

Summary Report

**WATERSHED REHABILITATION UNIT 96-2
Partial Removal of the K&K Road
Phase VII: North Fork Slide Creek**

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Introduction

Redwood Creek drains a 280-square-mile watershed in the mountainous, coastal region of northwestern California. The watershed is characterized by high relief, steep unstable slopes, and narrow valley bottoms. Redwood Creek and its tributary streams are subject to frequent flooding from winter storms, and basin soils are naturally unstable and highly erodible. Landslides and earthflows are widespread, and even under natural conditions streams swelled by winter rains transport large volumes of sediment. With over 90% of the forests in the basin harvested, and _ of the basin in active timber management, sediment levels in Redwood Creek are twice the mean annual erosion rates for the north coast (U.S. Congress, House, Committee on Government Operations 1976).

Redwood National Park (RNP) is located in the lower _ of the Redwood Creek watershed. Redwood National Park was established "in order to preserve significant examples of the primeval coastal redwood (*Sequoia sempervirens*) forests and the streams and seashores with which they are associated for purposes of public inspiration, enjoyment, and scientific study" (Public Law 90-545). Original boundaries protected a ½-mile wide corridor of forest along the lower _ of Redwood Creek. Lands located upslope and upstream of this corridor remained in private ownership. Prior to the establishment of the park, much of these lands were forested with old growth mix conifer forests. Subsequent to the park's establishment, these lands were subject to aggressive timber harvesting. This timber harvesting and the related road construction adversely influenced erosion rates, sediment deposition and water quality within the entire basin. Studies indicated these activities caused unnatural and excessive erosion that resulted in adverse impacts to riparian habitat, anadromous fisheries, and amphibian species (Narver, 1971). The existence of several hundred miles of major haul roads and thousands of miles of tractor trails created severe erosion problems. The cutting of logging roads into steep slopes often resulted in massive slope failures, causing sediment to be delivered directly into perennial and intermittent stream channels. Surface runoff was intercepted and concentrated by inboard ditches along these roads, and often discharged onto slopes that had no natural drainage channels, resulting in severe gullying. During major storms, culverts and inboard ditches often became blocked, and water was diverted onto road surfaces, causing new gullies and saturating road fills, which in turn led to slope failures. Natural deep-seated mass movements in the prairies in the watershed were also greatly aggravated by roads. Road construction across unstable prairie grasslands altered natural drainage patterns, often resulting in deep gullies. The altering of drainage patterns, the resulting loss of top soil, soil compaction, and destruction of ground cover, combined with increase runoff rates were among the results of logging activities in the Redwood Creek basin. These factors led to increased sedimentation, increased streamside slope failures, greater bank erosion and loss of anadromous fish-spawning habitat. These events led to a general degradation of the watershed, including damage to the aquatic and riparian environments of the Redwood Creek corridor.

"In order to protect existing irreplaceable Redwood National Park resources from damaging upslope and upstream landuses, to provide a landbase sufficient to insure preservation of significant examples of the coastal redwood in accordance with the original intent of Congress, and to establish a more meaningful Redwood National Park for the use and enjoyment of visitors," Congress enacted the expansion legislation of 1978 (Public Law 95-250). The boundaries of Redwood National Park were expanded by approximately 48,000 acres, and Congress directed the National Park Service to undertake a watershed rehabilitation program. The primary goals of the rehabilitation program are to minimize man-induced erosion and speed the natural revegetation process by restoring the hillslope hydrology to conditions that existed prior to man's influence.

It is National Park Service policy to "actively seek to understand and preserve the soil resources of parks and to prevent, to the extent possible, the unnatural erosion, physical removal, or contamination of the soil, or its contamination of other resources..." It is also Park Service policy that "Terrain and plants may be manipulated where necessary to restore natural conditions on lands altered by human activity. Management activities may include, but will not be restricted to, removing constructed features, restoring natural gradients, and revegetating with native park species..." (National Park Service Management Policies, 1988). Management objectives of Redwood National Park are "to restore and/or maintain the natural ecosystems of the park" and "to continue with biological and physical restoration of park lands severely impacted by past land-use practices" (Redwood National Park, Statement for Management, 1992). These policies and objectives provided the guidance and direction for the removal of this

portion of the K&K Road.

Project Background and Description

The K&K Road, constructed in 1955, was a major haul road for Simpson Timber Company. It is located in the eastern portion of the Redwood Creek watershed in some of the most unstable and erodible terrain in the entire park. This terrain is characterized by soils that are prone to gullying and landscapes that exhibit large scale mass wasting.

Watershed Rehabilitation Unit 96-2 constitutes the seventh phase of a multi-year strategy to remove the K&K Road from within Redwood National Park. Work in previous years treated erosion problems on the adjacent hillslopes (Bundros and Huber, 1981; Spreiter and Johnson, 1981; Wosika, 1980) and removed the lower portion of the road (Sanders, 1997; Dame, 1994; Steensen and Bundros, 1993; Steensen, 1992a, 1992b, 1989). The 1996 project continues work initiated in 1995 on the Slide Creek section.

Unit 96-2 is located on the east side of Redwood Creek, approximately 12 miles southeast of Orick, California (Figure 1). The project addressed accelerated erosion problems along 2360 feet of the K&K Road and 300 feet of secondary roads. Restoration focused primarily on the removal of the stream crossings and unstable side cast fill, and restoring natural hillslope topography and drainage patterns interrupted by the K&K Road. The excavation of the stream crossings uncovered the natural channel bed and banks, and excavated fill was used to re-create the natural topography. Recovered organic and nutrient rich side cast was returned to the surface in order to help speed recovery of native vegetation. Vegetation disturbed during excavation was stockpiled and dispersed along the finished surface in order to provide habitat and simulate natural forest litter. This project involved the excavation of over 26400 yds³ of fill material, including 11700 yds³ associated with four stream crossings and a headwater swale. Methodology for road removal was consistent with past rehabilitation projects, employing heavy equipment for all excavations. Excavations were executed through IFB Contract (CX# 1443CX8480-96-002), and work was performed by Barber Construction Company of Blue Lake, California. Project costs are summarized in Table 1.

