

Summary Report
WATERSHED REHABILITATION UNIT 88-2
LOWER K&K ROAD AND SLOPE

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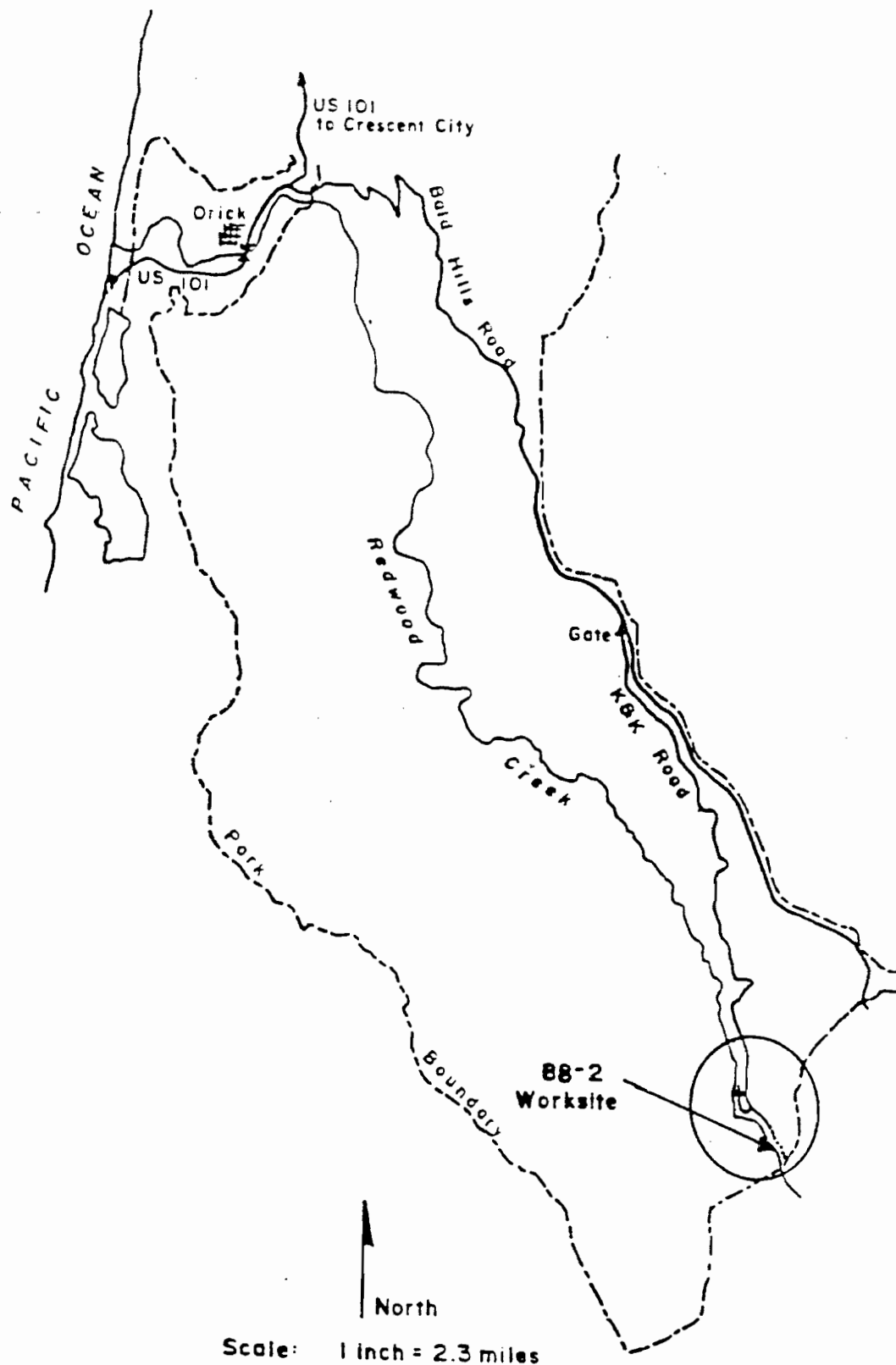
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MAP A- SITE LOCATION MAP



WATERSHED REHABILITATION UNIT 88-2

Lower K&K Road and Slope

INTRODUCTION

The Lower K&K Rehabilitation Project addressed erosion problems associated with road construction and timber harvest on naturally erosion-prone hillslopes and stream channels. The rehabilitation unit is located on the east side of Redwood Creek, between Copper Creek and Coyote Creek, about 14 miles southeast of Orick, California (Map A). Erosion control work treated 0.57 miles of the K&K Road and 0.52 miles of the Lower Ranch Road and adjacent skid trails (slopework). The 1988 project was completed by hourly rental agreements. It was the first phase of a several year project to rehabilitate the K&K Road.

