

Summary Report
WATERSHED RESTORATION UNIT 98-6
A-9-7-1 North Road

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INTRODUCTION

Background

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 2/3 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 1/3 of the Redwood Creek watershed.

Public Law 95-250 (March 27, 1978) directed that a watershed restoration program be developed for lands that had been timber harvested prior to becoming part of Redwood National Park. Timber harvesting and road construction that occurred on these lands before they were added to the park had adversely influenced erosion rates, sediment deposition, and water quality within the entire basin. These problems are being addressed in the restoration program. The purpose of the restoration program is to minimize human-induced erosion within Redwood National and State Parks, encourage the return of a natural pattern of vegetation, and protect redwood groves and aquatic communities. Ultimately, these efforts should result in the restoration of natural ecosystems to conditions similar to what would have existed without disturbance by humans. (Redwood National Park, Watershed Rehabilitation Plan, 1981)

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 A-9-7-1 North Road.

Site Description

The project area is located approximately one mile south of Orick at an elevation of approximately 700 feet above sea level (Figure 1). The A-9-7-1 was a haul road constructed in approximately 1968. It is located on the eastern side of the McArthur Creek sub-basin, except for its southernmost portion which crosses McArthur Creek to connect up with the West Side Access Road on the west side of the sub-basin (near MP 4.5). A short road connecting the A-9-7-1 Road with the A-9-7 on the west side of McArthur Creek (at approximately the mid-point of the A-9-7-1 Road) marks the point at which the A-9-7-1 Road is informally divided into the A-9-7-1 North and the A-9-7-1 South Roads.

On January 1, 1997, an eleven-year storm hit northern California, including the Redwood Creek basin, after three months of above average precipitation. This storm caused numerous failures, predominately mass movements along the roads in Redwood National Park. Five large debris flows (up to approximately 5,000 cubic yards of material) occurred along and immediately above the A-9-7-1 North Road as a result of this storm event. In addition, tension cracks, and occasional minor slumping of the fill outboard of these cracks, occurred along approximately 2,000 linear feet of the road bench, marking numerous incipient failures of the road sidecast material.

Redwood National Park received \$7.5 million from the Emergency Supplemental Appropriations Act for Recovery from Natural Disasters (PL 105-18) and \$0.5 million from the Federal Highway Administration's Emergency Relief for Federally Owned Roads (ERFO) to remove roads that had been damaged during the storm. Other roads that were public access or long term administrative access roads also received funds for repair. The A-9-7-1 North Road was one of the roads to be removed. Cost of the removal was paid for entirely by the NPS supplemental appropriation bill.

Watershed Restoration Unit 98-6 constitutes the first phase of a two-year strategy to remove the A-9-7-1 North Road. This project removed 1,900 feet of the A-9-7-1 Road, 700 feet of a spur road, and 1,300 feet of skid roads located immediately upslope of the A-9-7-1 North Road. This project involved the excavation of a total of 30,250 yds³ of fill material, including 7,400 yds³ associated with three stream crossings.

Restoration focused on the removal of the stream crossing fill and unstable side cast fill, and placement of this fill against the cutbanks on stable road reaches in order to restore more natural hillslope topography and drainage patterns interrupted by the A-9-7-1 North Road. The excavation of the stream crossing fill uncovered the natural channel bed and banks, and excavated fill was used to re-create the natural topography. Buried organic and nutrient rich material was returned to the surface in order to help speed recovery of native vegetation. Trees removed during excavation were stockpiled and dispersed along the finished surface in order to simulate natural forest litter; thereby providing habitat and shade for seedlings, and a reduction in potential surface erosion of the recontoured surfaces by reducing rain splash and retarding surface runoff.

Heavy equipment was used for all excavations. Excavations were executed through IFB Contract (CX# 1443-CX-8530-98-014), and work was performed by Lambert Excavating, Inc., of Arcata, California. Project costs are summarized in Table 1.

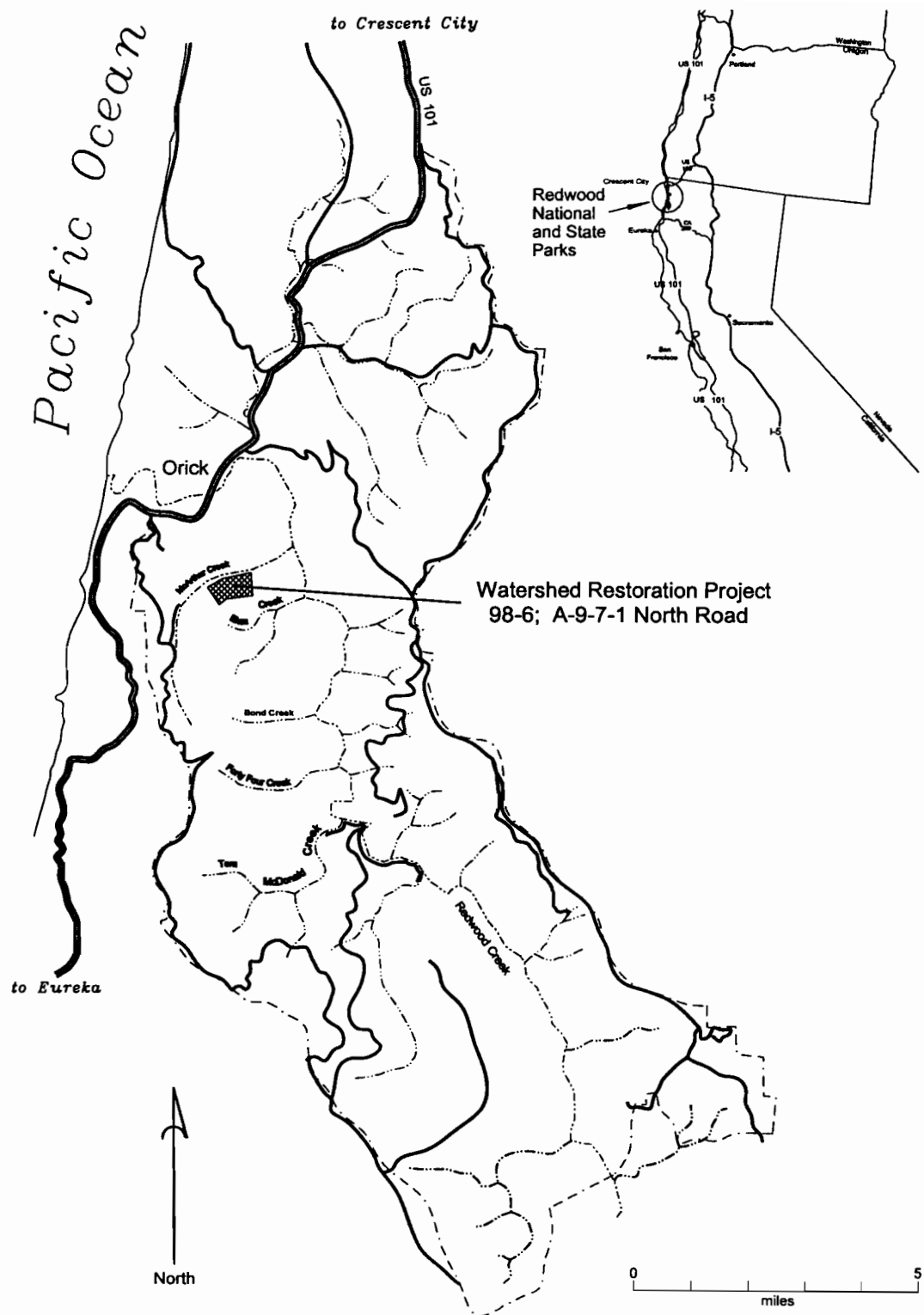


Figure 1. Location of Project Area.

