

WATERSHED RESTORATION PROJECT 00-05
L-2-2-1 ROAD REMOVAL

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February 2001

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INTRODUCTION

Redwood National Park is located in the lower third of the 280-square-mile 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 58,000 acres within a ½-mile wide corridor of forest along the lower third of Redwood Creek. Within these original boundaries approximately 10,640 acres were classified as old-growth redwood forest. Land located upslope and upstream of the boundaries remained in private ownership, primarily timber companies.

In 1978 Congress enacted Public Law 95-250. This legislation expanded the boundaries of Redwood National Park by approximately 48,000 acres to include land up to the watershed divide in the lower third of the Redwood Creek basin. The primary goal of the expansion was to help preserve primeval old growth redwood forest threatened by upstream and upslope management. The new boundaries totalled 106,000 acres, including an additional 8,900 acres of old growth forest. Concurrently, Congress authorized establishment of a watershed rehabilitation program in Redwood National Park (RNP) for lands added to the park. The primary goal of this program was to minimize human-induced erosion and speed the natural revegetation process by restoring the hillslope hydrology to conditions that existed prior to man's influences.

Redwood Creek and its tributary streams are subject to frequent flooding from winter storms, and basin soils are naturally unstable and highly erosive. Even under natural conditions landslides and earthflows are widespread. Until purchase by RNP, the additional 48,000 acres and lands upstream of RNP were the site of intense timber harvest practices and related road construction. These activities adversely influenced erosion rates, sediment deposition and water quality within the entire basin. Studies indicate 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 logging haul roads and thousands of miles of tractor skid trails disrupted hydrologic regimes and caused severe erosion.

Watershed restoration project Unit 00-05 was part of the program designed to restore disturbed lands (FIGURE 1). The purpose of the project was to remove roads in order to reduce future erosion problems and restore the natural landscape along the road corridor, as near as possible, to original topography. This was accomplished mainly by using heavy equipment to excavate road fill from stream channels and pulling back side-cast road fill to recreate original land configurations such as ridges, valleys and swales. Heavy equipment work was done under Watershed Restoration Indefinite In Quantity (IDIQ) contract awarded to Z Logging, L.L.C, of Orick, California. Work was performed by subcontractor Twin Parks Logging Company of Arcata, California, on the L-2-2-1 Road in McArthur Creek, a tributary of Redwood Creek.

The road was evaluated for restoration work due to erosion caused by an eleven-year storm event in January 1997 within the Redwood Creek basin. This storm followed several months of above-average precipitation in the basin. Heavy precipitation in combination with disrupted hydrologic patterns caused significant erosion. The most obvious and dramatic erosion events were numerous mass failures and debris flows, most of which originated from saturated side-cast fill material on major haul roads in Redwood National Park. Four mass failures originated from the L-2-2-1. The two largest failures moved an estimated 3,000-10,000 cubic yards of soil downslope. Because of the road prism failures, the L-2-2-1 road was evaluated and approved for removal under 1997 Storm Damage funding.

Location

The unit is located in Redwood National and State Parks (RNSP) approximately 1.5 miles due south of the Orick bridge over Redwood Creek (FIGURE 1). It is in Township 10 North, Range 1 East, Section 10.

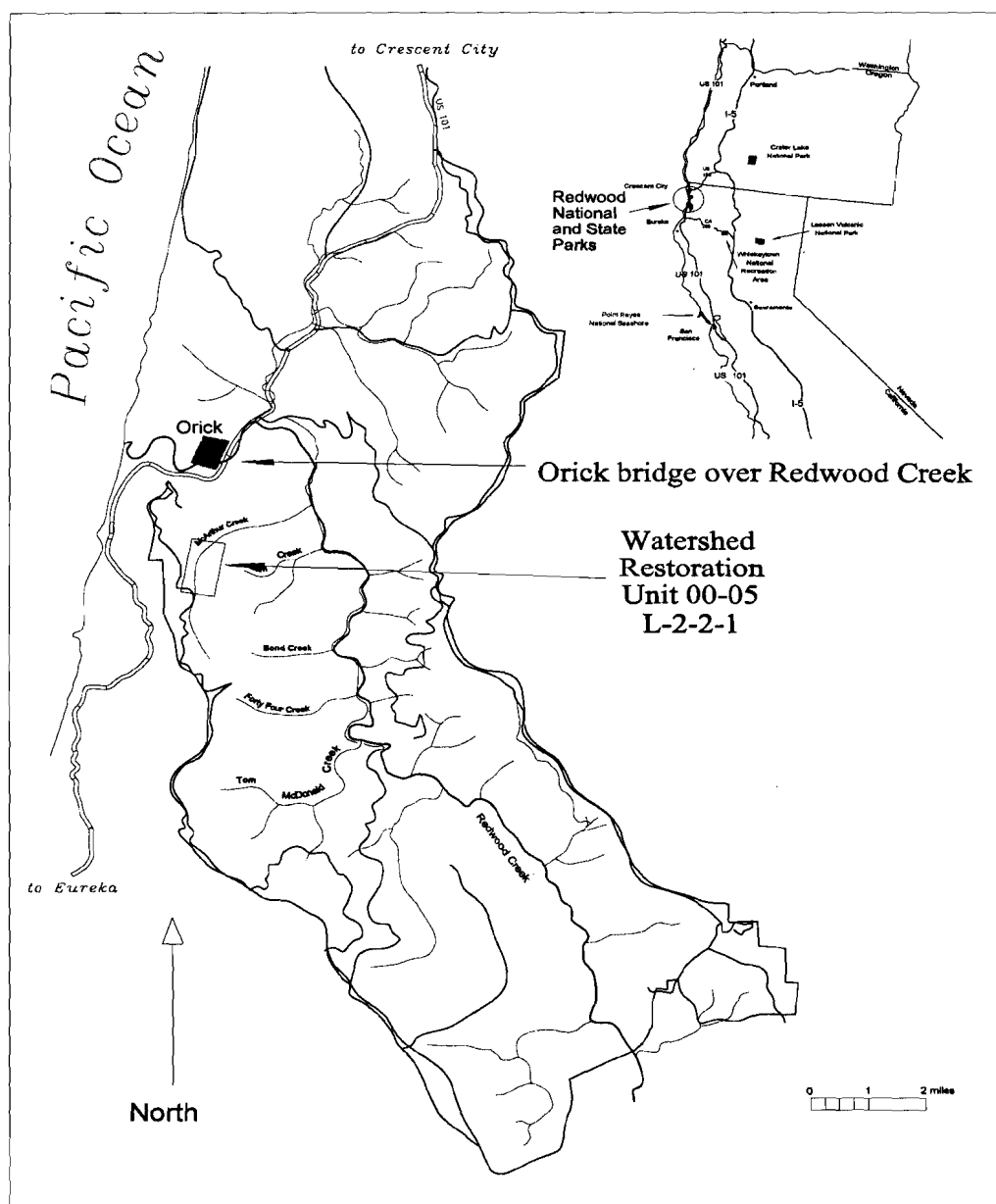


FIGURE 1. SITE LOCATION MAP.

Unit 00-05 included approximately 150 acres treated in the McArthur Creek watershed on a northwest- to northeast-facing slope. "Treated" acres are defined as the acreage from the ridgetop above the road to the main stream channel below the removed road, or to the next haul road up- or down-slope of the removed road. The L-2-2-1 road removal project included a 0.6 mile corridor of the main haul road plus seven skid road excavations adjacent to the main road corridor. The unit is located mid-slope, approximately 800 feet elevation, on the south ridge of McArthur Creek drainage.

The project occurred between July 14 and September 15, 2000. Noise restrictions were in place throughout the project for the benefit of nesting marbled murrelets. Work was prohibited two hours after sunrise and two hours prior to sunset. This was a relatively short-term project in which we completed road removal work on the L-2-2-1 in nine weeks. We then moved to another project (A140 Road in Lost Man Creek) whose access was prohibited for wildlife concerns until September 16, 2000.