Geology

The Redwood Creek basin is almost entirely underlain by the Jurassic-Cretaceous Franciscan formation. Exposures of these rocks typically shows closely spaced fractures and/or pervasive shearing. Fractures seem to have resulted from deformation from tectonic emplacement, likely by subduction, and from brecciation along high angle faults. The intensity and style of this disruption seems to be the rock characteristic that most influences differences in the erosion rates and landforms (Janda, unknown). The Grogan fault, which has a surface trace roughly coincident with the valley of Redwood Creek, separates the Franciscan formation into two major lithologies. In general, rocks on the west side of the basin consist of quartz-mica schist whereas unmetamorphosed sedimentary rocks are found on the east side. The Grogan fault is more linear than other major NNW trending faults in the region which suggests a near vertical dip (Hardin et al., 1982).

Rehabilitation Unit 96-2 is situated on the east side of the Redwood Creek basin, and is underlain by a structurally complex assemblage consisting mainly of sandstone and mudstone. This assemblage is a continuous series showing progressively more tectonic disruption of the primary sedimentary fabric. This series can be broken into three major units: (1) the relatively unbroken Coherent Lacks Creek Unit, (2) the more fractured and sheared Incoherent Coyote Creek Unit, and (3) melange containing tectonically-mixed blocks of sandstone, chert, volcanics, and exotics of high grade metamorphic rocks in a highly sheared matrix of sandstone and mudstone. These units occur as distinct mappable, subparallel, north-northwest trending belts that can be traced for tens of kilometers (Figure 2).

The north-northwest trend of these units and the younger faults that cut them is a signature of the overall tectonic structure of the northwest. This structure is dominated by north-north west trending, imbricated thrust faults that dip to the east and accounts for the prominent north-northwest trend of many of the ridges and rivers in the northern Coast Ranges as well as the obvious shearing. The overall amount of shearing in the major units can usually be predicted by the topography because the amount of shearing strongly influences both type and abundance of

landslides.

Coherent Lacks Creek Unit (KJfl)

The Coherent Lacks Creek Unit is characterized by relatively high proportions of sandstone with varying bedding thickness. Some sandstone units appear massive with exposures up to 10m thick whereas other units have beds several centimeters thick. Most beds are from 0.1 to 3m thick. Associated with these massive sandstone outcrops are interbedded sandstones and mudstones. These rocks possess the rhythmic bedding and internal sedimentary structure common of turbidite sequences located in the Franciscan formation. Due to complex folding and faulting, individual beds can rarely be traced more than 100m.

The most characteristic element of the landscape underlain by the coherent unit is V-shaped canyons with steep (typically 30-70%) side slopes. Steep straight hillslopes appear formed principally by episodic debris slides whose failure surfaces often conform to a sharply transitional contact between colluvium and bedrock. Hillslopes with shallower gradient (less than 50%) appear to be predominately eroded by fluvial erosion. Lithologic discontinuities cause high pore pressures and seepage forces and these lead to occasional deep-seated slumps and slides.

Steeper parts of the terrain underlain by the coherent unit pose particularly severe erosion problems following timber harvest. A substantial part of the shear strength of the regolith is related to tree roots and that strength is greatly reduced by root decay. Removal of vegetation drastically reduces evapotranspiration stress on soil moisture and allows soil moisture to remain at levels conducive to active mass movement longer than at forested sites. These consequences cause steep hillslopes to become more prone to shallow debris slides (Swanston et al., 1976).

Incoherent Unit of Coyote Creek (KJfc)

Areas underlain by the incoherent unit have a lower sandstone:mudstone ratio and massive sandstone beds are less common. In addition, the incoherent unit contains tectonic blocks of chert, greenstone and sandstone, and also isolated sequences of bedded sandstone and chert. Rocks in this unit are more brecciated and sheared particularly in the vicinity of the Grogan fault. The amount of shearing ranges from beds disturbed from closely spaced faults to stretched boudins of sandstone in a sheared mudstone matrix (Jones et al., 1978).

The increased fragmentation and shearing of the incoherent unit makes it more susceptible to deep-seated mass movement and less capable of supporting steep slopes. The exception to this are steep, debris slide-prone hillslopes which occur locally, particularly in areas adjacent to deeply incised streams. Large individual slump and blocks slides, often several tens of square hectometers in area, are well developed in areas underlain by the incoherent unit. Hillslopes tend to be more irregular with benches and breaks in slopes caused by both landsliding and lithologic discontinuities. Smaller, shallower, more active features often develop upon the toes of the large deep-seated landslides in response to greater pore pressures and seepage forces lower on the hillslope and/or removal of lateral support by stream erosion. Earthflows are less prevalent and individual failures have less tendency to coalesce than in melange. Consequently, many landslides in the incoherent unit are relatively stabilized and move so slowly they are capable of supporting coniferous forests. The more actively moving landslides are marked by grass-bracken fern prairie, grass-oak woodland, or brush.

Land Use History

The project area has been dominated by two major types of land use since the arrival of European traders and homesteaders to this region. Initially, cattle and sheep grazing were the dominate activities, which occurred along the prairies and grass-oak woodlands that dominate ridge tops and extend downslope as finger-like projections.

By the late 1950's, timber harvesting overtook ranching as the major activity. The construction of the K&K road, built between 1955 and 1958 by Simpson Timber Company, provided a direct route from the Klamath River basin to the mills in Korbel as well as access to timber in the Redwood Creek basin.

The logging history within Unit 95-3 is characterized by a succession of multiple entries followed by a major clear cut effort (Figure 3). The first entry began in the late 50's and continued through the mid-60's. During this entry, selective harvesting and seed-tree-leave method were utilized. Much of the timber harvesting concentrated on the lands below the K&K, bounded by the previously treated 2005 Road and the K&K itself. A narrow corridor adjacent to and immediately above the K&K was also harvested. All of the initial timber harvest areas were tractor yarded.

