUS VARIABLE WORKSHEET

Usability: Record the current usability

Open

Road is passable to a standard four-wheel drive vehicle during dry weather without clearing brush or making other improvements. Road typically shows evidence of recent maintenance including clearing culvert inlets and inboard ditches, grading, rolling dip or waterbar reconstruction, and or brushing.

Abandoned

Road lacks obvious maintenance. Ditches may lack cleaning and vegetation may be encroaching the road and road surface. Culverts may be partially or completely plugged, badly rusted or crushed. The road is typically not drivable without improvements.

Winterized

Road has been partially decommissioned and no longer part of the transportation network. Fill excavated from the crossings is pushed into large piles on one or both sides of the crossing site. Partial removal of stream crossing fill and large cross drains (tank traps) segment road and ditch drainage.

Recontoured

Road has been removed and is no longer accessible to vehicles. Sidecast material was retrieved, stream crossing fill material was excavated, and all excavated materials were placed in stable locations, shaped, and blended to match the surrounding topography.

Surface:

Record the dominant road surface material: asphalt, gravel, or soil (native material).

Surface Condition:

Record condition of road bed: poor, fair, or good.

Width (m):

Record appropriate width class (3-5, 5-8, 8-12, or greater than 12) for width of road from inside edge where cutbank meets inboard ditch or road bed to outside edge of fill.

Embankment Volume: m^3/m:

Estimate unit volume of sidecast fill material on outer edge of road. Enter number as estimated.

Grade %:

Using clinometer, record grade of road in direction of travel and indicate all significant changes in grade, especially through crossing approaches. Grade is always recorded as negative for traveling downslope from start address, or positive for traveling upslope from start address.

Pitch:

Pitch is the angle of the roadbed from edge (cutbank) to edge (embankment).

Insloped

Roadbed slants downward toward inboard ditch.

Outboard (outsloped):

Roadbed slants downward toward embankment edge of road.

Outboard bermed

Road is outsloped with bermed outer edge.

Flat

Road bed has level driving surface with no obvious slant.

Entrenched

Roadbed is lower in center than on both sides. Rilling or gullies can occur if a long section of road is entrenched with no outlet. See tread drainage below.

Crowned

Roadbed is elevated in center allowing surface flow to drain evenly off both sides.

Inboard Ditch:

Record current status of inboard ditch: open, vegetated, armored, gullied, filled, double (inboard and outboard), or none.

Vegetation Load:

Record current status of vegetation load by giving a relative ranking of high, medium, or low based on tree size and spacing, presence or absence of understory, load of down wood, and size and density of stumps.

Road Drainage:

Record the dominant road drainage process taking place over given segment of road:

Tread Drainage

Common road surface drainage where water flows with grade of road and may collect in slight tire depressions.

Rills/Tire Ruts

Surface drainage collects water in tire ruts or rills. Typically found on segments with steeper grade and/or unprotected roadbed, combined with entrenchment.

Road Gully

Rills and/or tire ruts often combine to develop into gullies. Occasionally, channelized flow will divert onto the road bed creating a gully. Road drainage is considered road gully once erosional scour has reached an approximate size of one foot wide and one foot deep or larger.

Waterbars

Road and/or ditch drainage is segmented by bermed cross drains. Drains can either be large ‘tank traps’ preventing vehicles travel or small ‘grooves’ that can be driven over. If a segment of road is usability; winterized, it has by definition road drainage; water bars.

Insloped/ditch

Only use with a road pitch that is insloped. Road drains along pitch, toward inboard ditch instead of draining along grade of road.

Outsloped/none

Only use with a road pitch that is outsloped. Road drains along pitch, toward outboard edge instead of draining along grade of road.

Action:

Recommend a particular course of action: monitor, clear, remove, replace or install for the following feature.

Action Feature:

Record the feature: road base, inboard ditch, inboard pitch, or outboard pitch.

CONTINUOUS VARIABLE WORKSHEET TEMPLATE

Route Name:
Date:

Surveyed by:
Pages:

Address	Usability	Surface	Surface Condition	Width	Embankment Volume	Grade	Pitch	Inboard Ditch	Vegetation Load	Road Drainage	Action	Action Feature
0.00												

MILL CREEK ADDITION – ROAD ASSESSMENT FORM – SHEET 1

Form version.1/14/04

Addendum to Definitions: Summary of changes since last version (12/30/02)

Water crossing site:

Added check box for Crossing Data Sheet Completed. This box should be checked if additional water crossing dimensions and data were collected and recorded on the Stream Crossing Volume Worksheet. These data and worksheets were used as an initial alternative method to estimating stream crossing volume. Data were used to create a scale drawing of crossing profile from which to measure upstream and downstream fill depth.

TOP MARGIN AREA

Data Entry by:

Initials of person that entered datasheet into database. To be filled out by office technician after entry into database, not by field technician.

Date Entered:

Record date assessment form was entered into database. To be filled out by office technician after entry into database, not by field technician.

Route Name:

The existing name assigned to the road as attributed in GIS line work (N:\GIS_Data\Agency\rnsp\roads\roads_rnpx, Feature Class: route.millroad)

Surveyed by:

Initials of person(s) collecting field data (example SEW/DRP)

Survey Date:

Date of field data collection, in MM/DD/YYYY format (06/17/2003).

Site Tagged:

Put a check in box to indicate whether a yellow aluminum tag with start address was nailed or attached to a nearby tree.

Check:

Put a check in box if the site warrants review by a more experienced person. It would assist the reviewer to record the issue of concern (if possible) in the comments area at the bottom of form page.

ASAP:

Put a check in box if the site should received treatments immediately to prevent further loss of the road or other resource.

Critical:

Put a check in box if site failure appears imminent and would likely result in loss of road, crossing, extreme sediment delivery, or loss of access to a section of the park.

Feature Address:

Enter start address for point features, or start and end address for interval features.

Point Feature:

Put a check in box if site is a crossing. All other features should have an interval address.

WATER CROSSING SITE

Feature:

Circle whether crossing is a swale or stream. A swale is a concave or spoon shaped hollow on the hillslope lacking channelized flow and does not exhibit stream banks separate from stream channel. It is the headwaters to the stream channel forming some distance downslope. Stream crossing includes all locations where a road crosses a channel, whether or not water is flowing, and whether or not a drainage structure has been provided.

Active Diversion:

Put a check in box if water or evidence of water is presently diverted from its natural channel at the inventory site.

Diversion Potential:

Circle Y if the road grade is continuous through the crossing so that stream could flow down the road, away from the crossing, if a culvert plugs. Record N if the crossing is the low point in the road (road slopes uphill away from both sides of the stream) or if the stream cannot divert if the culvert plugs.

Type:

Circle appropriate type of crossing feature.

Bridge

Road is on a structure that spans stream, supported by abutments on either side of the channel. Bridges may be constructed of railroad flatcars, log stringers, or metal beams. The driving surface may be covered with wood decking or covered with a blanket of 2 – 4 feet of fill.

Culvert

The stream crossing consists of a pipe buried beneath the road to convey the stream flow through the road. Culverts may be aluminum, galvanized metal, concrete or plastic. Pipe may be located slightly downroad from stream channel centerline, but is usually within crossing fill hinges. Circle culvert if present regardless of other drainage features (i.e. Humboldt logs).

Humboldt

Crossing is constructed of logs laid parallel to stream flow and covered with fill. Stream flow passes through the logs. It is possible to have both a Humboldt crossing and a culvert together at a stream crossing. However, in those cases, circle culvert.

Fill

The crossing is composed of fill material lacking a structure for passage of stream flow. This type of crossing is more common in swales lacking perennial flow.

Armored crossing

Crossing fill has been placed in the stream channel for vehicle access and armored such that water flows over the fill without great risk of eroding the fill. Visible crossing material is comprised mainly of rock and boulders and does not contain other drainage structures.

Armored swale

Same as armored crossing, but in a swale setting.

Drain swale

Topographic dip in the road that is matched to a minor natural swale upslope of the road. Drain swales are designed to carry only minor flows during runoff events.

Drain lens

A sub-grade drain structure composed of coarse rock extending from the inboard edge of the road to the outboard edge. The coarse rock is covered by geotextile fabric and then covered by road base aggregate. Drain lenses are often used to drain seeps or springs under a road without the need for a culvert cross drain.

Rolling dip

A broad, shallow, gentle dip (low point) in the road surface that collects road surface runoff and conveys it to the outer edge of the road. It can also drain an inboard ditch. Drivable.

Open cross drain

A deep, abrupt ditch constructed across a road to drain water from the road surface and/or inboard ditch. Generally, not drivable and placed at frequent intervals (approx. every 50 - 100 feet) on permanently closed roads.

Erosional Process:

Select the most appropriate process causing erosion. Select only one process that best represents the current situation.

None

There is no evidence of erosion or potential erosion currently at the site.

Gully

Gullies are a newly formed erosion feature caused by surface water flow. They are greater than 1 foot wide by 1 foot deep. A gully can be identified by its location away from the natural stream channel. Smaller erosion scars formed by surface flow are rills and may indicate potential for development into gullies if conditions are right.

Streambank

Select this process if the natural channel is undergoing accelerated erosion. Evidence would be raw channel banks – oversteepened and unvegetated.

Collapsing

A stream crossing will collapse as a culvert or Humboldt structure begins to fail. Sink holes develop and road fill will fall through into the drainage structure and be transported downstream.

Fill Failure

The edge of the stream crossing – within the hinge lines - is failing as a mass movement (landslide).

Undercutting

When a culvert bottom is rusted, it can develop holes and allow stream flow to erode fill from directly beneath the culvert leaving unsupported fill above. Undercutting may also occur if a culvert outlet is significantly (>3 ft.) above the channel bed (shotgun outlet) and is causing erosion of the stream channel or crossing fill directly below the culvert outlet.

Sediment transport: L M H

Circle H if there are obvious signs of high bedload transport during recent past years. Indicate the relative amount of sediment transported through the reach – not the ability of the stream to transport it. Consider upchannel sources for the sediment. Record as L if there is moss growing within the channel bed.

Upstream Sediment Plug: Y N Volume______(m3)

Circle Y if there is depositional sediment upstream of the crossing and record the volume in the space provided. If there is no sediment deposited upstream of the crossing site, circle N.

Adjacent Instability: Y N

Circle Y if there is a separate mass wasting feature within 50m up or down road of stream crossing. Adjacent instability can occur near or within a water crossing site, but must be separate from or additional to the crossing site erosional process. Adjacent instability is asking about fill or hillslope processes occurring near the crossing, but not to the crossing fill itself.

Stream/Floodplain Restriction:

Record the percentage of active stream/floodplain restricted by bridge abutments by estimating the ratio of impinged distance to entire bank full distance as measured perpendicular to stream flow.

Crossing Dimensions:

Estimate the dimensions, in meters, of crossing footprint used to calculate overall crossing volume.

Length on centerline

Distance measured perpendicular to direction of travel on roadbed and parallel to stream channel centerline from the upstream side of road to the downstream side of road. For crossings where road fill prism is wider at base near stream channel than it is at top near road bed, estimate the average length on centerline by entering the median value between the maximum and minimum centerline lengths.

Upstream

Channel Width

Estimate width of channel upstream of road crossing. This should be the width of the natural channel above the influence of road and represent an average width along the selected reach. Measured from bank to bank of active channel, at the 50-year recurrence interval storm stage.

Top width

On the upstream side of the road, estimate the distance from one side of the stream bank/valley wall to the opposite along the top of the road in the direction of travel.

Estimated Fill Depth

On the upstream side of the road, estimate the distance from the top of the road bed to the bottom of the stream channel. This estimate should be along an imaginary plane descending from the road bed aimed perpendicular to the grade of the stream channel.

Downstream

Channel Width

Estimate width of channel downstream of road crossing. This should be the width of the natural channel below the influence of road and represent an average width along the selected reach. Measured from bank to bank of active channel, at the 50-year recurrence interval storm stage.

Top width

On the downstream side of the road, estimate the distance from one side of the stream bank/valley wall to the opposite along the top of the road in the direction of travel.

Estimated Fill Depth

On the downstream side of the road, estimate the distance from the top of the road bed to the bottom of the stream channel. This estimate should be along an imaginary plane descending from the road bed aimed perpendicular to the grade of the stream channel.

Condition of Fill:

Record condition of fill.

Intact

The site has not been excavated (removed), nor washed out.

Failed/Washed-out___%

Record the percent if the crossing failed and has not been rebuilt.

Removed___%

Record the percent of the total stream crossing fill that has been previously excavated.

Bridge Approach Embankments

Calculate estimated volume of fill material in each bridge approach embankment. Left and right sides are determined looking downstream.

GULLY

Activity Level: L M H

Circle appropriate letter for Low, Medium, or High category based on objective observations of the site. Gullies with activity level High will either have water in the gully at the time of assessment or recent scour and an absence of colluvium accumulated along the base of the gully walls. They are generally rectangular in cross section, show signs of recent widening, and do not contain vegetation within the gully. Gullies with a Low activity level are inactive, or dry, and are not eroding material from within the gully. They typically show no sign of recent scour and have accumulations of colluvium at the base of the gully. Other signs of low activity include a U-shade cross section, no indication of recent widening, and vegetation established along the base of the gully or on the colluvium at the base of the gully.

Origin:

Follow evidence of gully channel upslope until source can be determined. If source is from other known road, indicate name of road and address.

Averaged size:

Estimate cross sectional shape of gully, top width, bottom width, and depth. Dimensions should be averaged for the reach of gully within the road footprint.

Destination:

Follow evidence of gully downslope until destination can be determined. If destination is another known road, record road name and address. If gully's immediate destination is slope, continue to follow until it can be determined if gully either disperses, joins a stream or swale, or other known road.

MASS WASTING SITE

Feature:

Swale

A swale is a concave or spoon shaped hollow on the hillslope lacking channelized flow. It is the headwaters to the stream channel forming some distance downslope.

Cutbank

The landslide site is located within the road cut on the inside edge of a road or landing.

Hillslope

The site is on a hillslope and involves more than just the road or landing fill.

Embankment cracks

The site is located on the outer edge of roads or landings in the sidecast fill or along the cutbench/fill interface. Typical indicators of embankment fill that has potential to fail includes cracks or scarps on the road surface that are parallel with the edge of the road or form a semicircle around a section of the outer edge of the road. Occasionally, the outer edge of a section of road has dropped down and the cracks and scarps have been subsequently smoothed over by road grading. Leaning and twisted trunked trees may also indicate unstable road fill.

Embankment failure

The site is located in the sidecast fill at the outside edge of a road or landing. Typical indicators of fill failure are a segment of road or landing with a segment of narrower surface due to a section of fill having slid downslope. The void is usually concave in shape and wider at the top, narrowing at the bottom. Material deposit may be visible at the downslope extent or may have been carried downstream if failure delivered to a creek. An embankment failure will typically contain vegetation differing in age from adjacent intact road segments or have minimal vegetation, if any, depending on how recent the fill failure was.

Process:

Select the landslide process that describes the feature being assessed.

Slow, deep-seated

Characterized by a large area of disturbance on a scale of 100's of feet. These landslides typically posses leaning trees, springs, numerous stepped scarps and benches. Roads and skid roads often 'ride' on deep-seated landslides.

Fast, shallow debris slide

These landslides typically include road and landing fill failures, small cutbank failures, or soil failures on hilllslopes. The upper portions will be evacuated, with the landslide mass resting within the failure area or completely evacuated.

Setting:

Select the location of the site.

Streamside (<55%)

Near a stream where sediment deposition is directly into the stream, <55% slope steepness.

Inner gorge (>55%)

The lower hillslope near a stream with slope steepness >55%

Headwall

A steep slope or precipice rising at the head of a valley or swale, characterized by broad steep converging slopes. They are generally unchannelized.

Break-in-slope

At the convex break in slope. The slope above is gentler than the slopes below.

Hillslope

The generally planar slope away from stream channels and not classified by any of the other selections above.

Distance to stream___(m):

Record the estimated distance from the base of the landslide (the toe area) to the nearest stream channel. This is usually an estimated distance taken from the scaled map tiles.

Slope___%:

Record the angle of the slope, measured in percent, of the natural hillslope below the base of fill or directly adjacent to slide track along the fall-line.

Recent Activity Class: Pre-industrial, pre-1997 post-1997

Circle the time frame period indicating the occurrence of the most recent movement.

Association(s):

Attempt to identify the primary factor(s) that relate to the mass movement feature. Circle all that apply: Road related, Water onto feature, Spring, Stream undercutting, None above.

Averaged Feature Dimensions:

Record average length, width, and depth

Length = parallel with failure direction (typically downslope),

Width = perpendicular to failure direction (typically measured across slope or along road),

Depth = thickness of failure mass (usually measured perpendicular to slope surface).

Delivered to Stream_______%:

An estimated percentage of the volume of the failure that has delivered to stream.

Surface erosion Level: L M H

Circle level of surface erosion, low, medium, or high based on observations of vegetative cover and/or surface rilling.

Future Erosion Potential: L M H

Subjective and relative ranking of the likelihood, rather than the magnitude, of erosion at the site during the next major storm (high, medium, low).

Future Deliverable Volume:

This volume represents total future sediment that will likely be delivered to a stream channel from the site during the next major storm. Typically it calculated based on a percentage of the overall feature volume. The percentage should be an objective estimation based on site conditions including but not limited to slope steepness, ground water emergence, road drainage, fill materials, adjacent instability, proximity to nearby sites, and vegetative cover.

Potential for Extreme Erosion: L M H

A subjective assessment of the capability of the site to erode significantly more volume than is estimated in the future deliverable volume. This is a worst case scenario that identifies the potential for an unusually large magnitude failure. This field should be used for “flagging” critical sites. An example might be a stream diversion that would end up draining onto a landing that may fail catastrophically, scouring hillslopes or channels below.

Extreme Erosion Potential Volume:

If an extreme erosion event occurs, circle the volume category that is likely to result from such an event.

SPRING/SEEP SITE

Source:

Circle area from which spring or seep is emanating. Springs and Seeps refer to locations where roads cross areas of emergent groundwater. A spring has a distinct stream emanating from a well defined point, whereas a seep has no well defined source and appears to saturate a large area. Springs typically emanate from underground conduits that intersect the water table and seeps emanate from a bedding or fault plane. The source data recorded should indicate the area type from which water is appearing: slope, cutbank, roadbed, embankment fill.

Flow Rate ______gpm:

Estimate the flow rate of ground water in gallons per minute. Imagine how long it would take to fill a gallon milk jug given the amount of water that is flowing from the site at time of data collection. Although not an accurate way to measure, the purpose of data taken is to give a relative flow rate for the time of year data was taken.

Destination:

Follow path of spring/seep's flow to determine destination and circle appropriate option. If destination is another known road, record road name and address. If the destination is slope, continue to follow water path until it can be determined if spring/seep either disperses, joins a stream or swale, or other known road.

LANDING SITE

Embankment Volume:

Estimate the unit volume of landing fill at three or more points along the outer edge of landing fill and record the average.

Distance along edge:

Measure the distance along the outer edge of landing, along the cutbench/fill interface.

Water Onto Landing: Y N

Circle Y if there is evidence of water flowing onto or collecting on landing. Indicators will include hydrophilic plants growing on landing surface, closed depressions containing live or dried mosses and/or hydrophilic plants, road drainage features (water bar, cross drain, tire rut rill) are directed toward landing surface or across landing fill, road grade is negative approaching both sides of landing, or inboard ditch has a low point coincident with landing and does not drain properly.

BOTTOM MARGIN AREA

Comments:

Use this field to comment on anything of significance not reported elsewhere on the form, including but not limited to: complexity, urgency, description of extreme erosion potential, or special treatment prescriptions. Keep comments brief and to the point.