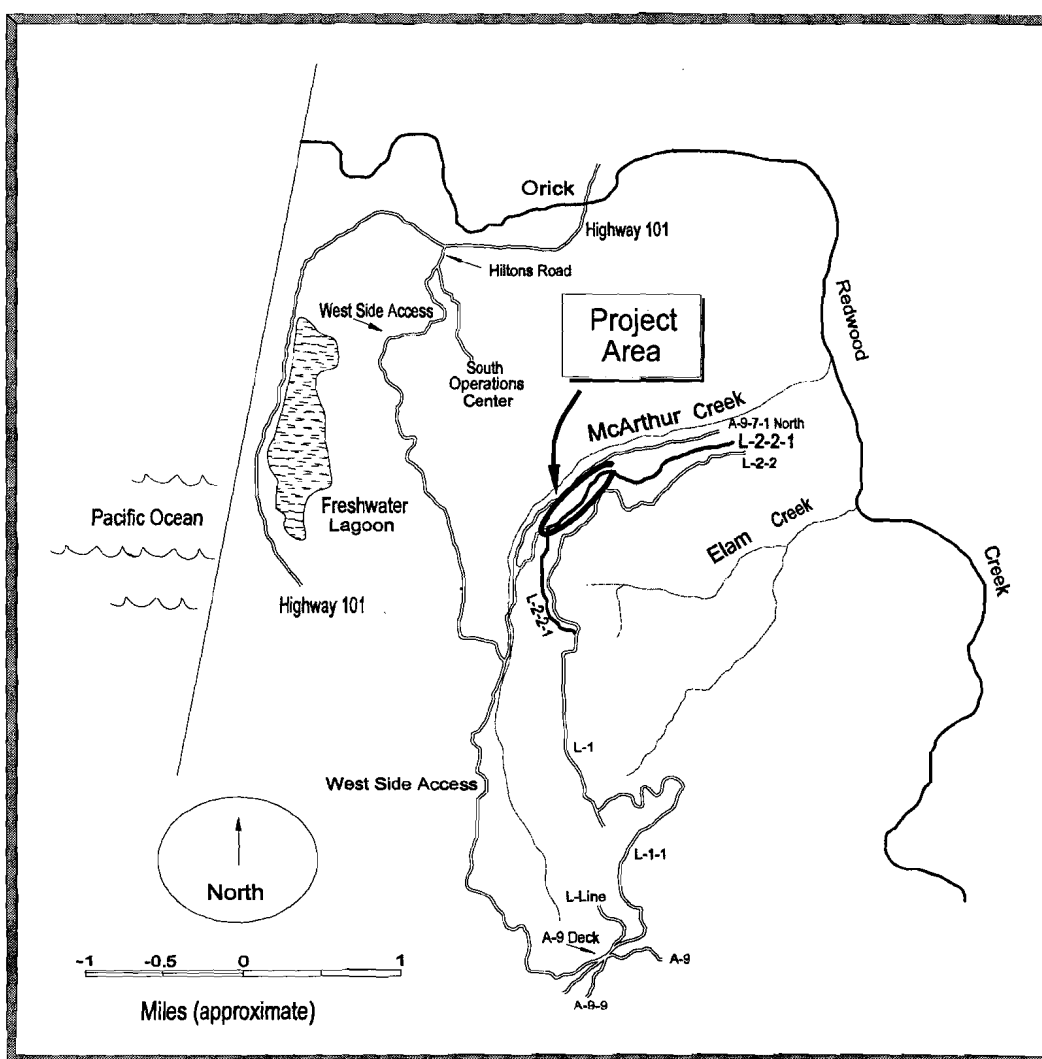


FIGURE 2. PROJECT AREA AND ACCESS.

Road and Logging History

Watershed restoration Unit 00-05 had been quickly and intensely harvested for timber beginning in 1971 and ending in 1976 just prior to RNSP expansion (FIGURE 3). Clearcut tractor yarding was the primary method of timber harvest. The goal of the clearcut was most likely to extract as many healthy conifer trees as possible, as quickly as possible, with the understanding that the land would soon be converted to National Park land. Although timber operators followed what were the best practices at that time, they left very few trees standing on this unit.

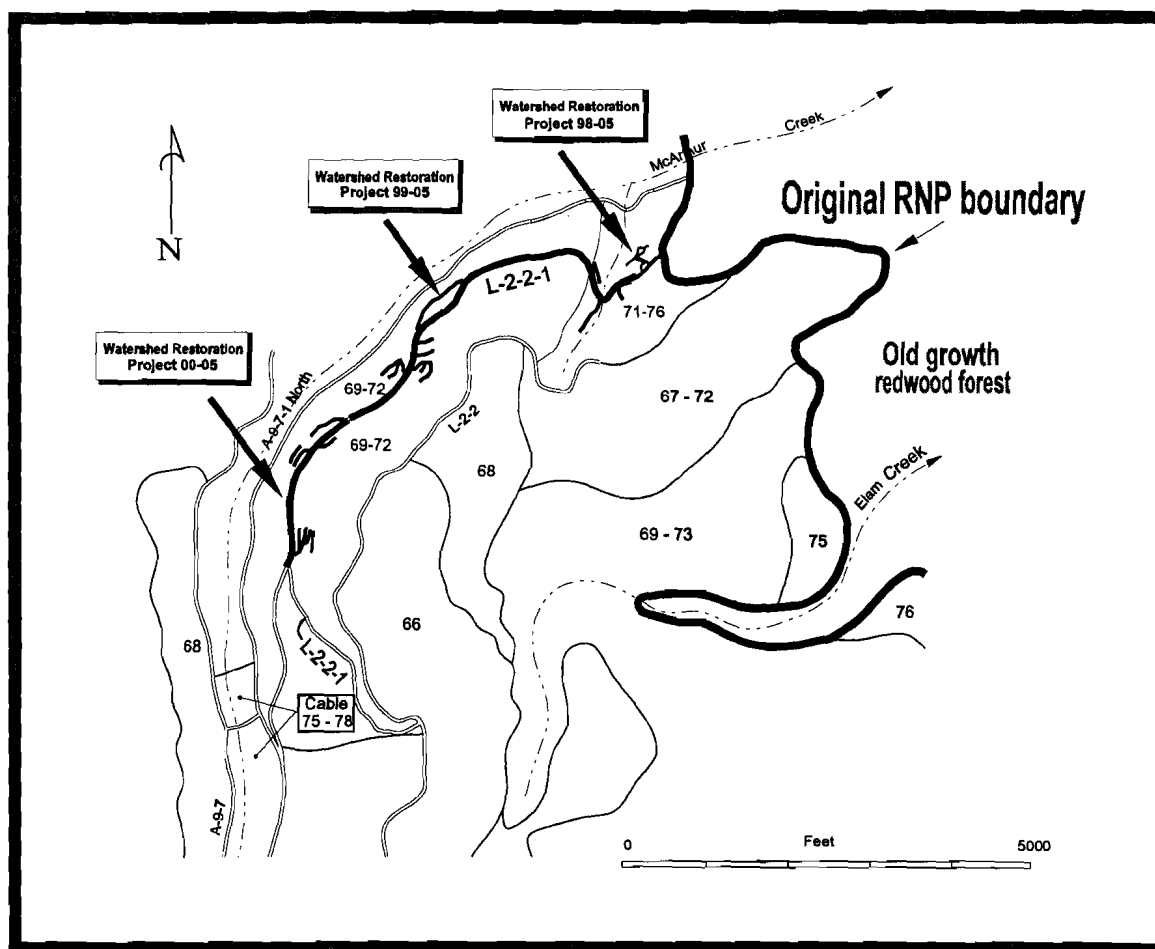


FIGURE 3. LOGGING HISTORY. THE EASTERNMOST END OF THE L-2-2-1 BEGINS CLOSE TO THE ORIGINAL 1968 PARK BOUNDARY, WHERE UNCUT OLD GROWTH CONIFEROUS FOREST CONTINUES FOR OVER A MILE BEFORE REACHING THE REDWOOD CREEK FLOODPLAIN.

Tractor yarding employed large bulldozers to build roads directly to trees. This type of access created a dense network of skid roads that crisscrossed the entire hillslope. As a result, there was very little hillslope surface area above and below the L-2-2-1 that was not disturbed (FIGURE 4). Tractor yarding also resulted in major disruption of natural hydrologic conditions. Hydrologic disruption along the L-2-2-1 road corridor is evidenced by large debris flows, gullies, and slope failures due to interception of ground water and diversions of surface flow.

Timber operators built bridges called "Humboldt crossings" which enabled them to cross small stream channels with their equipment. These Humboldt crossings were constructed by placing logs lengthwise in the stream channel and packing soil around them to build a road surface. There were numerous Humboldt crossings of varying size in Unit 00-05. The packed soil in virtually all of the crossings was partially eroded downstream. This soil, and the soil from debris flows, gullies and slope failures, traveled down McArthur Creek and eventually reached Redwood Creek's floodplain. Increased sedimentation in Redwood Creek and its tributaries jeopardizes the habitat and therefore the continued existence of the threatened Southern Oregon/Northern California Coast coho salmon, and the Southern Oregon and California Coastal chinook salmon.

