

Summary Report
WATERSHED RESTORATION UNIT 98-4
C-LINE NORTH

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INTRODUCTION

Background

Redwood National and State Parks are removing logging roads from park lands as part of their watershed restoration program.

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 C-Line North Road.

Site Description

Redwood National Park (RNP) is located in the lower 1/3 of the Redwood Creek basin, a 280-square-mile watershed in the mountainous, coastal region of northwestern California (Figure 1). The basin 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 in the basin, 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).

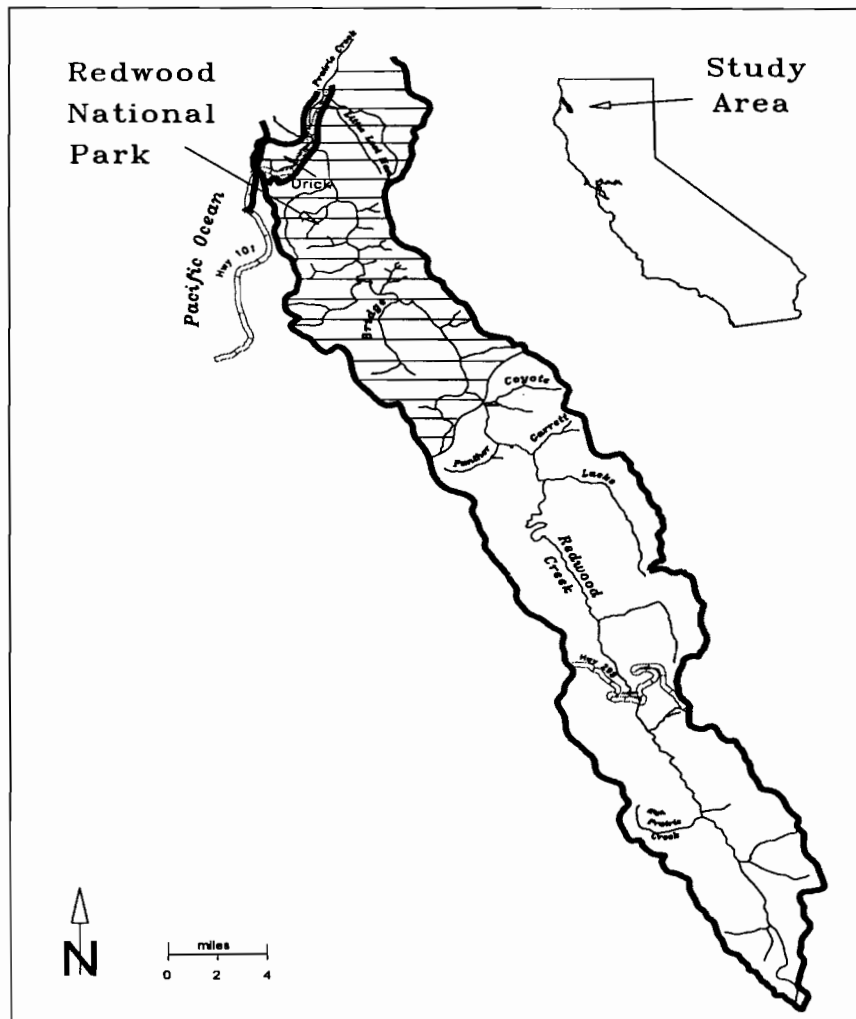


Figure 1. Map of Redwood National Park and Redwood Creek basin

The project area is located fifteen miles south of Orick at an elevation of approximately 1500 feet above sea level (Figure 2). The C-Line was a major haul road constructed in approximately 1950. It was located on the west side of the Redwood Creek basin. Within the park it ran from the West Side Access Road near MP 9, along the northwest side of the Tom McDonald Creek sub-basin, to the M-Line at the mouth of Forty Four Creek. A stream crossing (C-Line Pond) was excavated in 1993, severing the C-Line into two sections: C-Line North and C-Line South.