Data Entry By: ____________
Date Entered: ____________

Mill Creek Property - Road Assessment Form - Sheet 1

Version 12/30/02

Check ☐
ASAP ☐
Critical Site ☐

Route Name: ____________ **Surveyed By:** ____________ **Survey Date:** ____________ **Site Tagged** ☐ (tag with starting address)

Feature Address: Start ____________ End ____________ **Point Feature** ☐ (point features enter start address only)

WATER CROSSING SITE (record as point feature at centerline of feature)

Feature: Stream crossing Swale crossing ☐ **Active Diversion** **Diversion Potential:** Y N

Type: Bridge Culvert Humboldt Fill Armored crossing Armored swale Drain swale Drain lens Rolling dip Open cross drain

Erosional Process: None Gully Streambank Collapsing Fill failure Undercutting

Sediment Transport: L M H **Upstream Sediment Plug:** Y N Volume ________ (m^3)

Adjacent Instability: Y N **Stream/Floodplain Restriction:** ________ %

Crossing Dimensions: Length on centerline ________ (m)

Upstream
Channel width ________ (m) Top width ________ (m) Estimated fill depth ________ (m)

Downstream
Channel width ________ (m) Top width ________ (m) Estimated fill depth ________ (m)

Condition of Fill: Intact Failed/washed out ________ (%) Removed ________ (%)

Bridge Approach Embankments: Right ________ (m^3) Left ________ (m^3)

GULLY (record as interval feature, enter origin and destination in feature address start and end fields respectively)

Activity Level: L M H

Origin: slope swale stream spring road accumulation

other road name ____________ intercept address ____________

Averaged size: top width ________ (m) bottom width ________ (m) depth ________ (m)

Destination: slope swale stream inboard ditch roadbed

other road name ____________ intercept address ____________

Slope Destination: dispersed slope swale stream

other road name ____________ intercept address ____________

MASS WASTING SITE (record as interval feature)

Feature: Swale Cutbank Hillslope Embankment cracks Embankment failure

Process: Slow, deep-seated Fast, shallow debris slide **Torrent Potential:** L M H

Setting: Streamside (<55%) Inner gorge (>55%) Headwall Break in slope Hillslope

Distance to stream ________ (m) Slope ________ %

Recent Activity Class: Pre-industrial Pre-1997 Post-1997

Association(s): Road related Water onto feature Spring Stream undercutting None above

Averaged Feature Dimensions:

Length ________ (m) Width ________ (m) Depth ________ (m)

Delivered to Stream ________ % **Surface Erosion Level:** L M H

Future Erosion Potential: L M H **Future Deliverable Volume:** ________ (m^3)

Potential for Extreme Erosion: L M H

Extreme Erosion Potential Volume: <500 500-1000 1k-2k 2k-5k >5k

SPRING/SEEP SITE (record as interval feature)

Source: slope cutbank roadbed embankment fill **Flow Rate:** ________ gpm

Destination: slope swale stream inboard ditch gully roadbed

other road name ____________ intercept address ____________

Slope Destination: dispersed slope swale stream

other road name ____________ intercept address ____________

LANDING SITE (record as interval feature)

Embankment Volume: ________ (m^3/m) **Distance Along Edge:** ________ (m)

Water Onto Landing: Y N

Comments:

MILL CREEK ADDITION – ROAD ASSESSMENT FORM – SHEET 2

Site Diagram: Road Assessment Form Sheet 2 is used as a back page to Sheet 1 for diagramming sites as needed to illustrate site conditions. Use of Sheet 2 is not mandatory, but rather used to clarify complex sites, show relationships between features, or orient future reviewers to site.

Mill Creek Property - Road Assessment Form - Sheet 2

Version 12/30/02

Site Diagram (indicate approximate scale and label routes where applicable)

N

MILL CREEK ADDITION – ROAD ASSESSMENT FORMS – SHEET 3 AND SHEET 4

Road Assessment forms sheets 3 and 4 are used to collect data related to road construction, reengineering, and maintenance requirements. Record current condition and/or recommended prescriptions for installation, replacement, repair, or monitoring of bridges, retaining walls, culverts, stream crossings, climbing turn/switchbacks, and road armoring

Data Entry By: ____________
Date Entered: ____________

Mill Creek Property - Road Assessment Form - Sheet 3

Version 12/30/02

Check ☐
ASAP ☐
Critical Site ☐

Route Name: ____________ **Surveyed By:** ____________ **Survey Date:** ____________ **Site Tagged** ☐ (tag with starting address)

Feature Address: Start ____________ End ____________ **Point Feature** ☐ (point features enter start address only)

Bridge

Size: length ______ (ft) width ______ (ft)

Abutment Materials: Earth Wood Concrete Gabion **Abutment Condition:** Poor Fair Good

Stringer Materials: Wood Steel Concrete **Stringer Condition:** Poor Fair Good

Decking Materials: Wood Steel Concrete **Decking Condition:** Poor Fair Good

Handrail Materials: Wood Steel Concrete **Handrail Condition:** Poor Fair Good

Bull Rail Materials: Wood Steel Concrete **Bull Rail Condition:** Poor Fair Good

ACTION(S)

☐ Monitor: Abutment Stringers Decking Handrails Bull Rails

☐ Repair: Abutment Stringers Decking Handrails Bull Rails

● Replace | Install Abutment: Earth Wood Concrete Gabion

Left Abutment: length ______ (ft) width ______ (ft) height ______ (ft)

Right Abutment: length ______ (ft) width ______ (ft) height ______ (ft)

● Replace | Install Bridge: length ______ (ft) width ______ (ft)

● Replace | Install Handrails: length ______ (ft) Replace | Install Bull Rails: length ______ (ft)

☐ Replace Stringers: length ______ (ft)

☐ Replace Decking: length ______ (ft) width ______ (ft)

☐ Remove Bridge ☐ Clear Channel

Retaining Wall

ConstructionType: Log crib Wood Gabion Concrete Cellular Geotextile

length ______ (ft) width ______ (ft) height ______ (ft)

Condition: Poor Fair Good

ACTION(S)

☐ Monitor ☐ Remove

☐ Repair length ______ (ft) width ______ (ft) height ______ (ft)

● Replace | Install Wood crib Wood Gabion Concrete Cellular Geotextile

length ______ (ft) width ______ (ft) height ______ (ft)

Culvert

Size : Diameter ______ (ft) Length ______ (ft) ☐ Cross Drain

Construction Material: Wood Steel Aluminum Plastic Concrete

Properly Sized: Y N **Pluging Potential:** L M H

Culvert Condition: Poor ☐ Rust holes ☐ Tears/holes ☐ Separations Fair Good

Inlet Components: Trash rack Headwall Flared inlet Drop inlet

Inlet Condition: Poor ______ % pluged ______ % crushed Fair Good

Outlet Components: Downdrain assembly Energy dissipator Half pipe

Outlet Condition: Poor ______ % pluged ______ % crushed Fair Good

Culvert Grade: ______ % **Critical Dip @ Site:** Y N

Shotgun outlet: Y N **Drains onto embankment fill:** Y N

Migration Outlet Drop: now ______ (m) @bankfull ______ (m)
Outlet Pool Dimensions: length ______ (m) width ______ (m)
@ bankfull length ______ (m) width ______ (m)

ACTION(S)

☐ Monitor: Culvert Trash rack Headwall Downdrain Embankment fill

☐ Repair: Trash rack Headwall Drop inlet Flared inlet Downdrain Energy dissipator

● Replace | Install Trash rack

● Replace | Install Headwall: length ______ (ft) width ______ (ft) height ______ (ft)

● Replace | Install Culvert: diameter ______ (ft.) length ______ (ft.)

● Replace | Install Flared inlet: diameter ______ (ft.)

● Replace | Install Drop inlet: diameter ______ (ft.)

● Replace | Install Downdrain: diameter ______ (ft.) length ______ (ft.)

● Replace | Install Energy dissipator: length ______ (ft) width ______ (ft) height ______ (ft)

● Replace | Install Critical dip ☐ Clear: Culvert Inlet Outlet

☐ Remove: Culvert Trash rack Drop inlet

Comments:

Data Entry By: ____________
Date Entered: ____________

Mill Creek Property - Road Assessment Form - Sheet 4

Version 12/30/02

Check ☐
ASAP ☐
Critical Site ☐

Route Name: ____________ **Surveyed By:** ____________ **Survey Date:** ____________ **Site Tagged** ☐ (tag with starting address)

Feature Address: Start ____________ End ____________ **Point Feature** ☐ (point features enter start address only)

Armored Stream Crossing

Size: length ______ (ft) width ______ (ft) height ______ (ft)

Condition: Poor Fair Good

ACTION(S)

- ☐ Monitor ☐ Remove
- ☐ Repair length ______ (ft) width ______ (ft) height ______ (ft)
- ● Replace | Install length ______ (ft) width ______ (ft) height ______ (ft)

Armored Drain Swale

Size: length ______ (ft) width ______ (ft) height ______ (ft)

Condition: Poor Fair Good

ACTION(S)

- ☐ Monitor ☐ Remove
- ☐ Repair length ______ (ft) width ______ (ft) height ______ (ft)
- ● Replace | Install length ______ (ft) width ______ (ft) height ______ (ft)

Drain Swale

Condition: Poor Fair Good

ACTION(S)

- ☐ Monitor
- ☐ Remove
- ☐ Repair
- ● Replace | Install

Climbing Turn/Switchback

Condition: Poor Fair Good

ACTION(S)

- ☐ Monitor
- ☐ Reconstruct
- ☐ Repair
- ● Replace | Install

Drain Lens

Size: length ______ (ft) width ______ (ft) height ______ (ft)

Condition: Poor Fair Good

ACTION(S)

- ☐ Monitor ☐ Remove
- ☐ Repair length ______ (ft) width ______ (ft) height ______ (ft) Fabric ______ (ft^2)
- ● Replace | Install length ______ (ft) width ______ (ft) height ______ (ft) Fabric ______ (ft^2)

Rolling Dip

Condition: Poor Fair Good

ACTION(S)

- ☐ Monitor
- ☐ Remove
- ☐ Repair
- ● Replace | Install

Open Cross Drain

Condition: Poor Fair Good

ACTION(S)

- ☐ Monitor
- ☐ Remove
- ☐ Repair
- ● Replace | Install

Barrier Berm

Condition: Poor Fair Good

ACTION(S)

- ☐ Monitor
- ☐ Remove
- ☐ Repair
- ● Replace | Install

Road Armoring

Condition: Poor Fair Good

ACTION(S)

- ☐ Monitor
- ☐ Repair length ______ (ft) width ______ (ft) height ______ (ft)
- ● Replace | Install length ______ (ft) width ______ (ft) height ______ (ft)

APPENDIX C

SOIL MAP UNIT DESCRIPTIONS

The following Soil Map Unit descriptions are taken directly from the Map Unit Descriptions published as part of the Soil Survey of Redwood National and State Park, California (USDA 2008).

***174--Bigtree-Mystery Complex, 2 To 9 Percent Slopes

Map Unit Setting

General location: Throughout Redwood National & State Parks.
Major uses: Recreation, wildlife habitat, and watershed.
MLRA: 4B - Coastal Redwood Belt
Map unit landscape: mountains
Landscape setting: Gently sloping alluvial fans and low terraces.
Elevation: 5 to 670 feet (2 to 205 meters)
Mean annual precipitation: 60 to 75 inches (1520 to 1900 millimeters)
Mean annual air temperature: 50 to 55 degrees F. (10 to 13 degrees C.)
Frost-free period: 300 to 320 days

Map Unit Composition
**Bigtree--50 percent
**Mystery--25 percent
Minor components: 26 percent

Major Component Description

*Bigtree and similar soils
Slope: 2 to 9 percent
Aspect: None noted
Landform: Alluvial fan
Fan remnant
Low terrace
Parent material: Alluvium derived from mixed sources
Typical vegetation: Overstory of redwood, Sitka spruce, western hemlock, red alder and willow, a shrub layer of salmonberry, blackberry and stink currant, and an herb layer of swordfern and redwood sorrel. Logged areas have a higher proportion of red alder, salmonberry, blackberry, and stink currant.

Selected Properties and Qualities of Bigtree

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Moderate
Available water capacity to 60 inches: About 10.1 inches (Very high)

Selected Hydrologic Properties of Bigtree

Present annual flooding: ---
Present annual ponding: None
Surface runoff: Low
Current water table: None noted.

Natural drainage class: Well drained
Hydrologic Soil Group: B

California Land Use Interpretive Groups
Land capability nonirrigated: 2e-2
Ecological site: F004BX111CA, Sequoia sempervirens/polystichum munitum-oxalis oregana

Typical Profile
**A--0 to 10 in (0 to 26 cm); loam
**Bw--10 to 47 in (26 to 120 cm); loam
**2C1--47 to 57 in (120 to 145 cm); sandy loam
**2C2--57 to 63 in (145 to 160 cm); silt loam

*Mystery and similar soils
Slope: 2 to 9 percent
Aspect: None noted
Landform: Alluvial fan
Fan remnant
Low terrace
Parent material: Overbank alluvium derived from mixed sources
Typical vegetation: Overstory of redwood, Sitka spruce, western hemlock, red alder and willow, a shrub layer of salmonberry, blackberry and stink currant, and an herb layer of swordfern and redwood sorrel. Logged areas have a higher proportion of red alder, salmonberry, blackberry and stink currant.

Selected Properties and Qualities of Mystery

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Moderate
Available water capacity to 60 inches: About 9.9 inches (High)

Selected Hydrologic Properties of Mystery

Present annual flooding: Occasional
Present annual ponding: ---
Surface runoff: High
Current water table: Present
Natural drainage class: Well drained
Hydrologic Soil Group: B

California Land Use Interpretive Groups
Land capability nonirrigated: 2e-2
Ecological site: F004BX111CA, Sequoia sempervirens/polystichum munitum-oxalis oregana

Typical Profile
**Oi--0 to 1 in (0 to 3 cm); slightly decomposed plant material
**A--1 to 24 in (3 to 60 cm); very fine sandy loam
**2Bw--24 to 41 in (60 to 104 cm); fine sandy loam
**3CAb--41 to 60 in (104 to 152 cm); silt loam

Minor Components

****Fluventic Dystrudepts loamy-skeletal and similar soils
Composition: About 10 percent
Slope: 2 to 9 percent
Landform: Alluvial fan
Fan remnant
Low terrace
Typical vegetation: Overstory of redwood, Sitka spruce, western hemlock, red alder and willow, a shrub layer of salmonberry, blackberry and stink currant, and an herb layer of swordfern and redwood sorrel. Logged areas have a higher proportion of red alder, salmonberry, blackberry, and stink currant.
Ecological site: Not Assigned

****Fluvaquentic Endoaquepts and similar soils
Composition: About 5 percent
Slope: 2 to 9 percent
Landform: Backwater channels and depressions on low terraces and flood plain
Typical vegetation: None assigned
Ecological site: Not Assigned

****Fluvents and similar soils
Composition: About 3 percent
Slope: 0 to 4 percent
Landform: On flats adjacent to the stream channel
Typical vegetation: None assigned
Ecological site: Not Assigned

****Riverwash
Composition: About 3 percent
Slope: 2 to 9 percent
Landform: Active channel
Typical vegetation: None assigned
Ecological site: Not Assigned

****Typic Palehumults and similar soils
Composition: About 3 percent
Slope: 5 to 40 percent
Landform: Older terrace
Typical vegetation: None assigned
Ecological site: Not Assigned

****Arents and similar soils
Composition: About 2 percent
Slope: 0 to 4 percent
Landform: Old mill sites on terrace
Typical vegetation: None assigned
Ecological site: Not Assigned

***534--Coppercreek-Ahpah-Lackscreek Complex, 15 To 30 Percent Slopes

Map Unit Setting

General location: Western part of Lower Redwood Creek Basin

Major uses: Timber production, recreation, wildlife habitat and watershed. areas in redwood national park are being treated for watershed rehabilitation and may be used for hiking and equestrian trails.
MLRA: 4B - Coastal Redwood Belt
Map unit landscape: mountains
Landscape setting: Steep mountain slopes.
Elevation: 415 to 2495 feet (127 to 761 meters)
Mean annual precipitation: 90 to 100 inches (2290 to 2550 millimeters)
Mean annual air temperature: 50 to 55 degrees F. (10 to 13 degrees C.)
Frost-free period: 240 to 270 days

Map Unit Composition
**Coppercreek--40 percent
**Ahpah--20 percent
**Lackscreek--20 percent
Minor components: 20 percent

Major Component Description

*Coppercreek and similar soils
Slope: 15 to 30 percent
Aspect: None noted
Landform: Shoulders of broad ridge
Parent material: Colluvium and residuum derived from sandstone
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock and tanoak, a shrub layer of tanoak, huckleberry, and rhododendron, and a sparse herb layer. Redwood is the most abundant conifer in old-growth areas. The second-growth vegetation is dominated by Douglas-fir, tanoak and, in areas that have been burned, by blueblossom.

Selected Properties and Qualities of Coppercreek

Surface area covered by coarse fragments: 0 to 0 percent coarse subangular gravel, 0 to 0 percent subangular cobbles, 0 to 0 percent subangular stones
Depth to restrictive feature: None noted
Slowest permeability class: Moderately slow
Available water capacity to 60 inches: About 7.9 inches (High)

Selected Hydrologic Properties of Coppercreek

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 4e-1
Ecological site: F004BX103CA, Sequoia sempervirens-pseudotsuga menziesii/vaccinium ovatum-rhododendron macrophyllum

Typical Profile
**Oi--0 to 2 in (0 to 5 cm); slightly decomposed plant material
**A--2 to 6 in (5 to 15 cm); loam
**BAt--6 to 13 in (15 to 32 cm); gravelly clay loam
**Bt--13 to 41 in (32 to 105 cm); gravelly clay loam
**BCt--41 to 62 in (105 to 157 cm); very gravelly clay loam

*Ahpah and similar soils
Slope: 15 to 30 percent
Aspect: None noted
Landform: Tops of ridge
Parent material: Residuum and colluvium derived from sandstone
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock and tanoak, a shrub layer of tanoak, huckleberry, and rhododendron, and a sparse herb layer. Redwood is the most abundant conifer in old-growth areas. The second-growth vegetation is dominated by Douglas-fir, tanoak and, in areas that have been burned, by blueblossom.
Selected Properties and Qualities of Ahpah

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: Bedrock (paralithic)--20 to 40 inches; bedrock (lithic)--40 to 60 inches
Slowest permeability class: Moderate above the bedrock
Available water capacity to 60 inches: About 5.4 inches (Moderate)

Selected Hydrologic Properties of Ahpah

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: B

California Land Use Interpretive Groups
Land capability nonirrigated: 4e-8
Ecological site: F004BX103CA, Sequoia sempervirens-pseudotsuga menziesii/vaccinium ovatum-rhododendron macrophyllum

Typical Profile
**Oi--0 to 2 in (0 to 6 cm); slightly decomposed plant material
**A--2 to 11 in (6 to 27 cm); gravelly loam
**Bw--11 to 25 in (27 to 63 cm); gravelly loam
**CB--25 to 38 in (63 to 96 cm); very gravelly loam
**Cr--38 to 45 in (96 to 115 cm); soft or bedrock
**R--45 to 60 in (115 to 152 cm); bedrock

*Lackscreek and similar soils
Slope: 15 to 30 percent
Aspect: None noted
Landform: Locally steep or strongly convex areas on ridge
Parent material: Colluvium and residuum derived from sandstone
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock and tanoak, a shrub layer of tanoak, huckleberry, and rhododendron, and a sparse herb layer. Redwood is the most abundant conifer in old-growth areas. The

second-growth vegetation is dominated by Douglas-fir, tanoak and, in areas that have been burned, by blueblossom.

Selected Properties and Qualities of Lackscreek

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: Bedrock (lithic)--20 to 40 inches
Slowest permeability class: Very slow above the bedrock
Available water capacity to 60 inches: About 4.1 inches (Low)

Selected Hydrologic Properties of Lackscreek

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 4e-8
Ecological site: F004BX103CA, Sequoia sempervirens-pseudotsuga menziesii/vaccinium ovatum-rhododendron macrophyllum

Typical Profile
**Oi--0 to 3 in (0 to 8 cm); slightly decomposed plant material
**A--3 to 6 in (8 to 15 cm); gravelly loam
**Bt--6 to 27 in (15 to 69 cm); very cobbly clay loam
**C--27 to 35 in (69 to 90 cm); extremely gravelly clay loam
**R--35 to 60 in (90 to 152 cm); bedrock

Minor Components
****Sasquatch and similar soils
Composition: About 10 percent
Slope: 15 to 30 percent
Landform: Shoulders of broad ridge
Typical vegetation: None assigned
Ecological site: Not Assigned

****Ahpah umbric epipedon and similar soils
Composition: About 8 percent
Slope: 15 to 30 percent
Landform: Tops of ridge
Typical vegetation: None assigned
Ecological site: Not Assigned

****Rock Outcrop
Composition: About 2 percent
Slope: 15 to 50 percent
Landform: Very steep and strongly convex mountain slope
Typical vegetation: None assigned

Ecological site: Not Assigned

***549--Scaath-Rockysaddle-Wiregrass Complex, 50 To 75 Percent Slopes

Map Unit Setting

General location: Lower Redwood Creek Basin
Major uses: Timber production, recreation, wildlife habitat and watershed. Areas in redwood national park are being treated for watershed rehabilitation and may be used for hiking and equestrian trails.
MLRA: 4B - Coastal Redwood Belt
Map unit landscape: mountains
Landscape setting: Very steep, deeply incised mountain slopes.
Elevation: 560 to 2660 feet (171 to 812 meters)
Mean annual precipitation: 75 to 90 inches (1900 to 2290 millimeters)
Mean annual air temperature: 50 to 55 degrees F. (10 to 13 degrees C.)
Frost-free period: 240 to 290 days

Map Unit Composition
**Scaath--40 percent
**Rockysaddle--25 percent
**Wiregrass--20 percent
Minor components: 15 percent

Major Component Description

*Scaath and similar soils
Slope: 50 to 75 percent
Aspect: None noted
Landform: Narrow ridges and convex to uniform upper mountain slope
Parent material: Colluvium and residuum derived from sandstone
Typical vegetation: Overstory of Douglas-fir, redwood, tanoak and madrone, a shrub layer of tanoak and huckleberry, and a sparse herb layer. Douglas-fir is more abundant than redwood. The second-growth vegetation is dominated by tanoak and Douglas-fir and, in areas that have been burned, by blueblossom.

