

Summary Report
WATERSHED REHABILITATION UNIT 90-2
LOWER K&K, CAMP, AND SPUR ROADS

David L. Steensen
Redwood National Park
February, 1992

TABLE OF CONTENTS

INTRODUCTION	1
Geology/Geomorphology	1
Soils	3
Land Use History	4
Erosional Features	7
REHABILITATION WORK	7
Project Implementation	7
Primary Treatments	11
Haul Road Stream Crossings	11
Outsloping	14
Exported Outsloping	14
Other Primary Treatments	17
Secondary Treatments	17
Rock Armor	17
Straw Mulch	17
DISCUSSION	20
REFERENCES	21

FIGURES

Map A: Site Location Map.....	2
Map B: General Geomorphology.....	5
Map C: Land Use History Map.....	6
Map D: Erosion Control Treatment Map.....	8

TABLES

Table 1. Rehabilitation Work Cost Summary.....	9
Table 2. Miscellaneous Costs.....	10
Table 3. Other Contract Costs.....	10
Table 4. Haul Road Stream Crossing Excavation Costs..	12
Table 3. Outsloping Costs.....	15
Table 4. Exported Outsloping Costs.....	16
Table 5. Secondary Treatment Costs.....	18
Table 6. Labor Intensive Costs.....	19

WATERSHED REHABILITATION UNIT 90-2
Lower K&K Road and Slope

INTRODUCTION

The K&K Road is one of the largest man-caused sources of sediment within the Redwood Creek watershed. The portion through Redwood National Park passes through some of the most erodible terrain within the watershed. The Lower K&K is in a low hillslope position, parallels Redwood Creek, and has been a continuous sediment source and maintenance problem since the mid-1950's. Rehabilitation of the Park segment of the K&K will take several years to complete and Unit 90-2 was the third year of erosion control work. The 1991 Rehabilitation Project addressed erosion problems associated with road construction and timber harvesting on naturally erosion-prone hillslopes and stream channels.

The rehabilitation unit is located on the east side of Redwood Creek just south of and included a portion of the Copper Creek watershed (a major tributary to Redwood Creek). The unit is about 14 miles southeast of Orick, California (Map A). Erosion control work treated 1.25 miles of the K&K Road, 0.5 miles of Camp Road, and 0.5 miles of short spur roads (1600, 1610, 1700), as well as re-entering a portion of the 1900 Road. The 1990 project work-area treated about 170 acres of watershed. Twelve haul road stream-crossings were excavated and four of these were armored with rock to control erosion in extremely erodible materials. Over 64,300 cubic yards of unstable fill material was excavated and 53% of that volume was hauled by truck to stable storage sites. Nearly 1,500 feet of road was completely recontoured through a highly visible area known as Tick Prairie.

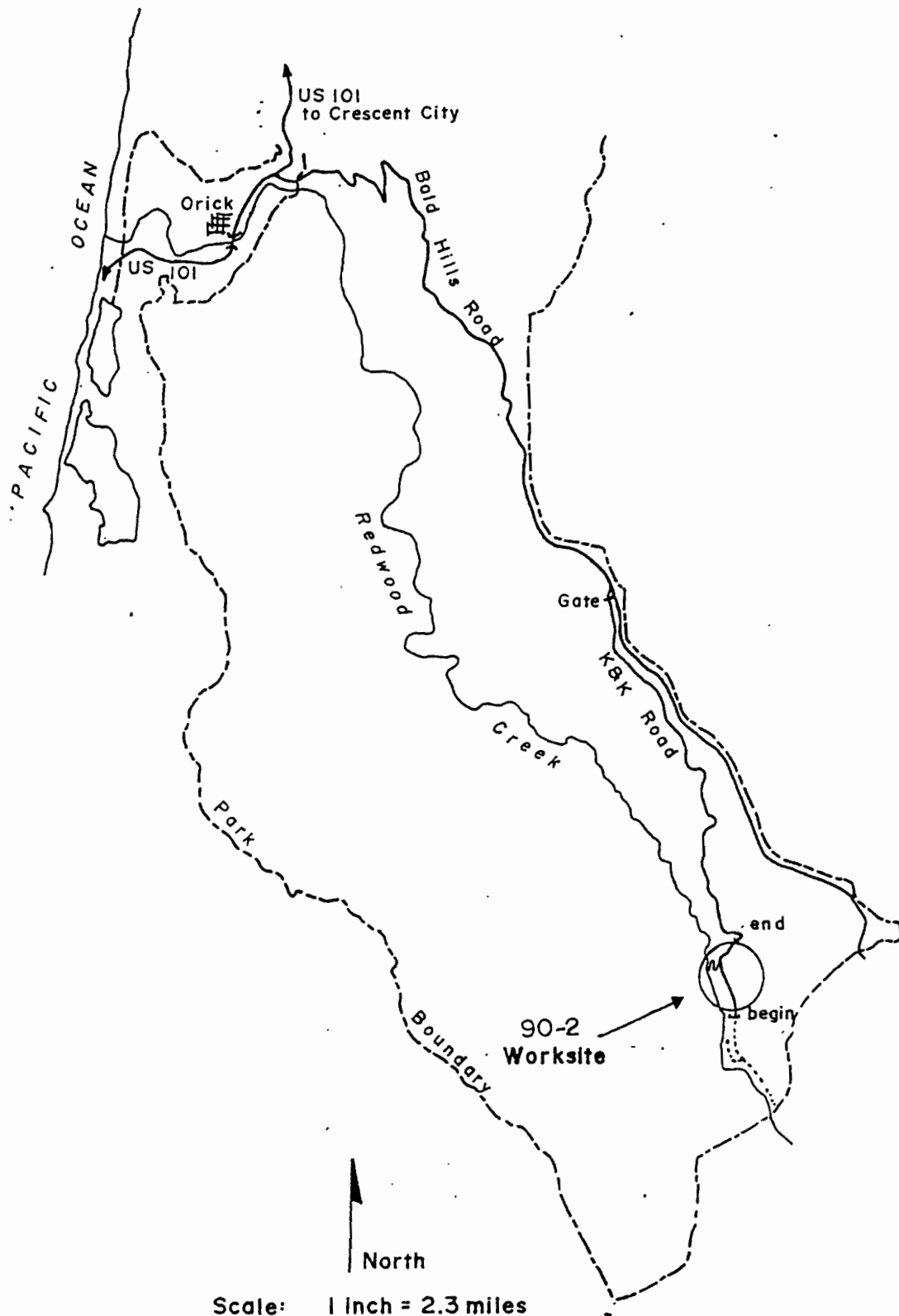
The 1990 project was implemented by IFB Contract (CX#8000-0-0012) and work was performed by Twin Parks Lumber Company of Arcata, California. Contract costs for erosion control work utilizing heavy equipment was \$224,212. Labor cost for brushing and site preparation was \$6,487. Labor and materials cost for straw mulch application was \$13,420. Personnel cost associated with site evaluation, planning, contract administration, and documentation was \$25,892 (not including costs borne by other divisions within Redwood National Park). The total project cost was \$269,741 (Table 1).

Geology/Geomorphology

The entire rehabilitation unit area is underlain by the Incoherent Coyote Creek Unit of the Franciscan Formation (JKf). 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 is not considered "melange", a term often used to describe Franciscan rocks in the California Coast Range that exhibit a greater degree of shearing and have more exotic blocks present.

Map A

90-2 SITE LOCATION MAP



Much of the 1990 work along the K&K is likely within or adjacent to 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 (also Franciscan Fm.). The fault zone is considerably straighter than other NNW trending faults in the region suggesting that it is nearly vertical.

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 complex translational/rotational slides (earthflows) support shrub or forest vegetation, and may be temporarily covered by small areas of grasslands. Large, resistant rocks form prominent points on the landscape and steep inner gorge topography is typical where these are near Redwood Creek.

The site mostly has a southwesterly slope aspect and has moderate relief from 400 feet to about 700 feet in elevation. The segment of the K&K within the Copper Creek watershed has a northwesterly aspect. 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 (Map B).