TABLE 1
RESTORATION WORK COST SUMMARY FOR UNIT 98-6, A-9-7-1 NORTH ROAD

Treatment	Quantity	# of Jobs	Total Costs		% of Grand Total using Contract	Average Unit Costs	
			Contract	H.E.R.E.		Contract	H.E.R.E.
Heavy Equipment							
Stream Crossings	7,409 yds ³	3	\$30,121	\$16,239	20		
Export Outslope	5,473 yds ³	1	\$16,419	\$10,377	11	\$2.11	\$2.30
Outslope	13,727 yds ³	5	\$39,762	\$26,912	26		
Skid Roads	3,645 yds ³	3	\$14,828	\$8,365	10		
Misc. Bid Items		3	\$29,344	\$125	20		
Non-Bid Items			\$0	\$0	0		
Subtotal	30,254 yds ³		\$130,474	\$62,018	87		
Project Implementation							
Mapping	77	NA	\$1,434		1		
Prescriptions and Layout	136	NA	\$2,868		2		
Surveying	121	NA	\$2,573		2		
Contract Preparation	92.5	NA	\$1,936		1		
Heavy Equipment Supervision	431.5	NA	\$9,307		6		
Photo Documentation	14	NA	\$287		0		
Report Writing	66	NA	\$1,352		1		
Subtotal	938	NA	\$19,756		13		
Grand Total			\$150,230	\$81,774	100		

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 in association with 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, et al., 1975). 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 (Harden et al., 1982).

Restoration Unit 98-6 is situated on the west side of the Redwood Creek basin, and is underlain by tightly folded and sheared Schist of Redwood Creek (Harden, et al., 1982), a quartz-albite-white mica-chlorite schist. The most common rock type within this unit is metamorphosed mudstone. Metamorphosed sandstones which locally display graded bedding are also present. Another

major lithologic component is metamorphosed basalt and tuff. Large metabasalt outcrops form prominent knobs on the landscape. Considerable variations in mineralogy, texture, lithology, and structure are evident but intense shearing and complex folding and faulting preclude mapping subunits. Metamorphosed sandstone exposures are present in the project area, but no metabasalt outcrops or exposures have been observed.

Timber Harvest History

A timber harvest history (Figure 2) of the McArthur Creek sub-basin was compiled through the comparison of historical aerial photographs. Prior to the start of logging, a continuous cover of old-growth Redwood and Douglas Fir was present over the eastern McArthur Creek sub-basin, with scattered Hemlock and Spruce occurring within and proximal to the floodplain. The first logging operations occurred in 1966. This logging was confined to the upper hillslopes, above the L-2-2 Road. Logging on these ridges continued into 1972. Following the construction of the A-9-7-1 Road in 1968, timber harvesting began on the lower hillslopes. Clear-cutting of the slopes from the edge of the floodplain up to the L-2-2 Road began in 1969. Cutting generally progressed in a northerly manner from 1969 until 1976, at which time logging on the slopes was completed. Harvesting within the McArthur Creek floodplain by cable yarding and minor amounts of tractor yarding occurred from 1975 until 1978. Redwood National Park acquired the land in 1978.

Except for the cable-harvested areas within the floodplain of McArthur Creek, all timber harvesting was done by tractor logging. Two other haul roads, the L-2-2-1 and the L-2-2, were constructed above the A-9-7-1 Road at the mid-slope and upper-slope positions respectively. In addition, an intensive network of skid roads was constructed during the logging operations. Little of the original ground surface on the entire eastern slope of the McArthur Creek sub-basin was left undisturbed by roads or their associated fill material.

Erosional Features

Erosional features include several debris flows, slumps, and incipient failures of sidecast fill material that occurred during the Jan. 1, 1997 storm event. Slightly older, but still recent (during and post-timber harvesting) debris flows and slumps are also present, and surface water diversions and interception of ground water flow have been present since the construction of the A-9-7-1 Road.

The Jan. 1, 1997 storm event caused a large debris flow, originating from the L-2-2-1 Road, to deposit approximately 3,000 cubic yards of sediment and large logs on the A-9-7-1 North Road and in the floodplain of McArthur Creek immediately below the road. This debris flow originated as a failure of the sidecast material in the L-2-2-1 Road. Another debris flow, originating from the L-2-2 Road deposited approximately 5,000 cubic yards of sediment and large logs into a swale immediately above the A-9-7-1 North Road. Many cubic yards of fine sediment from this debris flow were carried down onto the A-9-7-1 North Road by surface flow. Failure of sidecast material caused a slump of approximately 1,000 cubic yards on the outboard edge of the A-9-7-1 North Road, with the material being deposited onto the McArthur Creek floodplain. Another slump occurred adjacent to the previous slump. The cause of this slump was the failure of a saturated, over-steepened cut bank of the A-9-7-1 North Road overlain by sidecast fill material from an upslope skid road. The material from this slump was also