Geology/Geomorphology

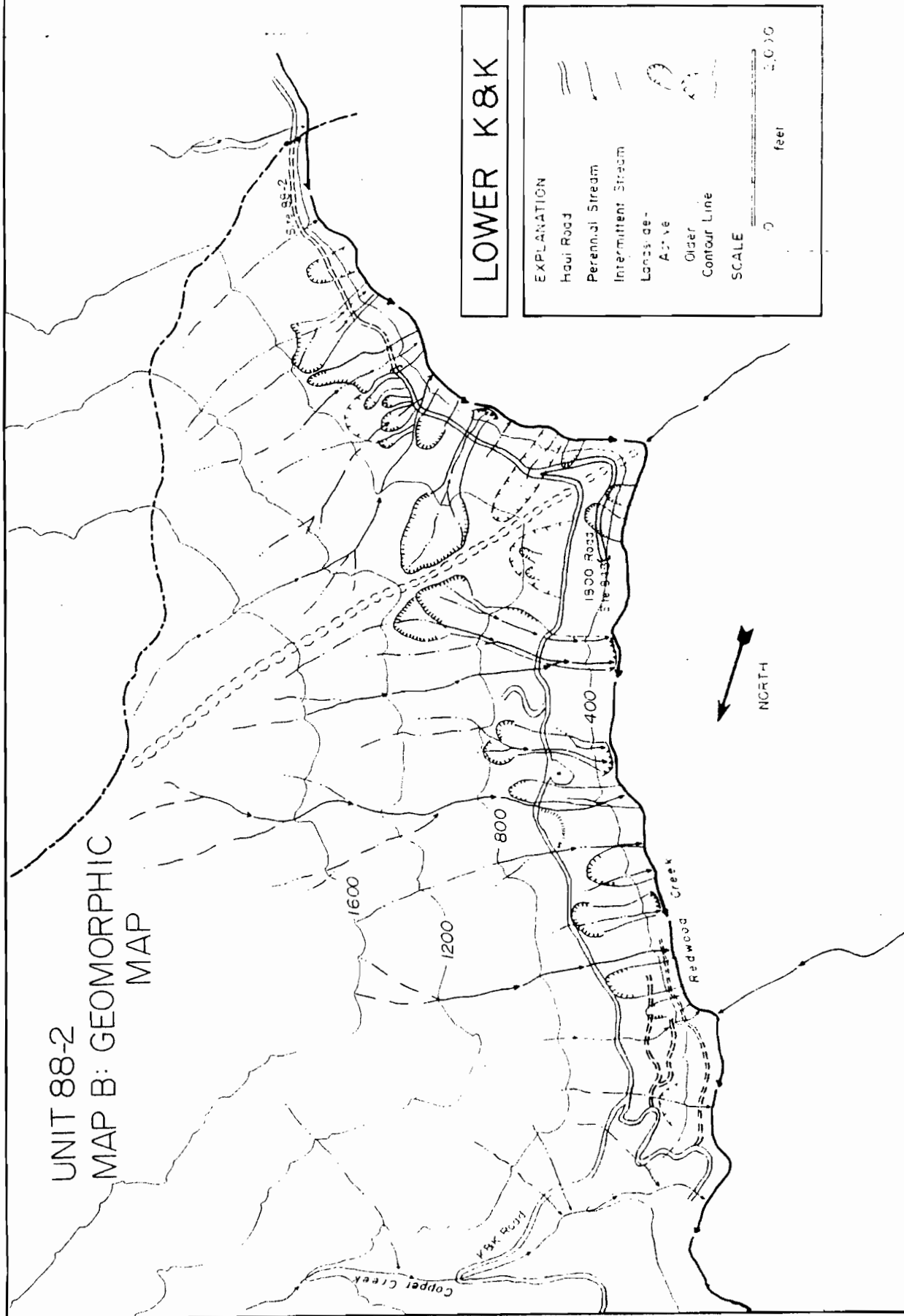
The entire rehabilitation unit area of 200 acres is underlain by the Incoherent Coyote Creek Unit of the Franciscan Formation. The Coyote Creek Unit is comprised of unmetamorphosed mudstones and sandstones, with a low sandstone/mudstone ratio (Harden and others, 1982). The rocks are typically more brecciated and sheared than other units, especially in the vicinity of the Grogan Fault Zone. Tectonic blocks of chert, greenstone, and sandstone are common and are usually in a sheared mudstone matrix. The Incoherent Coyote Creek Unit has not been named melange based on a lesser degree of shearing and absence of exotic blocks described in Franciscan melange elsewhere in the California Coast Range.

Much of the 1988 work along the K&K is likely within the Grogan Fault Zone. The Grogan Fault is defined along a zone of slightly metamorphosed and pervasively sheared rocks (Harden and others, 1982). The shear zone is of varying width and separates the Redwood Creek Schist from the unmetamorphosed rocks of the Incoherent Coyote Creek Unit and Coherent Lacks Creek Unit (all are Franciscan rocks). The fault zone is considerably straighter than other NNW trending faults in the region suggesting that it is nearly vertical. Blocks of Redwood Creek Schist and unmetamorphosed sandstones were commonly found juxtaposed along the rehabilitation unit, especially near Coyote Creek.

The rehabilitation unit occupies a varied landscape. Subdued, rolling topography is most often associated with the several large landslide complexes that dominate the character of the Lower K&K. These translational/rotational slides support grass-bracken fern prairie on the upper slopes with shrub or forest vegetation on the lower slopes. Earthflow movement rates and sediment yields have been summarized by Harden and others (1978), Nolan and others (1979), and Sonnevil (personal communication). Large, resistant rocks form prominent points on the landscape and steep inner gorge topography is typical where these are near Redwood Creek.

The site has a southwesterly slope aspect and has moderate relief from 400 feet to about 800 feet in elevation (Map B). Streams generally occupy poorly to moderately incised valleys and amount to nothing more than large gullies when they flow through landslide terrain. Stream gradients are mostly steep although quite variable in the tread/riser topography of the active landslides.

UNIT 88-2 MAP B: GEOMORPHIC MAP



Soils

Rehabilitation Unit 88-2 is dominated by Atwell Series Soils (Popenoe and Sturhan, 1988). They are mostly found in wet hollows, amphitheater shaped concavities, and along earthflow tracks underlain by mudstone. Atwell soils are imperfectly drained soils that typically have 30 to 35 percent clay content in the Bt horizon and have low permeability. The Cg horizon is commonly mottled indicating that the zone is saturated for part of the year. Even in natural conditions, these soils exhibit signs of fluvial erosion due to restricted internal drainage and a high runoff coefficient. Debris slides, flows, and slumps are common in disturbed materials where Atwell Soils occur.

In areas where slopes are convex or uniform in shape, Coppercreek and Slidecreek Soils are dominant. Coppercreek Soils are brown, deep (> 59 in.), well-drained soils. They contain 15 to 35 percent gravel and cobble-size rock fragments and are quite susceptible to fluvial erosion. Mass failure generally only occurs in areas where fill material has been oversteepened. Slidecreek Soils are quite similar except that they have a 35 to 60 percent rock fragment content and are therefore less prone to fluvial erosion.

Land Use History

Prior to construction of the K&K Road and subsequent logging, intensive land use consisted of running cattle and sheep on the grass prairie and grass-oak woodland areas of the upper hillslopes. The Lower Ranch Road, above the K&K, was constructed sometime before 1954 (1930's ?) and was used to access pasture land. The K&K Road was constructed between 1955 and 1958.

Timber harvest commenced soon after the road was completed and it appears that logging started above the K&K as selective cuts. As time progressed, these cuts became more complete (seed-tree leave and clearcut) and an increasing number of trees were removed from the downslope region between the K&K and Redwood Creek (Map C). From aerial photo analysis, it appears that much of the logging below the road was a salvage effort when the slopes began to fail. There are a couple of small (<5 ac.) stands of old growth remaining, possibly because they are growing on stable ground. The upslope areas were logged with either tractor or cable yarding methods, depending on the steepness of the terrain. The downslope areas were yarded by cable methods except one small swath near the present Park Boundary.

After Redwood National Park was expanded in 1978, Simpson Timber Company retained the privilege of using the K&K until 1987. Simpson was also required to maintain the road. In 1987, RNP became solely responsible for maintenance and management.