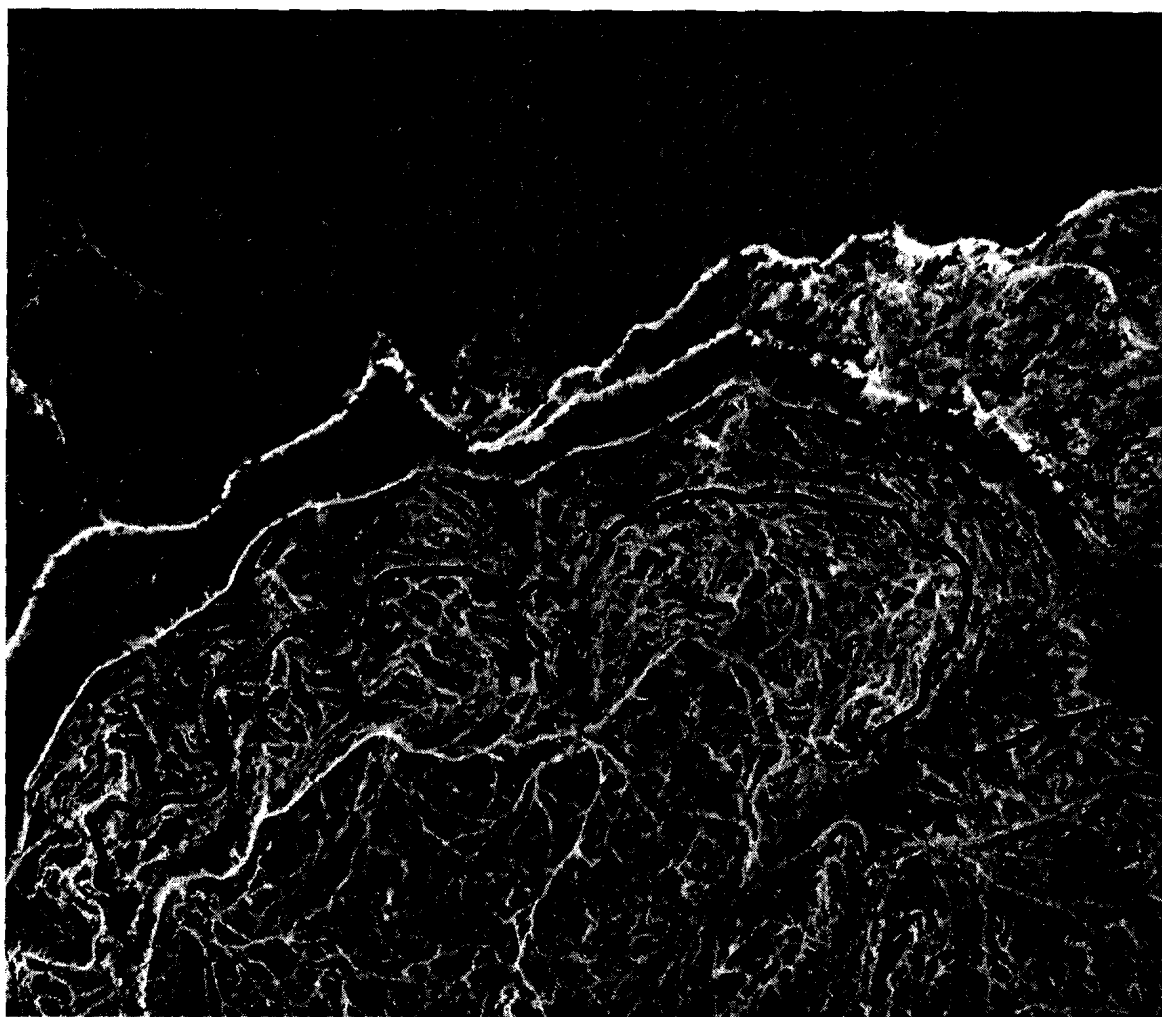


FIGURE 4. AERIAL PHOTOGRAPH SHOWING EXTENT OF LOGGING AND RELATED ROAD CONSTRUCTION BY 1974 NEAR THE L-2-2-1. ALL WHITE LINES ARE EITHER HAUL ROADS OR SKID TRAILS. THE L-2-2-1 ROAD IS SHOWN IN ITS ENTIRETY AS A THICK BLACK LINE. OLD GROWTH REDWOOD FOREST OCCUPIES THE UPPER THIRD OF THE PHOTOGRAPH, WHERE INDIVIDUAL TREES AND THEIR SHADOWS ARE VISIBLE.

GEOLOGY AND PHYSIOGRAPHY

The Redwood Creek basin is almost entirely underlain by the Jurassic-Cretaceous Franciscan formation. Exposures of these rocks typically show closely spaced fractures and/or shearing. Fractures seem to have resulted from deformation from tectonic activity, likely by subduction, and from brecciation along high angle faults.

Unit 00-05 is underlain by quartz-mica Redwood Creek schist unit of Franciscan assemblage (Harden et al., 1982). The schist in this unit is sheared, with complex folding and faulting, and is prone to mass wasting and fluvial erosion. However, in local areas, more competent schist forms resistant ridges between sub-basins and maintains more stable slopes to 70% or greater.

This unit drains into McArthur Creek, a tributary on the west side of Redwood Creek. McArthur Creek is separated from the ocean by its western ridge, which parallels the north-south coastline in the upper watershed (Figure 2). In the lower watershed, however, McArthur Creek swings east to join Redwood Creek. This drainage morphology is unusual for tributaries of Redwood Creek.

The flat-topped ridges east and west of McArthur Creek are the only ones of their kind in the Redwood Creek basin (Popenoe and Bevis, 1990) (FIGURE 5). They are topped by uplifted marine terraces containing sediments largely from the Klamath province (Harden et al, 1982). The marine sediments contain a high proportion of granitics, cherts, and other silicious metamorphic rocks. Slopes drop off steeply below the flat-topped ridges. It is not uncommon to find stable slopes approaching angles greater than 70% in the project unit.

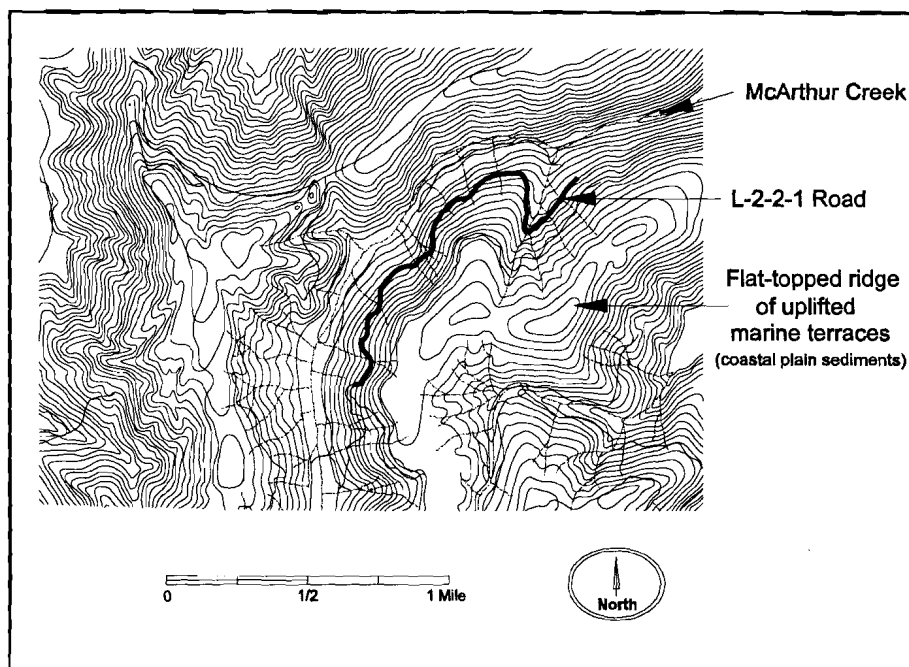


FIGURE 5. TOPOGRAPHIC MAP OF MCARTHUR CREEK.

Soils and Vegetation

The L-2-2-1 road is located predominantly in soils with brown clay loam B horizons (Coppercreek, Ahpah, Tectah, and Lackscreek). Wet soils with gray, mottled Cg horizons (Devilscreek) are found in some streams and hollows (Popenoe and Bevin, 1990). Soils on slopes below the uplifted marine terraces, including the L-2-2-1, contain mostly schist fragments (metamorphosed mudstone) mixed with a small percentage of terrace material (Popenoe and Bevis, 1990).

Soils of this unit support vegetation that thrives in the cool shade of north-facing slopes. Old-growth redwood, douglas-fir, western hemlock and western red cedar historically grew in these soils, and remnants of old-growth forest remain on the unit. Red alder now grows in dense stands wherever soil was disturbed by logging, especially along road corridors, and the twenty-year old trees are approximately 50-70 feet tall. Understory vegetation includes salal, rhododendron, huckleberry, salmonberry, and oregon grape. Swordfern reach head height in some of the shadiest areas, and water cress is found in some of the wettest.