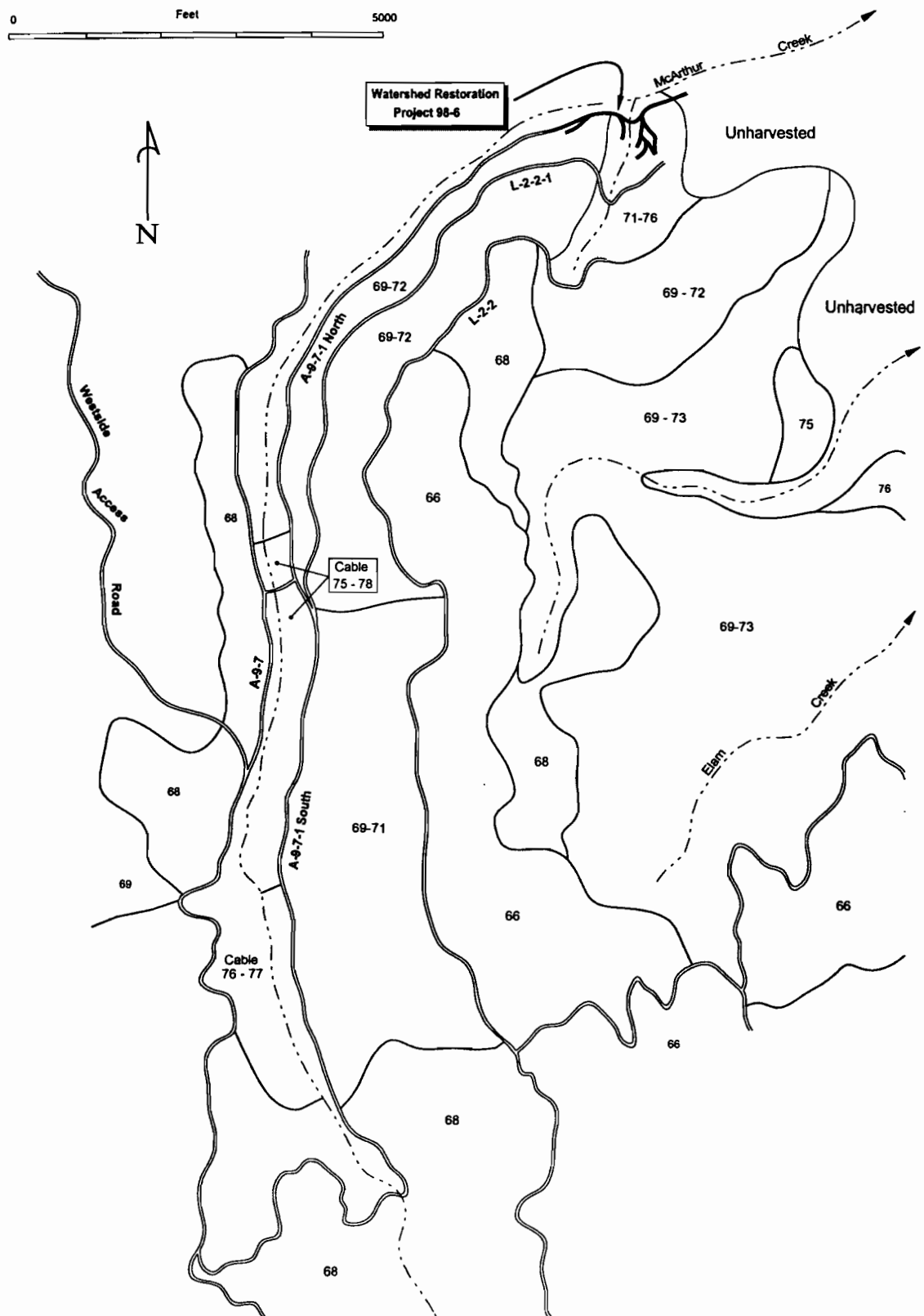


Fig 2. Timber harvest history of project area.

deposited onto the floodplain of McArthur Creek. A similarly-caused slump occurred in another location along the A-9-7-1 North Road, with material from this slump being deposited onto the A-9-7-1 North Road bench and the banks immediately adjacent to the McArthur Creek floodplain. Approximately 2,000 linear feet of tension cracks were present along the A-9-7-1 North Road following the Jan. 1, 1997 storm, marking incipient failure of sidecast fill material. In many cases, the road bench outboard of these cracks dropped up to eighteen inches. Failure of this amount of sidecast material would have deposited thousands of cubic yards of sediment onto the McArthur Creek floodplain and into the creek itself.

An approximately 5-year old debris flow, originating from failure of sidecast material on the L-2-2-1 Road deposited approximately 2,000 cubic yards of sediment and large logs onto the A-9-7-1 North Road bench and the banks immediately adjacent to the floodplain of McArthur Creek. Disruption of an upslope skid road stream-crossing by this debris flow caused a diversion of surface water out of the natural channel, onto skid roads and the A-9-7-1 North Road. A debris torrent that originated at the L-2-2-1 Road deposited sediment into the tributary of McArthur Creek at RX-1. The sediment and large logs flowed onto the floodplain of McArthur Creek and blocked the creek, causing ponding of water in McArthur Creek upstream of the tributary confluence. The tributary channel was aggraded up to ten feet at RX-1 with fine and coarse sediment. The A-9-7-1 North Road crossing of this tributary was washed out by this debris torrent, but was reconstructed within a couple of years with the culvert placed at the new, aggraded stream channel bottom elevation.

Throughout the hillslope area above the A-9-7-1 North, skid roads have caused diversion of surface flow and interception of ground water flow. This flow is often deposited onto road fill material which has insufficient drainage. This fill has the potential of becoming saturated and failing, causing further debris flows and slumps.

Threatened and Endangered Species Concerns and Work Schedule

Two bird species that are listed as threatened under the Endangered Species Act occupy areas in or near the project area: the Northern Spotted Owl and the Marbled Murrelet. On May 6, 1997, Coho Salmon were also listed as a threatened species. Because old-growth forests serve as critical habitat for these species, Redwood National and State Parks is considered a critical conservation area for their survival.

The U.S. Fish & Wildlife Service (USFWS), as administrator of the Endangered Species Act for Northern Spotted Owl and Marbled Murrelet, has set noise and habitat modification restriction guidelines designed to reduce human impact, especially to nesting sites during the breeding season. The areas of old-growth forest surrounding the eastern end of the A-9-7-1 North Road, the 100 Spur Road, and adjacent skid roads, are assumed to be used by Marbled Murrelets and Spotted Owls for nesting and foraging. In order to avoid adverse impacts to Marbled Murrelets due to heavy equipment operation noise, the project was planned to start on September 15, at the end of the nesting season.

In May, 1998, a Biological Assessment (BA) to determine the effects of the proposed restoration projects on threatened and endangered species and their critical habitat was completed by RNSP (RNSP, 1998). The purpose of the BA was to meet the criteria for formal consultation with the USFWS and National Marine Fisheries Service (NMFS) as required under Section 7 of the Endangered Species Act of 1973, as amended. The BA determined that work could proceed as of the requested start date of Sept. 15, 1998, and continue until November 1, with the possibility of an extension of the ending date contingent upon approval by NMFS.

RESTORATION WORK

Project Implementation

Restoration work focused on restoring the land to a condition similar to what would have existed without disturbance by humans. This included complete excavation of road fill out of stream crossings and swales, complete outsloping of the A-9-7-1 North Road and skid roads with high erosion potential, and rebuilding of interfluvial ridges; resulting in the road fill being shaped to mimic the natural hillslope topography above and below the road. Recontouring provides a solid, beneficial foundation morphologically, hydrologically, and aesthetically for landscape evolution. Figure 3 summarizes the types and locations of treatments performed during the heavy equipment phase of project 98-6

The project geologist, Phil Freiberg, mapped geomorphic and hydrologic features, prescribed restoration treatments, surveyed the volumes of all worksites before and after excavation, prepared the contract, oversaw heavy equipment operations as the contracting officer's technical representative (COTR), photo documented the work, and wrote the final report. Geologists Meredith Manning and Becca Smith served as site inspectors when the project geologist was not on site.

Heavy Equipment Phase

The heavy equipment phase included completion of all primary restoration treatments. A total of 1,900 feet of the A-9-7-1 North Road, 700 feet of the 100 Spur Road, and 1,300 feet of skid roads were removed at a total heavy equipment cost of \$130,473.30. A total of 30,250 yds³ of material was excavated from 3 haul road stream crossings (7,400 yds³), 457 feet of haul road export outslope (5,500 yds³), 1763 feet of haul road outslope (13,750 yds³), 674 feet of skid-road export outslope (1,800 yds³), and 586 feet of skid-road outslope (1,850 yds³). The haul road surface was ripped prior to placement of fill on fillsites.