Erosional Features

The Lower K&K Unit includes some of the most erodible terrain in the Redwood Creek Basin (Coleman, 1973; Janda and others, 1975; Kelsey, 1981). Erosion rates are naturally high and have been exacerbated by land-use practices. Virtually all of the sediment generated from the K&K entered directly into Redwood Creek.

The most notable features are the large complex landslides that are abundant along the adjacent reaches of Redwood Creek. All of the earthflow toes were well-vegetated prior to timber harvest, although differences in vegetation

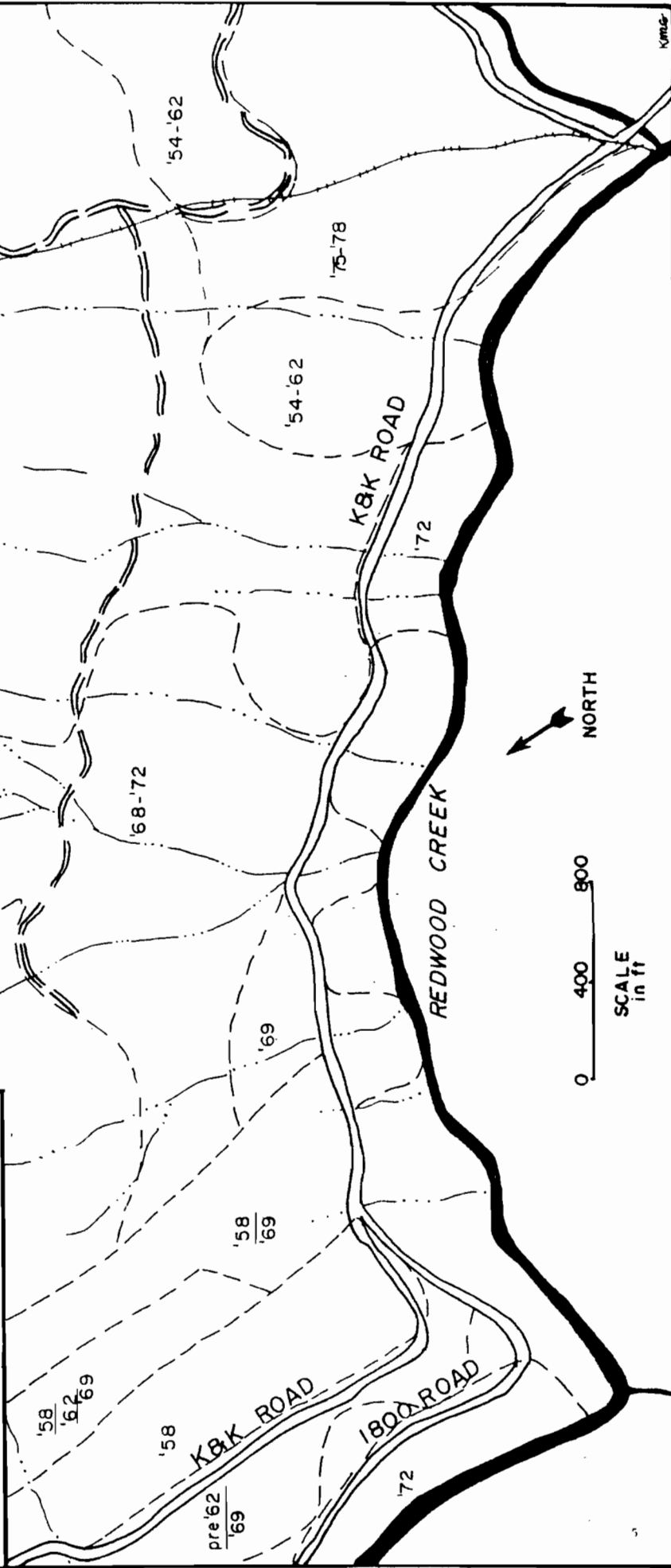
MAP C

LOWER K&K

UNIT 88-2

LOGGING HISTORY MAP
EXPLANATION

- STREAM
- HAUL ROAD
- ABANDONED ROAD
- CUT AGE BOUNDARY



size and/or type are visible in 1954 aerial photographs on some of the landslides.

Stream-side debris slides and slide scars are also visible in aerial photographs taken pre-logging. The number of these has greatly increased probably due to channel aggradation and resultant undercutting of unstable banks. The increased incidence of debris sliding is also partially a result of large quantities of fill material sidecast from the K&K adjacent to the banks of Redwood Creek.

Man-influenced sediment sources included stream crossing fills and large quantities of sidecasted materials. Four intermittent streams were crossed by the K&K in the section that was treated in Unit 88-2. Each of these crossings had misplaced culverts, with resultant gully systems developed away from the natural channels. The culverts themselves had a propensity for failure, which on several occasions, diverted streams several hundred feet down the K&K. Stream channel grades above the K&K were invariably undercut by road construction and channel instability has migrated several hundred feet upstream. Unstable headcuts and stream bank slides are persistent sediment sources.

Road-caused mass movements include debris torrents and debris slides, although more commonly road failures were part of larger, slope failures. In several locations, cutbank failures have migrated 200-300 feet upslope.

REHABILITATION WORK

Project Implementation

Field mapping, site evaluation, and prescription were accomplished between December, 1987, and mid-March, 1988, by D. Steensen and R. Kahler. Site morphology was mapped in the field on aerial photography at a scale of 1:600. Surveying and photo-documentation was completed by D. Steensen, R. Kahler, D. Short, K. Griffin, M. Horns, and J. Wood. Heavy equipment work was supervised by D. Steensen and R. Kahler. Table 1 summarizes the costs for the rehabilitation work on Unit 88-2.

Primary rehabilitation treatments included excavation of 4 haul road stream crossings, 2,550 feet of exported outsloping (truck-enhauled), and 255 feet of outsloping on the K&K Road. Treatments on the Lower Ranch Road (slopework) included 7 skid trail crossings and 2,700 feet of outsloping. Secondary treatments included placing rock channel armor in 3 of the 4 haul road crossings, and applying straw mulch to the finished slopes of the entire unit. Table 2 summarizes heavy equipment costs for 88-2. Refer to Map D for locations of individual worksites.

Heavy equipment utilized to accomplish this work consisted of a Caterpillar D8H bulldozer, a FiatAllis FE40L hydraulic excavator, and four 10 yd³ dump trucks. See Tables 3 through 7 for detailed information on equipment specifications.