Soils

Rehabilitation Unit 90-2 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. Subsurface horizons are commonly mottled (Cg horizons) indicating that the zone is saturated for part of the year. Even in natural conditions, these materials are prone to fluvial erosion due to principally to restricted internal drainage, fine grained character, 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 (> 60 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 over steepened. 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.

Near the end of the work unit, within the inner gorge region of Copper Creek, Elfcreek Soils become the primary soil type. Elfcreek soils are described by Popenoe and Sturhan (1988) as youthful, grayish soils formed in deep colluvium. These soils are found on lower hillslopes associated with imperfectly drained conditions. They generally lack mottles and have a 10-20% clay content with a 35-60% gravel fraction. Elfcreek soils are mostly dominated by debris sliding processes with local slumping of fill prisms.

Land Use History

Prior to timber harvesting the grass prairie and grass-oak woodland areas which dominate the ridge top areas were grazed by cattle and sheep (outside Unit 90-2 boundaries). It is unknown if Tick Prairie was exposed to grazing and may be one of the few prairies that wasn't. Under the canopy of the oaks native grasses dominate and no grazing pressure may one of the reasons. After construction of the K&K, hydroseeding of cutbank areas introduced a number of non-native species of grass and forbs, which continue to thrive in the disturbed areas away from the oak woodlands.

What is now known as the 1600 road was the first road constructed into this part of the Redwood Creek watershed (Map B). The 1600 followed what later became known as the 1800 Road on the east side of Redwood Creek, to the location of the old 1800 Bridge (washed out in the 1964 flood). The 1600 then continued downstream, paralleling and adjacent to the right bank of Redwood Creek and eventually crossed Copper Creek near the confluence with Redwood Cr. This road was abandoned within a couple of years of construction, presumably because of extreme maintenance problems related to the numerous earthflow toes which the road crossed. The K&K Road in its present alignment was constructed between 1955 and 1958 from the intersection of the "1800" into the Copper Creek drainage. In 1974, a short section was relocated around the Sweet Pea and Live Oak earthflows (Map D). The 1900 Road was the principal spur off of the K&K which accessed much of the forested area above the K&K and the entire south Copper Creek area (see Utley, 1980; Weaver et al., 1987).

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. Logging predominately utilized tractor yarding methods, but cable methods were also used within the unit. Very few old growth conifers remain within the unit, however "old growth" Oregon White Oak stands were virtually untouched in the woodlands near Tick Prairie.

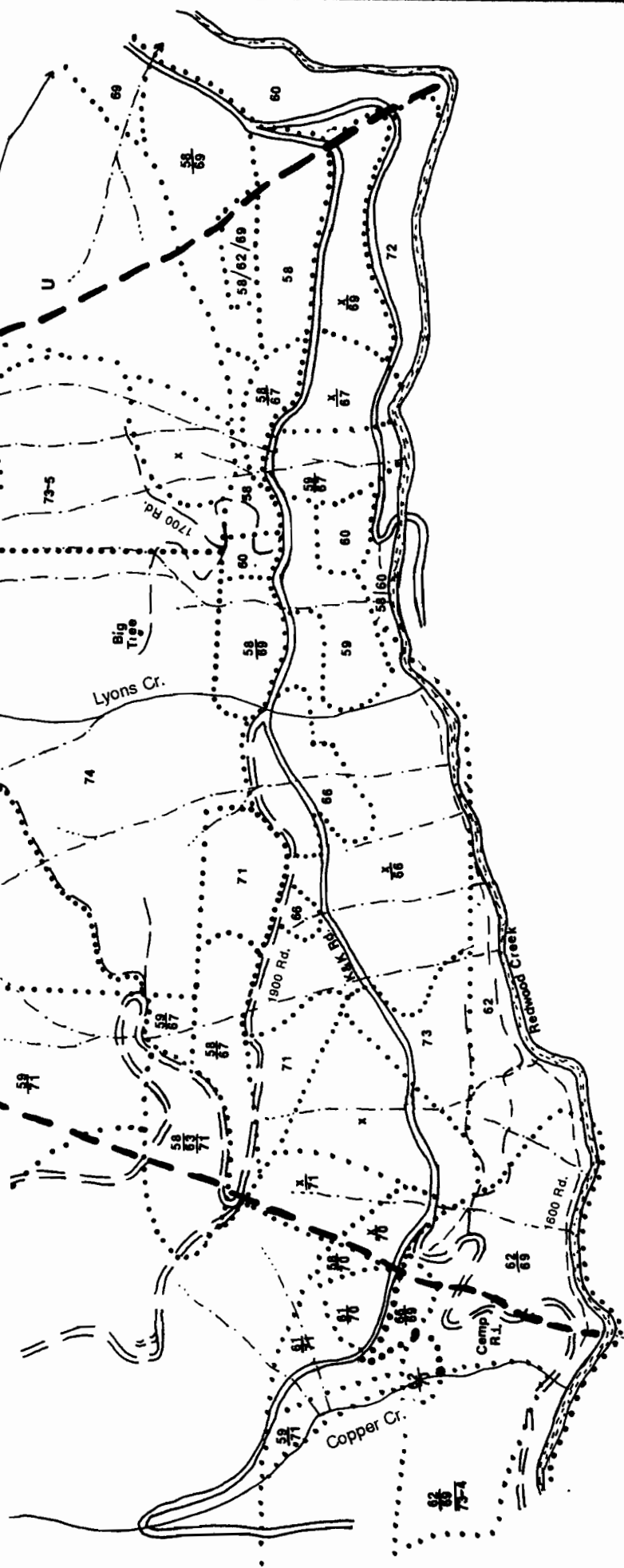
After Redwood National Park was expanded in 1978, Simpson Timber Company retained the privilege of using the K&K until 1987. Simpson was also required to maintain the road. In 1987, Redwood N.P. became solely responsible for maintenance and management.

Rehabilitation work on the K&K road began in the summer of 1988 and 2.1 miles of road (including 0.5 mi. of an old ranch road) encompassing 350 acres of watershed area was treated prior to the implementation of Unit 90-2. Units 88-2 and 89-2 are summarized by Steensen (1989, 1991). The 1900 road and a portion of the 1700 road was treated in 1980 (Unit 80-1, see Utley, 1980).

Map C - Land Use History

LEGEND

- 59 - Year logged.
 - 59 - Year first logged.
 - 74 - Year subsequently logged.
 - U - Uncut
 - x - Year of logging unknown
- (From Utley, 1981)



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 accelerated by land-use practices. Virtually all of the sediment generated from the K&K has entered Redwood Creek quickly.

The dominant 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 size and/or species composition are visible in 1954 aerial photographs on some of the landslides. Earthflow movement rates and sediment yields have been summarized by Harden and others (1978), Nolan and others (1979), and Sonnevil (personal communication).

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. Nine intermittent streams and one perennial stream was crossed by the K&K in the section that was treated in Unit 90-2. 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 (earthflows). In a number of locations, failures caused by the construction of cut slopes have migrated 300-400 feet upslope.

REHABILITATION WORK

Project Implementation

Field mapping, site evaluations, and prescriptions were accomplished between November, 1989, and mid-January, 1990, by D. Steensen. Mapping utilizing enlarged aerial photography at a scale of 1:600. Surveying and photo-documentation was completed by D. Steensen, M. Napolitano, T. Hardt, D. Short, K. Griffin, G. Bundros, and J. Wood. Rehabilitation work was supervised D. Steensen (contracting officers representative) and J. Wood (project inspector). The earthmoving work was performed by Twin Parks Lumber Company of Arcata, California.