The heavy equipment phase was done by "invitation for bid" contract, split into 22 base bid items and 8 optional bid items. The bid opening was scheduled for August 27, 1998 (with work beginning September 15). By the time of the bid opening however, no bids had been received. It is believed that this lack of bidders was caused by the bid opening being at a later date than any of the other restoration project contracts out for bid. Five other contracts had already been awarded, and the small pool of interested and qualified contractors had already been used up. The previously awarded contract had received only one bidder, and he was awarded the contract so he did not need to bid on this project.

In order to make progress on this project despite the lack of bidders, it was decided that the contract for an adjacent restoration project (the L-2-2-1 Road) should be modified to include work on the A-9-7-1 North Road. The L-2-2-1 Road is located just upslope of the A-9-7-1 North Road, so the contractor would be able to move his equipment easily from one project to the other. In fact, it was decided that the A-9-7-1 North Road would be used for the heavy equipment access to both work sites. The amount of work originally planned to be completed on the L-2-2-1 Road was reduced, thereby allowing enough time for the contractor to complete enough work on both sites to place the start of the following years work on both sites beyond

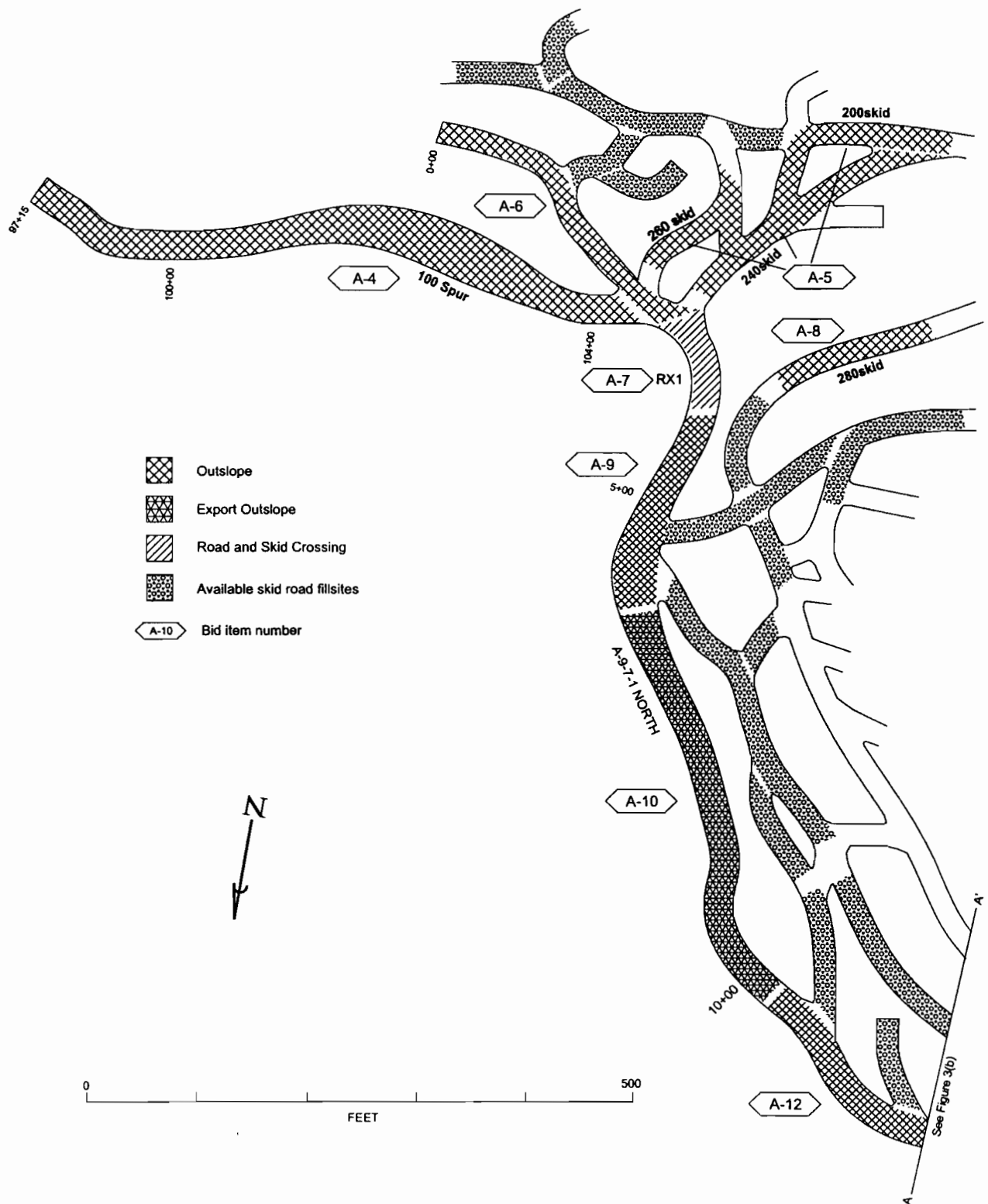


Figure 3(a). Treatment prescriptions and fill sites.