Primary Treatments

Haul Road Stream Crossings

Haul road-stream crossing excavations (RX) require the removal of road fill material from buried stream valleys and channels. Four crossings were excavated

**REHABILITATION UNIT 88-2
Lower K&K Road and Slope**

TABLE 1. Rehabilitation Work Cost Summary

	Worksite Quantity	Total Cost	Unit Cost
<u>Heavy Equipment Costs</u>			
Primary Treatments			
Haul Road Stream Crossings	4	\$21,587	3.15/yd ³
Skid Trail Stream Crossings	7	2,456	3.07/yd ³
Outsloping	2,954 LF.	8,579	1.12/yd ³
Exported Outsloping (Truck Endhauled)	2,553 LF.	89,099	3.30/yd ³
Secondary Treatments			
Importing Rock (truck)	200 yd ³	2,996	14.98/yd ³
Rock Placement	250 yd ³	1,021	4.08/yd ³
Miscellaneous	--	37,617	--
Total Heavy Equipment Costs		<u>\$163,355</u>	
<u>Labor Intensive Costs</u>			
Primary Treatments			
Copper Cr. Bridge Re-decking	--	4,182	--
Secondary Treatments			
Straw Mulch (includes materials, distribution, and spreading)	320 bales	3,776	11.80/bale
Miscellaneous			
Brushing (survey lines and roads)	--	1,877	--
Winterizing RX-6 @ 42+25 (South Side Slide)	--	1,249	--
Total Labor Intensive Costs		<u>\$11,084</u>	
<u>Project Implementation Costs</u>			
Evaluation			
Mapping	--	6,647	--
Prescription	--	3,474	--
Surveying	--	3,454	--
Drafting	--	544	--
Overall Planning	--	1,980	--
Supervision			
Heavy Equipment	--	15,114	--
Labor Intensive	--	172	--
Documentation			
Photo Documentation	--	595	--
Cost Analysis and Report	--	988	--
Total Project Implementation Costs		<u>\$32,968</u>	
TOTAL REHABILITATION PROJECT COST		<u>\$207,407</u>	

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TABLE 2. Summary of Heavy Equipment Costs

Treatment	Worksite Quantity	Total Quantity	Total Cost \$	Average Cost per Worksite Quantity \$	Average Unit Cost \$	Unit Cost Range \$
Primary Treatments						
Haul Road Stream Xing	4	6,850 yd ³	\$21,587	5,397	3.15/yd ³	2.76-3.52, per yd ³
Skid Trail Stream Xing	7	800 yd ³	2,456	351	3.07/yd ³	1.34-4.03, per yd ³
Exported Outsloping (truck)	2,553 ft.	27,034 yd ³	89,099	35/LF.	3.30/yd ³	1.17-4.00, per yd ³
Outsloping	2,954 ft.	7,670 yd ³	8,579	2.90/LF.	1.12/yd ³	0.75-2.30, per yd ³
Secondary Treatments						
Hauling Rock ¹	2	200 yd ³	2,996	1,498/site	14.98/yd ³	--
Rock Placement ²	3	250 yd ³	1,021	340/site	4.08/yd ³	2.84-5.22, per yd ³
Miscellaneous	--	--	37,617	--	--	--
Total Heavy Equipment Costs			\$163,355			

¹ Rock was hauled from the C-30 road which was 13 miles one-way. This included driving up the C-Line loaded for about 6 miles up Bald Hills Road for 2 miles, then down the K&K nine miles to the dump sites at RX-1 and RX-2. The trucks therefore traveled up the K&K empty.

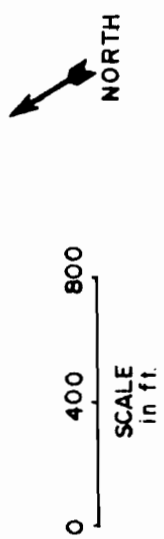
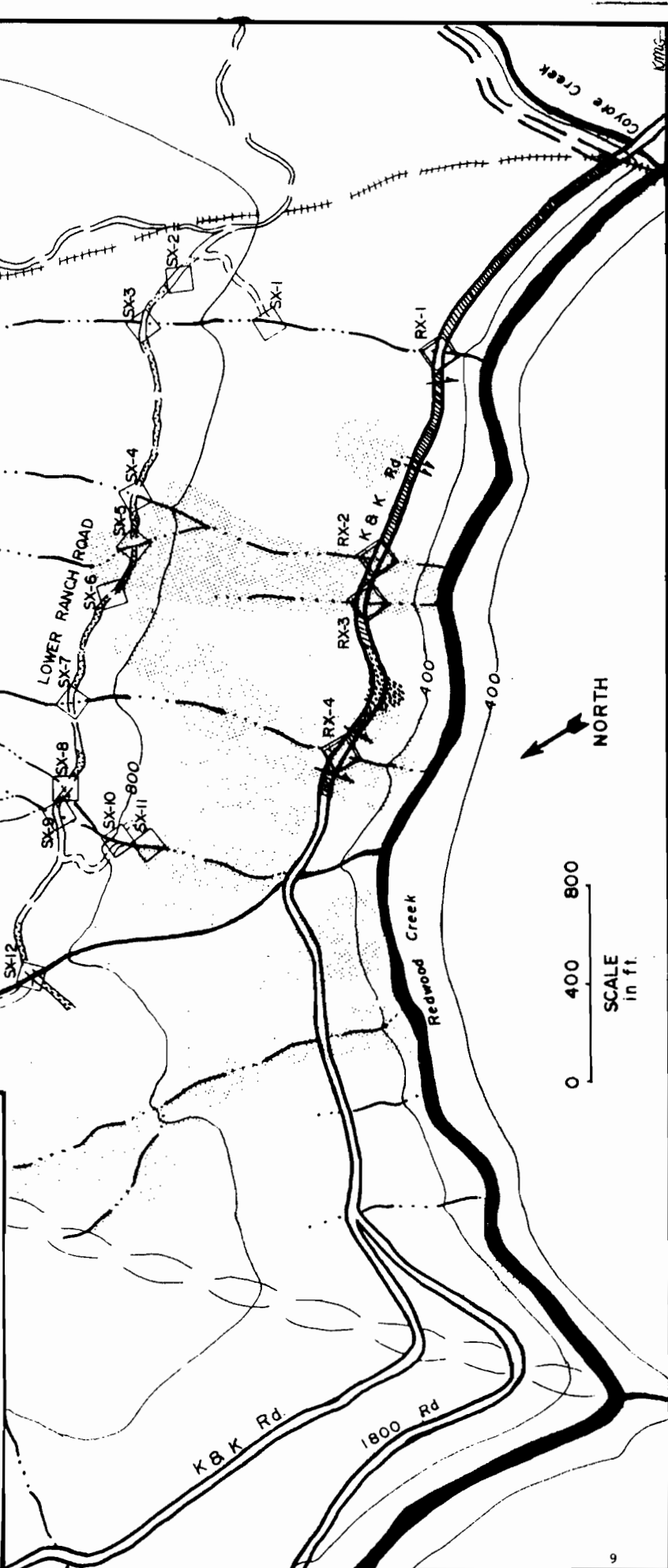
² Rock was placed in the channels at RX-1, RX-2, and RX-4. The K&K has impacted the immediate stream profiles of these crossings to the point that original channel grades were not expected to be found upon excavation. At RX-1 and RX-2 the upper portions of the channels had been undercut, and at RX-2 the original channel was routed out onto the Rainauge Earthflow. The stream location at RX-4 had no "original" channel. Upon excavation, the above hypotheses proved to be correct. Therefore, the channels were engineered to provide the most protection from downcutting and direct the flows into the most stable channels.