Erosion Processes and Hydrology

In the McArthur Creek watershed a combination of sheared schist bedrock and uplifted marine terrace geology allows water to readily infiltrate and percolate through cracks and fissures in the ground. Often this flow emerges in places contrary to normal expectations (for example, at the base of a cutbank on a ridge, which normally would be dry). The crisscrossing road network in this unit has intercepted groundwater flow in many locations, causing it to emerge on the ground surface sooner than it normally would under undisturbed conditions.

Emergent groundwater is common on the slope, and it is not surprising to find water at any elevation. Valley incision develops immediately downslope of the springs, and there is no trace of valley geomorphology above the springs. Seeps are especially common along the L-2-2-1 road, where road construction intersected groundwater flow and caused it to emerge higher on the slope than it would naturally. Large pools of water had established along the L-2-2-1 road in the twenty-two years since the road was last used. During that time bog ecosystems had developed along the road corridor, complete with soft, spongy ground, hydrophilic vegetation, and methane production. Springs are evident even during the driest months of the year.

Roads in this unit commonly divert, pond, and channel water away from its natural drainage, discharging concentrated flow onto normally dry hillslopes and causing ponded water to seep through road fill. I stated in the preceding section that these soils "hold up" to precipitation well following complete road removal, and so far, this appears to be true. Conversely, where water is unnaturally concentrated or ponded, or perched road fill is saturated, these soils move under gravity. Movement of these saturated soils cause massive debris flows continuing hundreds or thousands of feet downslope, evidenced by the mass soil movements of January 1997. During this time a total of five debris flows originated from the L-2-2-1 or the hillslope immediately above it. Two of the five debris flows were treated in 1998 as part of Unit 98-5. These occurred near stations 07+50 and 09+00, and are shown on the treatment map in the project report for that unit. Another was treated in 1999 near station 48+00. The fourth was treated this year, near station 89+00. The last debris flow will not be treated because it occurred on the section of the L-2-2-1 which is part of the Six-Hour Loop Horse Trail and is not approved for removal.

Figure 6 is a treatment map for Unit 00-05. Long arrows perpendicular to the road are stream channels. Work progressed from lower to higher work items (WI) on the map.

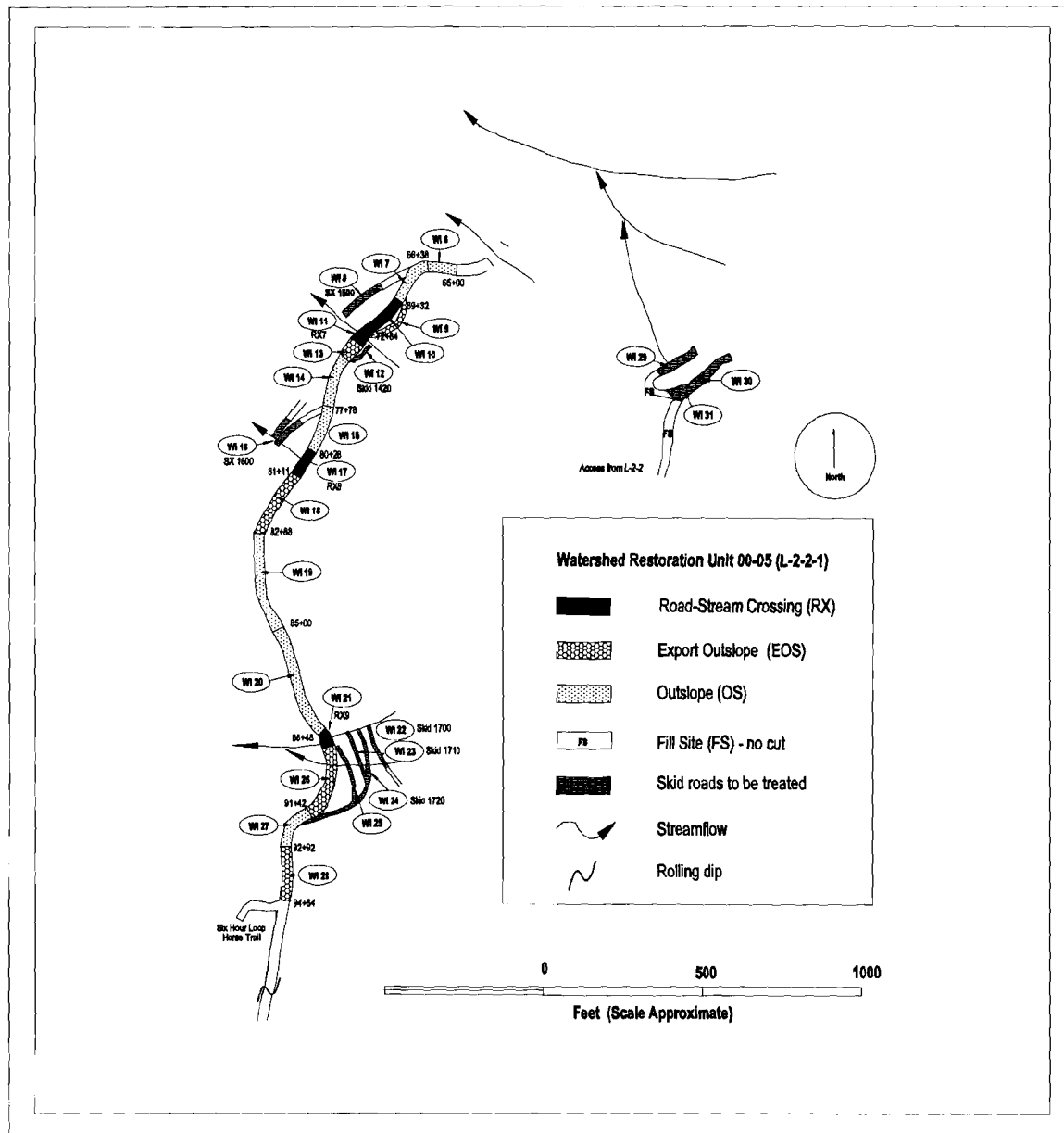


FIGURE 6. TREATMENT MAP FOR UNIT 00-05.

Wildlife Concerns and Work Schedule

The U.S. Fish and 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 management projects require consultation with FWS prior to project implementation. In joint cooperation, RNSP, FWS, and the National Marine Fisheries Service (NMFS) created a Biological Assessment followed by biological and conference opinions, adopted July 1998. This document outlines specific guidelines such that RNSP may continue watershed restoration work without adversely affecting critical habitat of the wildlife in question. These guidelines are designed to reduce human impact on nesting sites during the breeding season. Specifically, project areas where heavy equipment operates during the breeding season within ¼ mile of suitable marbled murrelet nesting habitat require a noise restriction period.

Watershed restoration Unit 00-05 was partially within the ¼-mile radius for suitable habitat (Figure 7); therefore, a time restriction was imposed on the project. Work was allowed to begin after July 10, which is outside the early part of the murrelet breeding season. Additionally, no equipment could be operated prior to two hours after sunrise or after two hours before sunset between July 11 and September 15, as these hours are prime feeding times for murrelets. These restrictions were a result of consultations with US Fish and Wildlife Service (FWS), who agreed to allow RNSP to perform the heavy equipment restoration work during the breeding season if RNSP complied with these terms. A designated amount of "incidental take", or acres of habitat disturbed by project noise greater than ambient level, is associated with each planned work project. This amount depends primarily upon proximity to suitable nesting habitat. RNSP reports annually in writing to identify the amount of work accomplished under this programmatic consultation and provides information that quantifies actual acres of affected marbled murrelet habitat disturbed by noise greater than ambient level.

Watershed Restoration Project 00-05, removal of the L-2-2-1 Road, was allowed 138 acres of incidental take for marbled murrelets and 138 acres for northern spotted owl. The numbers are identical because all the habitat is suitable for both species. This year's project (00-05) began on July 14 and ended on September 15. During that time for this project RNSP claimed 30 acres of incidental take.