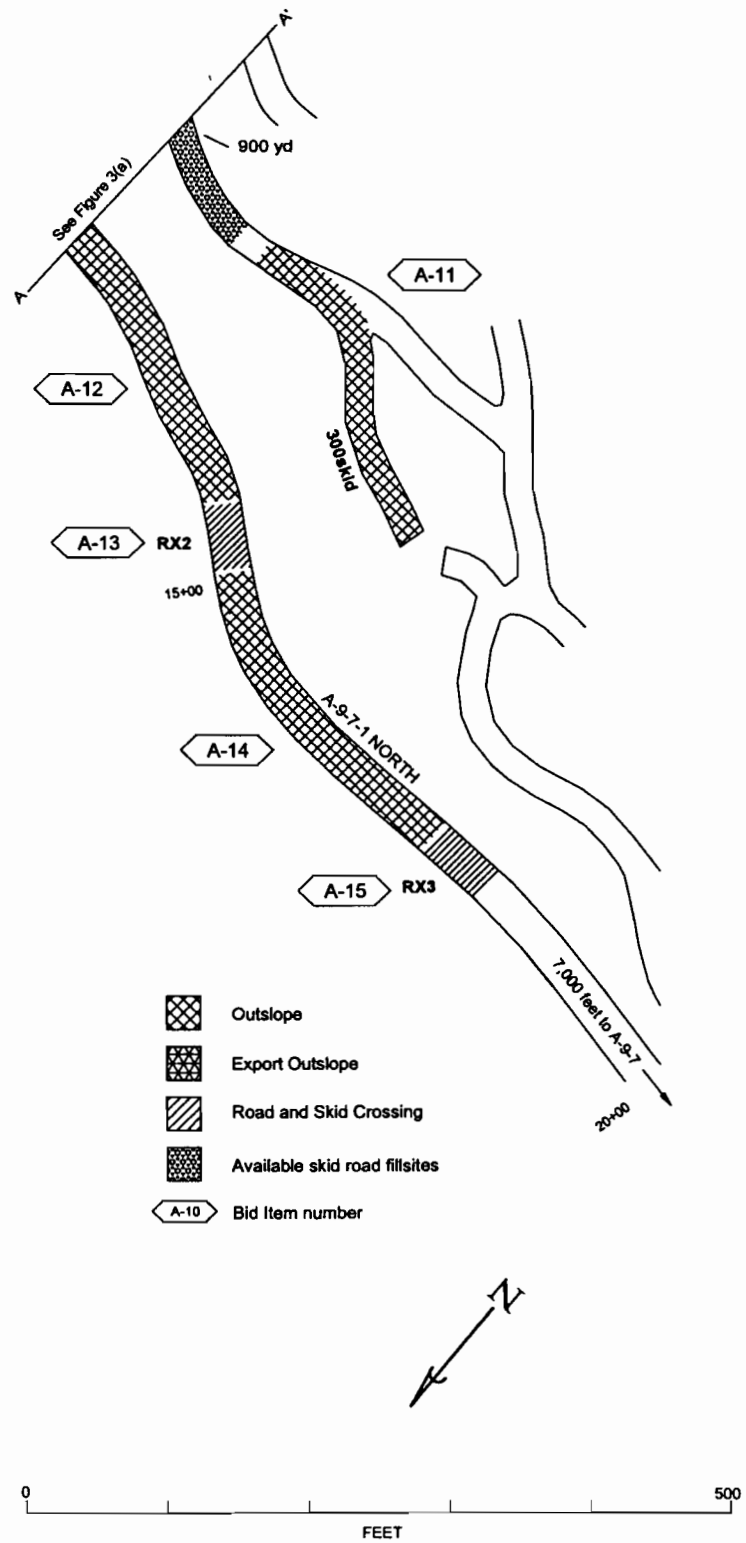


Figure 3(b). Treatment prescriptions and fill sites.

¼ mile of old-growth forest. This would allow for a July start up in 1999 because the endangered species restrictions would not apply beyond that ¼ mile distance. A completely new contract was written up (Contract No. 1443-CX-8530-98-014), containing 27 base bid items, and 23 optional base bid items. The tremendous amount of flexibility displayed by the contractor (Larry Lambert) and the contracting officer (Kris Swofford) made this last-minute change possible. The new contract was awarded to Lambert Excavating on September 16, 1998.

The heavy equipment work was scheduled to begin on September 15, but the contractor needed to make repairs on equipment following a previous restoration project. Heavy equipment work began on September 25, 1998 and was suspended for the winter season on November 20, 1998. The equipment used was a John Deere 892D-LC excavator, operated by Larry Lambert, and a Caterpillar D8H, operated by Paul Curtright.

Four days were spent opening the A-9-7-1 North Road for access to the work locations for both the L-2-2-1 Road restoration project and this project. Improvements to the A-9-7-1 North Road to allow access included brushing of young alder and fir trees for most of the 9,000 foot length, grading of the road surface, pioneering of short road segments through several debris flows on the road bench, and installation of culverts and cross road drains. Occasional work (more culvert installations, grading) on the A-9-7-1 North Road for access purposes was performed throughout the heavy equipment phase of the project.

Heavy Equipment Rental Equivalent (H.E.R.E.) rates are included in the excavation cost and production rate tables in order to normalize equipment costs for comparison of these costs with other restoration projects. H.E.R.E. rates for this project were calculated by adding 40% (profit) to the sum of the equipment rental rates and operator wages. Equipment rental rates (\$76.19/hour for the excavator and \$70.24/hour for the bulldozer) were determined from CalTrans equipment rental rate listings. Wages (Larry Lambert \$42.57/hour; Paul Curtright \$41.08/hour) were determined from Davis-Bacon wage determination guidelines.

Stream Crossings

A summary of stream crossing excavation costs and production rates is shown in Table 2 (Appendix). A narrative of atypical procedures during excavation, or atypical characteristics of each of the crossings follows.

RX-1

This was the largest crossing of the project. It replaced a previous crossing that had been destroyed by a debris torrent in 1972. The stream channel over which this crossing was built had aggraded with sediment from the debris torrent, so the planned excavation of this crossing was down to that aggraded surface, not the original stream channel. This is because the amount of sediment deposited downstream of the crossing was enormous (on the order of 10,000 cubic yards) and filled the valley of the stream channel and the floodplain of McArthur Creek. Excavation of all this sediment would have been cost-prohibitive and damaging to the floodplain environment. So the upper surface of this sediment slug was treated as a local base level for the stream which flowed through RX-1. The stream channel descended to this base level at the site of RX-1. Fine sediments had also accumulated above the crossing, below the level of the culvert

inlet.

Because the original stream channel had been scoured for many 100s of feet upstream by a debris torrent in 1972, planned excavation was down to any well-armored surface that would provide a concave-up grade in order to match the grade of the channel above the top of the crossing and the sub-horizontal grade of the upper surface of the aggraded debris torrent sediment below the bottom of the crossing. The mucky nature of the material required the operator to build a corduroy road of alder trees onto the material. Even so, it was deemed by the COTR to be too difficult and unnecessary to excavate to the designed top of the crossing. Instead, excavation was started approximately 40 feet downstream of the designed top, where the stream channel is comprised of coarse gravel and cobble-sized, angular schist fragments. Excavation of the saturated, fine material was done by the excavator scooping out the material into a pile, then allowing the pile to de-water overnight. This material had to be bucketed by the excavator several times, and sometimes mixed with drier material, before it could be pushed by the D8.

Most material was placed on the road bench to the right of the crossing. However, as this fill site filled up and access to it steepened, it became difficult for the bulldozer to push the wetter material into it. It was decided to finish filling that fillsite with dry material from the 100 Spur, and put the wetter material from RX-1 into the fillsite for the 100 Spur.

Excavation depth of the channel soon reached the level of the aggraded debris torrent sediments, at which point the excavation became sub-horizontal to match the grade of that surface. Though no original channel indicators were found (nor expected to be found), the excavation bottom was in coarse gravel and cobbles of schist, and large logs unburied at the appropriate depth were left in place to avoid the holes in the channel bottom that would have occurred if the logs had been removed.

RX-2

This crossing involved a swale with several areas of emergent and flowing water, and a debris flow of several hundred yards of material that was initiated by the failure of sidecast material on a skid road immediately above RX-2. Although the excavation morphology was more like that of an EOS, with no distinct stream channel, the amount of water in the swale warranted classifying it as a crossing.

Much material was able to be pushed out of the crossing by the bulldozer, except for that nearest the area of the most surface flow. This material had to be fed by the excavator to the D8. Lower and upper push roads were used by the bulldozer to push the material into the fill site, which was to the right of the crossing. The COTR had the operators push more material than necessary farther than necessary into the fill site, so that not enough material was available to fill the entire cut bank immediately to the right of the crossing. Large logs, with believed to be only minimal sediment associated with them, were left in place at the lower edge of the crossing. This was because the COTR felt that leaving the vegetation undisturbed, and the large logs in place, would act as a potential erosion buffer to McArthur Creek.