LOWER K&K

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MAP D: TREATMENT MAP

	HAUL ROAD		HAUL ROAD STREAM CROSSING
	SECONDARY ROAD		SKID TRAIL STREAM CROSSING
	PARK BOUNDARY		OUTSLOPING
	STREAM		EXPORTED OUTSLOPING
			DRAIN



in Unit 88-2 (Table 3). The crossings along the Lower K&K differ from most typical examples of stream excavations in RNP. Since the stream channels were poorly incised even in the natural state, the excavations do not resemble exhumed valleys, and look more like the gullies that exist up- and down-channel. RX-1, RX-2, and RX-4 are adjacent to exported outslope reaches (complete removal of the former road bench) which contributes to this appearance. RX-3 was designed with more substantial stream banks, which are artificial (composed mostly of road fill), to allow for predicted high sediment transport from the channel upslope.

Each of the crossings directs stream flow into areas that are not the natural flow course, but instead into flow courses that are more stable. The inherent instability of the pre-K&K channels, combined with almost complete obliteration by landslide movement and/or extensive sidecasted material, warranted abandoning the natural channels. RX-1 and RX-2 are routed into gully systems created by culvert "misplacement" that allowed erosion of fine material leaving cobble-boulder armoring deposits. RX-2 and RX-3 drain the left and right lateral gullies of the Rain Gauge Earthflow, respectively, and routing water away from this large landslide into more stable gullies seemed prudent. RX-3 was routed into what may have actually been the original channel, at least at some time in the past. The stream channel at RX-4 had been captured by movement of the Chickenfoot Earthflow in the recent past (<3-4 yrs ?) and what was originally a left lateral gully has now become an axial gully system. RX-4 was constructed to accomodate upslope changes in channel position and direct the flow into the present downslope channel by creating a wine-glass shaped depression to "catch" the stream wherever it may shift.

Heavy equipment utilized to excavate road-stream crossings in Unit 88-2 was a single hydraulic excavator (the excavator performed virtually all the work on the K&K; refer to Tables 3-7). Since all fill material from the crossings was exported, the excavator performed the work and placed the fill directly into dump trucks for disposal at either the Ingomar Club or Big Tree Rock Pit. This required the excavator to "bench" down the crossing, often 3 or 4 times, so that it could work the excavation and still allow the trucks to back down to where the excavator could load them.

Skid Trail Stream Crossings

Skid trail stream crossings (SX) are usually smaller versions of RX excavations and the "trails" were constructed for crawler tractors, not wheeled traffic. For Unit 88-2, the crossings along the Lower Ranch Road are included as SX since all were less than 200 yd³. Seven skid trail crossings were excavated in Unit 88-2 (Table 4). SX-2 through SX-6 had no fill removed as they were essentially "blown", although the sides were laid back somewhat (included as outslipping, below). SX-1 and SX-7 through 12 were treated mainly to reduce diversion potential, although SX-1 and SX-9 were actively diverting stream flow. Berms were constructed at SX-7 and SX-11 to correct diversion potential with little fill material excavated from the stream channels. SX-9 through SX-12 are located along a section of road where very little fill was necessary to construct the crossings; the road follows a wide, almost flat bench, which is the top of a major slump block (inactive in recent past).

Heavy equipment utilized to accomplish this work was a Caterpillar D8H with a U-Blade (Table 4). Access to the slopework was partly through Unit 80-1 (Big Tree Site) and two skid trail crossings were reopened. Travel time to the

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TABLE 3. Haul Road Stream Crossing Excavation Costs

Station	Excavated Volume ¹ yd ³	Total Cost \$	Unit Cost \$	Equipment Hours				Truck		Excavation Rate ³ yd ³ /pc-hr
				X	W/R	DT1	DT2	DT3	DT4	Endhaul Distance-ft
RX-1 @ 8+52	1,200	4,226	3.52/yd ³	11.5	9.4	12.75	12.75	12.75	12.75	8,050
RX-2 @ 19+27	1,450	4,176	2.88/yd ³	14.0	4.5	13.8	13.9	13.9	13.9	6,970
RX-3 @ 21+89	3,300	10,965	3.24/yd ³	31.75	12.0	37.5	37.5	37.5	37.5	6,710
RX-4 @ 28+52	900	2,490	2.76/yd ³	9.0	0.75	8.9	8.9	8.9	8.9	6,048
Total or Average	6,850	21,587	3.15/yd³							6,945
										103 yd³/hr

¹ The volumes are based on detailed pre-excavation surveys. Excavation limits were followed during the work and volumes correlated well with truck load numbers. Post-surveys were not performed.

Equipment Used:

X: 1986 FiatAllis FE40L (\$95/hr) with 3yd³ bucket, 36' reach, 243 h.p., operated by Chris Hake (Hake Construction Co.).

W/R: 1970 Caterpillar D8H 46A with rippers (\$94.47/hr), 13' U-blade, hydraulic 4-way tilt, 24" tracks, 270 h.p. powershift.

1968 Caterpillar D8H 46A with winch (\$89.47/hr), 13' U-blade, hydraulic 4-way tilt, 28" tracks, 270 h.p. powershift. Both Cats operated by Jay Franke (Twin Parks Lumber Co.). Only one Cat was on-site at a time.