Selected Properties and Qualities of Scaath

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: Bedrock (lithic)--20 to 40 inches
Slowest permeability class: Very slow above the bedrock
Available water capacity to 60 inches: About 2.2 inches (Very low)

Selected Hydrologic Properties of Scaath

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 7e

Ecological site: F004BX102CA, Pseudotsuga menziesii-sequoia sempervirens/lithocarpus densiflorus

Typical Profile
**Oi--0 to 2 in (0 to 5 cm); slightly decomposed plant material
**A--2 to 4 in (5 to 11 cm); gravelly loam
**BAt--4 to 9 in (11 to 22 cm); very cobbly clay loam
**Bt--9 to 22 in (22 to 55 cm); extremely gravelly clay loam
**R--22 to 60 in (55 to 152 cm); bedrock

*Rockysaddle and similar soils
Slope: 50 to 75 percent
Aspect: None noted
Landform: Concave to uniform scars from debris avalanche
Around rock outcrop and on toe slopes of mountain slope
Parent material: Colluvium derived from sandstone and mudstone
Typical vegetation: Overstory of Douglas-fir, redwood, tanoak and madrone, a shrub layer of tanoak and huckleberry, and a sparse herb layer. Douglas-fir is more abundant than redwood. The second-growth vegetation is dominated by tanoak and Douglas-fir and, in areas that have been burned, by blueblossom.

Selected Properties and Qualities of Rockysaddle

Surface area covered by coarse fragments: 0 to 0 percent coarse subangular gravel, 0 to 0 percent subangular cobbles, 0 to 0 percent subangular stones
Depth to restrictive feature: None noted
Slowest permeability class: Moderately slow
Available water capacity to 60 inches: About 4.7 inches (Low)

Selected Hydrologic Properties of Rockysaddle

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 7e
Ecological site: F004BX102CA, Pseudotsuga menziesii-sequoia sempervirens/lithocarpus densiflorus

Typical Profile
**Oi--0 to 2 in (0 to 6 cm); slightly decomposed plant material
**A--2 to 9 in (6 to 24 cm); extremely gravelly loam
**Bt--9 to 45 in (24 to 115 cm); very gravelly clay loam
**C--45 to 69 in (115 to 176 cm); extremely gravelly clay loam

*Wiregrass and similar soils
Slope: 50 to 75 percent
Aspect: None noted
Landform: Shoulders of broad ridge
Parent material: Colluvium and residuum derived from sandstone and mudstone

Typical vegetation: Overstory of Douglas-fir, redwood, tanoak and madrone, a shrub layer of tanoak and huckleberry, and a sparse herb layer. Douglas-fir is more abundant than redwood. The second-growth vegetation is dominated by tanoak and Douglas-fir and, in areas that have been burned, by blueblossom.

Selected Properties and Qualities of Wiregrass

Surface area covered by coarse fragments: 0 to 0 percent coarse subangular gravel, 0 to 0 percent subangular cobbles, 0 to 0 percent subangular stones
Depth to restrictive feature: None noted
Slowest permeability class: Moderately slow
Available water capacity to 60 inches: About 7.8 inches (High)

Selected Hydrologic Properties of Wiregrass

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 7e
Ecological site: F004BX102CA, Pseudotsuga menziesii-sequoia sempervirens/lithocarpus densiflorus

Typical Profile
**Oi--0 to 1 in (0 to 2 cm); slightly decomposed plant material
**A--1 to 9 in (2 to 22 cm); gravelly loam
**BAt--9 to 26 in (22 to 65 cm); gravelly clay loam
**Bt--26 to 46 in (65 to 118 cm); gravelly clay loam
**BCt--46 to 71 in (118 to 180 cm); very gravelly clay loam

Minor Components
****Rock Outcrop
Composition: About 10 percent
Slope: 30 to 120 percent
Landform: Ridges on mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Atwell and similar soils
Composition: About 5 percent
Slope: 50 to 75 percent
Landform: Along streams and in moist downslope-running concavities on mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

***580--Coppercreek-Tectah-Slidecreek Complex, 9 To 30 Percent Slopes

Map Unit Setting

General location: Mill, Rock, Wilson, and Hunter Creek Watersheds
Major uses: Timber production, recreation, wildlife habitat and watershed. Areas in mill and rock creek watersheds are being treated for watershed rehabilitation and may be used for hiking and equestrian trails.
MLRA: 4B - Coastal Redwood Belt
Map unit landscape: mountains
Landscape setting: Nearly level to moderately steep, broad ridges.
Elevation: 295 to 2300 feet (90 to 702 meters)
Mean annual precipitation: 70 to 100 inches (1780 to 2550 millimeters)
Mean annual air temperature: 50 to 55 degrees F. (10 to 13 degrees C.)
Frost-free period: 240 to 280 days

Map Unit Composition
**Coppercreek--40 percent
**Tectah--30 percent
**Slidecreek--20 percent
Minor components: 10 percent

Major Component Description

*Coppercreek and similar soils
Slope: 9 to 30 percent
Aspect: None noted
Landform: Moderately steep areas on broad ridge
Parent material: Colluvium and residuum derived from sandstone and mudstone
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock and tanoak, a shrub layer of tanoak, huckleberry and rhododendron, and a sparse herb layer. Redwood is the most abundant conifer in old-growth areas. The second-growth vegetation is dominated by Douglas-fir and, in areas that have been burned, by blueblossom.

Selected Properties and Qualities of Coppercreek

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Moderately slow
Available water capacity to 60 inches: About 9.6 inches (High)

Selected Hydrologic Properties of Coppercreek

Present annual flooding: None
Present annual ponding: None
Surface runoff: Medium
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 4e-1

Ecological site: F004BX103CA, Sequoia sempervirens-pseudotsuga menziesii/vaccinium ovatum-rhododendron macrophyllum

Typical Profile
**A--0 to 5 in (0 to 12 cm); loam
**AB--5 to 16 in (12 to 40 cm); clay loam
**Bt1--16 to 43 in (40 to 108 cm); clay loam
**Bt2--43 to 79 in (108 to 200 cm); clay loam

*Tectah and similar soils
Slope: 9 to 30 percent
Aspect: None noted
Landform: Tops of broad ridge
Parent material: Colluvium and residuum derived from sandstone and mudstone
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock and tanoak, a shrub layer of tanoak, huckleberry and rhododendron, and a sparse herb layer. Redwood is the most abundant conifer in old-growth areas. The second-growth vegetation is dominated by Douglas-fir and, in areas that have been burned, by blueblossom.

Selected Properties and Qualities of Tectah

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Slow
Available water capacity to 60 inches: About 7.3 inches (Moderate)

Selected Hydrologic Properties of Tectah

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: D

California Land Use Interpretive Groups
Land capability nonirrigated: 4e-5
Ecological site: F004BX103CA, Sequoia sempervirens-pseudotsuga menziesii/vaccinium ovatum-rhododendron macrophyllum

Typical Profile
**A--0 to 9 in (0 to 22 cm); clay loam
**BAt--9 to 15 in (22 to 38 cm); clay loam
**Bt1--15 to 28 in (38 to 70 cm); clay loam
**Bt2--28 to 60 in (70 to 152 cm); clay

*Slidecreek and similar soils
Slope: 9 to 30 percent
Aspect: None noted
Landform: Uniform to gently rounded areas on ridge
Parent material: Colluvium and residuum derived from sandstone and mudstone
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock and tanoak, a shrub layer of tanoak, huckleberry, and rhododendron, and a sparse herb layer. Redwood is the most abundant conifer in old-growth areas. The

second-growth vegetation is dominated by Douglas-fir, tanoak and, in areas that have been burned, by blueblossom.

Selected Properties and Qualities of Slidecreek

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Moderately slow
Available water capacity to 60 inches: About 6.0 inches (Moderate)

Selected Hydrologic Properties of Slidecreek

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 4e-4
Ecological site: F004BX103CA, Sequoia sempervirens-pseudotsuga menziesii/vaccinium ovatum-rhododendron macrophyllum

Typical Profile
**Oi--0 to 3 in (0 to 7 cm); slightly decomposed plant material
**A--3 to 11 in (7 to 28 cm); very gravelly loam
**BA--11 to 15 in (28 to 38 cm); very gravelly clay loam
**Bt--15 to 55 in (38 to 140 cm); very gravelly clay loam
**BCt--55 to 60 in (140 to 152 cm); extremely cobbly clay loam

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Minor Components

****Trailhead and similar soils
Composition: About 5 percent
Slope: 0 to 15 percent
Landform: Gently sloping areas of ridge
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock and tanoak, a shrub layer of tanoak, huckleberry and rhododendron, and a sparse herb layer. Redwood is the most abundant conifer in old-growth areas. The second-growth vegetation is dominated by Douglas-fir and, in areas that have been burned, by blueblossom.
Ecological site: Not Assigned

****Lackscreek and similar soils
Composition: About 3 percent
Slope: 15 to 50 percent
Landform: Spur ridges and upper mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Rock Outcrop
Composition: About 2 percent

Slope: 15 to 50 percent
Landform: Very steep and strongly convex mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

***581--Coppercreek-Slidecreek-Tectah Complex, 30 To 50 Percent Slopes

Map Unit Setting

General location: Mill, Rock, Wilson, and Hunter Creek Watersheds
Major uses: Timber production, recreation, wildlife habitat and watershed. Areas in mill and rock creek watersheds are being treated for watershed rehabilitation and may be used for hiking and equestrian trails.
MLRA: 4B - Coastal Redwood Belt
Map unit landscape: mountains
Landscape setting: Steep mountain slopes.
Elevation: 75 to 2170 feet (24 to 662 meters)
Mean annual precipitation: 70 to 100 inches (1780 to 2550 millimeters)
Mean annual air temperature: 50 to 55 degrees F. (10 to 13 degrees C.)
Frost-free period: 240 to 280 days

Map Unit Composition
**Coppercreek--40 percent
**Slidecreek--30 percent
**Tectah--20 percent
Minor components: 10 percent

Major Component Description

*Coppercreek and similar soils
Slope: 30 to 50 percent
Aspect: None noted
Landform: Uniform mountain slope
Parent material: Colluvium and residuum derived from sandstone and mudstone
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock and tanoak, a shrub layer of tanoak, huckleberry and rhododendron, and a sparse herb layer. Redwood is the most abundant conifer in old-growth areas. The second-growth vegetation is dominated by Douglas-fir and, in areas that have been burned, by blueblossom.

Selected Properties and Qualities of Coppercreek

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Moderately slow
Available water capacity to 60 inches: About 8.4 inches (High)

Selected Hydrologic Properties of Coppercreek

Present annual flooding: None
Present annual ponding: None

Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 6e
Ecological site: F004BX103CA, Sequoia sempervirens-pseudotsuga menziesii/vaccinium ovatum-rhododendron macrophyllum

Typical Profile
**A--0 to 8 in (0 to 20 cm); loam
**BA--8 to 15 in (20 to 38 cm); clay loam
**Bt--15 to 61 in (38 to 155 cm); gravelly clay loam
**BC--61 to 79 in (155 to 200 cm); very gravelly clay loam

*Slidecreek and similar soils
Slope: 30 to 50 percent
Aspect: None noted
Landform: Uniform to gently rounded mountain slope
Parent material: Colluvium and residuum derived from sandstone and mudstone
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock and tanoak, a shrub layer of tanoak, huckleberry and rhododendron, and a sparse herb layer. Redwood is the most abundant conifer in old-growth areas. The second-growth vegetation is dominated by Douglas-fir and, in areas that have been burned, by blueblossom.

Selected Properties and Qualities of Slidecreek

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Moderately slow
Available water capacity to 60 inches: About 6.3 inches (Moderate)

Selected Hydrologic Properties of Slidecreek

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 6e
Ecological site: F004BX103CA, Sequoia sempervirens-pseudotsuga menziesii/vaccinium ovatum-rhododendron macrophyllum

Typical Profile
**A--0 to 7 in (0 to 18 cm); gravelly loam
**BAt--7 to 14 in (18 to 36 cm); very gravelly clay loam
**Bt--14 to 61 in (36 to 155 cm); very gravelly clay loam
**BCt--61 to 79 in (155 to 200 cm); extremely gravelly clay loam

*Tectah and similar soils

Slope: 30 to 50 percent
Aspect: None noted
Landform: Linear to concave positions on mountain slope
Parent material: Colluvium and residuum derived from sandstone and mudstone
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock and tanoak, a shrub layer of tanoak, huckleberry and rhododendron, and a sparse herb layer. Redwood is the most abundant conifer in old-growth areas. The second-growth vegetation is dominated by Douglas-fir and, in areas that have been burned, by blueblossom.

Selected Properties and Qualities of Tectah

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Slow
Available water capacity to 60 inches: About 8.1 inches (High)

Selected Hydrologic Properties of Tectah

Present annual flooding: None
Present annual ponding: None
Surface runoff: Very high
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: D

California Land Use Interpretive Groups
Land capability nonirrigated: 6e
Ecological site: F004BX103CA, Sequoia sempervirens-pseudotsuga menziesii/vaccinium ovatum-rhododendron macrophyllum

Typical Profile
**A--0 to 4 in (0 to 9 cm); loam
**Bt1--4 to 19 in (9 to 48 cm); clay loam
**Bt2--19 to 63 in (48 to 160 cm); gravelly clay

Minor Components

****Lackscreek and similar soils
Composition: About 5 percent
Slope: 30 to 75 percent
Landform: Spur ridges and upper mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Rock Outcrop
Composition: About 3 percent
Slope: 30 to 75 percent
Landform: Very steep and strongly convex mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Debris Slides

Composition: About 2 percent
Slope: 50 to 75 percent
Landform: Hillslope hollows and on steep mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

***582--Slidecreek-Lackscreek-Coppercreek Complex, 50 To 75 Percent Slopes

Map Unit Setting

General location: Mill, Rock, Wilson, and Hunter Creek Watersheds
Major uses: Timber production, recreation, wildlife habitat and watershed. Areas in mill and rock creek watersheds are being treated for watershed rehabilitation and may be used for hiking and equestrian trails.
MLRA: 4B - Coastal Redwood Belt
Map unit landscape: mountains
Landscape setting: Very steep mountain slopes.
Elevation: 180 to 2270 feet (55 to 693 meters)
Mean annual precipitation: 70 to 100 inches (1780 to 2550 millimeters)
Mean annual air temperature: 50 to 55 degrees F. (10 to 13 degrees C.)
Frost-free period: 240 to 280 days

Map Unit Composition
**Slidecreek--40 percent
**Lackscreek--25 percent
**Coppercreek--15 percent
Minor components: 20 percent

Major Component Description

*Slidecreek and similar soils
Slope: 50 to 75 percent
Aspect: None noted
Landform: Uniform to gently rounded mountain slope
Parent material: Colluvium and residuum derived from sandstone and mudstone
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock and tanoak, a shrub layer of tanoak, huckleberry and rhododendron, and a sparse herb layer. Redwood is the most abundant conifer in old-growth areas. The second-growth vegetation is dominated by Douglas-fir and, in areas that have been burned, by blueblossom.

Selected Properties and Qualities of Slidecreek

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Moderately slow
Available water capacity to 60 inches: About 5.7 inches (Moderate)

Selected Hydrologic Properties of Slidecreek

Present annual flooding: None

Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 7e
Ecological site: F004BX103CA, Sequoia sempervirens-pseudotsuga menziesii/vaccinium ovatum-rhododendron macrophyllum

Typical Profile
**A--0 to 8 in (0 to 20 cm); gravelly loam
**BAt--8 to 15 in (20 to 39 cm); very gravelly clay loam
**Bt--15 to 50 in (39 to 127 cm); very gravelly clay loam
**CBt--50 to 71 in (127 to 180 cm); extremely gravelly clay loam

*Lackscreek and similar soils
Slope: 50 to 75 percent
Aspect: None noted
Landform: Narrow ridges and convex to uniform upper mountain slope
Parent material: Colluvium and residuum derived from sandstone and mudstone
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock and tanoak, a shrub layer of tanoak, huckleberry, and rhododendron, and a sparse herb layer. Redwood is the most abundant conifer in old-growth areas. The second-growth vegetation is dominated by Douglas-fir, tanoak and, in areas that have been burned, by blueblossom.

Selected Properties and Qualities of Lackscreek

Surface area covered by coarse fragments: 0 to 10 percent subangular cobbles, 0 to 20 percent coarse subangular gravel
Depth to restrictive feature: Bedrock (lithic)--20 to 40 inches
Slowest permeability class: Very slow above the bedrock
Available water capacity to 60 inches: About 3.2 inches (Low)

Selected Hydrologic Properties of Lackscreek

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 7e
Ecological site: F004BX103CA, Sequoia sempervirens-pseudotsuga menziesii/vaccinium ovatum-rhododendron macrophyllum

Typical Profile
**A--0 to 5 in (0 to 13 cm); gravelly loam
**BAt--5 to 17 in (13 to 42 cm); very cobbly clay loam
**Bt--17 to 40 in (42 to 102 cm); extremely gravelly clay loam
**R--40 to 79 in (102 to 200 cm); bedrock

*Coppercreek and similar soils
Slope: 50 to 75 percent
Aspect: None noted
Landform: Uniform mountain slope
Parent material: Colluvium and residuum derived from sandstone and mudstone
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock and tanoak, a shrub layer of tanoak, huckleberry and rhododendron, and a sparse herb layer. Redwood is the most abundant conifer in old-growth areas. The second-growth vegetation is dominated by Douglas-fir and, in areas that have been burned, by blueblossom.

Selected Properties and Qualities of Coppercreek

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Moderately slow
Available water capacity to 60 inches: About 6.9 inches (Moderate)

Selected Hydrologic Properties of Coppercreek

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 7e
Ecological site: F004BX103CA, Sequoia sempervirens-pseudotsuga menziesii/vaccinium ovatum-rhododendron macrophyllum

Typical Profile
**A--0 to 7 in (0 to 19 cm); gravelly loam
**Bt1--7 to 24 in (19 to 62 cm); gravelly clay loam
**Bt2--24 to 75 in (62 to 190 cm); very gravelly clay loam

Minor Components

****Debris Slides
Composition: About 10 percent
Slope: 50 to 90 percent
Landform: Hillslope hollows and on steep mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Rock Outcrop
Composition: About 5 percent
Slope: 30 to 90 percent
Landform: Very steep and strongly convex mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Tectah and similar soils
Composition: About 5 percent
Slope: 15 to 35 percent
Landform: Broad, gentler slopes away from ridge
Typical vegetation: None assigned
Ecological site: Not Assigned

***583--Trailhead-Wiregrass Complex, 9 To 30 Percent Slopes

Map Unit Setting

General location: Mill and Rock Watersheds
Major uses: Timber production, recreation, wildlife habitat and watershed. Areas in mill and rock creek watersheds are being treated for watershed rehabilitation and may be used for hiking and equestrian trails.
MLRA: 4B - Coastal Redwood Belt
Map unit landscape: mountains
Landscape setting: Nearly level to moderately steep, broad ridges.
Elevation: 155 to 2045 feet (48 to 624 meters)
Mean annual precipitation: 80 to 100 inches (2030 to 2550 millimeters)
Mean annual air temperature: 50 to 55 degrees F. (10 to 13 degrees C.)
Frost-free period: 240 to 280 days

Map Unit Composition
**Trailhead--65 percent
**Wiregrass--25 percent
Minor components: 10 percent

Major Component Description

*Trailhead and similar soils
Slope: 9 to 30 percent
Aspect: None noted
Landform: Gently sloping areas of ridge
Parent material: Colluvium and residuum derived from schist
Typical vegetation: Overstory of redwood, Douglas-fir, and tanoak, a shrub layer of tanoak, huckleberry and rhododendron, and a sparse herb layer. The second-growth vegetation is dominated by tanoak and Douglas-fir and, in areas that have been burned, by blueblossom.