The second entry into the project area occurred in the early 70's. In 1970, the entire unit bounded between the 2005 Road and the 2010 Road was reentered. In 1971, the entire area above the 2010 Road (excluding the prairies) was reentered. Both of these reentries were clearcut, with exception of small stands of residual hardwood forests. These stands were selectively cut, presumably to extract all conifers. All of these areas were tractor yarded.

The third and final entry, occurring in 1976, was a 20 acre clearcut located below the 2005 Road. This was the only area to be cable yarded.

The predominant use of tractor yarding resulted in a dense skid road network and major disruption of natural hydrologic conditions, including large gullies and slope failures due to diversions of surface and stream flows, reactivation of dormant mass wasting features, and in a number of failing roads and road-stream crossings. These conditions have led to increased sedimentation in the South Fork and Middle fork tributaries of Slide Creek crossed by the K&K. Slide Creek is a steep, high energy stream which carries the sediment to Redwood Creek. Slide Creek joins Redwood Creek immediately upstream of Rocky Gap, and approximately 5½ miles upstream of the Tall Trees Grove. The increased sedimentation in Slide Creek has posed direct risks to this preeminent park resource. Because of the severity of slope stability problems and the direct risks to downstream resources, the slopes adjacent to the K&K Road were assigned the highest priority for rehabilitation (Redwood National Park, Watershed Rehabilitation Plan, 1981).

Erosional Features

Erosional features associated with the slopes above and below Unit 96-2 were addressed in previous rehabilitation projects (Spreiter and Johnson, 1981; Bundros and Huber, 1981; Wosika, 1980). Erosional problems along the corridor of the K&K road in this reach were not fully treated until this year.

The most dominant erosional problems identified were associated with the road-stream crossings of the tributaries of the North Fork of Slide Creek. Post harvest influx of sediment and logging slash during storm events caused the channels of these tributaries to aggrade and become choked with large organic debris. In many places, the debris had deflected flow into channel sides resulting in undercutting of the natural stream banks. This process added more material into a system which was already overwhelmed by logging activity. The input of large organic debris, along with an increased bedload component, increased the frequency at which the culvert inlets plugged. When the culverts plugged, the steep gradient of the K&K (approximately 5-10% within the North Fork drainage) diverted flow down the road surface and discharged onto the natural hillslope. Major diversions at both of the tributaries in the project area occurred between 1968 and 1973. These diversions resulted in extreme gullying below the K&K Road. Estimates conducted during field mapping indicated these diversions resulted in the delivery of 25000 yds³ of sediment directly to the North Fork of Slide Creek.

Shallow gradient of the culvert in RX1 resulted in material being deposited at the outlet, causing flow to be diverted out of the channel. This diversion flowed downslope for approximately 1000 feet before reentering the channel. Periodic diversions resulted in substantial gullying of this slope.

Slopes above the K&K were characterized by intense skid trail networks. Prominent stream courses had been utilized as skidding corridors. These skid roads are in an advanced stage of erosion. Consequently, the benefits of treating these features were not recognized as warranting the degree of disturbance that would result from equipment operations.

Additionally, a large headwater swale had been crossed by both the K&K and several skid roads below. Construction of the K&K resulted in fill be used to bridge the swale but the skid roads used a large Humboldt crossing. This crossing was in advanced stage of decay and was beginning to fail into the creek, located immediately downslope. Substantial surface flow below the K&K increased the immediacy of having to remove the fill and Humboldt structure. Failure of this structure would likely have plugged the tributary and increased downstream sedimentation.

Wildlife Concerns and Work Schedule

The U.S. Fish & Wildlife Service (FWS), as administrator of the Endangered Species Act, has set noise restriction guidelines for management projects that do not remove or degrade suitable habitat for both the northern spotted owl and the marbled murrelet. These noise restrictions are designed to reduce human impact to nesting sites during the breeding season and apply to management projects that are located within a ¼ mile radius of suitable habitat. Additionally, FWS may impose restrictions due to impacts to foraging habitat. At the time of this project, the guideline stipulated that impacts to more than 40% of the available foraging habitat within a mile radius of nesting habitat would require consultations.

Project 96-2 was located entirely outside of the ¼ mile radius for suitable habitat and therefore was excluded from the noise restrictions. Additionally, the narrow corridor that equipment would be disturbing was minimal in relation to the amount of foraging habitat. With these two conditions, FWS imposed no restrictions on the startup date.

On July 26, the contract was awarded to Barber Construction of Blue Lake, California and the contractor was notified to proceed with work on August 6 and was given 60 calendar days to complete. By August 1, all equipment were located on site. The equipment used for this contract were owned by the contractor and included a Caterpillar® D9H bulldozer with single-tooth ripper shank, a Caterpillar® D6D bulldozer, a Caterpillar® 245 hydraulic excavator with 6 yd³ bucket, and a Caterpillar® 988 hydraulic loader with 8 yd³ bucket. Additionally, the contractor had two service trucks on site.

Operators for the equipment were Randall Moore on the 245 excavator, Oscar "Butch" Brundine on the D9H bulldozer, and Michael Moore on the D6D bulldozer and 988 loader. All operators were employees of Barber Construction Company. All operators had gained experience in restoration work in 1993, operating equipment for the contracts on the K&K Road and the C-Line Pond.

Heavy equipment typically operated 10 hours per day, 40 hours per week. Heavy equipment operations began on August 7 and were completed on August 21.

Project Implementation

The geologist for this project was M. Sanders. It was the project geologist's responsibility to perform all evaluation and formulation of rehabilitation prescriptions, complete the surveying and photo-documentation, generate plansheets and technical specifications for contracting, oversee heavy equipment operations as the contracting officer's technical representative, and complete final documentation. N. Youngblood and B. Smith, geologists at Redwood National Park, were designated as site inspectors. All work was overseen by Terry Spreiter, supervisory geologist for the Watershed Rehabilitation program.