DT1: 1973 Mack 10yd³ dump truck (\$44.29/hr), Model RL 700 L, Owned and operated by Bill Wortell.

DT2: 1972 International Harvester 10yd³ dump truck (\$44.30/hr), owned and operated by David Samuelson.

DT3: 1966 Peterbilt 10yd³ dump truck (\$43.25/hr), 280 hp, owned and operated by LaRoy Hake (Hake's Ditching and Excavating).

DT4: 1969 Peterbilt 10yd³ dump truck (\$44.49/hr), 400 h.p., Owned and operated by Denny Haddad.

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TABLE 4. Skid Trail Stream Crossing Excavation Costs

Site	Excavated Volume ¹ yd ³	Total Cost \$	Unit Cost \$	Equipment Hours		Avg. Blade Endhaul Dist (ft)	Excavation Rate yd ³ /pc-hr
				R	W		
SX-1	150	330	2.20/yd ³	3.50	0	35	42
SX-7	100	403	4.03/yd ³	0	4.50	200	22
SX-8	100	134	1.34/yd ³	0	1.50	50	67
SX-9	200	536	2.68/yd ³	0	6.00	35	33
SX-10	50	290	5.80/yd ³	0	3.25	75	15
SX-11	100	380	3.80/yd ³	0	4.25	35	23
SX-12	100	380	3.80/yd ³	0	4.25	35	23
TOTAL OR AVERAGE	800	2,456	3.07/yd³			66	30

Equipment Used:

R: Cat D8 ripper a/a

W: Cat D8 winch a/a

¹ All volumes are estimates. Rates may therefore vary.

sloped work accounted for about 1.5 hours per day.

The skid trail crossings that were reopened in Unit 80-1 were SC-4 and STC-25. STC-25 had been treated in 1980 by incomplete excavation of fill and construction of wooden checkdams to discourage downcutting. The checkdams at STC-25 had failed and were suspended 2 to 4 feet above the gullied channel when the route was opened. When the sloped work was finished, the bulldozer ditched out STC-25 completely, leaving it in an improved condition (the cost is included as winterization, Table 7). SC-4 was left essentially as it was found since it was functioning well.

Outsloping

Outsloping entails the removal of fill material from the outboard edge of a road and storing this material against the cutbank, essentially recontouring the road to the former topography. Most of the outsloping work in Unit 88-2 was performed on the Lower Ranch Road, which traversed highly visible grass prairie and grass-oak woodland. Outsloping is an appropriate erosion control treatment for grasslands as it restores natural runoff patterns and the slope has a more stable mass distribution as well as removing the physical scar of the road. Only a short segment of the K&K Road was outsloped (Table 5).

This work was accomplished with a Caterpillar D8H bulldozer as the only piece of excavating equipment (Table 4).

Exported Outsloping

Exported outslope treatments can either remove the entire road bench or just the outboard portion of the road, but in both cases the fill must be exported (endhauled) some distance to a stable fillsite. Most of the effort to treat Unit 88-2 was spent removing the entire road bench of the K&K and truck-endhauling the fill material to stable fillsites (Table 6). The inherent instability of the materials on this site warranted removing as much material as was practical and relieve some of the driving forces causing the large slope failures. For the most part, a 3-5 foot free-draining bench was left, at centerline inboard ditch elevation, to buttress persistent cutbank failures.

As was the case for the road-stream crossing excavations, virtually all the work was accomplished with the hydraulic excavator as a single piece of excavating equipment (Table 6). About half of worksites had cut-to-here stakes that could be reached from the former K&K by the excavator and the other half had to be benched so that the dump trucks could back down to where the excavator was working and be loaded directly. Two major fillsites were designated; the Big Tree Rock Pit, an average hauling distance of 6,000 feet, and the Ingomar Club, an average hauling distance of 8,000 feet from the worksites.

Secondary Treatments

Rock Armor

Rock channel armor was placed in the stream channels at RX-1, RX-2, and RX-4 (Table 2). The inherent instability of materials found along the Lower K&K, combined with the prediction that original channel morphology would most likely not be found, led to the decision to provide protection for the channels. RX-1 and RX-2 have drainage areas of 28 and 31 acres respectively (at the K&K Rd.)

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TABLE 5. Outslaping Costs

Station	Excavated Volume yd ³	Total Cost \$	Unit Cost \$	Equipment Hours			Linear Feet of Road LF	Volume per ft. yd ³ /ft	Excavation Rate yd ³ /pc-hr
				X	R	W			
OS @ 23+46	2,370	3,661	1.54/yd ³	14.25	0	18.5	354	6.7	72
OS @ 35+00	500 ¹	1,149	2.30/yd ³	5.5	0	7.0	100	5.0	40
OS Dooleyville to SX-7	4,360 ¹	3,340	0.76/yd ³	0	19.25	17.0	2,180	2.0	120
OS SX-7 to SX-8	100 ¹	89	0.89/yd ³	0	0	1.0	100	1.0	100
OS @ SX-12	240 ¹	246	1.03/yd ³	0	0	2.75	120	2.0	87
OS Raingauge Drain	100 ¹	94	0.94/yd ³	0	1.0	0	100	1.0	100
TOTAL OR AVERAGE	7,670	8,579	1.12/yd³				2,954	2.6	98

Equipment:

X: FiatAllis FE40L a/a

R: Cat D8H ripper a/a

W: Cat D8H winch a/a

¹ Volumes are estimated.

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TABLE 6. Exported (Truck End-Hauled) Outslowing Costs

Station	Excavated Volume yd	Total Cost \$	Unit Cost \$	Equipment Hours			Linear Feet of Road LP			Volume per ft. yd ³ /LP	Truck Endhaul Dist.-ft.	Excavation Rate yd ³ /pc-hr
				X	W/R	Hr	DT1	DT2	DT3	DT4		
EOS @ 0-00	9,500	34,867	3.67 yd ³	94.75	95.45	95.25	95.25	95.25	95.25	94.75	8,474	100
EOS @ 8+77	11,400	39,616	3.47 yd ³	131.00	55.35	129.50	129.50	129.70	111.20	128.70	7,500	87
EOS @ 19+47	1,900	4,554	2.39 yd ³	14.00	5.10	15.75	15.75	15.70	15.70	15.70	6,832	135
EOS @ 21+97	1,370	5,480	4.00 yd ³	16.25	6.20	19.20	19.20	19.20	19.20	19.20	6,628	84
EOS @ 27+00	2,000	2,340	1.17 yd ³	5.50	9.50	5.50	5.50	5.50	5.50	5.50	6,124	137
EOS @ 28+92	864	2,241	2.59 yd ³	8.00	1.00	7.90	7.90	8.40	7.90	7.40	5,954	90
TOTAL OR AVERAGE	27,034	89,099	3.29/yd³							2,553	6,920	100

Volumes are based on detailed pre-excavation surveys. Excavation limits were followed during the work and volumes correlated well with truck load numbers.