Selected Properties and Qualities of Trailhead

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Slow
Available water capacity to 60 inches: About 7.2 inches (Moderate)

Selected Hydrologic Properties of Trailhead

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: D

California Land Use Interpretive Groups
Land capability nonirrigated: 4e-5

Ecological site: F004BX109CA, Pseudotsuga menziesii-lithocarpus densiflorus/lithocarpus densiflorus-vaccinium ovatum

Typical Profile
**A--0 to 7 in (0 to 19 cm); gravelly loam
**AB--7 to 15 in (19 to 38 cm); gravelly clay loam
**Bt1--15 to 56 in (38 to 142 cm); gravelly clay
**Bt2--56 to 79 in (142 to 200 cm); clay

*Wiregrass and similar soils
Slope: 9 to 30 percent
Aspect: None noted
Landform: Moderately steep areas on broad ridge
Parent material: Colluvium and residuum derived from schist
Typical vegetation: Overstory of redwood, Douglas-fir, and tanoak, a shrub layer of tanoak, huckleberry and rhododendron, and a sparse herb layer. The second-growth vegetation is dominated by tanoak and Douglas-fir and, in areas that have been burned, by blueblossom.

Selected Properties and Qualities of Wiregrass
Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Slow
Available water capacity to 60 inches: About 9.2 inches (High)

Selected Hydrologic Properties of Wiregrass

Present annual flooding: None
Present annual ponding: None
Surface runoff: Medium
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 4e-1
Ecological site: F004BX109CA, Pseudotsuga menziesii-lithocarpus densiflorus/lithocarpus densiflorus-vaccinium ovatum

Typical Profile
**A--0 to 5 in (0 to 12 cm); loam
**BAt--5 to 12 in (12 to 31 cm); clay loam
**Bt1--12 to 35 in (31 to 90 cm); clay loam
**Bt2--35 to 67 in (90 to 170 cm); gravelly clay loam

Minor Components

****Rockysaddle and similar soils
Composition: About 5 percent
Slope: 0 to 30 percent
Landform: Steeper slopes adjacent to well incised drainages on mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Fortyfour and similar soils
Composition: About 3 percent
Slope: 0 to 30 percent
Landform: Convex slopes, ridge spurs and near tributary headwaters on mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Scaath and similar soils
Composition: About 2 percent
Slope: 0 to 30 percent
Landform: Convex slopes, ridge spurs and near tributary headwaters on ridge
Typical vegetation: None assigned
Ecological site: Not Assigned

***584--Wiregrass-Pittplace-Scaath Complex, 9 To 30 Percent Slopes

Map Unit Setting

General location: Mill and Rock Watersheds
Major uses: Timber production, recreation, wildlife habitat and watershed. Areas in mill and rock creek watersheds are being treated for watershed rehabilitation and may be used for hiking and equestrian trails.
MLRA: 4B - Coastal Redwood Belt
Map unit landscape: mountains
Landscape setting: Moderately steep main and spur ridges.
Elevation: 990 to 2030 feet (303 to 620 meters)
Mean annual precipitation: 80 to 100 inches (2030 to 2550 millimeters)
Mean annual air temperature: 50 to 55 degrees F. (10 to 13 degrees C.)
Frost-free period: 240 to 280 days

Map Unit Composition
**Wiregrass--40 percent
**Pittplace--25 percent
**Scaath--20 percent
Minor components: 15 percent

Major Component Description

*Wiregrass and similar soils
Slope: 9 to 30 percent
Aspect: None noted
Landform: Broader areas on ridge
Parent material: Colluvium and residuum derived from sandstone and mudstone
Typical vegetation: Overstory of tanoak, madrone, Douglas-fir and redwood, a shrub layer of tanoak, huckleberry and rhododendron, and a sparse herb layer. Douglas-fir is the most abundant conifer in old-growth areas. The second-growth vegetation is dominated by Douglas-fir and tanoak, in areas that have been burned, by blueblossom.

Selected Properties and Qualities of Wiregrass

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Moderately slow
Available water capacity to 60 inches: About 10.6 inches (Very high)

Selected Hydrologic Properties of Wiregrass

Present annual flooding: None
Present annual ponding: None
Surface runoff: Medium
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 4e-1
Ecological site: F004BX109CA, Pseudotsuga menziesii-lithocarpus densiflorus/lithocarpus densiflorus-vaccinium ovatum

Typical Profile
**A--0 to 12 in (0 to 30 cm); loam
**BA--12 to 20 in (30 to 51 cm); loam
**Bt1--20 to 50 in (51 to 128 cm); clay loam
**BC--50 to 79 in (128 to 200 cm); clay loam

*Pittplace and similar soils
Slope: 9 to 30 percent
Aspect: None noted
Landform: Broader areas on ridge
Parent material: Colluvium and residuum derived from sandstone and mudstone
Typical vegetation: Overstory of tanoak, madrone, Douglas-fir and redwood, a shrub layer of tanoak, huckleberry and rhododendron, and a sparse herb layer. Douglas-fir is the most abundant conifer in old-growth areas. The second-growth vegetation is dominated by Douglas-fir and tanoak, in areas that have been burned, by blueblossom.

Selected Properties and Qualities of Pittplace

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Slow
Available water capacity to 60 inches: About 9.9 inches (High)

Selected Hydrologic Properties of Pittplace

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: D

California Land Use Interpretive Groups
Land capability nonirrigated: 4e-5
Ecological site: F004BX109CA, Pseudotsuga menziesii-lithocarpus densiflorus/lithocarpus densiflorus-vaccinium ovatum

Typical Profile
**A--0 to 7 in (0 to 17 cm); clay loam
**Bt1--7 to 43 in (17 to 109 cm); paragravelly silty clay loam
**Bt2--43 to 63 in (109 to 160 cm); gravelly clay loam

*Scaath and similar soils
Slope: 15 to 30 percent
Aspect: None noted
Landform: Locally steep or strongly convex areas on ridge
Parent material: Colluvium and residuum derived from sandstone and mudstone
Typical vegetation: Overstory of Douglas-fir, redwood, tanoak and madrone, a shrub layer of tanoak and huckleberry, and a sparse herb layer. Douglas-fir is more abundant than redwood. The second-growth vegetation is dominated by coyote brush, tanoak and Douglas-fir. Logged areas that have been burned tend to be dominated by blueblossom.

Selected Properties and Qualities of Scaath

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: Bedrock (lithic)--20 to 40 inches
Slowest permeability class: Moderately slow above the bedrock
Available water capacity to 60 inches: About 4.1 inches (Low)

Selected Hydrologic Properties of Scaath

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 4e-8
Ecological site: F004BX109CA, Pseudotsuga menziesii-lithocarpus densiflorus/lithocarpus densiflorus-vaccinium ovatum

Typical Profile
**A--0 to 4 in (0 to 11 cm); gravelly loam
**BAt--4 to 10 in (11 to 25 cm); gravelly clay loam
**Bt--10 to 39 in (25 to 98 cm); very gravelly clay loam
**R--39 to 60 in (98 to 152 cm); bedrock

Minor Components

****Rock Outcrop
Composition: About 5 percent
Slope: 15 to 50 percent

Landform: Very steep and strongly convex mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Rockysaddle and similar soils
Composition: About 5 percent
Slope: 15 to 50 percent
Landform: Mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Trailhead and similar soils
Composition: About 5 percent
Slope: 0 to 20 percent
Landform: Gently sloping areas of ridge
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock and tanoak, a shrub layer of tanoak, huckleberry and rhododendron, and a sparse herb layer. Redwood is the most abundant conifer in old-growth areas. The second-growth vegetation is dominated by Douglas-fir and, in areas that have been burned, by blueblossom.
Ecological site: Not Assigned

***585--Wiregrass-Rockysaddle Complex, 30 To 50 Percent Slopes

Map Unit Setting

General location: Mill and Rock Watersheds
Major uses: Timber production, recreation, wildlife habitat and watershed. Areas in mill and rock creek watersheds are being treated for watershed rehabilitation and may be used for hiking and equestrian trails.
MLRA: 4B - Coastal Redwood Belt
Map unit landscape: mountains
Landscape setting: Steep mountain slopes.
Elevation: 665 to 2210 feet (204 to 675 meters)
Mean annual precipitation: 80 to 100 inches (2030 to 2550 millimeters)
Mean annual air temperature: 50 to 55 degrees F. (10 to 13 degrees C.)
Frost-free period: 240 to 280 days

Map Unit Composition
**Wiregrass--45 percent
**Rockysaddle--40 percent
Minor components: 15 percent

Major Component Description

*Wiregrass and similar soils
Slope: 30 to 50 percent
Aspect: None noted
Landform: Uniform to gently rounded mountain slope
Parent material: Colluvium and residuum derived from sandstone and mudstone

Typical vegetation: Overstory of Douglas-fir, redwood, tanoak, and madrone, and a sparse herb layer. Douglas-fir is more abundant than redwood. The second-growth vegetation is dominated by coyote brush, tanoak and Douglas-fir, in areas that have been burned, by blueblossom.

Selected Properties and Qualities of Wiregrass

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Moderately slow
Available water capacity to 60 inches: About 10.3 inches (Very high)

Selected Hydrologic Properties of Wiregrass

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 6e
Ecological site: F004BX109CA, Pseudotsuga menziesii-lithocarpus densiflorus/lithocarpus densiflorus-vaccinium ovatum

Typical Profile
**A--0 to 8 in (0 to 21 cm); loam
**BA--8 to 15 in (21 to 38 cm); loam
**Bt1--15 to 35 in (38 to 90 cm); clay loam
**Bt2--35 to 60 in (90 to 152 cm); clay loam

*Rockysaddle and similar soils
Slope: 30 to 50 percent
Aspect: None noted
Landform: Uniform to gently rounded mountain slope
Parent material: Colluvium and residuum derived from sandstone and mudstone
Typical vegetation: Overstory of Douglas-fir, redwood, tanoak, and madrone, and a sparse herb layer. Douglas-fir is more abundant than redwood. The second-growth vegetation is dominated by coyote brush, tanoak and Douglas-fir, in areas that have been burned, by blueblossom.

Selected Properties and Qualities of Rockysaddle
Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Slow
Available water capacity to 60 inches: About 6.2 inches (Moderate)

Selected Hydrologic Properties of Rockysaddle

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained

Hydrologic Soil Group: D

California Land Use Interpretive Groups
Land capability nonirrigated: 6e
Ecological site: F004BX109CA, Pseudotsuga menziesii-lithocarpus densiflorus/lithocarpus densiflorus-vaccinium ovatum

Typical Profile
**A--0 to 4 in (0 to 11 cm); gravelly loam
**AB--4 to 12 in (11 to 31 cm); gravelly loam
**Bt--12 to 54 in (31 to 138 cm); very gravelly clay loam
**CBt--54 to 61 in (138 to 155 cm); extremely cobbly clay loam

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Minor Components

****Debris Slide
Composition: About 5 percent
Slope: 50 to 90 percent
Landform: Hillslope hollows and on steep mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Rock Outcrop
Composition: About 5 percent
Slope: 30 to 90 percent
Landform: Very steep and strongly convex mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Scaath and similar soils
Composition: About 5 percent
Slope: 30 to 90 percent
Landform: Spur ridges and upper mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

***586--Wiregrass-Rockysaddle-Trailhead Complex, 30 To 50 Percent Slopes

Map Unit Setting

General location: Mill and Rock Watersheds
Major uses: Timber production, recreation, wildlife habitat and watershed. Areas in mill and rock creek watersheds are being treated for watershed rehabilitation and may be used for hiking and equestrian trails.
MLRA: 4B - Coastal Redwood Belt
Map unit landscape: mountains
Landscape setting: Nearly level to moderately steep, broad ridges and upper mountain slopes.
Elevation: 275 to 2185 feet (85 to 667 meters)
Mean annual precipitation: 80 to 100 inches (2030 to 2550 millimeters)
Mean annual air temperature: 50 to 55 degrees F. (10 to 13 degrees C.)

Frost-free period: 240 to 280 days

Map Unit Composition
**Wiregrass--40 percent
**Rockysaddle--30 percent
**Trailhead--15 percent
Minor components: 15 percent

Major Component Description

*Wiregrass and similar soils
Slope: 30 to 50 percent
Aspect: None noted
Landform: Mountain slope
Parent material: Colluvium and residuum derived from schist
Typical vegetation: Overstory of redwood, Douglas-fir, and tanoak, a shrub layer of tanoak, huckleberry and rhododendron, and a sparse herb layer. The second-growth vegetation is dominated by Douglas-fir and, in areas that have been burned, by blueblossom.

Selected Properties and Qualities of Wiregrass

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Slow
Available water capacity to 60 inches: About 10.0 inches (High)

Selected Hydrologic Properties of Wiregrass

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 6e
Ecological site: F004BX109CA, Pseudotsuga menziesii-lithocarpus densiflorus/lithocarpus densiflorus-vaccinium ovatum

Typical Profile
**A--0 to 8 in (0 to 20 cm); loam
**Bt1--8 to 39 in (20 to 98 cm); clay loam
**Bt2--39 to 69 in (98 to 175 cm); clay loam

*Rockysaddle and similar soils
Slope: 30 to 50 percent
Aspect: None noted
Landform: Linear to convex mountain slope
Parent material: Colluvium and residuum derived from schist

Typical vegetation: Overstory of redwood, Douglas-fir, and tanoak, a shrub layer of tanoak, huckleberry and rhododendron, and a sparse herb layer. The second-growth vegetation is dominated by Douglas-fir and, in areas that have been burned, by blueblossom.

Selected Properties and Qualities of Rockysaddle
Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Slow
Available water capacity to 60 inches: About 5.6 inches (Moderate)

Selected Hydrologic Properties of Rockysaddle

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 6e
Ecological site: F004BX109CA, Pseudotsuga menziesii-lithocarpus densiflorus/lithocarpus densiflorus-vaccinium ovatum

Typical Profile
**A--0 to 4 in (0 to 11 cm); gravelly loam
**Bt1--4 to 12 in (11 to 31 cm); very gravelly clay loam
**Bt2--12 to 54 in (31 to 138 cm); very gravelly clay loam
**CBt--54 to 61 in (138 to 155 cm); extremely gravelly silty clay loam

*Trailhead and similar soils
Slope: 30 to 50 percent
Aspect: None noted
Landform: Upper mountain slope
Parent material: Colluvium and residuum derived from schist
Typical vegetation: Overstory of redwood, Douglas-fir, and tanoak, a shrub layer of tanoak, huckleberry and rhododendron, and a sparse herb layer. The second-growth vegetation is dominated by Douglas-fir and, in areas that have been burned, by blueblossom.

Selected Properties and Qualities of Trailhead

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Slow
Available water capacity to 60 inches: About 7.7 inches (High)

Selected Hydrologic Properties of Trailhead

Present annual flooding: None
Present annual ponding: None
Surface runoff: Very high
Current water table: None noted.
Natural drainage class: Well drained

Hydrologic Soil Group: D

California Land Use Interpretive Groups
Land capability nonirrigated: 6e
Ecological site: F004BX109CA, Pseudotsuga menziesii-lithocarpus densiflorus/lithocarpus densiflorus-vaccinium ovatum

Typical Profile
**A--0 to 9 in (0 to 22 cm); loam
**Bt1--9 to 25 in (22 to 63 cm); clay
**Bt2--25 to 62 in (63 to 158 cm); gravelly clay
**BCt--62 to 79 in (158 to 200 cm); extremely cobbly clay

Minor Components

****Debris Slides
Composition: About 5 percent
Slope: 50 to 90 percent
Landform: Hillslope hollows and on steep mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Scaath and similar soils
Composition: About 5 percent
Slope: 30 to 75 percent
Landform: Convex slopes, ridge spurs and near tributary headwaters on ridge
Typical vegetation: None assigned
Ecological site: Not Assigned

****Rock Outcrop
Composition: About 3 percent
Slope: 30 to 90 percent
Landform: Very steep and strongly convex mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Rodgerpeak and similar soils
Composition: About 2 percent
Slope: 0 to 15 percent
Landform: Gently convex to planar areas on crest of ridge
Typical vegetation: A sparse overstory of Douglas-fir, tanoak, madrone and redwood, a dense shrub layer of huckleberry, salal, hairy manzanita and rhododendron, and a sparse herb layer. Douglas-fir is the most abundant conifer. The vegetation has been logged and recovery is slow. The brushy nature of the vegetation may be due to the slow conifer growth and a high frequency of fires on Rodger's Peak.
Ecological site: F004BX108CA, Sequoia sempervirens-pseudotsuga menziesii/polystichum munitum

***587--Rockcreek, 5 To 30 Percent Slopes

Map Unit Setting

General location: Mill and Rock Watersheds
Major uses: Timber production, recreation, wildlife habitat and watershed. Areas in mill and rock creek watersheds are being treated for watershed rehabilitation and may be used for hiking and equestrian trails.
MLRA: 4B - Coastal Redwood Belt
Map unit landscape: mountains
Landscape setting: Nearly level to moderately steep, broad ridges.
Elevation: 1785 to 2350 feet (545 to 717 meters)
Mean annual precipitation: 80 to 100 inches (2030 to 2550 millimeters)
Mean annual air temperature: 50 to 55 degrees F. (10 to 13 degrees C.)
Frost-free period: 240 to 280 days

Map Unit Composition
**Rockcreek--65 percent
Minor components: 35 percent

Major Component Description

*Rockcreek and similar soils
Slope: 5 to 30 percent
Aspect: None noted
Landform: Moderately broad, undulating ridge
Parent material: Weakly consolidated fluvial deposits
Typical vegetation: Overstory of tanoak, Douglas-fir, and Giant chinquapin, a shrub layer of tanoak, salal, huckleberry and rhododendron, and a sparse herb layer.

Selected Properties and Qualities of Rockcreek

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Moderately slow
Available water capacity to 60 inches: About 7.5 inches (Moderate)

Selected Hydrologic Properties of Rockcreek

Present annual flooding: None
Present annual ponding: None
Surface runoff: Medium
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 4e-1
Ecological site: F004BX113CA, Pseudotsuga menziesii-chrysolepis chrysophylla/vaccinium ovatum-rhododendron macrophyllum

Typical Profile
**A--0 to 9 in (0 to 22 cm); loam

**Bt1--9 to 35 in (22 to 90 cm); gravelly clay loam
**Bt2--35 to 65 in (90 to 165 cm); very cobbly clay loam

Minor Components

****Surpur and similar soils
Composition: About 10 percent
Slope: 5 to 30 percent
Landform: Saddle and shoulder of ridge
Typical vegetation: None assigned
Ecological site: Not Assigned
****Ustic Palehumults and similar soils
Composition: About 10 percent
Slope: 0 to 30 percent
Landform: Convex areas on broad, undulating ridge
Typical vegetation: Overstory of tanoak, Douglas-fir, and Giant chinquapin, a shrub layer of tanoak, salal, huckleberry and rhododendron, and a sparse herb layer.
Ecological site: Not Assigned

****Scaath and similar soils
Composition: About 5 percent
Slope: 0 to 50 percent
Landform: Strongly convex slopes, ridge spurs and near margins of ridge
Typical vegetation: None assigned
Ecological site: Not Assigned

****Ustic Palehumults and similar soils
Composition: About 5 percent
Slope: 0 to 30 percent
Landform: Moderately broad, undulating ridge
Typical vegetation: None assigned
Ecological site: Not Assigned

****Wiregrass and similar soils
Composition: About 5 percent
Slope: 0 to 50 percent
Landform: Gently concave slopes and in broad hollows on margins of ridge
Typical vegetation: None assigned
Ecological site: Not Assigned

***588--Surpur, Dry, 2 To 9 Percent Slopes

Map Unit Setting

General location: Mill and Rock Watersheds
Major uses: Timber production, recreation, wildlife habitat and watershed. Areas in mill and rock creek watersheds are being treated for watershed rehabilitation and may be used for hiking and equestrian trails.
MLRA: 4B - Coastal Redwood Belt
Map unit landscape: mountains

Landscape setting: Nearly level to moderately steep, mountain slopes and ridges.
Elevation: 1220 to 2245 feet (372 to 685 meters)
Mean annual precipitation: 80 to 100 inches (2030 to 2550 millimeters)
Mean annual air temperature: 50 to 55 degrees F. (10 to 13 degrees C.)
Frost-free period: 240 to 280 days

Map Unit Composition
**Surpur--75 percent
Minor components: 25 percent

Major Component Description

*Surpur and similar soils
Slope: 0 to 30 percent
Aspect: None noted
Landform: Broad ridgetops and upper mountain slope
Parent material: Colluvium and residuum derived from older, weakly consolidated fluvial, beach and dune deposits from mixed lithologies
Typical vegetation: Overstory of Douglas-fir, tanoak and redwood. There is a shrub layer of evergreen huckleberry, salal, tanoak and rhododendron, and a moderately dense herb layer dominated by swordfern.