RX-3

This crossing was a small, narrow, and relatively dry excavation. The size and steepness of the excavation made use of the bulldozer impractical, so all work was done by the excavator. An old-growth hemlock on the lower right bank of the crossing, limiting the swing of the boom, and

the steepness of the excavation, both contributed to forcing the operator to double and triple bail some of the material. It also prevented the operator from being able to completely fill to the top of the cutbank.

While excavating the right bank, fragments of metamorphosed sandstone were encountered. At this time the COTR was off site, and the operator, believing that he had hit bedrock, finished the slope and moved on to the left bank. After the COTR returned and observed the rock fragments and morphology of the finished right bank, he believed that the excavation of that bank was not complete. He then requested that the operator return to that bank to excavate further, while the time taken to do that would be kept track of. This was done because the COTR felt responsible for the error by not being on site during the excavation, and did not want the contractor to have to be responsible for the additional cost of returning and redoing the finished bank excavation. Once that excavation was completed, the operator returned and completed the left bank.

A large, unmovable root was on the outboard edge of the road made excavation of the left bank difficult, and the excavation was not completely finished before inclement weather shut down the project for the season. The remainder of that bank excavation will be included in the next section of outslowing.

Export Outslowing

A summary of export outslope excavation costs and production rates is shown in Table 3 (Appendix). Export outslope treatment was done on one road reach where there was not sufficient space against the cutbank, nor on immediately adjacent skid roads, to store all the material. The fill was pushed to other fill sites with the bulldozer.

EOS 5+85 was immediately up-station of a large landing, and involved a small, subtle swale. Previously-subsurface flow in this swale was apparently intercepted by the road cut, and became surface flow in the cutbank. For this reason, only minor amounts of fill could be placed against the cutbank. The remainder needed to be pushed a distance of up to 400 feet, up skid roads with grades up to 50%. Three skid roads were used, and two required two turns by the bulldozer to push material to these sites.

Outslowing

A summary of outslope excavation costs and production rates is shown in Table 4 (Appendix). In general, outslowing proceeded rapidly, with original ground surface being determined by soil and organic horizons, or by geometry. Most outslowing excavation was done by the excavator, as the sidecast fill prism was too narrow to allow much dishing out by the bulldozer without cutting into original ground.

An approximately 300 foot section of outslope 97+15 was wet, and since almost the entire road prism was fill, much of the fill had to be pushed by the bulldozer and double-bailed by the excavator. This slowed production along this stretch of the outslope.

Only minimal excavation was done along the length of outslope 0+00, because it was felt that that section of road was stable, and the amount of fill placed there (from RX-1) should be maximized.

A portion of outslope 4+11 involved pushing the material up a steep (50%) skid road to fillsites up to 400 feet away. This is because the morphology of the original slope was more concave-up than expected, so the actual excavated volume of 3,553 cubic yards was much greater than the design volume of 2,150 cubic yards.

Skid Roads

Skid road work involved a combination of outsloping and export outsloping. In most cases, the wet material and the confined work space precluded use of the bulldozer for moving material. Production rates were generally slow, but the volumes of the skid work were quite small. A summary of outslope excavation costs and production rates is shown in Table 5 (Appendix).

Several skid roads (200, 240, and 260 Skids) located on the right side of the tributary valley, between RX-1 and slopework associated with the L-2-2-1, were removed in order to re-channelize flow diverted onto these skid roads. This diverted flow caused saturation and failure of the skid road fill material, and diverted water onto the right bank of RX-1. Two subtle channels were defined by this work, with original ground indicators being layers of organic material and water flow. A veneer (up to two feet thick) of fill material was inadvertently left on the lower slope, between the two channels, but it is felt that this material will be stable and was not worth returning for.

The 280 Skid was located above RX-1 on the left bank of the tributary. The perching of the sidecast material immediately above the tributary, the fact that this material was saturated in spots, and the diversion of water down the skid road lead to the decision to remove this skid road. The excavation was carried out entirely by the excavator, due to limited work space, and involved short sections of both outsloping and export outsloping (where emergent water was present). This was a lump sum bid item.

The 300 Skid was located in a gentle swale immediately above RX-2. A portion of the sidecast material had failed in the winter of 1996-1997 onto the A-9-7-1 North Road at RX-2. With removal of the A-9-7-1 North Road below, the 300 Skid road sidecast material, saturated in locations, would be perched precariously above McArthur Creek. Excavation of this skid road was done by both bulldozer and excavator, and was relatively expedient. This was a lump sum bid item.

Miscellaneous Bid Items

A summary of miscellaneous bid item costs is shown in Table 6 (Appendix). All miscellaneous bid items were lump sum or unit price (each) items.

Move-in costs involved culvert installation, brushing of the A-9-7-1 North Road, clearing of sediment from several debris flows that originated above the A-9-7-1 North Road, cross-road drains (XRDs), and rolling dips. This large amount of work was deemed necessary by the contractor in order to use the A-9-7-1 North Road for continual access by equipment and service vehicles for both the work done on the A-9-7-1 North Road and the L-2-2-1 road. Cross-road drains and rolling dips were unit price (each) bid items. Culvert installation and debris flow sediment clearing were lump sum bid items, with all separated into individual items to provide flexibility as to how many of these items actually needed to be completed (based on road

conditions as the work progressed).

Move-out costs involved installation of cross-road drains and any other earthwork deemed necessary to provide good drainage of the road surface and the immediate surroundings. Cross-road drain installation was by unit price (each) to provide flexibility in the number of XRDs deemed necessary at the time of move-out.

Ripping was done to decompact the remaining road bench and inboard ditch underneath fillsites. The contractor chose to have a dozer with a winch, rather than one with rippers, so that the winch could be used to move large woody debris and pull equipment out of the mud when it got stuck. Since the dozer did not have rippers, decompaction was done by digging up the road bed with the excavator buckets. This was effective in terms of decompacting the road, but was much slower than a dozer with ripper teeth.

The opening of a 1,000 foot-long skid road to provide heavy equipment access to a portion of the L-2-2-1 Road work was included in the contract. It was decided during the heavy equipment work not to carry out that portion of the L-2-2-1 Road work, so that bid item was never begun nor completed.

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 generally not directly attributable to any specific bid item. Non-bid item times were recorded to compare the costs of the contract with that of an hourly rental. Table 7 (Appendix) provides a cost breakdown for non-bid items.

"Discussion time" is defined as periods of time where equipment operations were interrupted by discussions lasting 15 minutes or more. Several shorter discussion periods were sometimes combined into one when they added up to approximately 15 minutes (time was recorded in 15 minute intervals). Typically the contractor would stop to discuss the progress of a particular phase of a bid item or develop a strategy for the work with the other operators or COTR. On occasion, the COTR or site inspector would interrupt the operators to make sure that the specifications of the contract were understood and would be met.

"Stuck" refers to a piece of equipment getting stuck in the mud and needing to be pulled out with another piece of equipment. This includes both the time one piece was stuck and the time another piece spent assisting in rescuing the stuck equipment.

"Down time" occurred when equipment was unable to perform at its expected capacity. Down time was most often the result of mechanical failure.