Primary rehabilitation treatments included excavation of 12 haul road stream crossings, one skid-trail stream crossing, 2,450 feet of exported outsloping,

TABLE 1. REHABILITATION WORK COST SUMMARY, UNIT 90-2

TREATMENT	WORKSITE QUANTITY	TOTAL QUANTITY	ACTUAL TOTAL COST \$	ACTUAL AVERAGE UNIT COST \$	T.H.E.R.E. ¹ TOTAL COST \$	T.H.E.R.E. AVERAGE UNIT COST \$
HEAVY EQUIPMENT						
<u>Primary Treatments</u>						
Stream Crossing Excavations	18	20,865 yd ³	76,390	3.66/yd ³	41,728	2.00 yd ³
Outsloping	21	24,260 yd ³	38,300	1.58/yd ³	22,925	0.95 yd ³
Exported Outsloping	12	21,960 yd ³	74,600	3.40/yd ³	55,366	2.52 yd ³
<u>Other Primary Treatments</u>						
Ripping	1	10,560 ft.	3,000	0.28/ft.	1,270	0.12/ft.
Cross Road Drains	12	346 ft.	510	1.47/ft.	209	0.60/ft.
<u>Secondary Treatments</u>						
Rock Quarry and Transport ²	1	460 yd ³	(15,626) ²	(33.97/yd ³) ²	-	-
Rock Distribution	4	265 yd ³	2,000	7.55/yd ³	2,531	9.55/yd ³
Rock Placement	6	460 yd ³	3,000	6.52/yd ³	3,640	7.91/yd ³
<u>Other Contract Costs</u>	-	-	19,412	-	-	-
TOTAL HEAVY EQUIPMENT			<u>217,212</u>			
LABOR INTENSIVE						
Contract Straw Distribution	1	1,280 bales	7,000	5.47/bale	-	-
RNP Straw Delivery/Spread	-	1,280 bales	9,100	7.10/bale	-	-
Materials (straw)	-	-	4,320	3.20/bale	-	-
RNP Brushing	-	-	5,634	-	-	-
Other (See Table 8)	-	-	853	-	-	-
TOTAL LABOR INTENSIVE			<u>26,637</u>			
PROJECT IMPLEMENTATION						
<u>Evaluation</u>						
Mapping	-	-	4,370	-	-	-
Prescription	-	-	2,644	-	-	-
Surveying	-	-	3,867	-	-	-
Designing	-	-	556	-	-	-
Drafting	-	-	933	-	-	-
Contract Preparation	-	-	3,611	-	-	-
Overall Planning	-	-	646	-	-	-
<u>Supervision</u>						
Contract Supervision	-	-	6,714	-	-	-
Labor Crew Supervision	-	-	45	-	-	-
<u>Documentation</u>						
Photo-Documentation	-	-	1,006	-	-	-
Cost Analysis and Report	-	-	1,500	-	-	-
TOTAL PROJECT IMPLEMENTATION			<u>25,892</u>			
TOTAL REHABILITATION PROJECT COST			269,741			

1) Total Heavy Equipment Rental Equivalent: T.H.E.R.E. values are based on actual equipment time spent in completing the work specifications. T.H.E.R.E. costs are distinguished from H.E.R.E. costs found in following tables by the multiplication of a weighted cost factor that accounts for non bid-item costs such as equipment maintenance, travel, fueling, down time, etc. The cost values are computed using averages of like equipment from the Redwood Nat'l Park rental bid list for 1990. See Table 2 for a detailed description of these costs. See Table 2 for a breakdown of the miscellaneous, non-bid item costs.

2) Rock Quarry and Transport costs for Unit 90-2 were actually paid for through Unit 89-4, Y-Line Rock Pit Rehabilitation Project, and are not included in the total cost for the K&K Project.

TABLE 2. MISCELLANEOUS COSTS¹. UNIT 90-2, LOWER K&K.

ITEM	ACTUAL COST(\$)	H.E.R.E. COST(\$)	EQUIPMENT HOURS ²												PERCENT OF TOTAL COST (%) ³
			B1w	B2w	B3r	X	L	D1	D2	D3	D4	D5	WT	G	
Breaks	-	6,552	10.0	13.0	6.5	13.75	5.5	6.0	6.0	5.5	5.5	--	--	--	4.4
Discussion	-	1,080	1.5	1.5	1.75	4.0	--	--	--	--	--	--	--	--	0.7
Fueling ⁴	-	442	--	1.5	1.5	1.0	--	--	--	--	--	--	--	--	0.3
Travel	-	611	1.25	1.25	1.0	1.25	0.75	--	--	--	--	--	--	--	0.4
Open Roads	-	1,296	5.0	4.0	5.0	--	--	--	--	--	--	--	--	--	0.9
Road Watering	-	808	--	--	--	--	--	--	--	--	--	--	16.0	--	0.5
Road Grading	-	670	--	--	--	--	--	--	--	--	--	--	--	11.5	0.5
Down Time ⁵	-	4,592	--	2.0	--	27.0	--	--	--	--	--	1.0	1.0	--	3.1
Standby ⁶	-	3,049	--	--	--	--	--	20.0	20.0	10.0	20.0	--	--	--	2.1
Waiting ⁷	-	370	0.5	1.5	1.5	--	--	0.25	0.25	0.25	0.25	--	--	--	0.3
Move Util. Equip.	-	988	3.5	1.5	1.0	2.5	--	--	--	--	--	1.0	--	--	0.7
TOTALS		20,458	21.75	26.25	18.25	49.5	6.25	26.25	26.25	15.75	25.75	2.0	17.0	11.5	13.9

Footnotes:

- 1) Miscellaneous costs listed in this table should be viewed only as estimates. The time/cost reported is that which occurred during normal work hours. Any time spent maintaining, fueling, or moving equipment outside of normal work hours is not included. Miscellaneous costs are computed within the context of hourly rental agreement formats. For example, lunch break (Breaks) costs would have been borne by the Government, yet may not necessarily have been by the contractor.
- 2) B = bulldozer (w = winch, r = rippers), X = hydraulic excavator, L = loader, D = dump truck, WT = water truck, G = road grader. Refer to Table 4 for a complete description of equipment and specifications.
- 3) The percentage values listed are relative to the total H.E.R.E. costs, not actual costs.
- 4) Fueling costs shown in this table are only those that occurred within normal work hours. It is unknown how many hours were actually spent fueling.
- 5) The down time reported here is only for the piece of equipment that actually broke down. Other equipment that was affected by the down piece would be listed as standby. No standby was incurred for this project as a result of down equipment.
- 6) Standby may not have actually been borne by the contractor. It is listed here in the context of an hourly rental agreement format where standby costs would be borne by the Government. Standby costs for Unit 90-2 were incurred by rainy weather.
- 7) Waiting time refers to time spent by equipment such as dump trucks, that had to wait for the excavator or loader to accomplish some other task (such as rock armoring stream channels). Only time greater than 15 minutes was recorded.

TABLE 3. OTHER CONTRACT COSTS. UNIT 90-2, LOWER K&K.

ITEM	ACTUAL COST(\$)	H.E.R.E. COST(\$)	EQUIPMENT HOURS ¹		
			B2w	B3r	X
Move In	9,000	-	--	--	--
Move Out	3,000	-	--	--	--
1610 Open/Close	2,000	573	--	5.0	--
Maneze Cr. Culvert Replace	3,412	3,953	8.75	3.0	7.0
Record Keeping	2,000	-	n/a-	--	--
TOTAL	19,412	-	8.75	8.0	7.0

- 1) Refer to table 4 for detailed equipment specifications. Abbreviations are Bw = bulldozer with winch, Br = bulldozer with ripper teeth, X = hydraulic excavator, L = loader, D = dump truck.

and 5,325 feet of outsloping which included complete physical restoration of the Tick Prairie area. Secondary treatments included placing rock channel armor in 4 haul road crossings and 3 Drains. Straw mulch was applied to the finished slopes of the entire unit. Table 1 summarizes heavy equipment costs for 90-2. Tables 2 and 3 detail miscellaneous contract and non-contract costs. Refer to Map D for locations of individual worksites.