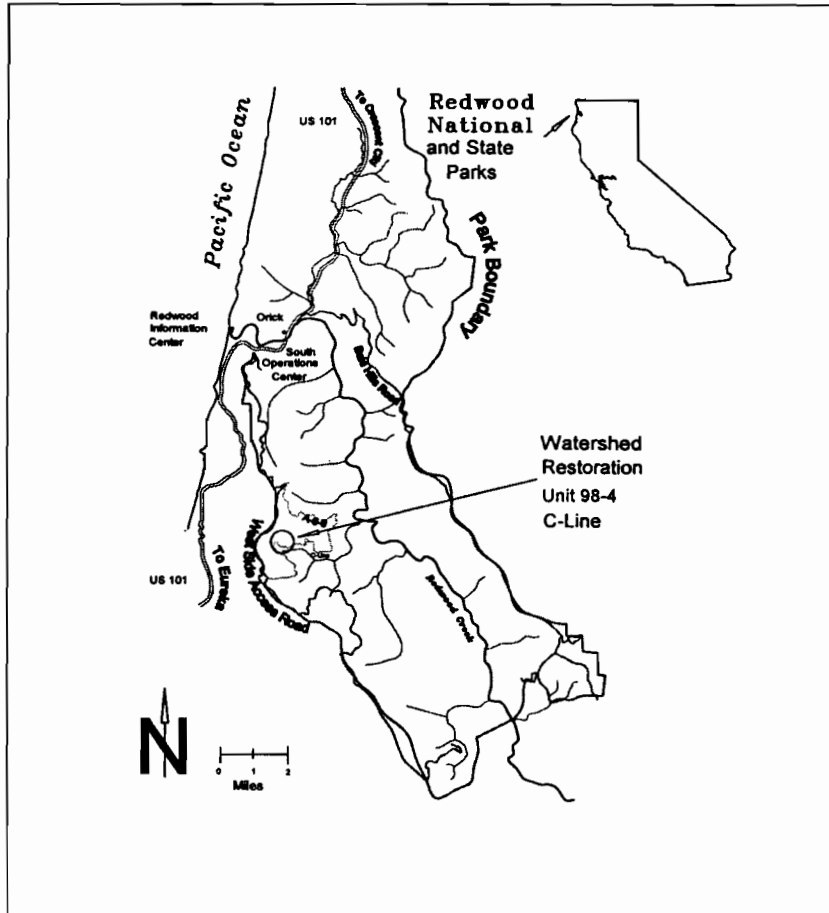


Figure 2. Location of Project Area

On January 1, 1997, after three months of above average precipitation, an eleven-year storm hit northern California. This storm caused numerous failures, predominately mass movements along the roads in Redwood National Park. A section of the C-Line North Road failed causing a large debris torrent, which severed access to the last two miles of the C-Line (north of the C-Line Pond excavation of 1993). Other sections of the C-Line North Road slumped indicating imminent mass failure. 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 damaged during the storm. Public access or long term administrative access roads also received funds for repair. The C-Line North was one of the roads to be removed.

The total cost for this project was \$205,000 (see Table 3, Appendix 1 for cost summary). The heavy equipment cost of \$166,000 was funded as follows: \$148,000 from ERFO; and \$18,000 from the Emergency Supplemental Appropriations Act. The salary cost of \$39,000 for implementation was funded by the Emergency Supplemental Appropriations Act.

This project removed 0.5 mile of the C-Line that included three stream crossings and one skid-road stream crossing. This project involved the excavation of a total of 57,350 yds³ of fill material, including 43,600 yds³ associated with the three stream crossings and the skid-road stream crossing.

Restoration focused on the removal of the stream crossing fill and unstable side cast fill, and placement of the fill against cutbanks on stable road reaches. The objective was to restore natural hillslope topography and drainage patterns altered by construction of the C-Line 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 exhumed and returned to the surface in order to help speed recovery of native vegetation. Trees and other vegetation removed during excavation was stockpiled and spread over the finished surface to reduce surface erosion, and provide habitat for microorganisms, insects, birds and small mammals.

Geology

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

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

The project area is situated on the west side of the Redwood Creek basin, and is underlain by the schist of Redwood Creek (Figure 3). 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.