Equipment Used (See Table 3):

X: Fiatallis a/a

W R: Cat D8 a/a

DT1-DT4: a/a

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TABLE 7. Miscellaneous Costs

Task	Task Cost \$	Equipment Hours (Hr)							% of Total Heavy Equip		
		X	R	W	DT1	DT2	DT3	DT4	WT	GRAD	
Open and Close K&K	4,408	12.50	0.	36.0	0.	0.	0.	0.	0.	0.	2.7
Lignin Application	6,795	0.	0.	0.	0.	0.	0.	0.	(76.3 tons)	0.	4.2
Road Watering	2,320	0.	0.	0.	0.	0.	0.	0.	58.0	0.	1.4
Road Grading	330	0.	0.	0.	0.	0.	0.	0.	0.	8.25	0.2
Other Road Improvements	183	1.0	0.	0.	0.50	0.50	0.50	0.50	0.	0.	0.1
Breaks	6,079	17.50	10.50	7.50	16.00	16.00	14.50	16.00	0.	0.	3.7
Paid Down Time	1,259	4.75	0.50	0.50	3.50	3.25	4.25	5.25	0.	0.	0.8
Standby w/ Operator	5,648	0.	0.	3.25	48.75	48.75	48.75	48.75	0.	0.	3.5
Travel	1,972	1.50	7.00	12.50	0.	0.	0.	0.	0.	1.25	1.2
Open/Close Slope Access	2,253	0.	12.25	12.25	0.	0.	0.	0.	0.	0.	1.4
Discussion	635	0.75	2.00	1.50	1.25	1.25	1.25	1.25	0.	0.50	0.3
Fueling	46	0.25	0.25	0.	0.	0.	0.	0.	0.	0.	0.03
Open Camp/Copper Cr Pit	756	0.	8.00	0.	0.	0.	0.	0.	0.	0.	0.4
Pillsite Winterize	1,230	0.	0.	13.75	0.	0.	0.	0.	0.	0.	0.8
Waiting for other equip.	220	0.	0.	0.	1.25	1.25	1.25	1.25	0.	0.	0.1
Straw Handling	45	0.	0.	0.50	0.	0.	0.	0.	0.	0.	0.03
Earthflow Sample Pits	546	5.75	0.	0.	0.	0.	0.	0.	0.	0.	0.3
Move In/Move Out	2,892	(\$860)	(\$414)	(\$737)	5.00	5.00	5.00	5.00	0.	0.	1.8
Total Misc. Costs	37,617										23.1

Equipment Used:

X, R, W, DT1-DT4 are all listed above (see Table 3)

WT: White Freightliner (\$40/hr) w/ 4000 gal. tank, operated by Don Hickox (DustBusters, Inc.)

GRAD: 1946 Allis-Chalmers road grader (\$40/hr), operated by Harlan Hanson (DustBusters, Inc.)

UNIT 88-2

TABLE 8. Labor Intensive Costs

Task	RNP		RUI		Total Cost \$	Unit Cost \$
	Person Hours	Cost \$	Person Hours	Cost \$		
Brushing						
Survey Lines	19	200	-	-	200	-
K&K Road	150	1,677	-	-	1,677	-
Straw Mulch						
Materials	-	-	-	-	1,002	3.13/bale
Distribution	75	837	-	-	837	2.62/bale
Spreading	125	1,395	75	542	1,937	6.05/bale
South Side Slide	110	1,249	-	-	1,249	-
Winterizing						
Copper Creek Br.	180	2,070	-	-	2,070	-
Re-decking						
Materials	-	-	-	-	2,112	-
Total Labor Intensive Costs					\$11,084	

RNP - Redwood National Park staff; Resources Management Work Crew.

RUI - Redwoods United Incorporated employees.

All labor costs are based on wages plus benefits and include transportation to and from worksites.

and designed channel grades were 35-42%. RX-4 has a drainage area of 67 acres and a grade of 30%. Rock was not placed at RX-3 since the drainage area is small, 11 acres, and the designed channel grade was a relatively low 27%.

Rock was hauled to the K&K from the C-30 Road, where a stockpile had been left for future rehabilitation sites on the east side of Redwood Creek. The rock was moved to and temporarily stored along the inboard ditch, upstation of RX-1 and RX-2. The rock used at RX-4 was not hauled in but rather "culled" from the large quantity of road rock placed along the reach of road spanning the Chickenfoot Earthflow.

Rock was placed in the channels in a "blanket" form, covering the channel bottom, about 5 feet up each bank, and along the entire length of the excavated channel reach. RX-1 and RX-2 each have about 100 yd³ of rock and RX-4 has about 50 yd³. The top of the armoring on all three channels was keyed by trenching below channel grade and into the banks and backfilling with rock creating a type of buried (or on-grade) checkdam which forces flow into the designed channel.

Straw Mulch

The K&K Road was treated with straw mulch on all excavated surfaces to inhibit sheetwash and provide cover for the seedbed (Table 8). This site has an almost direct southern exposure and summer conditions are usually hot and dry. The application rate was 4,000 pounds per acre (approximately 60 bales/ac).

DISCUSSION

The size of the K&K Road, the proximity to Redwood Creek, and the inherent instability of the terrane, required that this rehabilitation unit be the most cost-intensive site yet accomplished in RNP. Other sites where extensive truck-endhauling was necessary, such as G-Line, Unit 85-3 (Kenning and Wosika, 1986), and M-7, Unit 86-1 (Kenning, 1987), have been similar to the K&K (all were accomplished by hourly rental agreements). Costs to truck-endhaul fill on the K&K, \$3.30/yd³, was lower compared with the G-Line, \$4.86/yd³, and with the M-7 at \$4.69/yd³. As rehabilitation of the K&K progresses, it is predicted that the cost per mile of road treated will decrease, especially as emphasis of treatment shifts: from slope instability on the Lower K&K, to large road crossings on the middle portion of the K&K, to smaller crossings and prairie restoration on the upper portion of the K&K.