Heavy equipment utilized to accomplish this work consisted of three Caterpillar D8H bulldozers (two with winches, one with ripper teeth), a Case 220 hydraulic excavator, and five 10 yd³ dump trucks. A water truck and road grader were also used on-site. See Table 4 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. This work eliminates diversion potential at crossings and directly removes sediment sources. RX excavations in Unit 90-2 vary from typical examples of RX treatments in Redwood N.P., from the standpoint that all have been so greatly disturbed that the original channel elements were missing. Cobble/boulder lag deposits, fluvially deposited sands and gravels, and organic debris (logs, limbs, roots, etc.) are typically found at the original (pre-road) grade. Skid-trail stream crossing (SX) and Deep Drain (DD) treatments are similar to RX treatments but are usually lesser in scope.

Virtually no original channel elements were encountered during excavation. As of 1990 and the completion of three rehabilitation projects on the K&K with more than 25 crossing excavations (RX, SX, and DD) finished, in only one stream-crossing has any appreciable amounts of original elements been seen: RX-5 (Unit 89-2; see Steensen, 1991). There are three principal causes for this: 1) undercutting of the original grade by road construction, with the channel lag simply bulldozed away, 2) excessive mass movement that destroyed the original morphology, and 3) pre-disturbance channels were poorly developed in the actively evolving earthflow terrain. With no natural channel armoring expected, larger streams were secondarily treated with rock armoring to inhibit excessive downcutting (described below in the Secondary Treatments section).

All of the RX prescriptions treated channel instability and diversion potentials (Table 4). All were within recognized earthflows except RX-13, RX-17, RX-18, and RX-19. Most of the RX treatments through earthflow terrain were relatively routine with the exception of RX-12 (see discussion of RX treatments for Unit 88-2, Steensen, 1989; and Unit 89-2, Steensen, 1991). The RX treatments not within earthflows were also relatively straightforward.

Rehabilitation work at RX-11 entailed stabilizing a small stream that flows through the axial portion of the Big Tree Earthflow which has been the most active earthflow during the 1980's. The crossing was over-excavated in comparison to the design which resulted in minor slope adjustments the winter of 1991-92. In retrospect, the functioning of this crossing would have been

TABLE 4. HAUL ROAD STREAM CROSSING EXCAVATION COSTS. UNIT 90-2, LOWER K&K.

WORKSITE @ STATION	EXCAVATED VOLUME (yd ³)	ACTUAL COST(\$)	EQUIPMENT HOURS ¹					H.E.R.E. ²				H.E.R.E. TOTAL COST(\$)	MEAN UNIT COST (\$/yd ³)	PROD. ³ ENDHAUL DIST.(ft.)	RATE (yd ³ /hr)
			B1w	B2w	B3r	X	L	D1	D2	D3	D4				
RX-11 @ 85+50	1,730	8,650	--	9.0	1.5	11.75	2.75	7.0	7.0	7.0	7.0	4,379	2.53	4,100	33
RX-12 @ 92+69	3,100	12,400	2.0	19.75	4.25	27.75	2.0	7.5	7.5	7.5	7.5	8,343	2.69	3,670	36
RX-12 (Modified)	1,560	6,240	--	7.0	3.0	--	6.5	6.5	6.5	6.5	6.5	2,833	1.82	3,830	37
RX-13 @ 98+40	2,135	8,540	--	11.25	5.5	8.5	--	--	--	--	--	2,906	1.36	150	85
DITCH @ 94+65	2,110	4,220	--	8.25	1.0	6.0	--	--	--	--	--	1,793	0.86	75	138
RX-13N @ 04+31 (1900 Rd.)	205	210	2.5	--	--	--	--	--	--	--	--	223	1.09	40	100
RX-14 @ 04+63 (Old K&K)	580	2,900	3.0	--	5.25	--	--	--	--	--	--	787	1.36	75	70
RX-15 @ 111+55	720	2,880	--	1.25	3.5	3.5	--	--	--	--	--	1,018	1.41	50	87
RX-16 @ 121+31	1,605	6,420	2.5	4.5	6.5	9.25	--	--	9.25	--	--	2,746	1.71	280	71
RX-17 @ 126+92	560	1,000	--	1.0	--	3.5	--	--	--	--	--	649	1.10	40	124
DITCH (Camp Rd. Deck)	350	500	--	--	1.0	4.5	--	--	--	--	--	819	2.34	30	64
RX-18 @ 02+25 (1610 Rd.)	2,265	9,060	31.25	9.75	--	4.25	0.75	--	--	--	--	4,419	1.95	675	49
RX-19 @ 10+57 (Camp Rd.)	2,740	10,960	22.25	4.0	--	1.0	--	--	--	--	--	2,496	0.91	260	101
RX-20 @ 144+46	805	1,610	1.5	1.5	--	5.5	--	3.5	3.5	--	--	1,452	1.80	1,750	52
DD 94+00	235	300	--	--	--	2.0	--	--	--	--	--	320	1.36	45	118
DD 25+07 (Camp Rd.)	225	200	--	--	1.5	1.5	--	--	--	--	--	388	1.73	40	75
DD 36+89 (Camp Rd.)	100	200	--	--	--	1.25	--	--	--	--	--	200	2.00	25	80
SX-1 (Slopework)	50	100	--	--	--	1.25	--	--	--	--	--	200	4.00	25	40
TOTALS	20,865	76,390	65.0	77.25	33.0	91.5	12.0	24.5	24.5	21.0	21.0	35,970			
AVERAGES													1.72	1,370	56

Footnotes:

1) Hours listed are those that each piece of equipment worked on the individual bid item. The equipment abbreviations are as follows:

- B1w: Bulldozer (winch) - 1972 CAT D8H 46A, 270 h.p., 22 in. tracks, winch, 13 ft. U-blade (Twin Parks Lbr. Co.).
 B2w: Bulldozer (w/rippers) - 1968 CAT D8H 46A, 270 h.p., 24 in. tracks, 2.75 ft. ripper teeth (2), 13 ft. straight-blade (Twin Parks Lbr. Co.).
 B3r: Bulldozer (w/rippers) - 1968 CAT D8H 46A, 270 h.p., 24 in. tracks, 2.75 ft. ripper teeth (2), 13 ft. straight-blade (Twin Parks Lbr. Co.).
 L: Crawler Loader - 1965 CAT 977K 46H - 170 h.p., 20 in. tracks, 3 yd³ bucket, 18 ft. range (Twin Parks Lbr. Co.).
 D2: Dump Trk - 1988 Kenworth, 400 h.p., 12 yd³ sq. box, locking diff. (Wm. Richards).
 D4: Dump Trk - 1976 Kenworth, 395 h.p., 10 yd³ sq. box, locking diff. (D. Lytkke).
 WT: Water Trk - 1971 Mack, 318 h.p., 4,000 gallon capacity, self-drafting, spray bar (Timber Equipment Co.).

Other equipment on-site for which specific time was not monitored: 1) horse trailer (tool shed), 2) fuel trailer, 3) air compressor, 4) welder (generator), and 5) "The Ford".

2) H.E.R.E.: Heavy Equipment Rental Equivalent. H.E.R.E. values are based on actual equipment time spent in completing the work specifications. H.E.R.E. costs are distinguished from T.H.E.R.E. costs listed in Table 1 by not accounting for non bid-item costs such as equipment maintenance, travel, fueling, down time, etc. (these miscellaneous costs are broken down in Table x). H.E.R.E. cost values are computed using averages of like equipment from the Redwood Nat'l Park rental bid list for 1990. The actual value used is the average of the three lowest bids for the equipment class. H.E.R.E. rates for Unit 90-2 were: Bulldozer, 270 h.p., winch, 13 ft. U-blade = \$89.00/hr; Bulldozer, 270 h.p., ripper teeth, 13 ft. straight-blade = \$99.00/hr; Hydraulic Excavator, 2.5 yd³ bucket, 39 ft. reach = \$159.99/hr; Tracked loader, 170 h.p., 2.5 yd³ bucket, = \$120.00/hr; Dump trucks with 10 yd³ box and locking differential = \$43.56/hr. Water Truck with 3,800 gallon capacity and spray bars = \$50.50/hr; Road grader with 12 ft. blade = \$58.28/hr.