Primary rehabilitation treatments included the excavation of two haul road-stream crossings, two skid road-stream crossings, 195 feet of exported outslowing (fill material is endhauded), and 2046 feet of outslowing (Fig 4). Additional bid items included 1450 feet of ripping of the remaining road bench associated with the outslowing prescriptions and the construction of 4 rolling dips along the K&K Road, north of the project area.

Stream Crossings

Studies on previously harvested forest lands in the Redwood Creek basin have shown that sediment production from fluvial erosion is greater than or equal to that produced from mass movement (Hagans and Weaver, 1987; Janda et al., 1975). Man-induced fluvial erosion can best be addressed at road/stream intersections where excavation of fill from buried stream channels removes immediate sediment sources and eliminates the potential for diverted flows to gully natural slopes.

On previous rehabilitation projects along the K&K, original channel elements were normally not encountered in stream crossing excavations (Dame, 1994; Steenson and Bundros, 1993; Steenson, 1992a, 1992b, 1989). Project 96-2 pursued two major objectives, to arrest unnatural sedimentation and to restore impacted lands to the extent possible. These objectives helped guide the excavations of stream crossings.

TABLE 2 STREAM CROSSING EXCAVATION COSTS FOR UNIT 96-2: REMOVAL OF A PORTION OF THE K&K, PHASE VII										
BID ITEM	WORKSITE	VOLUME (yds ³)	HEAVY EQUIPMENT HOURS				H.E.R.E. COSTS ^(a)		FILLSITE DIST (feet)	EXCAVR ATE ^(b) (yds ³ /hr)
			D9H	D6D	245	988	TOTAL	UNIT		
10	RX 1	5343	43.5	8.25	19.5	11.5	\$14,340	\$2.68	100 ^(c)	64.6
12	RX 2	2698	7.5	1.5	4.75	0.0	\$2,516	\$0.93	50	196.2
9	SX 1	242	0.0	0.0	2.25	0.0	\$509	\$2.10	50	107.6
13	SX 2	291	0.0	1.0	1.0	0.0	\$332	\$1.14	50	145.5
Totals		8574	51.0	9.75	27.50	11.50	\$17,697	\$2.06 ^(d)	---	85.1 ^(d)

^(a) Heavy Equipment Rental Equivalent (H.E.R.E) is the cost to complete each job based on the actual hours worked. These costs are quoted by the contractor, and include the cost of an operator: Caterpillar® D9H dozer @ \$171.18/hr; Caterpillar® D6D dozer @ \$105.74/hr; Caterpillar® 245 hydraulic excavator @ \$226.10/hr; Caterpillar® 988 loader @ \$140.23/hr.

^(b) Excavation rate is based on the ratio of the total yardage excavated and the total of all equipment time used to complete the individual bid item.

^(c) Fill was either pushed to the fillsite by bulldozer or end-hauled by the 988 loader.

^(d) Represents the average for this statistic for all Stream Crossing treatments.

Stream crossing excavation rates were quite varied (Table 2). These rates are mainly attributed to site specific conditions, but some variability is the result of intrinsic errors in time keeping. Predominately the time keeping errors are associated with the difficulty in distinguishing which prescription the equipment is working. Excavations on each of the two tributaries of the North Fork of Slide Creek had both a haul road crossing (RX) and an associated skid road crossing (SX) immediately down channel. The excavations of these crossings were characterized by being continuous channel excavation. As excavations of the channel progressed, it was difficult to attach the respective times spent to the portion of the excavation. Because of these uncertainties, a better statistic would be to average all equipment time and volume excavated for each tributary. For RX1 and SX1, 5585 yds³ were excavated with a total equipment time of 85 hours. The production rate for this tributary is 65.7 yds³/hr. For RX2 and SX2, 2989 yds³ were excavated with a total equipment time of 15.75 hours. The production rate for this tributary is 189.8 yds³/hr.

The variability in these averages is recognized as being site specific. RX1 was characterized as being a very rocky crossing with much of the road fill composed of very large sidecast boulders. These were difficult to excavate and the time spent removing these rocks represents approximately half of all equipment time. Much of the remaining fill

was extremely wet and was very difficult to retrieve using bulldozers. Consequently, this material had to be handled several times by the 245 excavator before it could be pushed by the bulldozers to the fillsite. Additionally, an uphill push was required to get the fill to the available fillsite.

SX1 was a Humboldt crossing with a large sediment pond located upstream. While the bottom of this excavation was easy to establish, the removal of the fill was problematic. The channel was narrow for the equipment and the sideslopes very steep. Consequently, only the excavator was able to work this crossing. In order to remove the fill, the excavator was required to bucket load the fill up to the bulldozers. This required additional time on the excavator and hampered the efficiency of the bulldozers.

RX1/SX1 had many features that indicated natural channel. Channel lags, large old growth stumps and emergent flow helped guide the excavation. However, several features were very misleading and resulted in the excavations being truncated. In particular, a large amount of organic-rich material was thought to be original ground. Unfortunately, this was a lens of side-cast organic-rich fill placed over additional fill.

The excavations for RX2 and SX2 were markedly different from that of RX1 and SX1. While much of the fill was devoid of large rocks and therefore much easier for the bulldozer to efficiently excavate, the final grades were hard to establish due to lack of evidence of natural channel lags or features. Fillsites for this excavation were located immediately adjacent the crossing. Additionally, the fill was dry and easy to excavate and push to the fillsite. All of these factors are reflected in the production rate.

Export Outsloping

Export outslope (EOS) treatments are performed where the road fill needs to be endhailed to a stable fillsite. All endhauling on this project was performed either by dozer (in which case the material is pushed) or loader. Only one EOS treatment was performed on project 96-2. Costs for this treatment are summarized below.