"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 down time in that the equipment was able to be used but the contractor or operator choose not to use it. For this contract, there were times when the contractor had 3 pieces of equipment and only 2 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.

Labor Intensive Phase

Labor intensive restoration and erosion control work usually includes all secondary treatments for surface erosion which, in the past, have typically involved the application of straw mulch to critical areas on finished restoration worksites. Straw mulch was not applied on unit 98-6 for several reasons. Logs and topsoil were placed on the surface wherever possible. After restoration work was completed, redwood fronds and alder leaves naturally dropped from the surrounding second-growth forest onto the finished surface, which helped protect it from surface erosion. Natural revegetation, especially alder growth, is expected to be excellent. Previous studies indicate that straw may not be good in forest settings since it alters the soil to be more like that of a grassland and it may also introduce exotic species.

No labor intensive work was done on this project.

Documentation Phase

The final restoration phase is the documentation process. This includes post-heavy equipment volumetric surveys, photo point documentation, cost data compilation, and writing the restoration project report. This work was done by Phil Freiberg, with assistance from Tera Curren and Becca Smith, and was completed in January, 1999.

DISCUSSION

Project 98-6 met the goals of the watershed restoration program by minimizing human-caused potential erosion and sedimentation from roads into creeks and on hillslopes. Road fill was removed from stream crossings, swales, and road benches and natural topography and hydrology were restored. Topsoil was uncovered where possible. Woody debris was also spread on the finished slopes. A total of 30,250 surveyed yds³ were excavated from potentially unstable areas and moved to stable fillsites at a total heavy equipment cost of \$130,473 which equates to an overall average of \$4.31/yds³. Much of the work involved small and partly-saturated stream crossings, a narrow road prism, confined work spaces, and wet slopework.

The contractor on this project, Larry Lambert, was very good at this type of work. He was well aware of the characteristics that indicate original ground and usually recognized them easily during excavation. Larry was very conscientious in his work, striving to produce a good product. His bulldozer operator, Paul Curtwright, had operating experience only on level, dry, desert surfaces and, therefore, had some apprehension about operating on the steep, slippery slopes necessary for this project. Larry had to spend some time explaining to him what needed to be done and how best to do it, but Paul was able to learn these things relatively quickly.

Following completion of the heavy equipment work and post-excavation surveys, the contractor wanted to negotiate the prices of two of the bid items. The COTR agreed with the contractors desired prices, feeling they were fair and justified. Excavation of RX-1 (Bid Item A-7) was slower than was anticipated because the material immediately above the crossing and proximal to the channel within the crossing was very saturated. This necessitated double- and triple-bailing of some of the material by the excavator. Additionally, an increase in the actual volume (3,942 cubic yards) over the design volume (2,850 cubic yards) due to final crossing morphology caused added complications in fill placement. The price was increased from \$3.00/yd³ to \$4.00/yd³. Outslope 4+11 (Bid Item A-9) involved the excavation of more material than designed, due to the concave-up morphology of the original slope surface. The design volume was 2,150 cubic yards, and the actual volume was 3,553 cubic yards. Much of the material excavated could not fit against the cutbank, so it had to be pushed by the bulldozer up several steep (up to 50% grade) skid roads a distance of up to 400 feet, with two and sometimes three turns needed to be made by the bulldozer to accomplish this. For these reasons the contractor felt that a unit price more comparable to that of an export outslope would be appropriate. The price was increased from \$2.20/yd³ to \$4.00/yd³.

The price of a third bid item, RX-3 (Bid Item A-15), was increased to compensate the contractor for having to return to previously finished work to excavate further. The cause of this was the COTR being off-site for a period of time while the excavation was performed. The COTR felt that he was at fault for the improper initial excavation, and that the contractor should not have to bear the cost of the extra work involved in having to return to excavate further. The price was increased from \$4.00/yd³ to \$5.20/yd³ to accomplish this compensation.

The day following the termination of the heavy equipment work, a 5-year return interval storm event occurred. The high amount of surface flow resulting from the storm caused incision of the gravel and cobble sediment in the stream channel above the top of the excavation at RX-1. This incision resulted in approximately 20 to 30 cubic yards of sediment being removed and transported downstream. This erosion could have been avoided if excavation of RX-1 had been

carried out all the way to the “top” stake, as designed. Additional effects of the storm were numerous rills on fill slopes, and several instances of small (less than five cubic yards) slumps in fill slopes due to concentrated subsurface flow.

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APPENDIX

Excavation Costs and Production Rates

Calculation of H.E.R.E. Rates

H.E.R.E. rates for this report were calculated in the following way:

Hourly rates for the equipment were obtained from 1998 CalTrans heavy equipment rental rate lists. For the John Deere 892D-LC this rate was \$66.19. A rate of \$10/hour was added to that for the thumb, for a total of \$76.19. No rate was listed for a D8H, so the rate for a D8K was used, \$70.24.

Hourly wages for the equipment operators were obtained from Davis-Bacon wage listings. For the excavator operator, this was \$39.61 for regular hours and \$53.20 for overtime hours; for the bulldozer \$38.26 and \$51.18, respectively.

The ratio of overtime to regular hours was calculated. It was assumed that this ratio would apply equally to all bid items. Hours worked were as follows:

892D-LC	Reg.	196.75	D8H	Reg.	173.0
	O.T.	<u>57.5</u>		O.T.	<u>48.25</u>
	Total	254.25		Total	221.25

Average hourly rates were then calculated as follows:

For the excavator operator: $\{(196 \times 39.61) + (57.50 \times 53.20)\} / 254.25 = \$42.57/\text{hour}$

For the bulldozer operator: $\{(173 \times 38.26) + (48.25 \times 51.18)\} / 221.25 = \$41.08/\text{hour}$

H.E.R.E. rates were calculated by summing the hourly equipment rates and wages, and adding 40% profit:

For the excavator: $(76.19 + 42.57) + \{(76.19 + 42.57) \times .40\} = \$166.26/\text{hour}$

For the bulldozer: $(70.24 + 41.08) + \{(70.24 + 41.08) \times .40\} = \$155.85/\text{hour}$

TABLE 2
STREAM CROSSING EXCAVATION COSTS AND PRODUCTION RATES FOR UNIT 98-6, A-9-7-1 NORTH ROAD

Worksite	Volume (yd ³)	Equipment Hours		Total Costs		Unit Costs		Original Bid (\$/yd ³)	Average Fillsite Dist. (ft)	Excav. Rate (yds ³ /hr)
		John Deere 892D-LC	Cat. D8H	Actual	H.E.R.E. ^a	Actual (\$/yd ³)	H.E.R.E. ^a (\$/yd ³)			
RX-1	3,942	29.25	23.00	\$15,768	\$8,444	\$4.00	\$2.14	\$3.00	250	75
RX-2	3,063	24.25	17.25	\$12,252	\$6,717	\$4.00	\$2.19	\$4.00	200	74
RX-3	404	6.50	0.00	\$2,101	\$1,079	\$5.20	\$2.67	\$4.00	75	62
Total/Ave.	7,409	60.00	40.25	\$30,121	\$16,239	\$4.07	\$2.19			74

^a Heavy Equipment Rental Equivalent (H.E.R.E.) is the cost to complete each job based on the actual hours worked.
These rates are: John Deere 892D-LC hydraulic excavator @ 168/hr.; Caterpillar D8H bulldozer @ 156/hr.