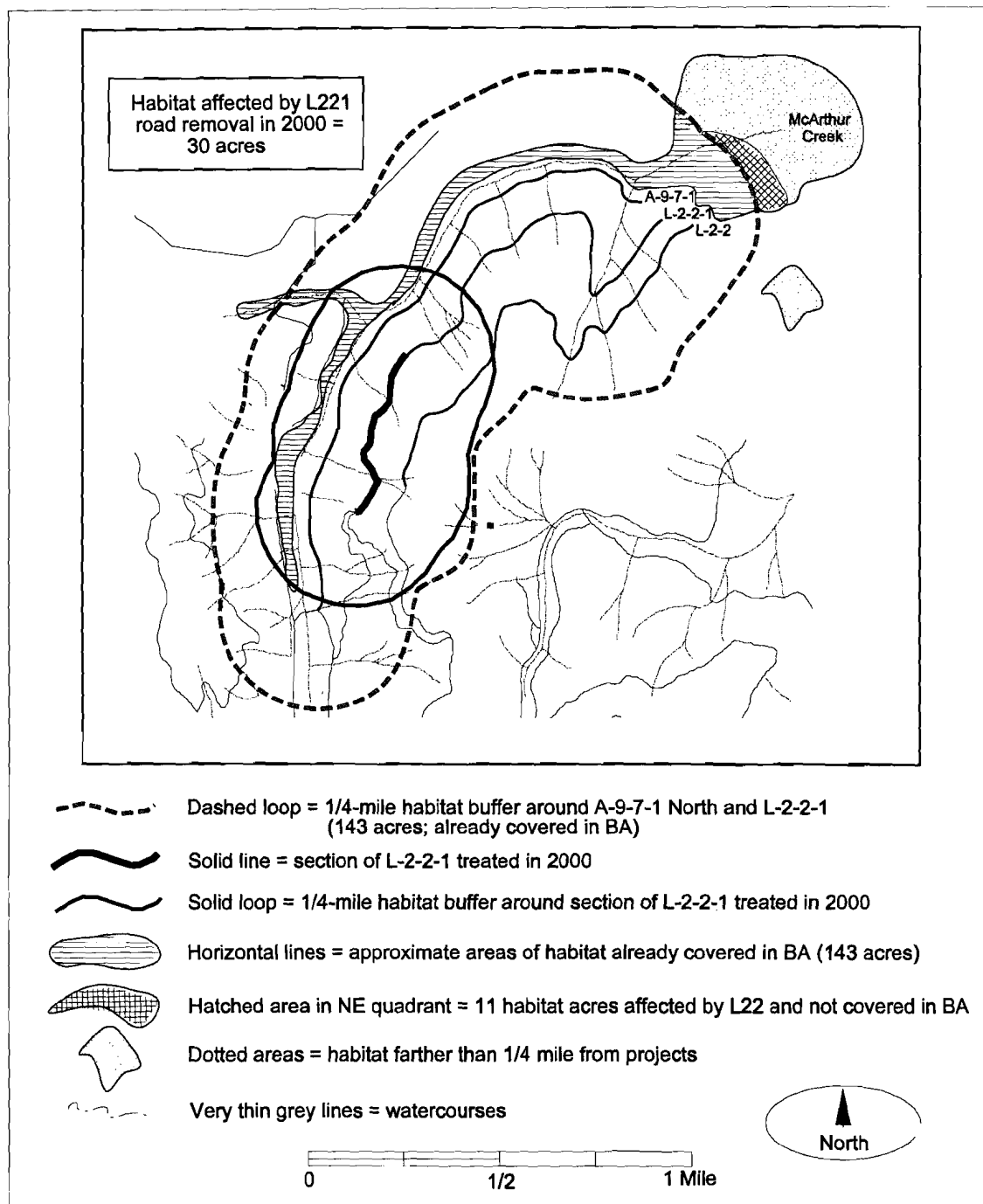


FIGURE 7. THICK BLACK LINE REPRESENTS A QUARTER-MILE AREA AROUND PROJECT 00-05 ON THE L-2-2-1 ROAD. WITHIN THIS AREA ARE 30 ACRES OF NORTHERN SPOTTED OWL AND MARBELED MURRELET HABITAT POTENTIALLY AFFECTED BY THE PROJECT. THE HABITAT IN QUESTION IS SHOWN IN HORIZONTAL LINES AND REPRESENTS OLD-GROWTH RESIDUAL OR SUITABLE SECOND-GROWTH REDWOOD STANDS.

RESTORATION WORK

Heavy equipment work was done under Indefinite In Quantity (IDIQ) contract awarded to Larry Zuber of Z Logging, L.L.C., of Orick, California for \$207,748.70 (TABLE 1). This contract was subcontracted to Jay Franke of Twin Parks Lumber Company of Arcata, California, who performed the actual implementation. Two pieces of equipment were used to complete the contract: a rented John Deere 892E-LC hydraulic excavator, and a Caterpillar D8H bulldozer owned by the subcontractor. In general the subcontractor, Jay Franke, operated the bulldozer, and the excavator was operated by Patrick Williams of Arcata, California. Williams is usually a bulldozer operator and had worked in RNSP on two previous contracts, but wanted to learn excavator operations. The L-2-2-1 was an extremely narrow, wet and steep road (up to 70% slopes). William's first experience on an excavator was a tough proving ground, but he performed well despite.

Heavy equipment typically operated 8-11 hours daily, five days a week, depending upon the time between sunrise and sunset and the two-hour wildlife restrictions at either end of the day. Both pieces of equipment performed beautifully with minimal breakdowns. Excavation rates in Tables 2, 3, and 4 reflect earth moving hours and brushing hours only, and do not reflect time that the equipment was broken down or otherwise unemployed. "Brushing" refers to the time spent clearing vegetation from work areas, moving it to stockpile areas, breaking it down into manageable sizes (including 25-year-old alder trees), moving stockpiles more than once, etc. I did not count as "brushing" the time spent laying trees on the finished slope, because a much more significant time was spent preparing it for the final task of laying it on the slope. Additionally, the contractors usually do earthwork and place vegetation on the finished slope in tandem, so separating the two tasks would have yielded inaccurate results.

Project Implementation

The geologist responsible for this project was Meredith Manning. It was my responsibility to perform the following tasks: evaluate and formulate rehabilitation prescriptions, survey and photo-document the project, generate plansheets and technical specifications for contracting, oversee heavy equipment operations as the contracting officer's technical representative (COTR), and complete the final documentation. I planned, developed, and oversaw the previous road removal work on the L-2-2-1 in 1998 and 1999 with Larry Lambert of Lambert's Excavating. The Supervisory Geologist for this project was Terry Spreiter. The Storm Damage Coordinator was Darci Short, Sherri Romanini managed the budget, and Kris Swofford from Point Reyes National Seashore was the Contracting Officer for the project.

The table on the following page shows primary treatments for Project 00-05. This project had a relatively high percent of haul-road stream crossings. Notice the crossings accounted for nearly half the total excavation volume for the project.

Treatment	Number	Linear Feet	% Total by Length of Road	% Total by Volume
Haul Road-Stream Crossings	6	811	27%	47%
Skid Road-Stream Crossings	2	298	N/A	5%
Haul Road Export Outslope	2	360	12%	8%
Skid Road Export Outslope	4	541	N/A	13%
Haul Road Outslope	7	1793	61%	27%
Skid Road Outslope	0	N/A	N/A	0%

Road opening consisted mainly of clearing 22-25 year old alder trees approximately 50-60 feet tall (see Figure 8, "Before" photo on page 15). The bulldozer was required to "clear" them from the area and stockpile them in an "out of the way" location, so that the excavator could place them on the finished slope later in the process. During last year's work (Unit 99-05), the majority of the dense stands were cleared from the main road bench. However, these prolific alders still required clearing on the slopes adjacent to the road bench for this year's work (Unit 00-05). The L-2-2-1 road was relatively narrow ('15' wide) and skid roads were even narrower ('12' wide) and the piles of alder trees were constantly in the way. Dealing with these trees slowed production considerably (see the columns "Heavy Equipment Hours-Brushing Only" in Tables 2, 3 and 4, Appendix). Even alder stands which were outside the area of excavation confined the excavator swing radius to a minimum, which also significantly slowed production.

Although alder trees are becoming prolific and difficult to manage due to their density and height, it is still beneficial to spread them over the finished slope with other large organic material rather than bury them in the fill material. There is a good reason for this. Buried trees may "pipe" or funnel water through fill material, and will eventually break down, causing fill material to settle and pond water. Unnaturally ponded water or any concentrated flow outside of the normal channel creates a potentially unstable hillslope and creating such a situation during road removal projects is contrary to RNSP's watershed restoration goals.

Another cause of low production on haul road-stream crossings (RX's) was the amount of large woody material buried in or at the bottom of the fill material, which had to be separated from the fill material. This large woody "debris" came from old growth redwood trees, and were typically 5-8 feet in diameter, their lengths up to 40 feet long. During road construction in the 1970s these giant logs were thrown in the bottom of the channel and then covered with fill material. They were used to fill space in the channel so less soil material would need to be imported to create a road bench. These logs acted as temporary culverts which allowed water to flow subsurface along the buried logs. These Humboldt crossings were built to last only as long as the timber harvest season. Winter rains following harvest began the erosional process of washing away the fill material and uncovering the logs which lay at the channel bottom.

During road-stream crossing excavations, particularly in RX6.5 and RX9, we uncovered large amounts of these intertwined logs at the bottom of the fill material. Some of these monsters were too large to be moved, even with the combined power of both bulldozer and excavator. The moveable logs had to be separated from the fill material, stockpiled out of the way of excavation work, and placed on top of the finished slope. It was a tedious process. About twenty percent of total excavation time was spent separating large woody debris from fill material on each crossing, which significantly reduced production rates for each.