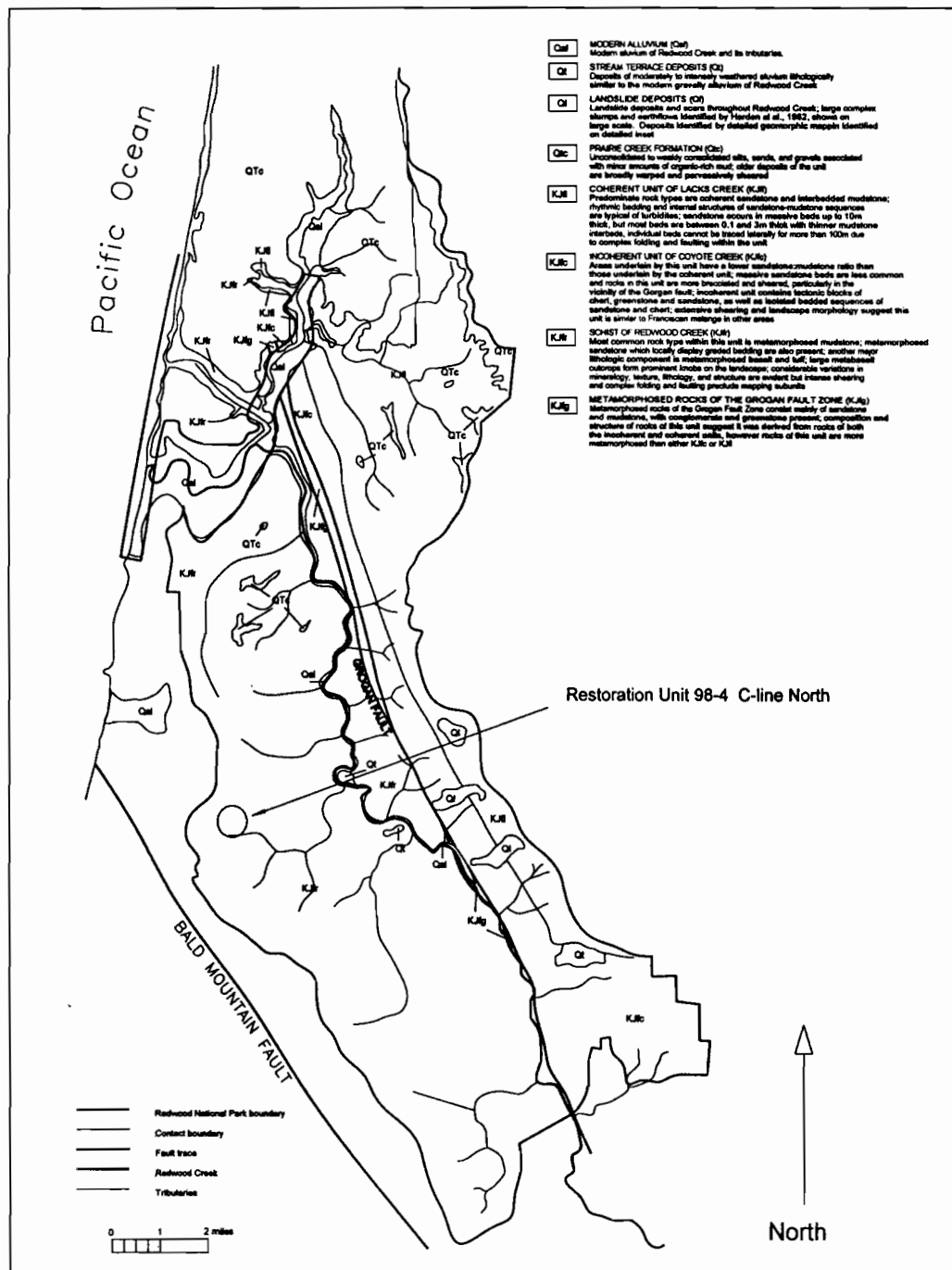


Figure 3. Geology Map

Timber Harvest History

The 1948 air photos covering Tom McDonald Creek show that no road construction or timber harvest had begun in the area. By 1954, the C-Line had been constructed and timber harvesting had begun (Figure 4). During the pre 1954 harvest all timber above the C-Line was tractor-yarded, and all timber below the C-Line was cable-yarded. The project area was clear cut except for a few remaining "undesirable" trees. In 1973 the project area was re entered and a few of the previously "undesirable" trees were extracted. During the re entry a few pre-existing skid trails were used, a few new ones were constructed, but negligible ground disturbance occurred.