TABLE 3 EXPORT OUTSLOPING COSTS FOR UNIT 96-2: REMOVAL OF A PORTION OF THE K&K ROAD, PHASE VII										
BID ITEM	WORKSITE	VOLUME (yds ³)	EQUIPMENT HOURS				H.E.R.E. COSTS ^(a)		FILLSITE DIST ^(b)	EXCAV. RATE ^(c) (yds ³ /hr)
			D9H	D6D	245	988	TOTAL	UNIT		
6	EOS	3137	9.75	2	7	14.5	\$5,496	\$1.75	300	94.3

^(a) Heavy Equipment Rental Equivalent (H.E.R.E) is the cost to complete each job based on the actual hours worked. These costs are quoted by the contractor, and include the cost of an operator: Caterpillar® D9H dozer @ \$171.18/hr; Caterpillar® D6D dozer @ \$105.74/hr; Caterpillar® 245 hydraulic excavator @ \$226.10/hr; Caterpillar® 988 loader @ \$140.23/hr.

^(b) Fill was either pushed to the fillsite by bulldozer or end-hauled by the 988 loader.

^(c) Excavation rate is based on the ratio of the total yardage excavated and the total of all equipment time used to complete the individual bid item.

The EOS prescription was used to treat impacts to a headwater swale. The K&K and a skid road located immediately downslope crossed this swale. This skid trail was constructed across the swale and then continued across the southern tributary of the North Fork. This crossing was the Humboldt crossing treated as SX1. Similar to SX1, large side-cast logs were used to construct the skid road across the swale. These logs were in a state of advanced deterioration and failure posed an immediate threat to the channel below.

Initial excavation was performed with the D9H. The D9H stockpiled fill and the 988 loader endhailed the fill to an

available fillsite. As the K&K was dishd down, however, emergent flow made the surface impassable for the dozer. The excavator was then used to stockpile the fill and the loader continued to endhaul.

Excavation of this swale was hampered by the amount of woody debris. When excavation began, many of the standing trees were knocked downslope forming an interlaced network of trees. Consequently, these needed to be moved for the excavator to recover the sidecast fill. Removing these trees usually resulted in splintering because of the interlacing. It wasn't long before the excavator was shoveling mulch instead of stockpiling trees. Had these trees been more effectively handled, the rate of excavation would have been greater and the finished product would be more pleasing.

Outsloping

TABLE 4 OUTSLOPING COSTS SUMMARY FOR UNIT 96-2: REMOVAL OF A PORTION OF THE K&K ROAD, PHASE VII									
BID ITEM	WORKSITE	VOLUME (yds ³)	EQUIPMENT HOURS				H.E.R.E. COSTS ^(a)		EXCAV. RATE ^(b) (yds ³ /hr)
			D9H	D6D	245	988	TOTAL	UNIT	
4	OS 1	5510	2.75	15.5	24.25	0.0	\$7,593	\$1.38	129.6
5	OS 2	1694	0.0	4.25	5.0	0.25	\$1,615	\$0.95	178.3
7	STOS 1	106	0.0	0.0	1.25	0.0	\$283	\$2.67	84.8
8	OS 3	809	0.0	5.0	6.25	0.0	\$1,942	\$2.40	71.9
11	OS 4	4085	9.0	14.0	13.0	0.0	\$5,855	\$1.43	116.7
14	OS 5	2269	5.75	4.5	4.25	0.0	\$2,421	\$1.07	156.5
	MOD 1	218	0.0	0.0	1.75	0.0	\$396	\$1.82	124.6
TOTALS		14691	17.50	43.25	55.75	0.25	\$20,103	\$1.37	126.9 ^(c)

^(a) Heavy Equipment Rental Equivalent (H.E.R.E) is the cost to complete each job based on the actual hours worked. These costs are quoted by the contractor, and include the cost of an operator: Caterpillar® D9H dozer @ \$171.18/hr; Caterpillar® D6D dozer @ \$105.74/hr; Caterpillar® 245 hydraulic excavator @ \$226.10/hr; Caterpillar® 988 loader @ \$140.23/hr.

^(b) Excavation rate is based on the ratio of the total yardage excavated and the total of all equipment time used to complete the individual bid item.

^(c) Represents the average for this statistic for all Outsloping treatments.

Outsloping (OS) treatments are used to reconstruct the original contours along a road corridor. This involves the removal of fill from the outboard edge of a road and placing it along the cutbank. Recontouring restores natural drainage patterns and results in the recovery of original side cast soil elements. Recovering the original sidecast topsoil from the outboard edge of the road and distributing it across the finished excavation enhances the process of revegetation dramatically (Popenoe and Martin, 1990). In addition, the dispersal of organics (i.e. trees, sidecast logs and rootwads, etc.) along the finished slopes is believed to provide additional organic material for revegetation as well as provide suitable habitat for wildlife.

Excavation rates for outslope treatments are summarized in Table 4. Variations in excavation rates along OS reaches were the result of site specific conditions. Production rates were the highest when the D9H could retrieve the bulk of

the fill, the 245 pulled the remainder and the D6D finished the slopes. Where a piece of equipment was restricted, production rates fell. The lower rates were attributed to limited access of the D9H to the bulk of fill or to stretches of the K&K that had steep sideslopes. In these cases, the excavator not only retrieved the sidecast fill but also was used to dress up the finished slope.

Miscellaneous Bid Items

Miscellaneous bid items on this project included Move In and Move Out costs. Additional bid items were ripping and the construction of four rolling dips. All of these miscellaneous bid items were Lump Sum items. Table 5 provides a cost breakdown for miscellaneous bid items.