Haul Road- and Skid Road-Stream Crossings (RX and SX)

The L-2-2-1 was a secondary haul road. In order to maintain grade on contour for loaded log trucks, the road was constructed across nine perennial streams, only a few of which had culverts installed during construction. In addition, the timber harvest method used in this unit, tractor logging, created a series of densely-spaced skid roads above and below the L-2-2-1 haul road. Many of these skid roads crossed stream channels, and during the mapping phase I determined which skid crossings should be removed with heavy equipment. My criteria were based primarily on potential for failure and secondarily on cost-effectiveness of removing the crossing based on access to the site.

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 this project, haul road-stream crossings accounted for 47% of total sediment excavated, while skid road-stream crossings accounted for five percent. Excavation rates for RX and SX treatments are summarized in Table 2 (Appendix).

Under the IDIQ contract, contractors bid on price per yard for each treatment (such as RX, SX, EOS, and OS). Price differentials are added to volume that is excessively wet, or requires long push distances to fill sites. Typically the need to apply these price differentials will be unknown until the work is in progress. On this project, I applied either excessive moisture or fillsite distance differentials (or both) to three of the six haul road-stream crossing sites (RX6.5, RX8, and RX9).

Haul road-stream crossing RX6.5 developed into a very wet area, as expected. The excavation material became so gooey that the excavator operator had to construct a "corduroy" road. Corduroy roads are logs laid lengthwise along a road corridor so that heavy equipment can walk across them as the logs float over the mud below. Otherwise, the heavy equipment sinks in the mud and requires another piece of heavy equipment to pull out.

Also, the sticky mud conditions in RX6.5 prohibited the bulldozer from accessing most of the excavation. The excavator had to double-and triple-lift the material out of the hole to an area in which the bulldozer could gain access to haul it away to a stable fillsite. The degree of difficulty of excavation due to excessive moisture drove down the production rate and drove up the price per yard excavated because the moisture differential applied to this crossing.

Crossing RX7 was narrow and relatively steep (approximately 50-60% side slopes), and had an active culvert crossing which ran water year-round. We had to excavate around the flowing water that was diverted to one side of the crossing excavation.

Crossing RX7.5 was originally an EOS site which became much deeper and steeper than I envisioned. There was no running water at this site but the confined space caused a swing restriction with the excavator.

Crossing RX8 turned out to be even steeper at approximately 60% side slope grade but had little running water. A large, immovable log was left at the bottom of this crossing (between this excavation and the skid crossing excavation immediately below). This log caused some water to pond at the bottom of the excavation.

Crossing RX9 was the most complex to excavate because it was extremely steep and very wet. The finished excavation not only had over 60% side slopes but also an average channel grade of 60% from the top to the bottom of excavation. This channel had a debris slide as a result of the 1997 January 15-year storm event. The material we excavated from the channel had slid from a road at a higher elevation and scoured below original grade, moving both the fill material and the original topsoil layer downstream. A jumble of vegetation and fill material was deposited in its place. During excavation we had no visual clues of original channel bottom. Instead we had to find bedrock in some areas to determine if we were excavating deeply enough to avoid further slides.

The last crossing, RX10, was also originally an EOS but turned out to be a crossing due to the overall difficulty of the excavation. There was much more fill material over the edge of the road than I anticipated. Fortunately, the excavation was dry to the bottom of the fill material. It is an area that clearly runs water in the winter but dries completely in the summer. This crossing is at the intersection of the Six-Hour Loop Horse Trail.

The images on the following page shows pre- and post-excavation of RX7.

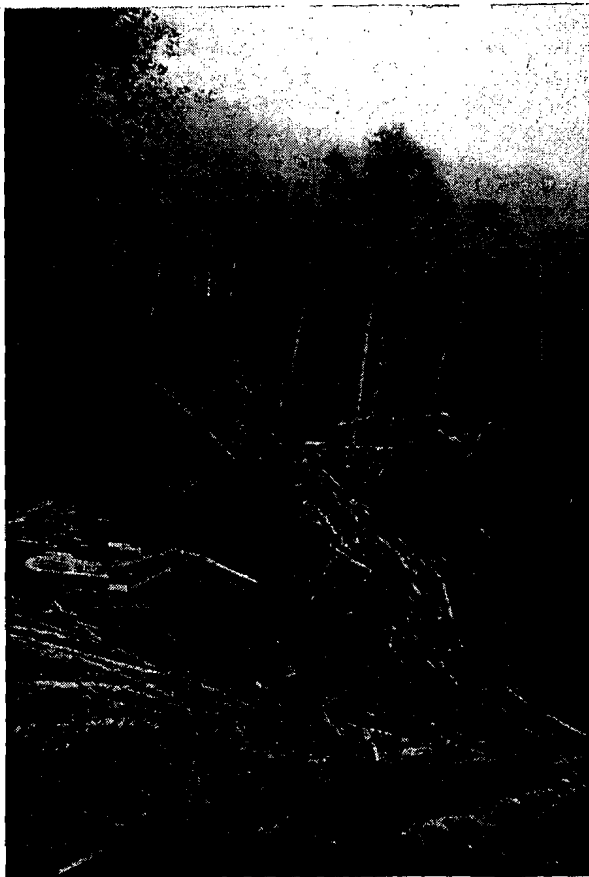
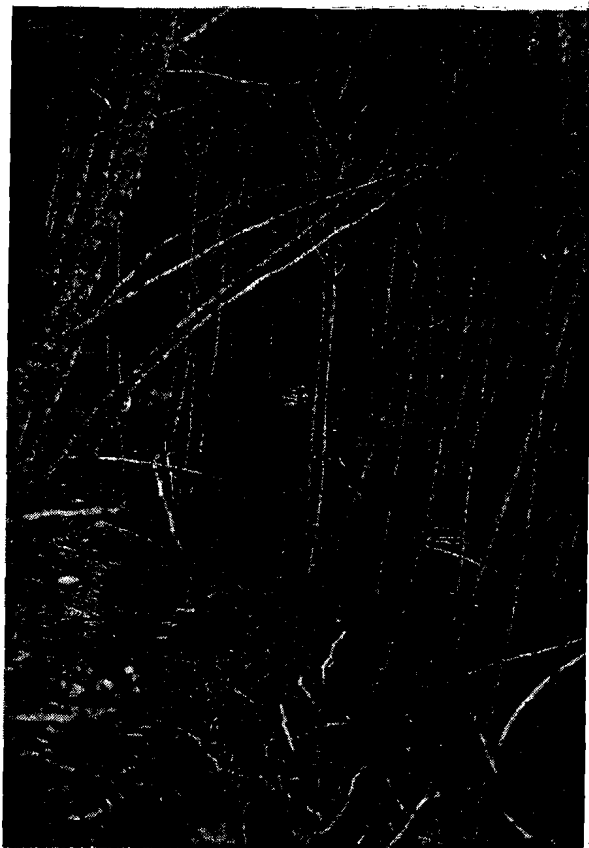


FIGURE 8. BEFORE, DURING AND AFTER PHOTOGRAPHS OF THE EXCAVATION OF RX7.

Exported Outslowing (EOS)

Export outslope (EOS) treatments are performed where sufficient fill space does not exist directly onsite so fill material needs to be moved to a more distant, stable fillsite. All material moved in this manner was performed by bulldozer; that is, all material was pushed to the fillsite instead of transported by dump truck or loader.

Along the main haul road, export outslope was the second least common treatment, accounting for only 12% of the total length of road treated. In terms of total volume, haul road export outslope accounted for 8% of total sediment excavated, while skid road export outslope accounted for 13% of total. Excavation rates for EOS treatments are summarized in Table 3 (Appendix).

The L-2-2-1 cuts across many headwater swales. Headwater swale excavations commonly became EOS treatments, due to lack of fill storage onsite. Many of these EOS treatments became wide, shallow bowls upon completion of excavation, because there were many small side channels that fed the swale which had been buried during road construction. In addition, two EOS treatments (Work Items 13 and 18) became road-stream crossing excavations. In other words, I didn't accurately predict the actual depth or extent of fill material involved in the excavation during the planning and layout phase of the project. On these two sites, reality only became clear during the course of the excavation work.

Outsloping (OS)

Outsloping (OS) treatments involve the removal of fill from the outboard edge of a road and placing it along a stable section of cutbank, usually directly on-site. Recontouring in this manner restores natural drainage patterns and results in the recovery of original sidecast soil. Original topsoil is the first soil layer to be sidecast downslope during road construction. Long buried under fill material, the topsoil is the last to be retrieved during outsloping. This material rich in organic matter gets distributed over the finished slope, and enhances the revegetation process dramatically (Popenoe and Martin, 1990).