Cost savings relative to other truck-endhauling projects can be attributed to two main items. First, the use of only one piece of excavating equipment on the K&K worksites. Typically, two pieces would be used. For example, a bulldozer and either an excavator or a loader combination have been used to do most large scale truck-endhauling. The use of a "big" excavator with a 3 yd³ bucket, as well as the fact that the K&K was essentially one type of erosion control work (EOS), allowed the K&K site to do be done without the other piece. Second, the use of lignin for dust control helped reduce costs for watering and road maintenance in general (see Appendix). See Table 7 for full information concerning miscellaneous costs.

The key element in endhauling efficiency is matching the hauling capability with the production rate of the excavating equipment. On some worksites, costs may have been lowered had a fifth dump truck been used, since the excavator often waited 2-4 minutes between the departure of the fourth and arrival of the first

truck (in a cycle). This would have required that the extra truck be used only periodically since on several worksites, where the backup distance was short, four trucks seemed to work fine.

The operators for this site were experienced with the RNP rehabilitation approach and they did excellent work. Overall, the use of larger equipment was appropriate for the rehabilitation of a road such as the K&K, and equipment such as scrapers, larger dump trucks, and perhaps even larger bulldozers may be useful higher on the K&K where the road bench remains wide for long distances.

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APPENDIX

PART I

All field mapping, prescription notes, survey data, volume calculations, stream discharge calculations, and photo-point descriptions are on file at:

Redwood National Park
South Operations Center
219 Hilton Road
P.O. Box 7
Orick, CA 95555

PART II

Lignin Dust Control

Most rehabilitation work that has utilized dump trucks to transport road fill has typically used a watering truck for dust control. When as many as 200 truck loads per day travel along 2-3 mile sections of dirt or rocked roads, controlling the dust becomes both a safety and a production concern. Other forms of dust control are available, such as lignin and magnesium chloride. We used applications of lignin for dust control along the hauling route in rehabilitation Unit 88-2. A comparison of actual costs with probable costs of other means of dust control are shown below in Table A1.

TABLE A1. Dust Control Costs for Unit 88-2

ACTUAL COST

2 applications of lignin (61.3 tons)	\$ 5,456
Water Truck (\$40/hr)	\$ 3,460 ¹

Total =	\$ 8,916 ²

PROBABLE COSTS USING WATERING TRUCK

Full Time:

8 hours/day, 6 days/week, at \$55/hr³ \$ 18,480

Part Time⁴:

5 hours/day, 6 days/week, at \$55/hr \$ 11,550

¹ The cost for this water truck was only available to RNP from the contractor that sprayed the lignin, DustBusters, Inc., of Arcata. Had we not purchased lignin from them, the \$40/hr truck couldn't have been used. \$400 of the water truck costs are actually grader costs, also \$40/hr.

² Had the water truck cost \$55/hr (see note 3) the total dust control cost would have been \$10,214.

³ The only water truck bid for 1988 hourly equipment rental was \$55/hr. As mentioned above, this would have been our cost had we not purchased lignin from DustBusters, who then offered a truck for \$40/hr.

⁴ It is not known if RNP could have rented the water truck for only 5 hours/day. Many contractors would not "bother" to have an operator travel all the way to a site for a short work day.

APPENDIX

The use of lignin for dust control on the hauling route in Unit 88-2 saved between \$8,826 and \$9,924 over using a water truck full time (the dump trucks were hauling 11-12 hours/day). The fact that we needed to apply lignin twice outlined the point that the road surface needs to be in excellent shape for the lignin to remain effective with sustained heavy traffic. The second application was much smaller in volume and was concentrated on areas where the road surface was not in good condition. While 80% of the treated road surface remained intact for the duration of the project short sections of road, usually near the landslides, fell apart and needed to be graded once every week or so (from Table A1, part of the water truck costs are actually grader costs). For the last three weeks of the project, we utilized a water truck 5 hours per day to control dust on the worst sections of road.

Some observations concerning driving surface management may be useful for other projects where truck endhauling may be needed. First, the lignin works well on hard, graded surfaces that do not have a lot of coarse fragments. It tends to break apart readily on rocky, and/or soft areas. Second, it may be useful to apply the lignin after trucks have been driving the road for a week or so to make sure that the road is hard and the bad spots can be identified. A water truck and grader on-site during this week would make sure the road is in top condition. A little grader/water truck work may still be necessary as time goes on. Third, using magnesium chloride may be advantageous where fog can re-moisturize the material, or where a water truck could give it a little shot of water every few days (if the water truck didn't need to be paid for idle time). Mag-chloride is may also be a better bet since it can be graded several times (lignin cannot). Although, in situations where road conditions cannot be kept in a decent state, and top production is a priority, the water truck/grader combo is probably the best way to go (observe any large-scale construction project, such as the Park Bypass project, and the water trucks and graders are working nonstop).

Had we not used any form of dust control, the loss in production could have been substantial, although an accurate estimate is unknown. Wosika (Kenning and Wosika, 1986) states that the decrease in production could be as high as 30 to 50% that of a graded and well watered road. When the hauling route along the K&K was in its worse condition (80% good) the decrease in production was about 15%. At a 15% loss of in hauling production, we essentially broke even comparing the cost of dust control/grading and the extra time the excavator would be sitting idle, waiting for trucks. Had no lignin been applied and little upkeep of the driving surface, the loss in production would almost certainly have been greater than 15%. Therefore, at least for the situation along the K&K during rehabilitation work, dust control/grading proved cost-effective and utilizing lignin saved money.



Unit: 88-2 PP4a Dwnstm. Rd STA 8+18 6-6-88 MH& RK 35mm



Unit: 88-2 PP4a K and K EOS 0+00 Sta 8+18 10-19-88 DLS & MMH 35mm



Unit: 88-2 PP5 dwnstm sta 8+52 RX-1 6-6-88 MH + RK 35mm



Unit: 88-2 PP4a K and K RX-1 Top Sta 8+52 DLS & MMH 35mm



Unit: 88-2 PP8b Upsta Rd. STA 14+50 6-6-88 MH & RK 35mm



Unit: 88-2 PP8b K+K EO58+77 STA 14+50 DLS & MMH 10-19-88 35mm



Unit: 88-2 PP15C Upstm RX3 STA 21+00 6-13-88 MH+KG 35mm



Unit: 88-2 PP15C K+K EO5 19+47 RX-3 STA 21+00 DLS & MMH 35mm



Unit: 88-2 PP17a Dwnstm Rd. STA 27+27 6-13-88 MH & KG 35mm



Unit: 88-2 PP17A OS 25+00 K&K Eos 27+00 Sta 27+27 10-19-88 DLS&MMH 35mm