TABLE 5: COSTS FOR MISCELLANEOUS BID ITEMS ON UNIT 96-2: REMOVAL OF A PORTION OF THE K&K ROAD, PHASE VII										
BID ITEM	JOB	QUANTITY	HEAVY EQUIPMENT HOURS				TOTAL COST		UNIT COST	
			D9H	D6D	245	988	CONTRACT	H.E.R.E. (a)	CONTRACT	H.E.R.E. (a)
1	MOVE IN	1	(b)				\$2,000	\$0	N/A	\$0
2	MOVE OUT	1	(b)				\$2,000	\$0	N/A	\$0
3	RIPPING (c)	1450	(d)				\$1,000	N/A (e)	\$0.69	N/A (e)
4	ROLLING DIPS	4	0.0	0.0	1.25	0.0	\$400	\$283	\$100	\$70.75
TOTAL							\$5,400			

(a) Heavy Equipment Rental Equivalent (H.E.R.E) is the cost to complete each job based on the actual hours worked. These costs are quoted by the contractor, and include the cost of an operator: Caterpillar® D9H dozer @ \$171.18/hr; Caterpillar® D6D dozer @ \$105.74/hr; Caterpillar® 245 hydraulic excavator @ \$226.10/hr; Caterpillar® 988 loader @ \$140.23/hr.

(b) Equipment is not operating during Move In and Move Out. Consequently, H.E.R.E. is a non-existent statistic for these bid items.

(c) Ripping was either performed by the Caterpillar® D9H dozer, utilizing a hydraulically activated, rear mounted, single toothed ripper or by the Caterpillar® 245 hydraulic excavator. Ripping was performed to meet the specifications of the contract and to facilitate work on much of the outsloping and export outsloping.

(d) Times were not recorded for ripping. See accompanying text for explanation.

(e) No hourly times were kept for the ripping prescription. Consequently, H.E.R.E. is a non-existent statistic for these bid items.

Ripping was done to 1450 feet of the total 1986 feet of road bench underlying the outslope prescriptions. The objective of ripping was to decompact the remaining road bench and to obliterate the inboard ditch. Because the remaining 536 feet of road bench had been cut in competent bedrock, ripping was not necessary. In several sections of the road the inboard ditch was up to 2 feet deep. Since this would act as a French drain, ripping the road bench would allow cross road draining instead.

Ripping was performed by both the D9H dozer and the 245 excavator. Because several pieces of the equipment were working in different locations, it was impossible to keep accurate times for ripping and the other bid items. Consequently, ripping times were not recorded individually but instead combined with the respective bid items for which the prescription treated. Thus, production rate for ripping is not available.

Rolling dips were constructed at various locations along the remaining K&K Road. These were installed to prevent the possibility of diversions due to plugged culverts. Because of uncertainties in the budget for future restoration work, rolling dips were constructed to minimize the impacts to the watershed in the event of a large storm occurring prior to possible treatment. Rolling dips were constructed at the remaining 2 crossings in the North Fork of Slide Creek and at the crossing of Airstrip Creek. An additional rolling dip was constructed at the crossing of a major gully along the Counts Hill Prairie. Rolling dips were constructed to allow flow to cross the K&K Road and be directed back into the downstream channel. In the event of a plugged culvert, the rolling dip would prevent diversion, minimizing the impacts to just the existing road prism.

Non-Bid Items

Non-bid items are categorized as jobs that result in non-recoverable costs on the part of the contractor. These items are distinguished by requiring time that is not directly attributable to any specific bid item. Non-bid items times are recorded to compare the costs of contract with that of hourly rentals. Table 6 provides a cost breakdown for Non-bid items.

Discussion time is defined as periods of time where equipment operations were interrupted by discussions lasting more than 15 minutes. Typically the operators would stop to discuss the progress of a particular phase of a bid item or develop a strategy for the work. Other times would include the contractor discussing the operations of the equipment. On occasion, the C.O.T.R. or site inspector would interrupt the operators to make sure that the specifications of the contract are understood and would be met.

Downtime occurred when equipment was unable to perform in its expected capacity. Downtime was most often the result of mechanical failure, predominately the rupturing of a hydraulic line. Downtime also included time equipment was either stuck or assisting in the rescuing of stuck equipment. Downtime for this contract were very low.

Fueling equipment and routine servicing were also included as a non-bid item. These times are a given necessity for the operations of equipment but could not be attributed to a specific job item. Consequently, these are also looked upon as an inherent cost to the contractor.

Idle time for equipment was recorded as a non-bid item but is markedly different than the previous items. Idle time represents the time a piece of equipment was inactive while work proceeded. Idle time differs from downtime in that the equipment is able to be used but the contractor or operator chooses not to use it. For this contract, there were times when the contractor had 4 pieces of equipment and only 3 operators. The extra equipment allowed the contractor greater flexibility in day to day planning, and in approaching specific worksites. In a rental situation, such flexibility would be prohibitively expensive as shown by the associated H.E.R.E. costs (see Table 6).

Discussion

The removal of this portion of the K&K Road and associated road-stream and skid trail crossings was the action most consistent with National Park Service Management Policies, PL 95-250 Section 101(6), 1980 General Management Plan, 1992 Statement for Management, and the 1981 Watershed Rehabilitation Plan. The implementation of this project effectively eliminated unnatural sediment sources associated with the road and disturbed hillslopes. Diversion potentials were eliminated through the restoration of natural hillslope topography and drainage patterns. This restoration minimized the potential for both hillslope and sidecast failures and delivery of unnaturally large quantities of sediment to Redwood Creek and its tributaries. The recovery of nutrient and organic-rich soil should greatly speed the recovery of native vegetation. The thorough treatment of this portion of the K&K and surrounding hillslopes has reduced the impacts to downstream resources in the Redwood Creek watershed, eliminated the costly drain on maintenance resources, and enhanced the visitor experience in this easily accessible portion of Redwood National Park.