Haul road outslope accounted for 27% of the total excavated volume. Excavation rates for outslope treatments are summarized in Table 4 (Appendix). In some areas, the natural slope grade that we tried to match was too steep (over 70%) and the existing road bench was too narrow (less than 15') for the excavator to fully swing and reach down to the base of the fillslope. This occurred on Work Item 20, on the far side of RX9. The steepness of slope and narrowness of road corridor prevented full excavator swing, and we were unable to place fill material completely to the top of the cutbanks on this work item.

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 item times are recorded to compare the cost of contract with that of hourly rentals. Table 5 (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 more than 15 minutes. Typically the contractors stop work to discuss progress of a particular phase of a bid item or develop strategy for the work. The COTR also interrupts the operators to discuss the current work and develop understanding of the contract specifications while the bid item is in progress.

Down time occurs when equipment is unable to perform in its expected capacity. On Unit 00-05, down time was most often the result of mechanical failure. Down time also included time equipment was either stuck or assisting in the rescuing of other stuck equipment. Down time was only recorded if the other piece of equipment was still working, as when the bulldozer received mechanical treatment while the excavator continued to work on bid items.

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 can physically be used, but the contractor or operator chooses not to use it or is unable to use it while waiting for another piece of equipment to move out of an area. There was significant idle time on this project for the bulldozer on the haul road-stream crossing treatments. Idle time occurred when the excavator was separating large woody material from fill material or maneuvering within a difficult area to excavate material to deliver to the bulldozer.

Under the Indefinite Quantities (IDIQ) contract, the contractor bids on price per foot of log left behind from timber harvest that RNSP wants to "salvage" for in-park use (usually milled into planks for walkways, etc). Table 5 (Appendix) reflects this cost for Log Salvage during Project 00-05.

DISCUSSION

Project 00-05 met the goals of Redwood National Park's watershed restoration program by removing a portion of the L-2-2-1 road and its associated road network. The work restored natural hydrologic patterns along the road corridor and adjacent hillslopes. Restoration work also restored natural landforms as practically as possible given the extent of damage caused by the tractor logging style of timber harvest. Both goals of restoring hydrology and landforms help minimize human-caused erosion in McArthur Creek.

We accomplished the entire Base Work Item schedule during two months of operation. A total of 46,535 cubic yards of fill material was excavated from potentially unstable locations and

moved to stable fill sites. The three-month project heavy equipment cost was \$207,748.70 with an overall average cost of \$4.46 per cubic yard. The cost per yard includes the Excessive Moisture and Fillsite Distance Differentials applied to three of the six crossings. The cost per yard also reflects the incredible steepness of excavations required to match existing slopes. In general, the steeper the excavation the higher the cost of the bid item.

Under the new IDIQ contracting, contractors do not bid on individual projects. Instead, they indicate their preference for current projects, and RNSP matches contractor to project based primarily on the contractor's equipment and the size of the road to be removed. Therefore, there were no competing bidders on this project as there historically have been under the Invitation for Bid (IFB) contracts.

The subcontractor on this project, Jay Franke of Twin Parks Lumber Company, Arcata, was a joy to work with. First, Jay is a talented listener. Second, he brings a wealth of knowledge to road removal projects because not only is he gifted in "reading" the landscape but fully understands the abilities and limitations of his equipment. If there is a way to accomplish something, Jay will figure out how, and do so in a safe manner. Jay makes the work look easy, yet anyone who has operated heavy equipment knows it isn't, especially on the steep, narrow road benches we worked on this year. His trainee, Pat Williams, demonstrated a willingness to learn, performed the work beautifully, and developed an ability to read the landscape and make good geomorphic decisions about the work with minimum supervision. It would be my pleasure to work with this talented team again in the future.

ACKNOWLEDGMENTS

Thanks to the other watershed restoration geologists for technical support from start to finish: Terry Spreiter, Becca Smith, Neal Youngblood, Phil Freiberg, Jim Howard, and Mike Sanders, from whom I borrowed prose for sections of this report.

Also thanks to Darci Short and Sheri Romanini for tackling—with patience and grace—the intricacies of funding the project; Kris Swofford for her sense of contracting humor, and Terry Hofstra for his unconditional support for doing it right the first time. Dick Mayle and Lynn Erickson-Levi graciously offer timely assistance in any way possible. Tim Tanno, Darlene Buckskin, Keith Richey ("Harry"), and Doug Smith put a lot of energy into my project site, helping me brush and survey for months at a time. Not enough thanks can be said for Rodney Poole for dropping everything else and helping me every time I asked. Thanks to the contractor, Larry Zuber, his subcontractor, Jay Franke, and his able assistant Pat Williams, for conscientious and thoughtful work and for making the project an enjoyable experience.

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APPENDIX

Excavation Cost and Production Rate Tables for Unit 00-05, L-2-2-1 Road

Table 2. Road-Stream Crossing

Table 3. Export Outslope Excavation

Table 4. Outslope Excavation

Table 5. Non-Bid Item Costs

Table 1. Restoration Work Cost Summary for Unit 00-05, L-2-2-1 Road

Treatment	Quantity (cubic yards)	Equipment Hours	Number of Sites	Total Cost		Percent of Grand Total	Average Unit Cost		
				Actual	H.E.R.E. (a)	(Actual cost)	Actual	H.E.R.E. (a)	
Heavy Equipment									
Haul Road Stream Crossings	23,797	342.75	6	115,548.75	\$ 73,266	56	\$ 4.86	\$ 3.08	
Skid Road Stream Crossings	1,887	31.50	2	9,435.00	\$ 6,676	5	\$ 5.00	\$ 3.54	
Haul Road Export Outslope	3,135	22.25	2	11,392.50	\$ 4,870	5	\$ 3.63	\$ 1.55	
Skid Road Export Outslope	5,453	45.75	5	27,265.00	\$ 9,815	13	\$ 5.00	\$ 1.80	
Haul Road Outslope	12,263	119.50	7	32,022.45	\$ 25,361	15	\$ 2.61	\$ 2.07	
Skid Road Outslope	---	---	0	---	---	---	---	---	
Non-Bid Item	---	---	---	12,085.00	12,085.00	6	---	---	
Subtotal or Weighted Average	46,535	562	22	207,748.70	\$ 132,074	100	\$ 4.46	\$ 2.84	

Project Implementation (b)	COTR hours	COTR OT hrs	Personnel hrs	Cost	Percent of Grand Total (Actual cost)
Mapping	8			\$ 204.56	0
Prescriptions and Layout				\$ -	0
Aerial Photo Interpretation	4			\$ 102.28	0
Brushing				\$ -	0
Surveying & DesignCAD	52			\$ 1,316.86	1
Contract Preparation	15			\$ 383.55	0
COTR Training				\$ -	0
Contract Administration/ Heavy Equipment Supervision	590	186	20	\$ 20,826.40	9
Miscellaneous Administration	8			\$ 204.56	
Photo Documentation	12			\$ 306.84	0
Report Writing	40			\$ 1,022.80	0
Subtotal	729	186	20	\$ 24,367.85	10
Grand Total				\$ 232,116.55	

- (a) Heavy Equipment Rental Equivalent (H.E.R.E.) is the estimated cost to complete each job based on actual hours worked. Cost is calculated from Cal-Trans 2000 Labor and Rental Rates and includes the cost of the operator for: Caterpillar D8H dozer @ \$235/hr and John Deere excavator @ 200/hr.
- (b) Cost is based on the salary and benefits of a GS-11 employee @ \$25.57/hr plus those for a GS-6 employee @ \$13.12/hr where applicable (i.e. for surveying and photo documentation assistance).