^b Excavation rate = volume excavated divided by the total of all equipment time for each worksite.

TABLE 3
EXPORT OUTSLOPE EXCAVATION COSTS AND PRODUCTION RATES FOR UNIT 98-6, A-9-7-1 NORTH ROAD

Worksite	Volume (yd ³)	Equipment Hours		Total Costs		Unit Costs		Original Bid (\$/yd ³)	Average Fillsite Dist. (ft)	Excav. Rate (yds ³ /hr)
		John Deere 892D-LC	Cat. D8H	Actual	H.E.R.E. ^a	Actual (\$/yd ³)	H.E.R.E. ^a (\$/yd ³)			
EOS 5+85	5,473	39.25	24.75	\$16,419	\$10,377	\$3.00	\$1.90	\$3.00	300	86
Total/Ave.	5,473	39.25	24.75	\$16,419	\$10,377	\$3.00	\$1.90	\$3.00	300	86

^a Heavy Equipment Rental Equivalent (H.E.R.E.) is the cost to complete each job based on the actual hours worked.
These rates are: John Deere 892D-LC hydraulic excavator @ 168/hr.; Caterpillar D8H bulldozer @ 156/hr.

^b Excavation rate = volume excavated divided by the total of all equipment time for each worksite.

TABLE 4
OUTSLOPE EXCAVATION COSTS AND PRODUCTION RATES FOR UNIT 98-6, A-9-7-1 NORTH ROAD

Worksite	Volume (yds ³)	Equipment Hours		Total Costs		Unit Costs		Original Bid (\$/yd ³)	Average Fillsite Dist. (ft)	Excav. Rate (yds ³ /hr)
		John Deere	Cat. D8H	Actual	H.E.R.E. ^a	Actual (\$/yd ³)	H.E.R.E. ^a (\$/yd ³)			
		892D-LC								
OS 97+15	4,709	26.25	28.00	\$11,302	\$8,726	\$2.40	\$1.85	\$2.40	50	87
OS 0+00	507	3.00	0.00	\$1,014	\$498	\$2.00	\$0.98	\$2.00	50	169
OS 4+11	3,553	26.25	47.75	\$14,212	\$11,807	\$4.00	\$3.32	\$2.20	300	48
OS 10+42	4,127	13.75	17.75	\$9,079	\$5,052	\$2.20	\$1.22	\$2.20	50	131
OS 15+29	831	5.00	0.00	\$4,155	\$830	\$5.00	\$1.00	\$5.00	50	166
Total/Ave.	13,727	74.25	93.50	\$39,762	\$26,912	\$2.90	\$1.96			82

^a Heavy Equipment Rental Equivalent (H.E.R.E.) is the cost to complete each job based on the actual hours worked.
These rates are: John Deere 892D-LC hydraulic excavator @ 166/hr.; Caterpillar D8H bulldozer @ 156/hr.

^b Excavation rate = volume excavated divided by the total of all equipment time for each worksite.

TABLE 5
SKID ROAD EXCAVATION COSTS AND PRODUCTION RATES FOR UNIT 98-6, A-9-7-1 NORTH ROAD

Worksite	Volume (yds ³)	Equipment Hours		Total Costs		Unit Costs		Original Bid (\$/yd ³)	Average Fillsite Dist. (ft)	Excav. Rate (yds ³ /hr)
		John Deere	Cat. D8H	Actual	H.E.R.E. ^a	Actual (\$/yd ³)	H.E.R.E. ^a (\$/yd ³)			
		892D-LC								
200 Skids	1,845	23.75	9.25	\$8,303	\$5,386	\$4.50	\$2.92	\$4.50	150	56
280 Skid	450	6.00	3.00	\$1,800	\$1,464	\$4.00	\$3.25	\$4.00	100	50
300 Skid	1,350	7.25	2.00	\$4,725	\$1,516	\$3.50	\$1.12	\$3.50	100	146
Total/Ave.	3,645	37.00	14.25	\$14,828	\$8,365	\$4.07	\$2.29			71

^a Heavy Equipment Rental Equivalent (H.E.R.E.) is the cost to complete each job based on the actual hours worked.
These rates are: John Deere 892D-LC hydraulic excavator @ 166/hr.; Caterpillar D8H bulldozer @ 156/hr.

^b Excavation rate = volume excavated divided by the total of all equipment time for each worksite.

TABLE 6
MISCELLANEOUS BID ITEM COSTS FOR UNIT 98-6, A-9-7-1 NORTH ROAD

Job	Quantity	Equipment Hours		Total Costs		Unit Costs		Original Bid (\$/unit)
		John Deere 892D-LC	Cat. D8H	Actual	H.E.R.E. ^a	Actual (\$/unit)	H.E.R.E. ^a (\$/unit)	
Move In ^b	1	27.75	18.00	\$20,750	NA	NA	NA	\$20,750
Move Out ^c	1	2.75	2.75	\$5,400	NA	NA	NA	\$5,400
Ripping ^d	3194 ft.	0.75	0.00	\$3,194	\$125	\$1.00/ft	\$0.04/ft	\$3,194
Total				\$29,344	\$125			\$29,344

^a Heavy Equipment Rental Equivalent (H.E.R.E.) is the cost to complete each job based on the actual hours worked. These rates are: John Deere 892D-LC hydraulic excavator @ 166/hr.; Caterpillar D8H bulldozer @ 156/hr.

^b Move In costs include improvement of A-9-7-1 North Road (Culvert installation, sediment clearing, brushing, construction of cross-road drains and rolling dips) to allow repeated use as access to work on the A-9-7-1 North Road and the L-2-2-1

^c Move Out costs include winterization (construction of rolling dips, water bars, and cross-road drains) of A-9-7-1 North Road to allow its use as access the following year.

^d Equipment hours spent ripping is not accurately reflected in this table, as ripping was often interspersed with other operations, making it difficult to separate time spent ripping from other operations.

TABLE 7
NON-BID ITEM COSTS FOR UNIT 98-6, A-9-7-1 NORTH ROAD

Job	Equipment Hours		Total H.E.R.E. Costs
	John Deere 892D-LC	Cat. D8H	
Discussions	5.00	3.50	\$1,376.00
Hand Labor	0.00	3.25	\$507.00
Hauling Fuel Tank	1.00	1.75	\$439.00
Walking Equipment	0.00	3.25	\$507.00
Stuck	0.25	0.25	\$80.50
Fueling	4.00	2.25	\$1,015.00
Subtotal	10.25	14.25	\$3,924.50
Idle	1.00	2.75	
Lunch/Breaks	15.25	11.75	
Down	1.25	8.75	
Totals	27.75	37.50	

^a Heavy Equipment Rental Equivalent (H.E.R.E.) is the cost to complete each job based on the actual hours worked. These rates are: John Deere 892D-LC hydraulic excavator @ 166/hr.; Caterpillar D8H bulldozer @ 156/hr.