TABLE 6: NON-BID ITEM COSTS FOR UNIT 96-2: REMOVAL OF A PORTION OF THE K&K ROAD, PHASE VII					
JOB	HEAVY EQUIPMENT HOURS				H.E.R.E.
	D9H	D6D	245	988	COSTS ^(a)
DISCUSSIONS ^(b)	0.0	0.0	0.0	0.0	\$0
DOWN ^(c)	9.5	0.0	0.5	0.0	\$1,739
FUEL & SERVICE ^(d)	3.5	3.75	5.25	2.0	\$2,463
SUB-TOTAL:	13.0	3.75	5.75	2.0	\$4,202
IDLE ^(e)	4.75	37.5	0.5	66.75	\$14,252
TOTAL:	17.75	41.25	6.25	68.75	\$18,454

^(a) Heavy Equipment Rental Equivalent (H.E.R.E) is the cost to complete each job based on the actual hours worked. These costs are quoted by the contractor, and include the cost of an operator: Caterpillar® D9H dozer @ \$171.18/hr; Caterpillar® D6D dozer @ \$105.74/hr; Caterpillar® 245 hydraulic excavator @ \$226.10/hr; Caterpillar® 988 loader @ \$140.23/hr.

^(b) Periods of time where equipment operations were interrupted for more than 15 minutes by discussions pertaining to the job were recorded as discussion time. These interruptions could be from anybody (the C.O.T.R., the contractor, etc.). For this contract, much of the discussions were very short interruptions (less than 15 minutes) or took place when operators were fueling or servicing equipment. See accompanying text.

^(c) Down time includes being broken-down, stuck, assisting with other pieces of equipment that are broken or stuck, or the time spent working on the equipment effecting repairs that are not routine servicing.

^(d) Fuel and servicing times are those spent fueling, lubing, and performing routine maintenance to equipment.

^(e) Idle time represents the number of hours a piece of equipment was inactive while work proceeded. The contractor for this project had, at times, 4 pieces of equipment and only 3 operators. Never where all 4 pieces operating simultaneously. The extra equipment allowed the contractor greater flexibility in day to day planning, and in approaching specific worksites. RNP would not be able to enjoy this flexibility in a rental situation because of the need to pay standby costs for idle time. This should be kept in mind when comparing H.E.R.E. costs with contract costs.

Success of this project did not come about without setbacks. Post excavation adjustments to both stream crossings (RX1 and RX2) occurred during the large storms in December 1996 and January 1997. The most grave adjustment occurred on RX1 during the December event. A marked amount of perched fill, originally believed to be original ground, failed during the storm. Original estimates of this failure placed the amount at 500 yds³. Of this 500 yds³, approximately 50% was deposited in the channel, and much of this material was transported during the December and January events. Investigation of the failure indicated underexcavation of the left bank of the crossing. During the excavation, it was assumed that original ground had been successfully uncovered. However, after the failure, several stumps and an outcrop of resistant bedrock were exposed. During the December event, a sizeable amount of emergent flow cascaded down the exposed bedrock. It is postulated that the material that was mistaken for original ground was likely a veneer of soil-rich material that had been sidecast overtop of previously sidecast fill. This area was likely very wet and in order to maintain the fill in its place, large boulders were than used to buttress the fill. This situation points out the intrinsic difficulties of restoration work for it exposes rather brutally the immediate consequences of underexcavation.

Adjustments to RX2 were less dramatic but represented a different problem. While excavation of RX2 succeeded in uncovering original bedrock, there was little material that resembled original channel elements. It is believed that the use of the channels upstream as skid roads resulted in much of the original channel armor being scoured out and removed, leaving little material available to provide a protective armor to the fresh excavation. The consequences were intensified by the amount of shearing in the underlying bedrock. This shearing is common in the melange of the Franciscan formation and is infamous for being highly unstable and easily erodible. The result in RX2 was

unexpectedly high downcutting and widening of the channel. This degree of adjustment may have been avoided with the importation and placement of a rock armor. The irony is that rock armoring has been considered unnecessary if the excavation of the crossing is complete. While this site is an anomaly, the use of rock armor may still be utilized for just such a situation.

While site conditions lend themselves considerably to the problems experienced at both stream crossings, an additional element may have been the size of the equipment. The adoption of the adage "Bigger is better" for equipment may have a limit to the "Bigger." While production rates typically increase with the increasing size of equipment, the increase in production rates does not come about without tradeoffs. The most apparent tradeoff is in the final product in meeting the intent of restoring land to its predisturbed condition. Large equipment is extremely effective at recovering the majority of the fill, but in the final sculpting of the excavation, it is too cumbersome. This was painfully obvious in the excavation of RX1. Because of the steepness of the sidebanks of the excavation, the equipment essentially "dug itself into a corner." The progress of the excavation restricted the access to portions of the jobsite. It is possible that smaller equipment may have been able to work the site more completely and possibly uncover clues to what was lying in wait. For the circumstances in RX2, the small amount of armoring that was remaining in the channel was indiscriminately incorporated in with the excavated fill. Smaller equipment would be capable of filtering out the larger rocks that could provide armor. Larger equipment is less agile and the time required would be pronounced.

Another consequence experienced with larger equipment was a production rate that was hard to monitor. The COTR for this contract was to observe all equipment operations and establish when excavations had met the specifications of the contract. With both large equipment and several pieces operating simultaneously, it became necessary for the COTR to be in more than one place at a time. The failure to monitor all equipment at all times allowed the operators at times to gauge progress. This resulted in several instances where the operators moved on thinking the job was complete and moving on to the next prescription. Typically this situation was remedied by having the operators return to the uncompleted portion of the job and complete it. Unfortunately, several instances occurred where it was physically impossible for the equipment to return. This situation could be avoided by insuring enough inspectors are on site as well as establishing and maintaining open communications with the operators. Understanding the operators' strategy and informing the operators of the objectives for the project would greatly reduce the ambiguities and uncertainties.