3) Production rate is computed based upon the time of all pieces of equipment used to accomplish the task at each worksite. It does not include any miscellaneous time (i.e. watering, etc.).

better served by removing less material than even the design specifications and armoring the lower part of the work with rock.

Work at RX-12 channelized Lyons Creek, the largest stream that crossed the K&K between Coyote and Copper Creeks, across the earthflow informally known as the Lyons Creek Slide. The channel morphology upstream of the worksite is characterized by a steep gradient, numerous debris jams, and a well-defined incised valley. At the point where Lyons Creek entered the earthflow, the channel gradient became very low with no banks or valley-side whatsoever. This resulted in a situation where a debris fan had grown out onto the earthflow and the stream had a high potential for diversion completely away from the channel downstream of the K&K road. The results of such a diversion, when it occurred, would likely result in massive gullying through the earthflow and large scale slope instability. The Lyons Creek channel downstream of the K&K road once again leaves the earthflow proper and occupies a relatively well incised valley.

The design criteria at RX-12 required that some sort of valley definition be created and be substantial enough to accommodate future debris deposition, since the low gradient nature of this stream reach could not be significantly changed. To reach this goal, the treatment specified that about one-third of the material excavated from the existing channel be placed adjacent to the left bank (earthflowward) to build up an artificial valley-side.

An interesting phenomenon took place during the course of excavation at RX-12. Relocating and concentrating mass on the earthflow destabilized the landslide beyond a threshold of failure. After one weekend, while work was not in progress, numerous and sizeable tension cracks (1-3 ft. wide, and 1-10 ft. deep) developed about one hundred feet upslope of the newly created levee and a circular arc failure developed that was observed by upthrust earthflow material into the channel. Approximately two to three feet of offset occurred. At this point a decision to alter the original design was made by cutting the levee crest down and endhauling the material to a stable fillsite. A judgement was made on how much of a levee to leave which required a balance between controlling the channel while not destabilizing the overall area such that earth movement would potentially result in channel destruction as well. A levee crest about two-thirds the height of the original design was the ultimate finished product. Some minor movement has taken place since the excavation was completed but the crossing is functioning as desired.

RX-13 included the construction of a long "Ditch" to drain the upslope portions above the large flat area known as the Ingomar Club. A ditch treatment is a properly sized channel that is excavated more or less on contour (roughly perpendicular to the general fall line of the hillslopes). Work at RX-13N realigned flow through inboard ditch diversions created as part of work on Unit 80-1 (Utley, 1981). The outlet of RX-13 feeds flow into an extensive gully system that is still actively evolving. There were no alternatives to this. Careful geomorphic mapping (1:600) of the downslope region revealed the location of the pre-disturbance channel which turned out to be severely disturbed by mass movement processes. Leaving the flow in the existing gully was the best alternative for the condition of the slope below the crossing.

RX-14, RX-15, RX-16, RX-17, and RX-20 were all relatively straightforward. By "straightforward" it is meant that the design simply connected the inlet channel with the outlet channel with consideration for matching sideslopes with surrounding terrain, appropriately sized channel widths for the drainage areas, and suitable profiles to minimize downcutting. RX-17 included the construction of a "Ditch" similar to that explained above for RX-13.

Work at RX-18 entailed creating a channel through two road benches, the 1600 road and the 1610 road. To cost-effectively match the inlet channel with an existing gully system, a variable channel grade was designed. Channel gradients of 50% were divided by lower gradient reaches. The steep portions were then armored with rock.

Work at RX-19 involved removing a buried log bridge that crossed Copper Creek at the confluence of Redwood Creek which was not known to exist until 1987. From 1987 to 1990, about one third of the bridge was exposed by fluvial processes. Flows in Redwood Creek have not been substantial since the time of excavation, but it is anticipated that the channel of Redwood Creek will shift toward Copper Creek in the future.

Outsloping

Outsloping (OS) 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. Outsloping is an appropriate rehabilitation measure in areas where treatments solely for erosion control do not encourage vigorous natural revegetation.

Outsloping accounted for a substantial part of the treated road length of Unit 90-2 relative to Unit 88-2 and 89-2 (Table 5). Most of the outsloped segments were adjacent to EOS or fillsite areas and served as a transition between them.

Longer segments of outsloping included the Old K&K Road, the K&K through Tick Prairie, and Camp Road. The work through Tick Prairie was designed to completely obliterate the road scar and restore the original contours as closely as possible.

Exported Outsloping

Exported outslope treatments (EOS) 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. A considerable portion of the effort to treat Unit 90-2 was spent excavating the entire road prism 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 to relieve some of the driving forces causing the road-related fill failures and discourage propagation of failure through the larger slope failures (e.g. earthflows).

Drain treatments were specified for a number of locations within the EOS treatments. Drains are channels constructed to convey storm gully flow and spring flow across the EOS and direct the flow into appropriate locations below

TABLE 5. OUTSLOPING COSTS. UNIT 90-2, LOWER K&K

BEGINNING STATION	EXCAVATED VOLUME (yd ³)	ACTUAL COST(\$)	EQUIPMENT HOURS ¹			L.F. OF TREAT.(ft.)	VOL./FT. (yd ³ /ft.)	H.E.R.E. ² TOTAL COST(\$)	H.E.R.E. UNIT COST (\$/yd ³)	TYPICAL BENCH WIDTH(ft.)	PROD. ³ RATE (yd ³ /hr)
			B1w	B2w	B3r						
00+18(Old K&K) 095	2,000		--	--	9.0	409	2.7	891	0.81	25	122
06+17(1700) 525	1,000		--	1.5	--	213	2.5	493	0.94	23	140
07+33(Old K&K) 730	1,000		--	--	3.5	343	2.1	347	0.48	25	209
11+68(Camp) 1,140	2,000		--	0.5	--	404	2.8	1,400	1.23	18	123
18+38(Camp) 380	500		--	3.0	--	168	2.3	267	0.70	28	127
21+87(Camp) 1,100	2,000		--	6.5	1.0	313	3.5	758	0.69	35	138
25+80(Camp) 900	2,000		3.5	3.0	3.5	282	3.2	1,005	1.12	30	86
77+88 4,220	6,000		--	14.75	7.0	527	8.0	2,846	0.67	40	156
85+95 1,550	3,000		1.0	6.5	0.5	269	5.8	2,117	1.37	46	92
89+36 1,560	3,000		--	5.0	5.5	196	7.9	1,709	1.10	31	104
99+23 3,245	4,000		16.0	2.75	1.0	617	5.3	2,488	0.77	28	134
108+00 1,265	1,500		1.0	1.5	3.0	260	4.9	1,039	0.82	29	145
112+12 255	500		1.5	--	1.0	160	1.6	313	1.23	16	85
115+35 1,540	2,000		3.5	3.5	3.25	386	4.0	945	0.61	32	150
125+64 150	300		--	--	1.5	96	1.6	149	0.99	22	100
132+33 480	400		3.25	1.0	--	322	1.4	538	1.17	34	88
136+55 1,340	2,000		0.5	9.25	--	359	3.7	2,348	1.75	30	71
TOTALS	21,305	33,200	30.25	58.75	48.5	5,324		19,652			
AVERAGES							4.0		0.92	30	120

Footnotes:

- Hours listed are those that each piece of equipment worked on the individual bid item. Refer to Table 4 for a complete description of equipment and specifications.
- H.E.R.E.: Heavy Equipment Rental Equivalent. Refer to Table 4 for a complete description of H.E.R.E cost derivation.
- Production rate is computed based upon the time of all pieces of equipment used to accomplish the task at each worksite.