Table 2. Road-Stream Crossing Excavation Cost and Production Rates for Unit 00-05, L-2-2-1 Road

Table 2. Road-Stream Crossing Excavation Cost and Production Rates for Unit 00-05, L-2-2-1 Road													
Work Item	Worksite (station numbers)	Surveyed Volume (cubic yards)	Heavy Equipment Hours (earth moving only)		Heavy Equipment Hours (brushing only)		Total Cost of Earth Moving		Unit Cost		Original Bid (price per cubic yard)	Average Fillsite Distance (feet) (b)	Excavation Rate
			Caterpillar D8H	John Deere 892E LC	Caterpillar D8H	John Deere 892E LC	Actual	H.E.R.E.	Actual (price per cubic yard)	H.E.R.E.			Earth + Brush Both Equip (cubic yards per hour) (c)
HAUL ROAD													
10	69+32-72+84	6,879	24.25	56.75	1.75	1.5	\$ 27,172.05	\$ 17,048.75	\$ 3.95	\$ 2.48	\$ 4.35	<100	82
	Moisture Differential	6,879	--	--	--	--	\$ 11,006.40	N/A	\$ 1.60	N/A	\$ 1.60		N/A
11	72+84-76+67	2,867	5.25	25.00		4.00	\$ 11,324.65	\$ 6,233.75	\$ 3.95	\$ 2.17	\$ 3.95	<100	84
13	73+67-75+35	3,624	11.00	10.25	6.00		\$ 16,670.40	\$ 4,635.00	\$ 4.60	\$ 1.28	\$ 3.70	<200	133
17	80+28-81+11	3,294	32.75	34.50	3.75	3.25	\$ 15,152.40	\$ 14,596.25	\$ 4.60	\$ 4.43	\$ 3.95	100-700	44
	Push Differential	750	--	--	--	--	\$ 1,500.00	N/A	\$ 0.60	N/A	\$ 0.60	300-700	N/A
21	88+48-89+59	3,638	37.25	51.00		1.00	\$ 15,825.30	\$ 18,953.75	\$ 4.35	\$ 5.21	\$ 3.95	<200	41
	Moisture Differential	3,638	--	--	--	--	\$ 3,092.30	N/A	\$ 0.85	N/A	\$ 0.85	N/A	N/A
28	92+92-94+64	3,495	24.25	30.50	1.00	2.00	\$ 13,805.25	\$ 11,798.75	\$ 3.95	\$ 3.38	\$ 3.85	<200	61
Total or Weighted Avg		23,797	134.75	208.00	12.50	11.75	\$115,548.75	\$ 73,266.25	\$ 4.86	\$ 3.08	---	---	65
(Does not include differentials)													
SKID ROADS													
8	Skid 1500	786	0.00	8.50		8.00	\$ 3,930.00	\$ 1,700.00	\$ 5.00	\$ 2.16	\$ 5.00	<100	48
16	Skid 1600	1101	10.75	12.25	5.25	1.75	\$ 5,505.00	\$ 4,976.25	\$ 5.00	\$ 4.52	\$ 5.00	<100	37
Total or Weighted Avg		1,887	10.75	20.75	5.25	9.75	\$ 9,435.00	\$ 6,676.25	\$ 5.00	\$ 3.54	---	---	41

- (a) Heavy Equipment Rental Equivalent (H.E.R.E.) is the estimated cost to complete each job based on actual hours worked. Cost is calculated from Cal-Trans 2000 Labor and rental rates and includes cost of the operator for: Caterpillar D8H dozer @ \$235/hr and John Deere 892E-LC excavator @ \$200/hr.
- (b) Fill material was pushed to the fillsite by bulldozer.
- (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.

Table 3. Export Outslope Excavation Cost and Production Rates for Unit 00-05, L-2-2-1 Road

													Excavation
Bid Item	Worksite (station numbers)	Surveyed Volume (cubic yards)	Heavy Equipment Hours (earth moving only)		Heavy Equipment Hours (brushing only)		Total Cost		Unit Cost		Original Bid (price per cubic yard)	Average Fillsite Distance (feet) (b)	Rate
			Caterpillar	John Deere	Caterpillar	John Deere	Actual	H.E.R.E. (a)	Actual	H.E.R.E. (a)			Earth + Brush Both Equip (cubic yards per hour) (c)
			D8H	892E LC	D8H	892E LC							
HAUL ROAD													
18	81+11-82+88	1,200	3.00	3.00			4,620.00	\$ 1,305.00	\$ 3.85	\$ 1.09	\$ 3.70		200
26	89+59-91+42	1,935	9.00	7.25			6,772.50	\$ 3,565.00	\$ 3.50	\$ 1.84	\$ 3.50		119
Total or Weighted Avg		3,135	12.00	10.25	0.00	0.00	\$ 11,392.50	\$ 4,870.00	\$ 3.63	\$ 1.55	--	--	141
SKID ROADS													
12	Skid 1420	3,070	6.25	10.00		2.50	\$ 15,350.00	\$3,468.75	\$ 5.00	\$ 3.02	\$ 5.00	<100	164
22	Skid 1700	339	3.00	2.75	0.75	1.00	\$ 1,695.00	\$1,255.00	\$ 5.00	\$ 3.70	\$ 5.00	<100	45
23	Skid 1710	1,755	8.75	11.75	1.00	2.50	\$ 8,775.00	\$4,406.25	\$ 5.00	\$ 2.51	\$ 5.00	<100	73
24	Skid 1720	(Deleted work item)											
25	Skid 1740	289	1.00	2.25			\$ 1,445.00	\$685.00	\$ 5.00	\$ 2.37	\$ 5.00	<100	89
Total or Weighted Avg		5,453	19.00	26.75	1.75	6.00	\$ 27,265.00	\$9,815.00	\$ 5.00	\$ 1.80	---	---	102

- (a) Heavy Equipment Rental Equivalent (H.E.R.E.) is the estimated cost to complete each job based on actual hours worked. Cost is calculated from Cal-Trans 2000 Labor and Rental Rates, and includes cost of the operator for: Caterpillar D8H dozer @ \$235/hr and John Deere 892E LC excavator @ \$200/hr.
- (b) Fill material was pushed to the fillsite by bulldozer.
- (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.

Table 4. Outslope Excavation Cost and Production Rates for Unit 00-05, L-2-2-1 Road

													Excavation Rate
Bid Item	Worksite (station numbers)	Surveyed Volume (cubic yards)	Heavy Equipment Hours (earth moving only)		Heavy Equipment Hours (brushing only)		Total Cost		Unit Cost		Original Bid (price per cubic yard)	Average Fillsite Distance (feet) (b)	Earth + Brush Both Equip (cubic yards per hour) (c)
			Caterpillar	John Deere	Caterpillar	John Deere	Actual	H.E.R.E.	Actual	H.E.R.E. (a)			
			D8H	892E LC	D8H	892E LC							
HAUL ROAD													
6	65+00-66+38	3,093	15.00	22.50	7.75	2.5	\$ 7,577.85	\$ 8,025.00	\$ 2.45	\$ 2.59	\$ 2.45	<100	65
7	66+38-69+32	3,170	14.00	15.50	13.00	1.00	\$ 7,766.50	\$ 6,390.00	\$ 2.45	\$ 2.02	\$ 2.35	<100	73
14	75+35-77+78	1,779	11.50	21.50	6.75	6.50	\$ 5,070.15	\$ 7,002.50	\$ 2.85	\$ 3.94	\$ 2.50	<100	38
15	77+78-80+28	2,165	0.50	6.50	0.50	0.50	\$ 6,170.25	\$ 1,417.50	\$ 2.85	\$ 0.65	\$ 2.50	<100	271
19	82+88-85+00	741	0.75	2.75		3.25	\$ 2,111.85	\$ 726.25	\$ 2.85	\$ 0.98	\$ 2.50	<100	110
20	85+00-88+48	694	0.00	5.00		0.50	\$ 1,804.40	\$ 1,000.00	\$ 2.60	\$ 1.44	\$ 2.50	<100	126
27	91+42-92+92	621	0.00	4.00	6.00	3.00	\$ 1,521.45	\$ 800.00	\$ 2.45	\$ 1.29	\$ 2.85	<100	48
Total or Weighted Avg		12,263	41.75	77.75	34.00	17.25	\$ 32,022.45	\$ 25,361.25	\$ 2.61	\$ 2.07	--	--	72

- (a) Heavy Equipment Rental Equivalent (H.E.R.E.) is the estimated cost to complete each job based on actual hours worked. Cost is calculated from Cal-Trans 2000 Labor and Rental Rates, and includes cost of the operator for: Caterpillar D8H dozer @ \$235/hr and John Deere 892E-LC excavator @ \$200/hr.
- (b) Fill material was pushed to the fillsite by bulldozer.
- (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.

Table 5. Non-Bid Item Costs for Unit 00-05, L-2-2-1 Road

Item	Heavy Equipment Hours		Actual Costs	H.E.R.E. Costs (a)
	Caterpillar D8H	John Deere 892E LC		
Move In	---	---	\$ 4,800.00	---
Misc. Move In	---	---	\$ 1,200.00	---
Move Out	---	---	\$ 1,600.00	---
Misc. Move Out	---	---	\$ 1,185.00	---
Culvert Installation	---	---	---	---
Log Salvage	5.75	5.00	\$ 3,300.00	\$ 2,351.25
Discussion	19.00	19.50	---	\$ 8,365.00
Down	19.00	8.00	---	\$ 6,065.00
Idle/Maintenance	49.50	17.50	---	\$ 15,132.50
Total	93.25	50.00	\$ 12,085.00	\$ 31,913.75

(a) Heavy Equipment Rental Equivalent (H.E.R.E.) is the estimated cost to complete each job based on actual hours worked.

Cos is calculated from Cal-Trans 2000 Rental Rates and Peterson Rents of Eureka.

Cost includes cost of the operator for: Caterpillar D8H dozer @ \$235/hr and John Deere excavator @ \$200/hr.