Selected Properties and Qualities of Surpur

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Moderately slow
Available water capacity to 60 inches: About 9.6 inches (High)

Selected Hydrologic Properties of Surpur

Present annual flooding: None
Present annual ponding: None
Surface runoff: Medium
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 4e-1
Ecological site: F004BX113CA, Pseudotsuga menziesii-chrysolepis chrysophylla/vaccinium ovatum-rhododendron macrophyllum

Typical Profile
**A--0 to 7 in (0 to 17 cm); loam
**BAt--7 to 11 in (17 to 29 cm); gravelly loam
**Bt--11 to 39 in (29 to 100 cm); clay loam
**CBt--39 to 67 in (100 to 170 cm); very paragravelly loam

Minor Components

****Surpur and similar soils
Composition: About 10 percent
Slope: 0 to 30 percent
Landform: Broad ridgetops and upper mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Squashan and similar soils
Composition: About 5 percent
Slope: 0 to 30 percent
Landform: Broad ridgetops and upper mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Ustic Palehumults and similar soils
Composition: About 3 percent
Slope: 0 to 30 percent
Landform: Mountainside
Typical vegetation: None assigned
Ecological site: Not Assigned

****Wiregrass and similar soils
Composition: About 3 percent
Slope: 0 to 30 percent
Landform: Areas of graywacke and/or mudstone on mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Pittplace and similar soils
Composition: About 2 percent
Slope: 0 to 30 percent
Landform: Areas of graywacek and/or mudstone ridge
Typical vegetation: None assigned
Ecological site: Not Assigned

****Scaath and similar soils
Composition: About 2 percent
Slope: 10 to 30 percent
Landform: Areas of graywacke with convex slopes and spur mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

***590--Sasquatch-Yeti-Footstep Complex, 5 To 30 Percent

Map Unit Setting

General location: Near coast and along Highway 101.
Major uses: Timber production, recreation, wildlife habitat and watershed.
MLRA: 4B - Coastal Redwood Belt
Map unit landscape: mountains
Landscape setting: Nearly level to moderately steep, broad ridges.
Elevation: 180 to 1295 feet (56 to 395 meters)
Mean annual precipitation: 65 to 90 inches (1650 to 2290 millimeters)

Mean annual air temperature: 50 to 55 degrees F. (10 to 13 degrees C.)
Frost-free period: 250 to 300 days

Map Unit Composition
**Sasquatch--45 percent
**Yeti--20 percent
**Footstep--15 percent
Minor components: 20 percent

Major Component Description

*Sasquatch and similar soils
Slope: 5 to 30 percent
Aspect: None noted
Landform: Moderately steep areas on broad ridge
Parent material: Colluvium and residuum derived from sandstone and mudstone
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock, tanoak. There is a shrub layer of salmonberry, thimbleberry and huckleberry, and a dense herb layer dominated by swordfern and oxalis on the forest floor. Rhododendron, huckleberry and salal are common shrubs on higher more inland sites.

Selected Properties and Qualities of Sasquatch

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Slow
Available water capacity to 60 inches: About 10.9 inches (Very high)

Selected Hydrologic Properties of Sasquatch

Present annual flooding: None
Present annual ponding: None
Surface runoff: Medium
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 4e-1
Ecological site: F004BX108CA, Sequoia sempervirens-pseudotsuga menziesii/polystichum munitum

Typical Profile
**Oi--0 to 2 in (0 to 4 cm); slightly decomposed plant material
**A--2 to 19 in (4 to 49 cm); loam
**Bt1--19 to 65 in (49 to 165 cm); clay loam
**Bt2--65 to 79 in (165 to 200 cm); paragravelly clay loam

*Yeti and similar soils
Slope: 5 to 30 percent
Aspect: None noted

Landform: Tops of broad ridge
Parent material: Colluvium and residuum derived from sandstone and mudstone
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock, tanoak. There is a shrub layer of salmonberry, thimbleberry and huckleberry, and a dense herb layer dominated by swordfern and oxalis on the forest floor. Rhododendron, huckleberry and salal are common shrubs on higher more inland sites.

Selected Properties and Qualities of Yeti

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Slow
Available water capacity to 60 inches: About 9.4 inches (High)

Selected Hydrologic Properties of Yeti

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: D

California Land Use Interpretive Groups
Land capability nonirrigated: 4e-5
Ecological site: F004BX108CA, Sequoia sempervirens-pseudotsuga menziesii/polystichum munitum

Typical Profile
**A--0 to 16 in (0 to 41 cm); loam
**Bt1--16 to 37 in (41 to 93 cm); clay loam
**Bt2--37 to 51 in (93 to 130 cm); gravelly clay
**C--51 to 60 in (130 to 152 cm); gravelly clay

*Footstep and similar soils
Slope: 5 to 30 percent
Aspect: None noted
Landform: Narrow ridges and convex to uniform upper mountain slope
Parent material: Colluvium and residuum derived from sandstone and mudstone
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock, tanoak. There is a shrub layer of salmonberry, thimbleberry and huckleberry, and a dense herb layer dominated by swordfern and oxalis on the forest floor. Rhododendron, huckleberry and salal are common shrubs on higher more inland sites.

Selected Properties and Qualities of Footstep

Surface area covered by coarse fragments: 0 to 25 percent coarse subangular gravel, 0 to 5 percent subangular cobbles
Depth to restrictive feature: Bedrock (lithic)--20 to 39 inches
Slowest permeability class: Moderately slow above the bedrock
Available water capacity to 60 inches: About 3.8 inches (Low)

Selected Hydrologic Properties of Footstep

Present annual flooding: None
Present annual ponding: None
Surface runoff: Medium
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 7e
Ecological site: F004BX108CA, Sequoia sempervirens-pseudotsuga menziesii/polystichum munitum

Typical Profile
**A--0 to 15 in (0 to 38 cm); gravelly loam
**Bt--15 to 26 in (38 to 66 cm); very gravelly clay loam
**CBt--26 to 31 in (66 to 80 cm); extremely gravelly clay loam
**R--31 to 79 in (80 to 200 cm); bedrock

Minor Components

****Ladybird and similar soils
Composition: About 10 percent
Slope: 15 to 30 percent
Landform: Moderately steep spur ridge
Typical vegetation: Overstory of redwood and a subcanopy of Douglas-fir, western hemlock, and tanoak. There is a shrub layer of dogwood, cascara sagrada, huckleberry and salal, and a dense herb layer dominated by swordfern and oxalis on the forest floor. Following logging, the vegetation is heavily dominated by red alder, which gives way to coniferous forest in about 30 to 50 years.
Ecological site: Not Assigned

****Sisterrocks and similar soils
Composition: About 8 percent
Slope: 0 to 30 percent
Landform: Uniform to gently rounded areas on ridge
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock, tanoak. There is a shrub layer of salmonberry, thimbleberry and huckleberry, and a dense herb layer dominated by swordfern and oxalis on the forest floor. Rhododendron, huckleberry and salal are common shrubs on higher more inland sites.
Ecological site: Not Assigned

****Footstep and similar soils
Composition: About 2 percent
Slope: 15 to 50 percent
Landform: Spur ridges and upper mountain slope
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock, tanoak. There is a shrub layer of salmonberry, thimbleberry and huckleberry, and a dense herb layer dominated by swordfern and oxalis on the forest floor. Rhododendron, huckleberry and salal are common shrubs on higher more inland sites.

Ecological site: F004BX104CA, Sequoia sempervirens-pseudotsuga menziesii/vaccinium ovatum-rhododendron macrophyllum

***591--Sasquatch-Sisterrocks-Ladybird Complex, 30 To 50 Percent

Map Unit Setting

General location: Near coast and along Highway 101.
Major uses: Timber production, recreation, wildlife habitat and watershed.
MLRA: 4B - Coastal Redwood Belt
Map unit landscape: mountains
Landscape setting: Steep, moist, mountain slopes, with strong coastal fog influence.
Elevation: 15 to 1850 feet (5 to 565 meters)
Mean annual precipitation: 65 to 90 inches (1650 to 2290 millimeters)
Mean annual air temperature: 50 to 55 degrees F. (10 to 13 degrees C.)
Frost-free period: 250 to 300 days

Map Unit Composition
**Sasquatch--45 percent
**Sisterrocks--25 percent
**Ladybird--15 percent
Minor components: 15 percent

Major Component Description

*Sasquatch and similar soils
Slope: 30 to 50 percent
Aspect: None noted
Landform: Mountain slope
Parent material: Colluvium and residuum derived from sandstone and mudstone
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock, tanoak. There is a shrub layer of salmonberry, thimbleberry and huckleberry, and a dense herb layer dominated by swordfern and oxalis on the forest floor. Rhododendron, huckleberry and salal are common shrubs on higher more inland sites.

Selected Properties and Qualities of Sasquatch

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Moderately slow
Available water capacity to 60 inches: About 8.0 inches (High)

Selected Hydrologic Properties of Sasquatch

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.

Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 6e
Ecological site: F004BX108CA, Sequoia sempervirens-pseudotsuga menziesii/polystichum munitum

Typical Profile
**Oi--0 to 1 in (0 to 3 cm); slightly decomposed plant material
**A--1 to 17 in (3 to 43 cm); gravelly loam
**Bt1--17 to 46 in (43 to 117 cm); gravelly clay loam
**Bt2--46 to 79 in (117 to 200 cm); gravelly clay loam

*Sisterrocks and similar soils
Slope: 30 to 50 percent
Aspect: None noted
Landform: Uniform to gently rounded mountain slope
Parent material: Colluvium and residuum derived from sandstone and mudstone
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock, tanoak. There is a shrub layer of salmonberry, thimbleberry and huckleberry, and a dense herb layer dominated by swordfern and oxalis on the forest floor. Rhododendron, huckleberry and salal are common shrubs on higher more inland sites.

Selected Properties and Qualities of Sisterrocks

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Moderately slow
Available water capacity to 60 inches: About 6.5 inches (Moderate)

Selected Hydrologic Properties of Sisterrocks

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 6e
Ecological site: F004BX108CA, Sequoia sempervirens-pseudotsuga menziesii/polystichum munitum

Typical Profile
**A--0 to 16 in (0 to 40 cm); gravelly loam
**Bt1--16 to 41 in (40 to 105 cm); very gravelly clay loam
**Bt2--41 to 67 in (105 to 170 cm); very gravelly silty clay loam

*Ladybird and similar soils
Slope: 30 to 50 percent
Aspect: None noted
Landform: Mountain slope

Parent material: Colluvium and residuum derived from sandstone and mudstone
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock, tanoak. There is a shrub layer of salmonberry, thimbleberry and huckleberry, and a dense herb layer dominated by swordfern and oxalis on the forest floor. Rhododendron, huckleberry and salal are common shrubs on higher more inland sites.

Selected Properties and Qualities of Ladybird

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Moderately slow
Available water capacity to 60 inches: About 8.7 inches (High)

Selected Hydrologic Properties of Ladybird

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 6e
Ecological site: F004BX108CA, Sequoia sempervirens-pseudotsuga menziesii/polystichum munitum

Typical Profile
**A--0 to 7 in (0 to 18 cm); gravelly loam
**AB--7 to 15 in (18 to 37 cm); gravelly silty clay loam
**Bt--15 to 55 in (37 to 140 cm); gravelly clay loam
**CBt--55 to 60 in (140 to 152 cm); very gravelly loam

Minor Components

****Footstep and similar soils
Composition: About 10 percent
Slope: 30 to 50 percent
Landform: Spur ridges and upper mountain slope
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock, tanoak. There is a shrub layer of salmonberry, thimbleberry and huckleberry, and a dense herb layer dominated by swordfern and oxalis on the forest floor. Rhododendron, huckleberry and salal are common shrubs on higher more inland sites.
Ecological site: Not Assigned

****Yeti and similar soils
Composition: About 3 percent
Slope: 15 to 30 percent
Landform: Summit of ridge
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock, tanoak. There is a shrub layer of salmonberry, thimbleberry and huckleberry,

and a dense herb layer dominated by swordfern and oxalis on the forest floor. Rhododendron, huckleberry and salal are common shrubs on higher more inland sites.
Ecological site: Not Assigned

****Rock Outcrop
Composition: About 2 percent
Slope: 30 to 90 percent
Landform: Very steep and strongly convex mountain slope
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock, tanoak. There is a shrub layer of salmonberry, thimbleberry and huckleberry, and a dense herb layer dominated by swordfern and oxalis on the forest floor. Rhododendron, huckleberry and salal are common shrubs on higher more inland sites.
Ecological site: Not Assigned

***592--Sisterrocks-Ladybird-Footstep Complex, 50 To 75 Percent

Map Unit Setting

General location: Near coast and along Highway 101.
Major uses: Timber production, recreation, wildlife habitat and watershed.
MLRA: 4B - Coastal Redwood Belt
Map unit landscape: mountains
Landscape setting: Very steep, moist, mountain slopes, with strong coastal fog influence.
Elevation: 15 to 1695 feet (5 to 518 meters)
Mean annual precipitation: 65 to 90 inches (1650 to 2290 millimeters)
Mean annual air temperature: 50 to 55 degrees F. (10 to 13 degrees C.)
Frost-free period: 250 to 300 days

Map Unit Composition
**Sisterrocks--35 percent
**Ladybird--30 percent
**Footstep--20 percent
Minor components: 15 percent

Major Component Description

*Sisterrocks and similar soils
Slope: 50 to 75 percent
Aspect: None noted
Landform: Mountain slope
Parent material: Colluvium and residuum derived from sandstone and mudstone
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock, tanoak. There is a shrub layer of salmonberry, thimbleberry and huckleberry, and a dense herb layer dominated by swordfern and oxalis on the forest floor. Rhododendron, huckleberry and salal are common shrubs on higher more inland sites.

Selected Properties and Qualities of Sisterrocks

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Moderately slow
Available water capacity to 60 inches: About 3.4 inches (Low)

Selected Hydrologic Properties of Sisterrocks

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 7e
Ecological site: F004BX108CA, Sequoia sempervirens-pseudotsuga menziesii/polystichum munitum

Typical Profile
**A--0 to 7 in (0 to 18 cm); gravelly loam
**BA--7 to 13 in (18 to 32 cm); very gravelly clay loam
**Bt1--13 to 32 in (32 to 82 cm); extremely gravelly sandy clay loam
**Bt2--32 to 60 in (82 to 152 cm); extremely gravelly clay loam

*Ladybird and similar soils
Slope: 50 to 75 percent
Aspect: None noted
Landform: Mountain slope
Parent material: Colluvium and residuum derived from sandstone and mudstone
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock, tanoak. There is a shrub layer of salmonberry, thimbleberry and huckleberry, and a dense herb layer dominated by swordfern and oxalis on the forest floor. Rhododendron, huckleberry and salal are common shrubs on higher more inland sites.

Selected Properties and Qualities of Ladybird

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: None noted
Slowest permeability class: Moderately slow
Available water capacity to 60 inches: About 9.0 inches (High)

Selected Hydrologic Properties of Ladybird

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups

Land capability nonirrigated: 7e
Ecological site: F004BX108CA, Sequoia sempervirens-pseudotsuga menziesii/polystichum munitum

Typical Profile
**Oi--0 to 2 in (0 to 5 cm); slightly decomposed plant material
**A--2 to 16 in (5 to 41 cm); gravelly loam
**BAt--16 to 23 in (41 to 59 cm); gravelly clay loam
**Bt--23 to 53 in (59 to 135 cm); gravelly clay loam
**2C--53 to 60 in (135 to 152 cm); very gravelly loam

*Footstep and similar soils
Slope: 50 to 75 percent
Aspect: None noted
Landform: Narrow ridges and convex to uniform upper mountain slope
Parent material: Colluvium and residuum derived from sandstone and mudstone
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock, tanoak. There is a shrub layer of salmonberry, thimbleberry and huckleberry, and a dense herb layer dominated by swordfern and oxalis on the forest floor. Rhododendron, huckleberry and salal are common shrubs on higher more inland sites.

Selected Properties and Qualities of Footstep

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: Bedrock (lithic)--20 to 40 inches
Slowest permeability class: Moderately slow above the bedrock
Available water capacity to 60 inches: About 2.6 inches (Low)

Selected Hydrologic Properties of Footstep

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 7e
Ecological site: F004BX108CA, Sequoia sempervirens-pseudotsuga menziesii/polystichum munitum

Typical Profile
**A--0 to 7 in (0 to 18 cm); gravelly loam
**Bt1--7 to 14 in (18 to 35 cm); very gravelly loam
**Bt2--14 to 28 in (35 to 70 cm); extremely gravelly clay loam
**R--28 to 79 in (70 to 200 cm); bedrock

Minor Components

****Rock Outcrop
Composition: About 5 percent

Slope: 30 to 50 percent
Landform: Ridge
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock, tanoak. There is a shrub layer of salmonberry, thimbleberry and huckleberry, and a dense herb layer dominated by swordfern and oxalis on the forest floor. Rhododendron, huckleberry and salal are common shrubs on higher more inland sites.
Ecological site: Not Assigned

****Sasquatch and similar soils
Composition: About 5 percent
Slope: 0 to 30 percent
Landform: Gently concave slopes and in broad hollows on margins of ridge
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock, tanoak. There is a shrub layer of salmonberry, thimbleberry and huckleberry, and a dense herb layer dominated by swordfern and oxalis on the forest floor. Rhododendron, huckleberry and salal are common shrubs on higher more inland sites.
Ecological site: Not Assigned

****Typic Dystrudepts and similar soils
Composition: About 3 percent
Slope: 0 to 30 percent
Landform: Convex positions, formed in sandy marine deposits on ridge
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock, tanoak. There is a shrub layer of salmonberry, thimbleberry and huckleberry, and a dense herb layer dominated by swordfern and oxalis on the forest floor. Rhododendron, huckleberry and salal are common shrubs on higher more inland sites.
Ecological site: F004BX102CA, Pseudotsuga menziesii-sequoia sempervirens/lithocarpus densiflorus

****Debris Slides
Composition: About 2 percent
Slope: 50 to 90 percent
Landform: Hillslope hollows and on steep mountain slope
Typical vegetation: Overstory of redwood, Douglas-fir, western hemlock, tanoak. There is a shrub layer of salmonberry, thimbleberry and huckleberry, and a dense herb layer dominated by swordfern and oxalis on the forest floor. Rhododendron, huckleberry and salal are common shrubs on higher more inland sites.
Ecological site: Not Assigned

***756--Oragran-Weitchpec Complex, 30 To 50 Percent Slopes

Map Unit Setting

General location: Little Bald Hills southeast of the town of Hiouchi.
Major uses: Recreation, wildlife habitat and watershed.
MLRA: 5 - Siskiyou-Trinity Area
Map unit landscape: mountains
Landscape setting: Steep mountain slopes.
Elevation: 845 to 2135 feet (259 to 652 meters)
Mean annual precipitation: 90 to 120 inches (2290 to 3050 millimeters)
Mean annual air temperature: 50 to 55 degrees F. (10 to 13 degrees C.)

Frost-free period: 100 to 150 days

Map Unit Composition
**Oragran--40 percent
**Weitchpec--25 percent
Minor components: 35 percent

Major Component Description

*Oragran and similar soils
Slope: 30 to 50 percent
Aspect: None noted
Landform: Mountain slope
Parent material: Residuum weathered from peridotite or serpentinite
Typical vegetation: Overstory of scattered Jeffery pine, knobcone pine and Douglas-fir. There is a shrub layer of huckleberry oak and manzanita.

Selected Properties and Qualities of Oragran

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: Bedrock (lithic)--10 to 20 inches
Slowest permeability class: Moderately slow above the bedrock
Available water capacity to 60 inches: About 2.3 inches (Very low)

Selected Hydrologic Properties of Oragran

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: D

California Land Use Interpretive Groups
Land capability nonirrigated: 6e
Ecological site: F005XB105CA, Pinus jeffreyi-pseudotsuga menziesii/lithocarpus densiflorus var. echinoides-arctostaphylos nevadensis/xerophyllum tenax

Typical Profile
**Oi--0 to 1 in (0 to 2 cm); slightly decomposed plant material
**A--1 to 3 in (2 to 8 cm); very stony loam
**Bw--3 to 13 in (8 to 33 cm); stony silt loam
**R--13 to 17 in (33 to 43 cm); bedrock

*Weitchpec and similar soils
Slope: 30 to 50 percent
Aspect: None noted
Landform: Mountain slope
Parent material: Residuum weathered from serpentinite
Typical vegetation: Overstory of scattered Jeffery pine, knobcone pine and Douglas-fir. There is a shrub layer of huckleberry oak and manzanita.