TABLE 6. EXPORTED OUTSLOPING¹ COSTS. UNIT 90-2, LOWER K&K

BEGINNING STATION	EXCAVATED VOLUME (yd ³)	ACTUAL COST(\$)	EQUIPMENT HOURS ²										L.F. OF TREAT.(ft.)		H.E.R.E. TOTAL UNIT COST(\$)				H.E.R.E. TYPICAL MEAN ³ ENDHAUL RATE (yd ³ /hr)			
			B1w	B2w	B3r	X	L	D1	D2	D3	D4	D5										
04+70 (1700)	175	200	--	1.5	--	--	--	--	--	--	--	--	--	82	2.1	134	0.76	10	50-B	117		
20+06 (Camp)	550	2,000	1.5	4.0	--	0.5	--	--	--	--	--	--	--	181	3.0	570	1.04	23	395-B	92		
83+15	2,440	8,000	--	6.5	5.5	9.0	--	9.0	9.0	9.0	9.0	--	9.0	194	12.6	4,131	1.69	27	4,240-T	43		
88+67	2,230	9,000	--	13.0	10.0	9.0	--	9.0	9.0	9.0	9.0	--	9.0	363	6.1	5,155	2.31	23	3,930-T	33		
105+40	2,930	12,000	4.5	4.5	2.5	28.25	4.0	20.0	20.0	20.0	20.0	--	20.0	260	11.3	9,533	3.25	27	3,590-T	24		
113+72	1,135	5,000	9.5	--	0.5	3.25	--	2.5	2.5	2.5	2.5	--	2.5	163	7.0	1,851	1.63	15	960-T	49		
119+21	825	2,000	1.75	--	1.5	5.0	--	3.0	3.0	3.0	3.0	--	3.0	182	4.5	1,627	1.97	42	323-P	41		
121+65	1,150	5,000	5.5	1.5	4.75	--	--	--	--	--	--	--	--	246	4.7	1,093	0.95	19	134-P	98		
130+00	2,085	8,000	12.0	10.25	3.5	1.5	--	--	--	--	--	--	--	233	8.9	2,567	1.23	45	278-B	77		
135+55	675	3,000	1.25	6.0	2.5	3.5	--	--	--	--	--	--	--	100	6.8	1,453	2.15	23	150-B	51		
140+14	7,415	20,000	34.75	30.0	7.5	11.25	36.5	34.5	34.5	34.5	34.5	1.0	34.5	412	18.0	18,740	2.53	25	2,145-T	56		
144+74	350	400	--	1.0	--	2.5	--	--	--	--	--	2.75	--	33	10.6	609	1.74	23	1,260-T	56		
TOTALS	21,960	74,600	70.75	78.25	38.25	73.75	40.5	78.0	78.0	78.0	78.0	3.75	78.0	2,449		47,461						
AVERAGES														9.0		2.16		2,203		61		

1) Exported outsloping refers to the treatment where some or all of the road prism is removed from the site and stored in a fillsite that is not the remaining bench.

2) Refer to table 4 for detailed equipment specifications. Abbreviations are Bw = bulldozer with winch, Br = bulldozer with ripper teeth, X = hydraulic excavator, L = loader, D = dump truck.

3) Mean endhaul distance is a volume-weighted value. Suffix definitions are as follows: B = Blade (local) endhailed, T = Truck endhailed, P = Partial (some portion truck, some portion blade endhailed).

4) Production rate is the total volume of the task divided by the total equipment hours used to accomplish the task, regardless of the function of the equipment.

the excavations. Portions of three Drains were secondarily treated with rock armor.

Large individual EOS treatments included segments through the Big Tree Earthflow, Lyons Creek Slide, and the Copper Creek Slide. The Sweet Pea Earthflow and Live Oak Slide were not treated by EOS (they were treated by OS) since the road segments were judged not to be contributing to forces driving any local failures. Many smaller EOS treatments were adjacent to stream crossing excavations where materials could fail into or impact downslope streams or treated wet swales, etc.

Other Primary Treatments

Other rehabilitation treatments employed on Unit 90-2 include cross-road drain (XRD) and ripping (decompaction) of road benches and fill areas (refer to Table 1, these costs are not presented elsewhere). Cross-road drains are large waterbars constructed across the road to disperse runoff and were employed in areas where winterization was necessary (for example, at the end of Unit 90-2). See Map D for locations of where these were applied.

Secondary Treatments

Rock Armor

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 channels where gradients and estimated peak flows would combine to create an energetic (i.e., erosive) environment. Rock armor is warranted where excessive erosion that may result within unprotected channel excavations could result in disturbances that may propagate upstream (such as headcuts). Upstream migration of headcuts may cause stream-side slumping and mobilization of larger slope features, resulting in significantly larger amounts of sediment produced regardless of the amount of material eroded from the crossing excavation itself.

Rock was placed in the channels in a "blanket" form, covering the channel bottom. 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.

Rock was hauled to the K&K from the Y-Line Rock Pit, where stockpiles were created as a by-product of the Unit 89-4 project (Johnson, 1990). Costs for rock armor transport and placement and the areas where rock was applied is found in Table 7.

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 7 and Table 8). This site has a southerly to southwesterly aspect and summer conditions are usually hot and dry. The application rate was 5,000 pounds per acre (approximately 63

TABLE 7. SECONDARY TREATMENT COSTS (CONTRACT). UNIT 90-2, LOWER K&K.

ITEM	WORKSITE QUANTITY	ACTUAL COST(\$)	EQUIPMENT HOURS ¹				H.E.R.E. COST(\$)	H.E.R.E. UNIT COST(\$)
			B2w	X	L	D5		
<u>Rock Quarry and Transport</u>	<u>1</u>	<u>(15,626)²</u>						
<u>Rock Distribution</u>	<u>3</u>	<u>2,000</u>						
RX-11	50 yd ³	-	--	1.75	--	--	585	11.70/yd ³
RX-18	180 yd ³	-	--	--	9.5	3.25	1,282	7.12/yd ³
RX-20	50 yd ³	-	--	--	1.5	--	180	3.60/yd ³
Drain @ 140+82	25 yd ³	-	--	--	0.75	--	123	4.92/yd ³
<u>Rock Placement</u>	<u>7</u>	<u>3,000</u>						
RX-11	50 yd ³	-	--	2.0	--	--	320	6.40/yd ³
RX-12	80 yd ³	-	--	4.75	1.0	--	880	11.00/yd ³
Drain @ 105+57	25 yd ³	-	--	0.75	--	--	107	4.28/yd ³
Drain @ 107+71	50 yd ³	-	--	1.25	--	--	213	4.26/yd ³
RX-18	180 yd ³	-	--	7.25	--	--	1,160	6.44/yd ³
Drain @ 140+82	25 yd ³	-	--	0.5	--	--	80	3.20/yd ³
RX-20	50 yd ³	-	--	2.25	--	--	360	7.20/yd ³
<u>Straw Bale Place</u>	<u>1,280 bales</u>	<u>7,000</u>						
Equip. Hrs. used to place straw ³		-	0.75	5.75	2.0	--	1,227	n/a
TOTALS		12,000	0.75	26.25	14.75	3.25	6,517 (Rock:11.50/yd)	

Footnotes

1) Refer to Table 4 for a complete description of equipment abbreviations and definitions.

2) Rock quarry and transport costs for Unit 90-2 were actually paid for through Unit 89-4, Y-Line Rock Pit Rehabilitation Project, and are not included in the total cost for the 90-2 project.

3) Contract straw costs are not thoroughly documented beyond actual bid price. For example, any labor costs associated with straw bale placement were not monitored (see Table 8 for detailed cost analysis for RNP labor costs for straw bale placement).

TABLE 8. LABOR INTENSIVE COSTS. UNIT 90-2, LOWER K&K.

TASK	RNP ¹		RUI ²		TOTAL COST(\$)	UNIT COST(\$)
	Person Hrs	Cost(\$)	Person Hrs	Cost(\$)		
Brush Survey Lines	480	5,634	-	-	5,634	-
Straw Mulch						
Materials Price	-	-	-	-	4,320	3.38/bale
Delivery (unloading, etc.)	114	1,337	-	-	1,337	1.04/bale
Spreading	560	6,563	80	1,200	7,763	6.06/bale
RNP Backhoe work	66	853	-	-	853	-
TOTALS	1,220 hr	\$14,387	80 hr	\$1,200	<u>\$19,907</u>	-

1) Redwood National Park, Research and Resources Management Support Branch (Labor Crew).