Typically, outslope and export outslope treatments were quite successful. The recovery of original soil elements will allow for quick revegetation of grasses and small plants. The placement of recovered organics atop the finished slopes helped minimize surface erosion. Restoring natural drainage patterns eliminated concentrated surface flow thereby reducing the erosion to the finished slopes. The one consolation to the outsliping prescription is the very large landing between RX1 and RX2 (Outslope prescription 4). The large bedrock outcrop adjacent to the road was likely used for road rock and as an occasional borrow pit. Consequently, the amount of material removed from this outcrop was far greater than what was recovered during excavation of the outsliping prescription. This resulted in a large reach of the cutbank remaining exposed and an unnatural break in the slope immediately below. Compounding this problem, much of the recovered sidecast was very high in rock content and low in soil elements, so the expected rate of revegetation will be very slow.

Another issue that must be considered is the amount of experience the contractor and the operators had with restoration work. While both the contractor and his operators worked both contracts in 1993, several revisions in strategy and objectives were implemented. These changes, while seemingly subtle, created consternation on the part of the COTR. Strategies on the part of the operators indicated that there was not a complete understanding in the objectives of the project. This was particularly evident in the handling and distribution of the organics and large woody debris. Unfortunately, the COTR accepts much of the burden for not adequately defining the desired product nor requiring the operators to return and complete the task to the desired goal. These factors will likely lead to revisions in the language used in the contract to require greater care in the handling and distribution of uncovered or disturbed organic material.

Method for payment on this contract was based almost exclusively on Unit pricing. Unit pricing allowed for the flexibility in tailoring excavations to the uncovered natural conditions. By pricing excavations by the unit (in this case by the yd³), increasing the volume of the excavation results in an increase of the price paid to the contractor. Additionally, if designed excavations were overestimated, the price paid is for the quantity moved. This results in a more equitable payment scheme for all parties. While this has not been a problem in the park, unit pricing also helps to insure integrity on the part of a contractor. If excavations were paid for by lump sum, a contractor would receive the same amount even if the contractor knowingly underexcavated. The additional protection for this is having an inspector on site at all times, but for some operations this may not be possible. Through unit pricing, a contractor will be paid only for what is moved. Therefore, it would be to the contractor's best interest to insure excavations are complete.

While this project was exempt from threatened and endangered species restrictions, the climate may change in the future. This creates major concerns for the effective removal and treatment of erosion problems throughout the park. Additionally, with the decline in anadromous fish stocks in the tributaries and mainstem of Redwood Creek, there becomes an obvious tradeoff from protection of one species at the detriment of another.

Finally, the most important skill acquired during the administration of this project was the ability to maintain flexibility in the design. Unlike typical contracted work, watershed restoration aims at recovering a product, not constructing it. Because the pre-existing features are initially covered, all designs are based upon extrapolation of the surrounding conditions. Consequently, these surrounding conditions provide guidance towards meeting the ideal but by no means provide a total map to reaching it. Because there is no way to know what lies under a road until it is excavated, there must be flexibility towards guiding the excavation by what is uncovered. This flexibility is what makes the difference between creating an engineered product and restoring a natural condition. Clearly, a national park should be afforded nothing but the best. And that is only natural.

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TABLE 1							
REHABILITATION WORK COST SUMMARY FOR UNIT 96-2: REMOVAL OF A PORTION OF THE K&K ROAD, PHASE VII							
TREATMENT	QUANTITY	# of JOBS	TOTAL COSTS		% OF GRAND TOTAL USING H.E.R.E. ^(a)	UNIT COSTS	
			CONTRACT	H.E.R.E. ^(a)		CONTRACT	H.E.R.E. ^(a)
HEAVY EQUIPMENT							
STREAM CROSSINGS	8574	4	\$21,702	\$17,591		\$2.53	\$2.06
EXPORT OUTSLOPING	3137	1	\$9,411	\$5,496		\$3.00	\$1.75
OUTSLOPE	14691	7	\$29,382	\$20,209		\$2.00	\$1.37
MISC. BID ITEMS ^(b)	---	4	\$5,400	\$283			
MISC. NON-BID ITEMS ^(c)	---	3	\$0	\$4,202			
SUB-TOTAL:			\$65,895	\$47,782			
LABOR INTENSIVE ^(d)							
SUB-TOTAL:			\$0		0.0		
PROJECT IMPLEMENTATION ^(e)							
MAPPING	85 hrs	---	\$1,530				
PRESCRIPTIONS AND LAYOUTS	68 hrs	---	\$1,224				
SURVEYING ^(f)	84 hrs	---	\$2,772				
CONTRACT PREP	67 hrs	---	\$1,206				
HEAVY EQUIPMENT SUPERVISION	106 hrs	---	\$1,908				
PHOTO DOC	24 hrs	---	\$432				
REPORT	hrs	---	\$0				
CONTRACT ADMINISTRATION	62 hrs	---	\$1,116				
SUB-TOTAL:	496 hrs	---	\$10,188				
		GRAND TOTAL:	\$76,083	\$51,386	100.0		

^(a) Heavy Equipment Rental Equivalent (H.E.R.E) is the cost to complete each job based on the actual hours worked. These costs are quoted by the contractor, and include the cost of an operator: Caterpillar® D9H dozer @ \$171.18/hr; Caterpillar® D6D dozer @ \$105.74/hr; Caterpillar® 245 hydraulic excavator @ \$226.10/hr; Caterpillar® 988 loader @ \$140.23/hr.

^(b) See Table 4 for detailed information on miscellaneous bid items.

^(c) See Table 5 for detailed information on non-bid items.

^(d) Conventional labor costs were not incurred on this contract. Brushing, a typical labor cost, was done by project geologist and falls under the implementation costs under Prescriptions and Layouts.

^(e) Project implementation costs (except for surveying, see note (g) below) are based on the salary and benefits of a GS-9 employee.

^(f) Surveying costs are based on the salary and costs of one GS-9 employee (@ \$18/hr) and salary and benefits for one WG-5 employee (@ \$15/hr). Both of these people worked together so actual hourly rate is the sum of the two or \$33/hr.