Selected Properties and Qualities of Weitchpec

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: Bedrock (lithic)--20 to 40 inches
Slowest permeability class: Moderately slow above the bedrock
Available water capacity to 60 inches: About 2.9 inches (Low)

Selected Hydrologic Properties of Weitchpec

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: B

California Land Use Interpretive Groups
Land capability nonirrigated: 6e
Ecological site: F005XB105CA, Pinus jeffreyi-pseudotsuga menziesii/lithocarpus densiflorus var. echinoides-arctostaphylos nevadensis/xerophyllum tenax

Typical Profile
**A--0 to 8 in (0 to 20 cm); gravelly silt loam
**Bt--8 to 35 in (20 to 89 cm); very gravelly sandy loam
**R--35 to 39 in (89 to 99 cm); bedrock

Minor Components

****Lithic Haploxeralfs ultramafic and similar soils
Composition: About 10 percent
Slope: 50 to 70 percent
Landform: Mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Oragran moderately deep and similar soils
Composition: About 10 percent
Slope: 30 to 50 percent
Landform: Mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Walnett and similar soils
Composition: About 10 percent
Slope: 30 to 50 percent
Landform: Mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Rock Outcrop
Composition: About 5 percent

Slope: 30 to 75 percent
Landform: Mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

***759--Jayel-Walnett-Oragran Complex, 30 To 75 Percent Slopes, Extremely Stony

Map Unit Setting

General location: Little Bald Hills southeast of the town of Hiouchi.
Major uses: Recreation, wildlife habitat and watershed.
MLRA: 5 - Siskiyou-Trinity Area
Map unit landscape: mountains
Landscape setting: Very steep mountain slopes and broad ridges.
Elevation: 180 to 3010 feet (55 to 918 meters)
Mean annual precipitation: 90 to 120 inches (2290 to 3050 millimeters)
Mean annual air temperature: 50 to 55 degrees F. (10 to 13 degrees C.)
Frost-free period: 100 to 180 days

Map Unit Composition
**Jayel extremely stony--35 percent
**Walnett extremely stony--20 percent
**Oragran--20 percent
Minor components: 25 percent

Major Component Description

*Jayel extremely stony and similar soils
Slope: 30 to 50 percent
Aspect: None noted
Landform: Mountain slope
Broad ridge
Parent material: Colluvium and residuum weathered from serpentinized peridotite
Typical vegetation: Overstory of scattered Jeffery pine, knobcone pine and Douglas-fir. There is a shrub layer of huckleberry oak, manzanita, evergreen huckleberry, and tanoak.

Selected Properties and Qualities of Jayel extremely stony

Surface area covered by coarse fragments: 0 to 30 percent subangular stones
Depth to restrictive feature: Bedrock (lithic)--20 to 40 inches
Slowest permeability class: Slow above the bedrock
Available water capacity to 60 inches: About 4.7 inches (Low)

Selected Hydrologic Properties of Jayel extremely stony

Present annual flooding: None
Present annual ponding: None

Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: D

California Land Use Interpretive Groups
Land capability nonirrigated: 7e
Ecological site: F005XB105CA, Pinus jeffreyi-pseudotsuga menziesii/lithocarpus densiflorus var. echinoides-arctostaphylos nevadensis/xerophyllum tenax

Typical Profile
**Oi--0 to 1 in (0 to 2 cm); slightly decomposed plant material
**A--1 to 11 in (2 to 28 cm); stony clay loam
**Bw--11 to 32 in (28 to 81 cm); stony clay
**R--32 to 40 in (81 to 102 cm); bedrock

*Oragran and similar soils
Slope: 30 to 75 percent
Aspect: None noted
Landform: Mountain slope
Parent material: Residuum weathered from peridotite or serpentinite
Typical vegetation: Overstory of scattered Jeffery pine, knobcone pine and Douglas-fir. There is a shrub layer of huckleberry oak, manzanita, evergreen huckleberry, and tanoak.

Selected Properties and Qualities of Oragran

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: Bedrock (lithic)--10 to 20 inches
Slowest permeability class: Moderately slow above the bedrock
Available water capacity to 60 inches: About 3.4 inches (Low)

Selected Hydrologic Properties of Oragran

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: D

California Land Use Interpretive Groups
Land capability nonirrigated: 7e
Ecological site: F005XB105CA, Pinus jeffreyi-pseudotsuga menziesii/lithocarpus densiflorus var. echinoides-arctostaphylos nevadensis/xerophyllum tenax

Typical Profile
**Oi--0 to 1 in (0 to 2 cm); slightly decomposed plant material
**A--1 to 3 in (2 to 8 cm); very stony loam
**Bw--3 to 19 in (8 to 48 cm); stony silt loam
**R--19 to 23 in (48 to 58 cm); bedrock

*Walnett extremely stony and similar soils

Slope: 30 to 75 percent
Aspect: None noted
Landform: Mountain slope
Parent material: Colluvium and residuum weathered from serpentinized peridotite
Typical vegetation: Overstory of scattered Jeffery pine, knobcone pine and Douglas-fir. There is a shrub layer of huckleberry oak, manzanita, evergreen huckleberry, and tanoak.

Selected Properties and Qualities of Walnett extremely stony

Surface area covered by coarse fragments: 10 to 30 percent subangular stones
Depth to restrictive feature: Bedrock (lithic)--60 to 79 inches
Slowest permeability class: Moderately slow above the bedrock
Available water capacity to 60 inches: About 5.4 inches (Moderate)

Selected Hydrologic Properties of Walnett extremely stony

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 7e
Ecological site: F005XB105CA, Pinus jeffreyi-pseudotsuga menziesii/lithocarpus densiflorus var. echinoides-arctostaphylos nevadensis/xerophyllum tenax

Typical Profile
**Oi--0 to 1 in (0 to 2 cm); slightly decomposed plant material
**A--1 to 5 in (2 to 13 cm); very stony loam
**Bt--5 to 43 in (13 to 109 cm); very gravelly clay loam
**C--43 to 61 in (109 to 155 cm); extremely gravelly loam
**R--61 to 65 in (155 to 165 cm); bedrock

Minor Components

****Lithic Haploxeralfs ultramafic and similar soils
Composition: About 10 percent
Slope: 50 to 70 percent
Landform: Mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Gasquet extremely stony and similar soils
Composition: About 5 percent
Slope: 15 to 30 percent
Landform: Mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Rock Outcrop
Composition: About 5 percent
Slope: 30 to 75 percent
Landform: Mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Ultic Haploxeralfs fine-loamy and similar soils
Composition: About 5 percent
Slope: 30 to 75 percent
Landform: Mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

***760--Jayel-Walnett-Oragran Complex, 9 To 30 Percent Slopes, Extremely Stony

Map Unit Setting

General location: Little Bald Hills southeast of the town of Hiouchi.
Major uses: Recreation, wildlife habitat and watershed.
MLRA: 5 - Siskiyou-Trinity Area
Map unit landscape: mountains
Landscape setting: Broad ridges and moderately steep mountain slopes.
Elevation: 1535 to 2410 feet (469 to 735 meters)
Mean annual precipitation: 90 to 120 inches (2290 to 3050 millimeters)
Mean annual air temperature: 50 to 55 degrees F. (10 to 13 degrees C.)
Frost-free period: 100 to 180 days

Map Unit Composition
**Jayel extremely stony--30 percent
**Walnett extremely stony--25 percent
**Oragran--25 percent
Minor components: 20 percent

Major Component Description

*Jayel extremely stony and similar soils
Slope: 9 to 30 percent
Aspect: None noted
Landform: Mountain slope
Broad ridge
Parent material: Colluvium and residuum weathered from serpentinized peridotite
Typical vegetation: Overstory of scattered Jeffery pine, knobcone pine, Douglas-fir and Port-Orford cedar. There is a shrub layer of huckleberry oak and manzanita and Idaho and California fescues, bromes and sedges in the herb layer.

Selected Properties and Qualities of Jayel extremely stony

Surface area covered by coarse fragments: 0 to 30 percent subangular stones
Depth to restrictive feature: Bedrock (lithic)--20 to 40 inches
Slowest permeability class: Slow above the bedrock
Available water capacity to 60 inches: About 4.7 inches (Low)

Selected Hydrologic Properties of Jayel extremely stony

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: D

California Land Use Interpretive Groups
Land capability nonirrigated: 6e
Ecological site: F005XB105CA, Pinus jeffreyi-pseudotsuga menziesii/lithocarpus densiflorus var. echinoides-arctostaphylos nevadensis/xerophyllum tenax

Typical Profile
**Oi--0 to 1 in (0 to 2 cm); slightly decomposed plant material
**A--1 to 11 in (2 to 28 cm); stony clay loam
**Bw--11 to 32 in (28 to 81 cm); stony clay
**R--32 to 40 in (81 to 102 cm); bedrock

*Oragran and similar soils
Slope: 9 to 30 percent
Aspect: None noted
Landform: Mountain slope
Broad ridge
Parent material: Residuum weathered from peridotite or serpentinite
Typical vegetation: Overstory of scattered Jeffery pine, knobcone pine and Douglas-fir. There is a shrub layer of huckleberry oak and manzanita.

Selected Properties and Qualities of Oragran

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: Bedrock (lithic)--10 to 20 inches
Slowest permeability class: Moderately slow above the bedrock
Available water capacity to 60 inches: About 2.3 inches (Very low)

Selected Hydrologic Properties of Oragran

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: D

California Land Use Interpretive Groups
Land capability nonirrigated: 6e

Ecological site: F005XB105CA, Pinus jeffreyi-pseudotsuga menziesii/lithocarpus densiflorus var. echinoides-arctostaphylos nevadensis/xerophyllum tenax

Typical Profile
**Oi--0 to 1 in (0 to 2 cm); slightly decomposed plant material
**A--1 to 3 in (2 to 8 cm); very stony loam
**Bw--3 to 13 in (8 to 33 cm); stony silt loam
**R--13 to 17 in (33 to 43 cm); bedrock

*Walnett extremely stony and similar soils
Slope: 9 to 30 percent
Aspect: None noted
Landform: Mountain slope
Broad ridge
Parent material: Colluvium and residuum weathered from serpentinized peridotite
Typical vegetation: Overstory of scattered Jeffery pine, knobcone pine, Douglas-fir and Port-Orford cedar. There is a shrub layer of huckleberry oak and manzanita and Idaho and California fescues, bromes and sedges in the herb layer.

Selected Properties and Qualities of Walnett extremely stony

Surface area covered by coarse fragments: 10 to 30 percent subangular stones
Depth to restrictive feature: Bedrock (lithic)--60 to 79 inches
Slowest permeability class: Moderately slow above the bedrock
Available water capacity to 60 inches: About 5.4 inches (Moderate)

Selected Hydrologic Properties of Walnett extremely stony

Present annual flooding: None
Present annual ponding: None
Surface runoff: Medium
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 6e
Ecological site: F005XB105CA, Pinus jeffreyi-pseudotsuga menziesii/lithocarpus densiflorus var. echinoides-arctostaphylos nevadensis/xerophyllum tenax

Typical Profile
**Oi--0 to 1 in (0 to 2 cm); slightly decomposed plant material
**A--1 to 5 in (2 to 13 cm); very stony loam
**Bt--5 to 43 in (13 to 109 cm); very gravelly clay loam
**C--43 to 61 in (109 to 155 cm); extremely gravelly loam
**R--61 to 65 in (155 to 165 cm); bedrock

Minor Components

****Weitchepec and similar soils

Composition: About 10 percent
Slope: 15 to 50 percent
Landform: Mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Gasquet extremely stony and similar soils
Composition: About 5 percent
Slope: 9 to 30 percent
Landform: Mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Rock Outcrop
Composition: About 5 percent
Slope: 30 to 75 percent
Landform: Mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

***761--Gasquet-Walnett-Jayel Complex, 9 To 50 Percent Slopes

Map Unit Setting

General location: Little Bald Hills southeast of the town of Hiouchi.
Major uses: Recreation, wildlife habitat and watershed.
MLRA: 5 - Siskiyou-Trinity Area
Map unit landscape: mountains
Landscape setting: Moderately steep to steep mountain slopes.
Elevation: 510 to 2515 feet (156 to 768 meters)
Mean annual precipitation: 90 to 120 inches (2290 to 3050 millimeters)
Mean annual air temperature: 50 to 55 degrees F. (10 to 13 degrees C.)
Frost-free period: 140 to 180 days

Map Unit Composition
**Gasquet extremely stony--30 percent
**Walnett extremely stony--25 percent
**Jayel--20 percent
Minor components: 25 percent

Major Component Description

*Gasquet extremely stony and similar soils
Slope: 9 to 40 percent
Aspect: None noted
Landform: Mountain slope
Parent material: Colluvium and residuum weathered from serpentinized peridotite
Typical vegetation: Overstory of Douglas-fir, tanoak, and madrone. There is a shrub layer of evergreen huckleberry, huckleberry oak, and coffeeberry.

Selected Properties and Qualities of Gasquet extremely stony

Surface area covered by coarse fragments: 5 to 15 percent subangular stones
Depth to restrictive feature: Bedrock (lithic)--60 to 472 inches
Slowest permeability class: Slow above the bedrock
Available water capacity to 60 inches: About 9.4 inches (High)

Selected Hydrologic Properties of Gasquet extremely stony

Present annual flooding: None
Present annual ponding: None
Surface runoff: Very high
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: D

California Land Use Interpretive Groups
Land capability nonirrigated: 6e
Ecological site: F005XB105CA, Pinus jeffreyi-pseudotsuga menziesii/lithocarpus densiflorus var. echinoides-arctostaphylos nevadensis/xerophyllum tenax

Typical Profile
**Oi--0 to 1 in (0 to 2 cm); slightly decomposed plant material
**A--1 to 10 in (2 to 25 cm); stony loam
**Bt--10 to 61 in (25 to 155 cm); stony clay loam
**R--61 to 65 in (155 to 165 cm); bedrock

*Walnett extremely stony and similar soils
Slope: 9 to 50 percent
Aspect: None noted
Landform: Mountain slope
Parent material: Colluvium and residuum weathered from serpentinized peridotite
Typical vegetation: Overstory of Douglas-fir, tanoak, and madrone. There is a shrub layer of evergreen huckleberry, huckleberry oak, and coffeeberry.
Selected Properties and Qualities of Walnett extremely stony

Surface area covered by coarse fragments: 10 to 30 percent subangular stones
Depth to restrictive feature: Bedrock (lithic)--60 to 79 inches
Slowest permeability class: Moderately slow above the bedrock
Available water capacity to 60 inches: About 5.4 inches (Moderate)

Selected Hydrologic Properties of Walnett extremely stony

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: C

California Land Use Interpretive Groups
Land capability nonirrigated: 6e
Ecological site: F005XB105CA, Pinus jeffreyi-pseudotsuga menziesii/lithocarpus densiflorus var. echinoides-arctostaphylos nevadensis/xerophyllum
tenax

Typical Profile
**Oi--0 to 1 in (0 to 2 cm); slightly decomposed plant material
**A--1 to 5 in (2 to 13 cm); very stony loam
**Bt--5 to 43 in (13 to 109 cm); very gravelly clay loam
**C--43 to 61 in (109 to 155 cm); extremely gravelly loam
**R--61 to 65 in (155 to 165 cm); bedrock

*Jayel and similar soils
Slope: 9 to 50 percent
Aspect: None noted
Landform: Mountain slope
Parent material: Colluvium and residuum weathered from serpentinized peridotite
Typical vegetation: Overstory of Douglas-fir, tanoak, and madrone. There is a shrub layer of evergreen huckleberry, huckleberry oak, and coffeeberry.

Selected Properties and Qualities of Jayel

Surface area covered by coarse fragments: None noted.
Depth to restrictive feature: Bedrock (lithic)--20 to 40 inches
Slowest permeability class: Slow above the bedrock
Available water capacity to 60 inches: About 4.6 inches (Low)

Selected Hydrologic Properties of Jayel

Present annual flooding: None
Present annual ponding: None
Surface runoff: High
Current water table: None noted.
Natural drainage class: Well drained
Hydrologic Soil Group: D

California Land Use Interpretive Groups
Land capability nonirrigated: 6e
Ecological site: F005XB105CA, Pinus jeffreyi-pseudotsuga menziesii/lithocarpus densiflorus var. echinoides-arctostaphylos nevadensis/xerophyllum tenax

Typical Profile
**A--0 to 12 in (0 to 30 cm); clay loam
**Bw--12 to 40 in (30 to 102 cm); gravelly clay
**R--40 to 60 in (102 to 152 cm); bedrock

Minor Components

****Lithic Haploxeralfs and similar soils
Composition: About 10 percent
Slope: 50 to 70 percent
Landform: Mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Oragran moderately deep and similar soils
Composition: About 10 percent
Slope: 30 to 50 percent
Landform: Mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

****Ultic Haploxeralfs fine-loamy and similar soils
Composition: About 5 percent
Slope: 30 to 50 percent
Landform: Mountain slope
Typical vegetation: None assigned
Ecological site: Not Assigned

APPENDIX D

MILL CREEK ADDITION BRIDGES

PLANS OF ACTION

Plan of Action form field definitions

- **Br No.** Caltrans Bridge Inventory Item number. *This Information provided by Caltrans on the form.*
- **Owner.** Name of agency who owns the Bridges. *Information provided by Caltrans on the form.*
- **Location.** Distance from nearest main road. Reference the most recent Caltrans Bridge Inspection Report (BIR) for this information. *Information provided by Caltrans on the form.*
- **Facility Carried**. Name the road the bridge carries. Reference the most recent Caltrans Bridge Inspection Report (BIR) for this information. *Information provided by Caltrans on the form.*
- **Name.** Name the creek/river that intersects the bridge**.** *Information provided by Caltrans on the form.*

- **Completed By.** Name of agency that is responsible for completing the Plan of Action.
- **Date.** Provide the date of when the Plan of Action form was completed.

1)

- **<u>Scour Vulnerability Rating</u>.** *Caltrans has completed a hydraulic evaluation and possibly a Structural and Geotechnical evaluation for all scour critical bridges. The evaluations should provide the details as to why the bridge is considered scour critical. Caltrans is not providing this information on the form, but this information is summarized on the Caltrans scour BIR. This BIR should also have a summary of the scour history. The scour history is taken from past routine BIR's. The history should also include any scour information the local agency may have knowledge of. If additional details regarding the scour rating and history are needed, contact your Area Bridge Maintenance Engineer or Charles Ineichen by e-mail at: charles_ineichen@dot.ca.gov.*
- **Scour Evaluation Summary.** Summarize why the bridge became/is scour critical and provide some details of the present hydraulic concerns at the bridge site.
- **Scour History.** Report any known history of scour problems, drift/debris problems at the bridge site, channel meandering, bank erosion, approach washout, or any channel degradation and mining operation in proximity to site, etc.

    - a) **Foundation type.** Identify the bridge foundation type. As-built plans are a good source as is any engineer who may have worked on the project.

    - b) **Foundation material.** Identify the foundation material. Foundation Reports and/or Log of Test Borings are a good source for this information. The county may also want to do a field visit to assess the ground material. This entry also can be left unknown.

- Scour review. Provide any known past hydraulic studies including the Caltrans evaluation and the date.
- Structural assessment. Provide any known past structural assessment studies in relation to the scour potential and the date done at the bridge site.
  Critical Elevation. If any study provides an elevation in which the bridge becomes unstable, provide that information.
- Geotechnical Assessment. Provide any known past geotechnical assessment studies and the date done at the bridge site.
  Critical Elevation. If any study provides an elevation in which the bridge foundation becomes unstable, provide that information.