2) Redwoods United Incorporated.

bales/ac) for the main portion of the K&K up through Tick Prairie. From Tick Prairie to the end of the unit, and for Camp Road, the application rate was 4,000 pounds per acre (roughly 50 bales/ac) because of a northwesterly to northerly aspect. See Table 8 for a detail of straw mulch costs.

DISCUSSION

The size of the K&K Road, its proximity to Redwood Creek, and the inherent instability of the terrane, required that this rehabilitation unit be the one of the most effort-intensive sites yet accomplished in Redwood National Park. Examples of other sites in Redwood where extensive truck-endhauling was necessary are the G-Line, Unit 85-3 (Kenning and Wosika, 1986), the M-7, Unit 86-1 (Kenning, 1987), and the earlier Lower K&K units: Unit 88-2 and Unit 89-2 (Steensen, 1989; 1992). Unit 90-2 was the third phase of a several year project to rehabilitate the K&K Road and it is likely that the last segment of the Lower K&K, through the Copper Creek valley, will also be an effort-intensive site. The 1991 project will treat the segment of the K&K from the end of 90-2 to the intersection of the K&K with the 2002 and 2004 Roads. The K&K from the forecasted end of the 1991 project up to Counts Hill Prairie is considered the Middle K&K and from Counts Hill to the gate at Bald Hills Road is the Upper K&K.

Unit 90-2 differed from Unit 88-2 and to a lesser extent Unit 89-2 from the standpoint that there were more frequent stable areas encountered along the road. Several small fillsites were utilized as well as several larger areas where fill was placed from several source areas. As a consequence, a longer segment of the road and more disturbed watershed area was treated in 1990 relative to 1988 and 1989.

The Lower K&K Rehabilitation Project addressed erosion problems associated with road construction and timber harvest on naturally erosion-prone hillslopes and stream channels. Direct sediment sources to Redwood Creek that were minimized included removal of stream crossing fills and large quantities of sidecasted materials. Haul road-stream crossing excavations removed road fill material from stream valleys and channels and eliminated diversion possibility. Relief to some of the driving forces causing road-related fill failures was accomplished by removing as much material as was practical (i.e., within limits of equipment capability, cost, etc.) and landscapes now conform with existing conditions outlying the treated area. Stabilization of the drainage systems was likely the greatest cost-effective contribution toward future stability. Rock armoring has played a key role in stabilizing a number of channel excavations.

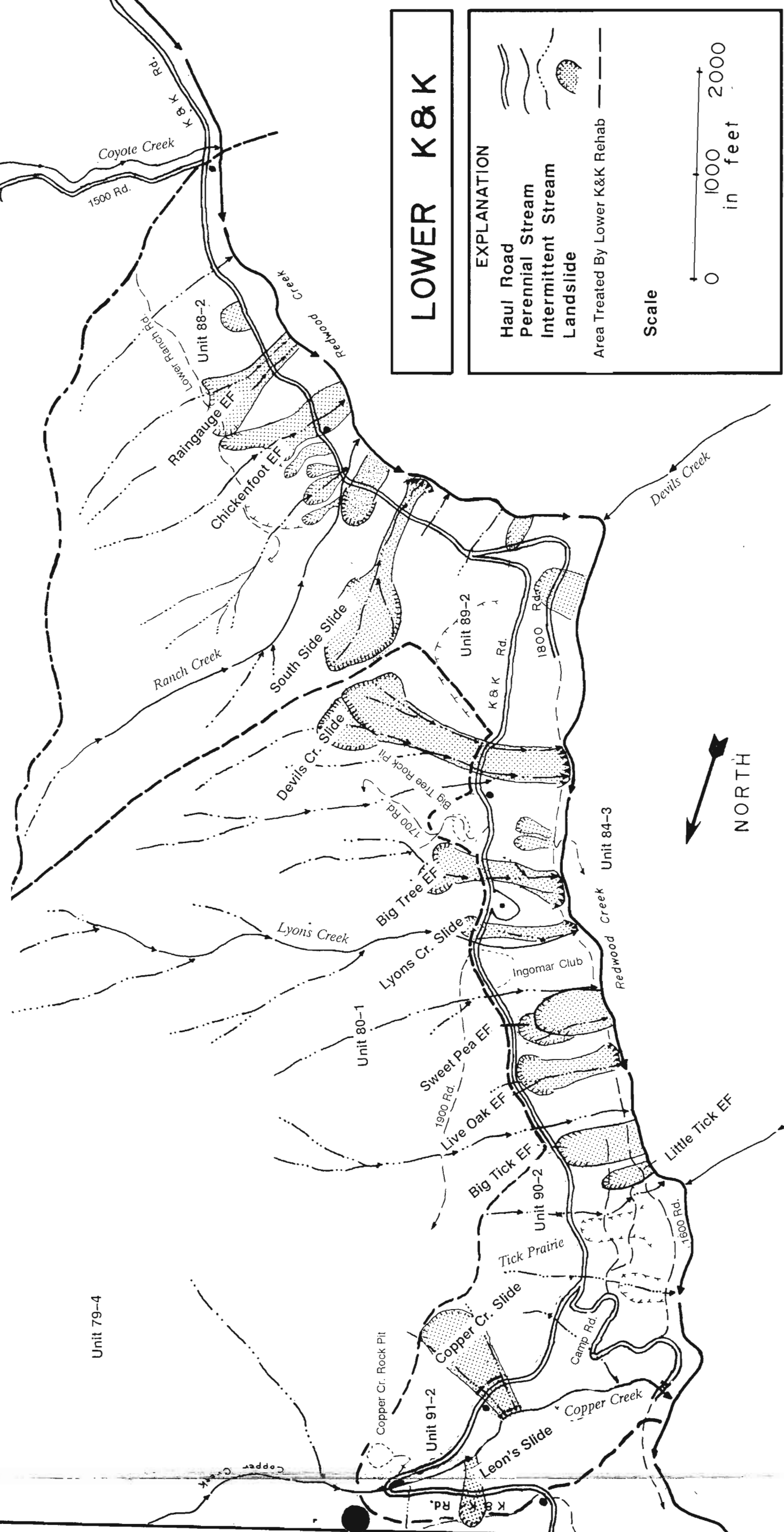
As with numerous past accounts of work experiences with heavy equipment operators, the execution of work on Unit 90-2 went remarkably smooth due to the experience and capabilities of the contractor. Twin Parks Lumber Company is the most experienced contractor that has worked on rehabilitation projects in Redwood National Park. Familiarity with the procedures and goals of the program enabled them to perform outstanding work without complications. Working with this contractor has validated the principle that experienced operators are indispensable in implementing successful rehabilitation work.