2)

- **<u>NBIS Coding Information</u>.** *NBI data is taken from the most recent Caltrans BIR and is found on the Structure Inventory and Appraisal Sheet attached to all routine Caltrans BIR's. Information can also be referenced in the Federal Highway Administration Publication of "Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges". Report No. FHWA-PD-96-001.*
  - Inspection Date. Reference latest routine Caltrans BIR. *Information provided by Caltrans on the form.*
  - Item 113 Scour. Bridge coding regarding its vulnerability to scour. *Information provided by Caltrans on the form.*
  - Item 60 Substructure. This item describes the physical condition of piers, abutments, piles, fenders, footings or other components. *Information provided by Caltrans on the form.*
  - Item 61 Channel and Channel Protection. This item describes the physical conditions associated with the flow of water through the bridge. *Information provided by Caltrans on the form.*
  - Item 71 Waterway Adequacy. This item appraises the waterway opening with respect to passage of flow through bridge. *Information provided by Caltrans on the form.*

3)

- **<u>Scour Countermeasure.</u>** *In accordance with guidelines from Hydraulic Engineering Circular 18 and 23 (HEC 18 and HEC 23) published by the Federal Highway Administration.*
- **A) Completed Scour Countermeasure.** Indicate and give details and dates of any recent scour countermeasure that has been implemented in regards to addressing the current scour critical status of the bridge. All applicable studies, lead agencies, subcontractors and as-builts should be noted.
- **B) Proposed Scour Countermeasures.**
  - **Countermeasures Not Required.** Indicate and provide details as to why no scour countermeasures are required at this time.
  - **Install Scour Countermeasures.** Indicate and provide details and dates including reference to any hydraulic, structural or geotechnical studies that

have been completed for the purpose of scour mitigation. Provide estimated cost to all proposed scour countermeasure for the bridge site
   - **Close Bridge.** Provide dates, details and detour**.**

4)

- **<u>Countermeasure Implementation Schedule</u>.**
   - Proposed Construction Project**.** Identifies the proposed project and identify the lead agency and all subcontractors, if any, involved in the proposal. An estimated date of completion should be given.
   - Maintenance Project**.** Identifies if project is in house.
   - Other scheduling information**.**

5)

- **<u>Monitoring Plan</u>.** *Monitoring is an option of providing scour countermeasure at a bridge site. It can be used as the scour mitigation proposal or as a supplement to a more permanent scour countermeasure. Monitoring a bridge for scour encompasses a large and varied amount of options. It can be as simple as inspecting the bridge for hydraulic damage on a regular interval and/or after a significant hydraulic event, or as complex as monitoring the bridge at different discharge levels using various monitoring devices. A monitoring plan could be the precipitous leading to Bridge Closure.*
  Monitoring, if used, should include provisions for:
   - **Monitoring Plan Summary.** Provide details of the extent of monitoring. What information the monitoring will provide. What action will be implemented if the information indicates a scour problem? If an engineering firm is contracted for the monitoring plan, provide the details.
   - **Monitoring Authority.** Identify responsible agency for implementation and action of monitoring. Indicate who is in charge of overseeing and carrying out the monitoring plan.
      - **Regular Inspection program.** Indicate the frequency of the monitoring and will cross sections and comparison of historical cross sections be required. Indicate the items to watch for.
      - **Increased Inspection Interval.** Indicate the need for and increased interval and items to watch for.
      - **Fixed Monitoring Devices.** Identify the type of instrument. This type of monitoring can be dependant on increasing channel flows and an identified discharge that could potential cause scour concerns. The monitoring or interval is usually increased as discharge increases. *Further information on monitoring devices can be found at the following website:* http://www.dot.ca.gov/hq/structur/strmaint/smi.htm *reference the Plan of Action Links.*
      - **Other Monitoring Program.** Identify any other methods of monitoring.

6)

- **Bridge Closure Plan.**
  - **Bridge ADT.** Can be found on the most recent routine Caltrans BIR on the Structure Inventory and Appraisal Sheet. *Information provided by Caltrans on the form.* The agencies should update as necessary.
  - **Built.** Identifies the year the bridge was built**.** Found in archived records or on the most recent Caltrans BIR's.
  - **% Trucks.** Found in research projects or on the most recent Caltrans BIR's. *Information provided by Caltrans on the form.* The agencies should update as necessary.
  - **Bridge Length.** Found in as-built plans or on the most recent Caltrans BIR's. *Information provided by Caltrans on the form.*

  - **Closure Plan Summary.** Provide summary of closure.

  - **Scour Monitoring Criteria for Considering Bridge Closure.** Should be filled out if monitoring is used in consideration for bridge closure.

  - **Person. Area Responsible for Closure**. Identify responsible person/position responsible for closure.

  - **Contact People.** Identify responsible person/position who will be in charge of the bridge during closure.

  - **Responsible for re-opening after inspection**. Identify responsible person/position responsible for re-opening the bridge**.**

7)

- **Detour Route.**
  - **Detour Route Description.** Provide a map with a viable detour in case of bridge closure/failure.
  - **Average ADT.** Provide average daily traffic on alternate route. Can be found in recent research studies or possible alternate bridges within route by referencing the most recent routine Caltrans BIR's
  - **%Trucks.** Provide average daily truck traffic on alternate route. Can be found in recent research studies or possible alternate bridges within the detour route by referencing the most recent routine Caltrans BIR's for the appropriate bridge.
  - **Length of Detour.** Provide length of detour in miles.

- **Bridges on Detour Route.** Provide a list of Bridges along the detour that are over water, the feature intersected, the Sufficiency Rating and load limitations and the bridges own 113 code.
  - Bridges Number**.** Caltrans Bridge Inventory Item number.
  - Waterway**.** Identify the waterway beneath the bridge.

- Sufficiency Rating**.** Found on the most routine Caltrans BIR on the Structure Inventory and Appraisal sheet.
- Load Rating. Found on the most recent routine Caltrans BIR.
- Scour 113 Code**.** Found on the most recent routine Caltrans BIR on the Structure Inventory and Appraisal sheet.

BRIDGE SCOUR EVALUATION - PLAN OF ACTION				
Br. No. **01P0021**	**Owner** **Parks**	**Location** **Mill Creek**	**Facility Carried** **Child's Hill RD**	**Name** **East Fork Mill Creek**
Plan of Action Completed By: **Gerhard Panuschka**			**Date of Completion:** **30Nov2009**	

1. SCOUR VULNERABILITY RATING

Scour Evaluation Summary:

At the time of this inspection, no debris was observed. A slight flow of water was passing through the channel beneath the bridge. The log supports at the abutments are starting to get undermined, and the logs are rotting. However, no settlement of the superstructure was noted.

Scour History:

Observations: A cut in the embankment along the Abutment 1 timber crib wall was noted during previous investigations in 2003, 2006, and 2008. Undermining of the bottom transverse log of the Abutment 1 crib wall was also noted during an investigation in 2008. The undermining was up to 2 feet below the log and 2 feet back from the face along a distance of 7 feet on the downstream side. Work recommendations dated 10/23/2008 called for the repair of the undermining along the bottom of the crib wall at Abutment 1.

a. **Foundation Type** ☒ Spread footing ☐ Pile Extension ☐ Footing on Piles ☐ Unknown

b. **Foundation Material** ☒ Known _**Timber logs w/dirt backfill**_ ☐ Unknown

Scour Review: Done By: **Gerhard Panuschka** Date: **04Nov2009**

Structural Assessment: Done By: Date:
Critical Elevation: ________________

Geotechnical Assessment: Done By: Date:
Critical Elevation: ________________

2. NBIS CODING INFORMATION

		Most Recent
Inspection date		
Item 113	Scour	3
Item 60	Substructure	5
Item 61	Channel & Channel Protection	6
Item 71	Waterway Adequacy	7

3. COUNTERMEASURE RECOMMENDATION

A. Completed Countermeasures:

No countermeasures are currently in place.

B. Proposed Countermeasures:

☐ **Countermeasures Not Required. (Please explain)**

☒ **Install Scour Countermeasures** (See 4 and 5)

	Estimated Cost
_X_ Riprap with monitoring program	$ 80,000
___Guide bank	$
___Spurs / Bendway weirs / Barbs	$
___Relief bridge / Culvert	$
___Channel improvements	$
___Monitoring	$
___Monitoring device	$
___Check Dam	$
___Substructure Modification	$
_X_ Bridge replacement	$ 500,000
___Other ___________________________________	$

☐ **Close Bridge** (See 6)

4. COUNTERMEASURE IMPLEMENTATION SCHEDULE

Countermeasure Implementation Project Type:

☒ Proposed Construction Project

Lead Agency State Parks

☒ Maintenance Project

Advertised Date: NA

Other scheduling information: **Bridge will be added to Project Identification Data (PID) list for replacement as soon as budget becomes available.**

5. MONITORING PLAN

Monitoring Plan Summary:

State Parks maintenance personnel will monitor structure several times a year, and after main runoff events. Maintenance personnel will be trained in observing and identifying scour, how to minimize scour (removal of debris, filling of scour holes, etc.), and what steps to take when significant scour occurs. Bridge may be closed after significant scour events pending evaluation of structural integrity of bridge by engineer.

State Parks personnel will inspect the bridge in early winter for debris. Another inspection is planned in spring. In consultation with the District's Environmental Coordinator and the California Department of Fish and Game, woody debris may be removed or manipulated.

Monitoring Authority: **State Parks – North Coast Redwoods District Trail Maintenance**

☒ **Regular Inspection Program of _____6_mo.** ☐ w/surveyed cross sections
Items to Watch: undermining the footing

☐ **Increased Inspection Interval of _______ mo.** ☐ w/surveyed cross sections
Items to Watch:.

☐ **Underwater Inspection Program** **Frequency _______ mo.**
Items to Watch:

☐ **Fixed Monitoring Device**
Type of Instrument:
Installation location(s):
Sample Interval: ☐ 30 min. ☐ 1 hr. ☐ 6 hrs. ☐ 12 hrs. ☐ Other __________
Frequency of data logger downloading: ☐ Weekly ☐ Bi-weekly ☐ Monthly ☐ Other __________
Scour-critical discharge:__________
Action required if scour-critical elevation detected:

☒ **Other Monitoring Program**
Type: ☒ Visual
☐ Instrument
☐ Portable ☐ Geophysical ☐ Sonar
☐ Other gages

Flood monitoring required: ☐ Yes ☒ No
Flood monitoring event defined by:
☐ Discharge over __________
☐ Stage _______
☐ Elev. measured from _______

Frequency of flood monitoring: ☐ 1 hr. ☐ 3 hr. ☐ 6 hrs. ☐ Other
Scour critical elevation:
Action required if scour-critical elevation detected:

6. BRIDGE CLOSURE PLAN

Bridge ADT: 10	Built: 1950	% Trucks: 15	Bridge Length (ft): 59

Closure Plan Summary

State Parks Maintenance will report significant scour events to management. State Parks engineer or geologist will immediately inspect bridge condition and, if required, close bridge by setting up barricades and signs. State Parks engineer/geologist will determine countermeasures to protect the bridge from further damage. Bridge will be re-opened upon completion of countermeasures and if it is considered structurally sound.

Scour Monitoring Criteria for Consideration of Bridge Closure:

- ☐ Water surface elevation reaches ________________
- ☐ Overtopping road or structure
- ☒ Scour Measurement Results / Monitoring Device
- ☒ Loss of Riprap
- ☒ Observed amount of Settlement
- ☒ Loss of Road Embankment
- ☒ Debris Accumulation
- ☐ Other _________________

Person / Area Responsible for Closure: Jeff Bomke, Sector Superintendent, North Coast Redwoods District

Contact People (Name & Phone No.): Gerhard Panuschka: 916-445-8680

Responsible for re-opening after inspection: Jeff Bomke

7. DETOUR ROUTE

Detour route description (route number, from - to, etc.) – attach map.

Average ADT: 10	Year: 2003	% Trucks: 15	Length: 123.7 miles

Bridges on Detour Route:

Bridge Number	Waterway	Sufficiency Rating/ Load limitations	Scour 113 code

BRIDGE SCOUR EVALUATION - PLAN OF ACTION				
Br. No. **01P0014**	**Owner** **Parks**	**Location** **Mill Creek**	**Facility Carried** **Hamilton Rd**	**Name** **First Gulch**

Plan of Action Completed By: **Gerhard Panuschka**	**Date of Completion:** **30Nov2009**

1. SCOUR VULNERABILITY RATING

Scour Evaluation Summary:

At the time of this inspection, no scour and no debris was observed. A slight flow of water was passing through the channel beneath the bridge. Minor erosion along the banks was noted. Flat car sits on one big log (about 4' diameter) at each abutment.

Hamilton Road is the only road into the park. The road is open to the public on weekends all year.

Scour History:

During pervious investigations in 2003, 2006, and 2008, it was noted that there were cuts in the embankments beneath both abutments that were approximately 10 feet deep. Also reported in the 2006 investigation was a shifting of the low point in channel bed towards abutment 1. A slight degradation of the channel bed was also reported in 2008. Work recommendations dated 9/23/2003 called for an embankment protection beneath both abutments and the replacement of the existing timber log abutments.

a. **Foundation Type** ☒ Spread footing ☐ Pile Extension ☐ Footing on Piles ☐ Unknown

b. **Foundation Material** ☒ Known _**Timber logs w/dirt backfill**_ ☐ Unknown

Scour Review: Done By: **Gerhard Panuschka** Date: **04Nov2009**

Structural Assessment: Done By: NA Date:
Critical Elevation: _________________

Geotechnical Assessment: Done By: NA Date:
Critical Elevation: _________________

2. NBIS CODING INFORMATION

		Most Recent
Inspection date		
Item 113	Scour	3
Item 60	Substructure	6
Item 61	Channel & Channel Protection	6
Item 71	Waterway Adequacy	6

3. COUNTERMEASURE RECOMMENDATION

A. Completed Countermeasures:

No countermeasures are currently in place.

B. Proposed Countermeasures:

Bridge will be added to Project Identification Data (PID) list for replacement as soon as budget becomes available. In the meanwhile, bridge will be monitored on a regular basis (see 5).

☒ **Countermeasures Not Required. (Please explain)**

Parks Maintenance will monitor bridge – see below.

☐ **Install Scour Countermeasures** (See 4 and 5)

	Estimated Cost
___Riprap with monitoring program	$
___Guide bank	$
___Spurs / Bendway weirs / Barbs	$
___Relief bridge / Culvert	$
___Channel improvements	$
___Monitoring	$
___Monitoring device	$
___Check Dam	$
___Substructure Modification	$
_X_Bridge replacement	$ 500,000
___Other ________________________________	$

☐ **Close Bridge** (See 6)

4. COUNTERMEASURE IMPLEMENTATION SCHEDULE

Countermeasure Implementation Project Type:

☒ Proposed Construction Project

Lead Agency State Parks

☐ Maintenance Project

Advertised Date: NA

Other scheduling information: **Bridge will be added to Project Identification Data (PID) list for replacement as soon as budget becomes available.**

5. MONITORING PLAN

Monitoring Plan Summary:

State Parks maintenance personnel will monitor structure several times a year, and after main runoff events. Maintenance personnel will be trained in observing and identifying scour, how to minimize scour (removal of debris, filling of scour holes, etc.), and what steps to take when significant scour occurs. Bridge may be closed after significant scour events pending evaluation of structural integrity of bridge by engineer.

State Parks personnel will inspect the bridge in early winter for debris. Another inspection is planned in spring. In consultation with the District's Environmental Coordinator and the California Department of Fish and Game, woody debris may be removed or manipulated.

Monitoring Authority: **State Parks – North Coast Redwoods District Trail Maintenance**

☒ **Regular Inspection Program of _____6_mo.** ☐ w/surveyed cross sections
Items to Watch: undermining the footing
☐ **Increased Inspection Interval of _______ mo.** ☐ w/surveyed cross sections
Items to Watch:.
☐ **Underwater Inspection Program** **Frequency _______ mo.**
Items to Watch:
☐ **Fixed Monitoring Device**
Type of Instrument:
Installation location(s):
Sample Interval: ☐ 30 min. ☐ 1 hr. ☐ 6 hrs. ☐ 12 hrs.
☐ Other __________
Frequency of data logger downloading: ☐ Weekly ☐ Bi-weekly ☐ Monthly
☐ Other __________
Scour-critical discharge:__________
Action required if scour-critical elevation detected:

☒ **Other Monitoring Program**
Type: ☒ Visual
☐ Instrument
☐ Portable ☐ Geophysical ☐ Sonar
☐ Other gages

Flood monitoring required: ☐ Yes ☒ No
Flood monitoring event defined by:
☐ Discharge over __________
☐ Stage _______
☐ Elev. measured from _______

Frequency of flood monitoring: ☐ 1 hr. ☐ 3 hr. ☐ 6 hrs. ☐ Other
Scour critical elevation:
Action required if scour-critical elevation detected:

6. BRIDGE CLOSURE PLAN			
Bridge ADT: 10	**Built:** 1950	**% Trucks:** 10	**Bridge Length (ft):** 50

Closure Plan Summary

State Parks Maintenance will report significant scour events to management. State Parks engineer or geologist will immediately inspect bridge condition and, if required, close bridge by setting up barricades and signs. State Parks engineer/geologist will determine countermeasures to protect the bridge from further damage. Bridge will be re-opened upon completion of countermeasures and if it is considered structurally sound.

Scour Monitoring Criteria for Consideration of Bridge Closure:

- ☐ Water surface elevation reaches ________________
- ☐ Overtopping road or structure
- ☒ Scour Measurement Results / Monitoring Device
- ☒ Loss of Riprap
- ☒ Observed amount of Settlement
- ☒ Loss of Road Embankment
- ☒ Debris Accumulation
- ☐ Other _________________

Person / Area Responsible for Closure: Jeff Bomke, Sector Superintendent, North Coast Redwoods District

Contact People (Name & Phone No.): Gerhard Panuschka: 916-445-8680

Responsible for re-opening after inspection: Jeff Bomke

7. DETOUR ROUTE

Detour route description (route number, from - to, etc.) – attach map.

Average ADT: 10	**Year:** 2003	**% Trucks:** 10	**Length:** 123.7 miles

Bridges on Detour Route:

Bridge Number	Waterway	Sufficiency Rating/ Load limitations	Scour 113 code

BRIDGE SCOUR EVALUATION - PLAN OF ACTION				
Br. No. 01P0015	**Owner** Parks	**Location** Mill Creek	**Facility Carried** Rock Creek Rd	**Name** East Fork Mill Creek
Plan of Action Completed By: Gerhard Panuschka			**Date of Completion:** 30Nov2009	

1. SCOUR VULNERABILITY RATING

Scour Evaluation Summary:

At the time of this inspection, no scour and no debris was observed. A slight flow of water was passing through the channel beneath the bridge. This bridge is of concern because 1) it is supported behind the pin location and therefore the allowable loading listed on the flatcar superstructure may not be relevant, and 2) there is a log habitat structure in the channel approximately 150' upstream from the bridge. This habitat structure alters the flow patterns in the channel during high flow and tends to direct flow toward the South approach bank, which is relatively long. This approach bank needs to be protected by RSP.

This bridge is essential within Mill Creek since it provides access to the South and Southwest part of West Branch Mill Creek (approximately 10,000 acres).

Scour History:

There is only a very short documented history of the bridge. In 2002, a 25,000-acre redwood forest in the Mill Creek Watershed was purchased from a logging company by a conglomeration of environmental organizations. The land was donated to the California Dept. of Parks and Rec. to connect Jedediah Smith and Del Norte Coast Redwood State Parks. As part of the acquisition, eleven existing bridges formally used by logging trucks became the property of the State.

Observations: A cut in the embankment beneath Abutment 2 was noted during previous investigations in 2003 and 2006. It was recommended that State Parks consider planning to have the log abutments replaced.

a. **Foundation Type** ☒ Spread footing ☐ Pile Extension ☐ Footing on Piles ☐ Unknown

b. **Foundation Material** ☒ Known _**Timber logs w/dirt backfill**_ ☐ Unknown

Scour Review: Done By: **Gerhard Panuschka** Date: **04Nov2009**

Structural Assessment: Done By: Date:
Critical Elevation: ________________

Geotechnical Assessment: Done By: Date:
Critical Elevation: ________________

2. NBIS CODING INFORMATION		
		Most Recent
Inspection date		
Item 113	Scour	3
Item 60	Substructure	5
Item 61	Channel & Channel Protection	6
Item 71	Waterway Adequacy	7

3. COUNTERMEASURE RECOMMENDATION

A. Completed Countermeasures:

No countermeasures are currently in place.

B. Proposed Countermeasures:

☐ **Countermeasures Not Required. (Please explain)**

☒ **Install Scour Countermeasures** (See 4 and 5)

	Estimated Cost
_X_ Riprap with monitoring program	$ 80,000
___Guide bank	$
___Spurs / Bendway weirs / Barbs	$
___Relief bridge / Culvert	$
___Channel improvements	$
___Monitoring	$
___Monitoring device	$
___Check Dam	$
___Substructure Modification	$
_X_ Bridge replacement	$ 750,000
___Other ____	$

☐ **Close Bridge** (See 6)

4. COUNTERMEASURE IMPLEMENTATION SCHEDULE

Countermeasure Implementation Project Type:

☒ Proposed Construction Project

Lead Agency _State Parks_

☒ Maintenance Project

Advertised Date: NA

Other scheduling information: **Bridge was added to Project Identification Data (PID) list for replacement as soon as budget becomes available.**

5. MONITORING PLAN

Monitoring Plan Summary:

State Parks maintenance personnel will monitor structure several times a year, and after main runoff events. Maintenance personnel will be trained in observing and identifying scour, how to minimize scour (removal of debris, filling of scour holes, etc.), and what steps to take when significant scour occurs. Bridge may be closed after significant scour events pending evaluation of structural integrity of bridge by engineer.

State Parks personnel will inspect the bridge in early winter for debris. Another inspection is planned in spring. In consultation with the District's Environmental Coordinator and the California Department of Fish and Game, woody debris may be removed or manipulated.

Monitoring Authority: **State Parks – North Coast Redwoods District Trail Maintenance**

☒ **Regular Inspection Program of _____6_mo.** ☐ w/surveyed cross sections
Items to Watch: undermining the footing

☒ **Increased Inspection Interval of ____3_ mo.** ☐ w/surveyed cross sections
Items to Watch: **Erosion on South approach embankment.**

☐ **Underwater Inspection Program** **Frequency _______ mo.**
Items to Watch:

☐ **Fixed Monitoring Device**
Type of Instrument:
Installation location(s):
Sample Interval: ☐ 30 min. ☐ 1 hr. ☐ 6 hrs. ☐ 12 hrs. ☐ Other __________
Frequency of data logger downloading: ☐ Weekly ☐ Bi-weekly ☐ Monthly ☐ Other __________
Scour-critical discharge:__________
Action required if scour-critical elevation detected:

☒ **Other Monitoring Program**
Type: ☒ Visual
☐ Instrument
☐ Portable ☐ Geophysical ☐ Sonar
☐ Other gages

Flood monitoring required: ☐ Yes ☒ No
Flood monitoring event defined by:
☐ Discharge over __________
☐ Stage ________
☐ Elev. measured from ________

Frequency of flood monitoring: ☐ 1 hr. ☐ 3 hr. ☐ 6 hrs. ☐ Other
Scour critical elevation:
Action required if scour-critical elevation detected:

6. BRIDGE CLOSURE PLAN

Bridge ADT: 10	Built: 1950	% Trucks: 10	Bridge Length (ft): 90

Closure Plan Summary

State Parks Maintenance will report significant scour events to management. State Parks engineer or geologist will immediately inspect bridge condition and, if required, close bridge by setting up barricades and signs. State Parks engineer/geologist will determine countermeasures to protect the bridge from further damage. Bridge will be re-opened upon completion of countermeasures and if it is considered structurally sound.

Scour Monitoring Criteria for Consideration of Bridge Closure:

- ☐ Water surface elevation reaches ________________
- ☐ Overtopping road or structure
- ☒ Scour Measurement Results / Monitoring Device
- ☒ Loss of Riprap
- ☒ Observed amount of Settlement
- ☒ Loss of Road Embankment
- ☒ Debris Accumulation
- ☐ Other _________________

Person / Area Responsible for Closure: **Jeff Bomke, Sector Superintendent, North Coast Redwoods District**

Contact People (Name & Phone No.): **Gerhard Panuschka: 916-445-8680**

Responsible for re-opening after inspection: **Jeff Bomke**

7. DETOUR ROUTE

Detour route description (route number, from - to, etc.) – attach map.

Average ADT: 10	Year: 2003	% Trucks: 10	Length: 123.7 miles

Bridges on Detour Route:

Bridge Number	Waterway	Sufficiency Rating/ Load limitations	Scour 113 code

BRIDGE SCOUR EVALUATION - PLAN OF ACTION				
Br. No. 01P0016	**Owner** Parks	**Location** Mill Creek	**Facility Carried** West Branch Rd	**Name** Kelly Creek [1)]
Plan of Action Completed By: Gerhard Panuschka			**Date of Completion:** 30Nov2009	

1. SCOUR VULNERABILITY RATING

Scour Evaluation Summary:

At the time of this inspection, no debris was observed. A slight flow of water was passing through the channel beneath the bridge. This bridge is of concern because the SW abutment bank is severely eroded under the log supporting the flatcar superstructure. Furthermore, there is evidence that road runoff is causing additional abutment bank erosion at both abutments. A slack cable is hanging across the channel on the upstream side; the cable needs to be removed.

This watershed is vegetated with small trees only. Consequently, there is minimal chance for large debris in the channel.

Scour History:

A cut in the embankment beneath Abutment 1 was noted during previous investigations in 2003 and 2006. Work recommendations dated 10/23/2008 called for providing scour counter measures along the embankments at both abutments.

a. **Foundation Type** ☒ Spread footing ☐ Pile Extension ☐ Footing on Piles ☐ Unknown

b. **Foundation Material** ☒ Known _Timber logs w/dirt backfill_ ☐ Unknown

Scour Review: Done By: Gerhard Panuschka Date: 04Nov2009

Structural Assessment: Done By: Date:
Critical Elevation: ________________

Geotechnical Assessment: Done By: Date:
Critical Elevation: ________________

2. NBIS CODING INFORMATION

	Most Recent
Inspection date	
Item 113 Scour	3
Item 60 Substructure	6
Item 61 Channel & Channel Protection	6
Item 71 Waterway Adequacy	6

Note 1: Caltrans database shows "Chewy Creek" under Structure Name. The correct Structure Name is "Kelly Creek".

3. COUNTERMEASURE RECOMMENDATION

A. Completed Countermeasures:

No countermeasures are currently in place.

B. Proposed Countermeasures:

☐ **Countermeasures Not Required. (Please explain)**

☒ **Install Scour Countermeasures** (See 4 and 5)

	Estimated Cost
_X_ Riprap with monitoring program	$ 80,000
___Guide bank	$
___Spurs / Bendway weirs / Barbs	$
___Relief bridge / Culvert	$
___Channel improvements	$
___Monitoring	$
___Monitoring device	$
___Check Dam	$
___Substructure Modification	$
_X_ Bridge replacement	$ 500,000
___Other ______________________________	$

☐ **Close Bridge** (See 6)

4. COUNTERMEASURE IMPLEMENTATION SCHEDULE

Countermeasure Implementation Project Type:

☒ Proposed Construction Project

Lead Agency State Parks

☒ Maintenance Project

Advertised Date: NA

Other scheduling information: **Bridge will be added to Project Identification Data (PID) list for replacement as soon as budget becomes available.**

5. MONITORING PLAN

Monitoring Plan Summary:

State Parks maintenance personnel will monitor structure several times a year, and after main runoff events. Maintenance personnel will be trained in observing and identifying scour, how to minimize scour (removal of debris, filling of scour holes, etc.), and what steps to take when significant scour occurs. Bridge may be closed after significant scour events pending evaluation of structural integrity of bridge by engineer.

State Parks personnel will inspect the bridge in early winter for debris. Another inspection is planned in spring. In consultation with the District's Environmental Coordinator and the California Department of Fish and Game, woody debris may be removed or manipulated.

Monitoring Authority: **State Parks – North Coast Redwoods District Trail Maintenance**

☒ **Regular Inspection Program of _____6_mo.** ☐ w/surveyed cross sections

Items to Watch: undermining the footing

☒ **Increased Inspection Interval of ____3_ mo.** ☐ w/surveyed cross sections

Items to Watch:.

☐ **Underwater Inspection Program** **Frequency _______ mo.**

Items to Watch:

☐ **Fixed Monitoring Device**

Type of Instrument:

Installation location(s):

Sample Interval: ☐ 30 min. ☐ 1 hr. ☐ 6 hrs. ☐ 12 hrs.
☐ Other __________

Frequency of data logger downloading: ☐ Weekly ☐ Bi-weekly ☐ Monthly
☐ Other __________

Scour-critical discharge:__________

Action required if scour-critical elevation detected:

☒ **Other Monitoring Program**

Type: ☒ Visual
☐ Instrument
☐ Portable ☐ Geophysical ☐ Sonar
☐ Other gages

Flood monitoring required: ☐ Yes ☒ No

Flood monitoring event defined by:
☐ Discharge over __________
☐ Stage ________
☐ Elev. measured from ________

Frequency of flood monitoring: ☐ 1 hr. ☐ 3 hr. ☐ 6 hrs. ☐ Other

Scour critical elevation:

Action required if scour-critical elevation detected:

6. BRIDGE CLOSURE PLAN

Bridge ADT: 10	Built: 1950	% Trucks: 10	Bridge Length (ft): 40

Closure Plan Summary

State Parks Maintenance will report significant scour events to management. State Parks engineer or geologist will immediately inspect bridge condition and, if required, close bridge by setting up barricades and signs. State Parks engineer/geologist will determine countermeasures to protect the bridge from further damage. Bridge will be re-opened upon completion of countermeasures and if it is considered structurally sound.

Scour Monitoring Criteria for Consideration of Bridge Closure:

- ☐ Water surface elevation reaches ________________
- ☐ Overtopping road or structure
- ☒ Scour Measurement Results / Monitoring Device
- ☒ Loss of Riprap
- ☒ Observed amount of Settlement
- ☒ Loss of Road Embankment
- ☒ Debris Accumulation
- ☐ Other ________________

Person / Area Responsible for Closure: **Jeff Bomke, Sector Superintendent, North Coast Redwoods District**

Contact People (Name & Phone No.): **Gerhard Panuschka: 916-445-8680**

Responsible for re-opening after inspection: **Jeff Bomke**

7. DETOUR ROUTE

Detour route description (route number, from - to, etc.) – attach map.

Average ADT: 10	Year: 2003	% Trucks: 10	Length: 123.7 miles

Bridges on Detour Route:

Bridge Number	Waterway	Sufficiency Rating/ Load limitations	Scour 113 code

BRIDGE SCOUR EVALUATION - PLAN OF ACTION				
Br. No. 01P0017	**Owner** Parks	**Location** Mill Creek	**Facility Carried** West Branch Rd	**Name** West Branch Mill Creek
Plan of Action Completed By: Gerhard Panuschka			**Date of Completion:** 30Nov2009	

1. SCOUR VULNERABILITY RATING

Scour Evaluation Summary:

At the time of this inspection, no scour and no debris was observed. A slight flow of water was passing through the channel beneath the bridge. The South abutment sits on two massive logs with perpendicular smaller logs extending into the abutment fill (interlocked). This abutment is getting undermined. Road runoff is causing additional erosion at the abutments.

Recommendation: 1) cut ditches on the road on both sides of the bridge to divert road runoff off the side; 2) provide RSP to protect the eroded abutment fill.

Scour History:

Observations: Work recommendations dated 10/23/2008 called for placing scour countermeasures at Abutment 1 until the abutment is replaced.

a. **Foundation Type** ☒ Spread footing ☐ Pile Extension ☐ Footing on Piles ☐ Unknown

b. **Foundation Material** ☒ Known _**Timber logs w/dirt backfill**_ ☐ Unknown

Scour Review: Done By: **Gerhard Panuschka** Date: **04Nov2009**

Structural Assessment: Done By: NA Date:
Critical Elevation: ________________

Geotechnical Assessment: Done By: NA Date:
Critical Elevation: ________________

2. NBIS CODING INFORMATION

		Most Recent
Inspection date		
Item 113	Scour	3
Item 60	Substructure	5
Item 61	Channel & Channel Protection	7
Item 71	Waterway Adequacy	5

3. COUNTERMEASURE RECOMMENDATION

A. Completed Countermeasures:

No countermeasures are currently in place.

B. Proposed Countermeasures:

☐ **Countermeasures Not Required. (Please explain)**

☒ **Install Scour Countermeasures** (See 4 and 5)

	Estimated Cost
_X_ Riprap with monitoring program	$ 80,000
___Guide bank	$
___Spurs / Bendway weirs / Barbs	$
___Relief bridge / Culvert	$
___Channel improvements	$
___Monitoring	$
___Monitoring device	$
___Check Dam	$
___Substructure Modification	$
_X_ Bridge replacement	$ 350,000
___Other ________________________________	$

☐ **Close Bridge** (See 6)

4. COUNTERMEASURE IMPLEMENTATION SCHEDULE

Countermeasure Implementation Project Type:

☒ Proposed Construction Project

Lead Agency _State Parks

☒ Maintenance Project

Advertised Date: NA

Other scheduling information: **Bridge will be added to Project Identification Data (PID) list for replacement as soon as budget becomes available.**

5. MONITORING PLAN

Monitoring Plan Summary:

State Parks maintenance personnel will monitor structure several times a year, and after main runoff events. Maintenance personnel will be trained in observing and identifying scour, how to minimize scour (removal of debris, filling of scour holes, etc.), and what steps to take when significant scour occurs. Bridge may be closed after significant scour events pending evaluation of structural integrity of bridge by engineer.

State Parks personnel will inspect the bridge in early winter for debris. Another inspection is planned in spring. In consultation with the District's Environmental Coordinator and the California Department of Fish and Game, woody debris may be removed or manipulated.

Monitoring Authority: **State Parks – North Coast North District Trail Maintenance**

☒ **Regular Inspection Program of _____6_mo.** ☐ w/surveyed cross sections
Items to Watch: undermining the footing

☒ **Increased Inspection Interval of ____3_ mo.** ☐ w/surveyed cross sections
Items to Watch: Extent of undermining at South abutment.

☐ **Underwater Inspection Program** **Frequency _______ mo.**
Items to Watch:

☐ **Fixed Monitoring Device**
Type of Instrument:
Installation location(s):
Sample Interval: ☐ 30 min. ☐ 1 hr. ☐ 6 hrs. ☐ 12 hrs. ☐ Other __________
Frequency of data logger downloading: ☐ Weekly ☐ Bi-weekly ☐ Monthly ☐ Other __________
Scour-critical discharge:__________
Action required if scour-critical elevation detected:

☒ **Other Monitoring Program**
Type: ☒ Visual
☐ Instrument
☐ Portable ☐ Geophysical ☐ Sonar
☐ Other gages

Flood monitoring required: ☐ Yes ☒ No
Flood monitoring event defined by:
☐ Discharge over __________
☐ Stage ________
☐ Elev. measured from ________

Frequency of flood monitoring: ☐ 1 hr. ☐ 3 hr. ☐ 6 hrs. ☐ Other
Scour critical elevation:
Action required if scour-critical elevation detected:

6. BRIDGE CLOSURE PLAN

Bridge ADT: 10	**Built:** 1950	**% Trucks:** 10	**Bridge Length (ft):** 58

Closure Plan Summary

State Parks Maintenance will report significant scour events to management. State Parks engineer or geologist will immediately inspect bridge condition and, if required, close bridge by setting up barricades and signs. State Parks engineer/geologist will determine countermeasures to protect the bridge from further damage. Bridge will be re-opened upon completion of countermeasures and if it is considered structurally sound.

Scour Monitoring Criteria for Consideration of Bridge Closure:

- ☐ Water surface elevation reaches ________________
- ☐ Overtopping road or structure
- ☒ Scour Measurement Results / Monitoring Device
- ☒ Loss of Riprap
- ☒ Observed amount of Settlement
- ☒ Loss of Road Embankment
- ☒ Debris Accumulation
- ☐ Other ________________

Person / Area Responsible for Closure: **Jeff Bomke, Sector Superintendent, North Coast Redwoods District**

Contact People (Name & Phone No.): **Gerhard Panuschka: 916-445-8680**

Responsible for re-opening after inspection: **Jeff Bomke**

7. DETOUR ROUTE

Detour route description (route number, from - to, etc.) – attach map.

Average ADT: 10	**Year:** 2003	**% Trucks:** 10	**Length:** 123.7 miles

Bridges on Detour Route:

Bridge Number	Waterway	Sufficiency Rating/ Load limitations	Scour 113 code

BRIDGE SCOUR EVALUATION - PLAN OF ACTION				
Br. No. 01P0019	**Owner** Parks	**Location** Mill Creek	**Facility Carried** Child's Hill RD	**Name** Jane Creek
Plan of Action Completed By: Gerhard Panuschka			**Date of Completion:** 30Nov2009	

1. SCOUR VULNERABILITY RATING

Scour Evaluation Summary:

At the time of this inspection, no scour and no debris was observed. A slight flow of water was passing through the channel beneath the bridge. The channel has a steep slope and is armored with naturally occurring big boulders. Some erosion was noted at the abutments.

Scour History:

Observations: A cut in the embankment beneath Abutment 1 was noted during previous investigations in 2003, 2006, and 2008. Development of a scour hole near Abutment 1 was also reported in the 2008 inspection report. The scoured area of the embankment was approximately 10 feet long and 6 feet long.

a. **Foundation Type** ☒ Spread footing ☐ Pile Extension ☐ Footing on Piles ☐ Unknown

b. **Foundation Material** ☒ Known _**Timber logs w/dirt backfill**_ ☐ Unknown

Scour Review: Done By: **Gerhard Panuschka** Date: **04Nov2009**

Structural Assessment: Done By: NA Date:
Critical Elevation: ________________

Geotechnical Assessment: Done By: NA Date:
Critical Elevation: ________________

2. NBIS CODING INFORMATION

		Most Recent
Inspection date		
Item 113	Scour	3
Item 60	Substructure	5
Item 61	Channel & Channel Protection	7
Item 71	Waterway Adequacy	6

3. COUNTERMEASURE RECOMMENDATION

A. Completed Countermeasures:

No countermeasures are currently in place.

B. Proposed Countermeasures:

☐ **Countermeasures Not Required. (Please explain)**

☒ **Install Scour Countermeasures** (See 4 and 5)

	Estimated Cost
_X_ Riprap with monitoring program	$ 80,000
___Guide bank	$
___Spurs / Bendway weirs / Barbs	$
___Relief bridge / Culvert	$
___Channel improvements	$
___Monitoring	$
___Monitoring device	$
___Check Dam	$
___Substructure Modification	$
_X_ Bridge replacement	$ 500,000
___Other ________________________________	$

☐ **Close Bridge** (See 6)

4. COUNTERMEASURE IMPLEMENTATION SCHEDULE

Countermeasure Implementation Project Type:

☒ Proposed Construction Project

Lead Agency State Parks

☒ Maintenance Project

Advertised Date: NA

Other scheduling information: **Bridge will be added to Project Identification Data (PID) list for replacement as soon as budget becomes available.**

5. MONITORING PLAN

Monitoring Plan Summary:

State Parks maintenance personnel will monitor structure several times a year, and after main runoff events. Maintenance personnel will be trained in observing and identifying scour, how to minimize scour (removal of debris, filling of scour holes, etc.), and what steps to take when significant scour occurs. Bridge may be closed after significant scour events pending evaluation of structural integrity of bridge by engineer.

State Parks personnel will inspect the bridge in early winter for debris. Another inspection is planned in spring. In consultation with the District's Environmental Coordinator and the California Department of Fish and Game, woody debris may be removed or manipulated.

Monitoring Authority: **State Parks – North Coast Redwoods District Trail Maintenance**

☒ **Regular Inspection Program of _____6_mo.** ☐ w/surveyed cross sections
Items to Watch: undermining the footing

☐ **Increased Inspection Interval of _______ mo.** ☐ w/surveyed cross sections
Items to Watch:.

☐ **Underwater Inspection Program** **Frequency _______ mo.**
Items to Watch:

☐ **Fixed Monitoring Device**
Type of Instrument:
Installation location(s):
Sample Interval: ☐ 30 min. ☐ 1 hr. ☐ 6 hrs. ☐ 12 hrs. ☐ Other __________
Frequency of data logger downloading: ☐ Weekly ☐ Bi-weekly ☐ Monthly ☐ Other _________
Scour-critical discharge:__________
Action required if scour-critical elevation detected:

☒ **Other Monitoring Program**
Type: ☒ Visual
☐ Instrument
☐ Portable ☐ Geophysical ☐ Sonar
☐ Other gages

Flood monitoring required: ☐ Yes ☒ No
Flood monitoring event defined by:
☐ Discharge over __________
☐ Stage ________
☐ Elev. measured from ________

Frequency of flood monitoring: ☐ 1 hr. ☐ 3 hr. ☐ 6 hrs. ☐ Other
Scour critical elevation:
Action required if scour-critical elevation detected:

6. BRIDGE CLOSURE PLAN

Bridge ADT: 5	Built: 1950	% Trucks: 10	Bridge Length (ft): 63

Closure Plan Summary

State Parks Maintenance will report significant scour events to management. State Parks engineer or geologist will immediately inspect bridge condition and, if required, close bridge by setting up barricades and signs. State Parks engineer/geologist will determine countermeasures to protect the bridge from further damage. Bridge will be re-opened upon completion of countermeasures and if it is considered structurally sound.

Scour Monitoring Criteria for Consideration of Bridge Closure:

- ☐ Water surface elevation reaches ______________
- ☐ Overtopping road or structure
- ☒ Scour Measurement Results / Monitoring Device
- ☒ Loss of Riprap
- ☒ Observed amount of Settlement
- ☒ Loss of Road Embankment
- ☒ Debris Accumulation
- ☐ Other ______________

Person / Area Responsible for Closure: **Jeff Bomke, Sector Superintendent, North Coast Redwoods District**

Contact People (Name & Phone No.): **Gerhard Panuschka: 916-445-8680**

Responsible for re-opening after inspection: **Jeff Bomke**

7. DETOUR ROUTE

Detour route description (route number, from - to, etc.) – attach map.

Average ADT: 5	Year: 2003	% Trucks: 10	Length: 123.7 miles

Bridges on Detour Route:

Bridge Number	Waterway	Sufficiency Rating/ Load limitations	Scour 113 code