REFERENCES

- Coleman, S.M., 1973, The History of Mass Movement Processes in the Redwood Creek Basin, Humboldt County, California; Paper presented in lieu of M.S. Thesis, Dept. of Geosciences, Pennsylvania State University, 180 p.
- Harden, D.R., R.J. Janda, and K.M. Nolan, 1978, Mass Movement and Storms in the Drainage Basin of Redwood Creek, Humboldt County, California-a Progress Report; U.S. Geological Survey Open-File Report 78-486, 161p.
- Harden, D.R., H.M. Kelsey, S.D. Morrison, and T.A. Stephens, 1982, Geologic Map of the Redwood Creek Drainage Basin, Humboldt County, California; U.S. Geological Survey Water Resources Investigations 81-496, Map (1:62500) and legend.
- Janda, R.J., K.M. Nolan, D.R. Harden, and S.M. Coleman, 1975, Watershed Conditions in the Drainage Basin of Redwood Creek, Humboldt County, California, as of 1973; U.S. Geological Survey Open-File Report 75-568, 266 p.
- Johnson, L.E., 1990, Summary Report, Rehabilitation Unit 89-4, Y-Line Rock Pit #1 Rehabilitation Project; USDI-Redwood National Park In-Service Report, 13 p.
- Kenning, M.L. and E.P. Wosika, 1986, Summary Report of Erosion Control Work, 85-3, G-Line/G-2/G-4 Roads; USDI-Redwood National Park In-Service Report, 29 p.
- Kenning, M.L., 1987, Summary Report of Rehabilitation Unit 86-1, M-7/M-7-5 Roads, Bridge Creek Basin; USDI-Redwood National Park In-Service Report, 20 p.
- Nolan, K.M., R.J. Janda, and J.M. Duls, 1979, Recent history of two earthflows adjacent to Redwood Creek, IN Guidebook for A Field Trip to Observe Natural and Management Related Erosion in Franciscan Terrane of Northern California; Geological Society of America Cordilleran Section Meeting, San Jose, pp. XI-1 to XI-10.
- Popenoe, J.P. and N. Sturhan, 1988, Soils of The Lower K&K Road Watershed Rehabilitation Unit 88-2; USDI-Redwood National Park In-Service Report, 21 p.
- Sonnevil, R.A., personal communication, Redwood National Park, Orick, California.
- Spreiter, T.A., 1990, Watershed Restoration in Redwood National Park, Summer Field Seminar Booklet, Humboldt State University, Arcata, California, 41 p.

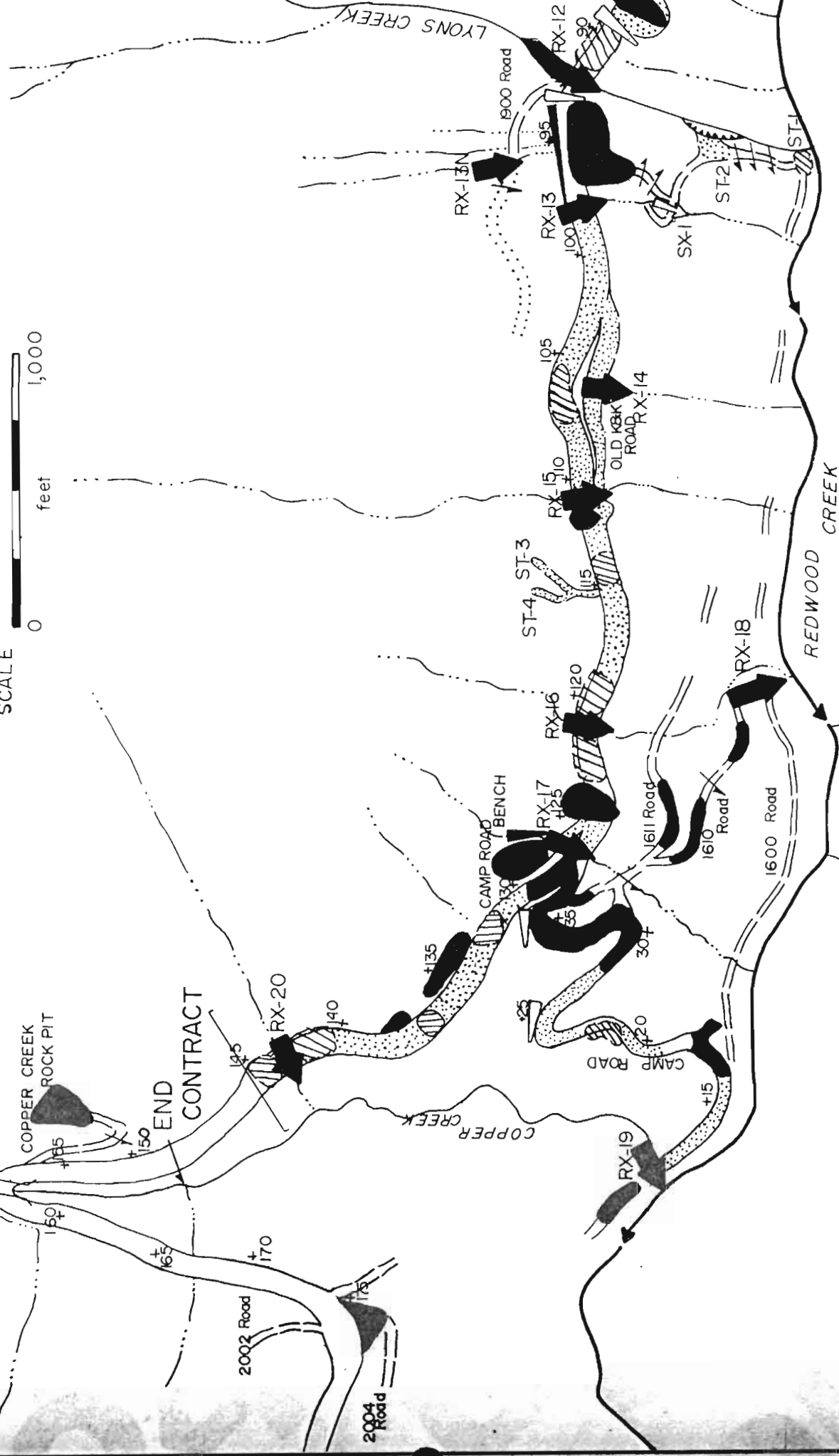
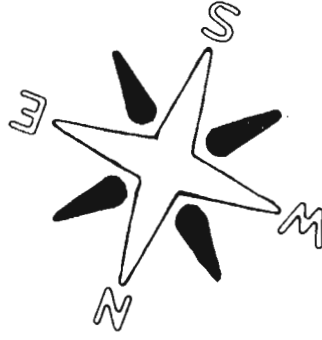
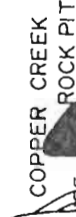
- Steensen, D.L., 1989, Summary Report, Rehabilitation Unit 88-2, Lower K&K Road and Slopes; USDI-Redwood National Park In-Service Report. 19 p.
- Steensen, D.L., 1992, Summary Report, Rehabilitation Unit 89-2, Lower K&K and 1800 Road; USDI-Redwood National Park In-Service Report. p.
- Utley, K., 1981, Summary Report, Rehabilitation Unit 80-1, South of Copper Creek (Big Tree); USDI-Redwood National Park In-Service Report xx p.
- Weaver, W.E, Hektner, M.M., Hagans, D.K., Reed, L.J., Sonnevil, R.A., and Bundros, G.J., 1987, An Evaluation of Experimental Rehabilitation Work, Redwood National Park: Redwood National Park Technical Report 19, USDI-National Park Service, Redwood National Park, Arcata, California, 205 p.

Map B - Generalized Geomorphology



REDWOOD NATIONAL PARK
WATERSHED REHABILITATION PROJECT 90-2

EXPLANATION	
	MAIN ROAD
	ABANDONED ROAD
	REHABILITATED ROAD
	FILL SITE
	OUTSLOPE
	EXPORTED OUTSLOPE
	STREAM CROSSING
	DITCH
	STATION NUMBER
	PERENNIAL STREAM
	INTERMITTENT "
	SKID TRAIL CROSSING
	DEEP DRAIN
	CROSS ROAD DRAIN



King, 90



90-2 PP2b 6/27/90 50mm K+K Road from 100ft. up 1700 rd. RX4 upstation OS DLS



90-2 PP2B 10/10/90 50mm K+K Road Post H.E. JFW



90-2 PP3 6/27/90 50mm K+K Road upchannel from RX11 L8 DLS



90-2 PP3 10/10/90 50mm K+K Road Post H.E. JFW



90-2 PP11 6/27/90 35mm K+K Road upchannel CL RX12 DLS



90-2 PP11 10/11/90 K+K Road Post H.E. JFW



90-2 PP53B 7/2/90 35mm Camp Rd. twd Top RX19 Bot RX19 DLS



90-2 PP53B 10/17/90 35mm Post H.E. K+K JFW



90-2 PP64B 7/2/90 35mm Pre H.E. K+K upsta EOS & RX20 Sta 143 + 35 DLS



90-2 PP64B 10/17/90 35mm Post H.E. K+K JFW