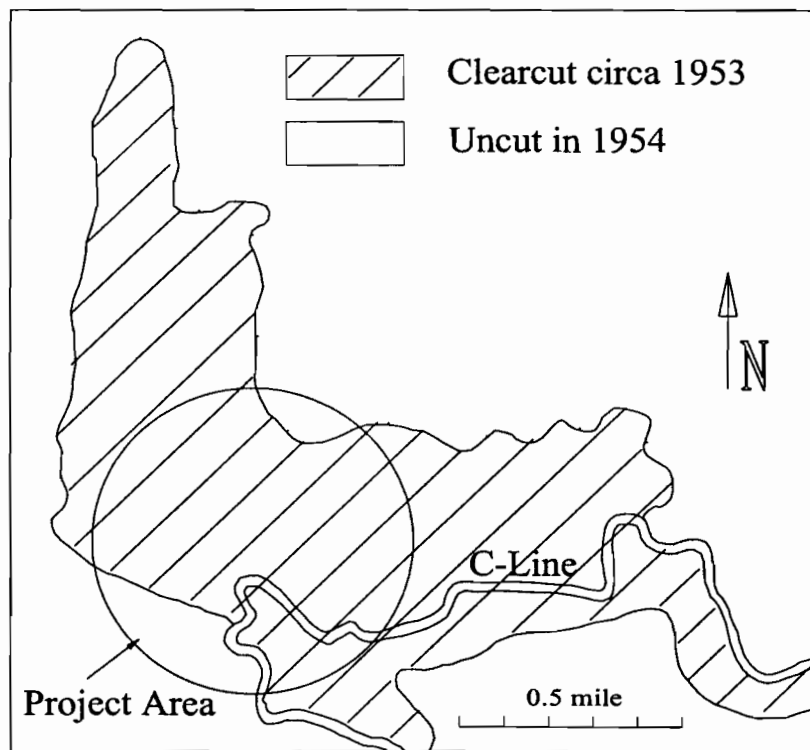


Figure 4. Timber Harvest History

In the early 1950s tractor-yarding was a relatively new phenomenon. Bulldozer technology developed during World War II had recently been applied to timber harvesting. Bulldozers were smaller, less powerful and less advanced than modern-day machines. Subsequently, the amount of earth moved during tractor-yarding on forested slopes was considerably less than what occurred in later decades (e.g. 1970s and 1980s). Skid trails were generally smaller and skid trail networks were less dense. Therefore, the disturbance to natural geomorphic and hydrologic conditions was considerably less than what typically occurred from tractor-yarding in later decades. Consequently, erosion problems created by tractor-yarding on the slopes above the C-Line had generally become benign by 1998. Erosion caused by cable-yarding below the C-Line had also become benign by 1998. The majority of the erosion problems in the project area were

caused by construction of the C-Line Road itself, where large quantities of earth were displaced, and natural hydrologic patterns were severely altered.

Erosional Features

The primary erosional features in the project area were gullies below culvert outlets at each of the three road-stream crossings, and two sidecast fill failures, one at station 01+75 on the Pondspur, and one at station 01+70 on the C-Line. None of the gullies below culvert outlets had advanced to the degree of eroding the road surface. The sidecast fill failure at station 01+75 on the Pondspur occurred during the January, 1997 storm. This failure resulted in a small debris flow involving a 30-foot section of road fill which deposited 50-100 cubic yards of fill and debris into a tributary of Tom McDonald Creek. The sidecast fill failure at station 01+70 on the C-Line occurred in the early 1970s. This was also a small debris flow which affected a 25-foot section of road fill and deposited approximately 50 cubic yards of fill and debris into another tributary of Tom McDonald Creek.

Threatened and Endangered Species Concerns and Work Schedule

The northern spotted owl and the marbled murrelet occupy areas in or near the project area. These two bird species are listed as threatened under the Endangered Species Act. The coho salmon is also listed as a threatened species. Because old-growth forests serve as critical habitat for these species, Redwood National Park is an important conservation area for their survival.

The U.S. Fish & Wildlife Service (USFWS) administers the Endangered Species Act for the protection of the northern spotted owl and the marbled murrelet. The USFWS has set restrictions to human activities which impact habitat of these bird species. Of particular relevance to this project are restrictions to heavy equipment noise affecting nesting sites during the breeding season. The project area is surrounded by dense second growth forest (45-50 years old) which is believed to be habitat for northern spotted owls. There is old growth forest below the C-Line within 3/8 mile of the project area. This patch of old growth forest is believed to be habitat for marbled murrelets.

In the dense second growth forest, heavy equipment noise has been proven to attenuate to ambient levels within a few hundred feet. Therefore, the USFWS determined that no adverse impact from this project would affect marbled murrelets. The project was planned to start on August 1 at the end of the spotted owl breeding season.

The National Marine Fisheries Service (NMFS) administers the Endangered Species Act for the protection of the coho salmon. Because this restoration work involves excavation of fill material from stream channels, there is a potential for adverse impacts to coho salmon from stream sedimentation. Therefore, in compliance with the NMFS coho protection guidelines, the project was slated to end by November 1, or at such time that fall rains increased stream flow to a point where sedimentation became a concern.

RESTORATION WORK

Project Implementation

Restoration work focused on restoring the land to a condition similar to what would have existed without human disturbance. The work included complete excavation of road fill from stream and swale crossings, complete outsloping of the road, and reconstruction of ridges. The objective was to re create the original landscape and restore natural hydrologic and geomorphic conditions. A summary of restoration costs is shown in Table 3, Appendix 1.

The project geologist, Jim Howard, mapped geomorphic and hydrologic features, prescribed restoration treatments (Figure 5), surveyed cut and fill 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. Physical Science Technicians Ingrid Corson and Kristine Leep served as site inspectors when the project geologist was not on site.

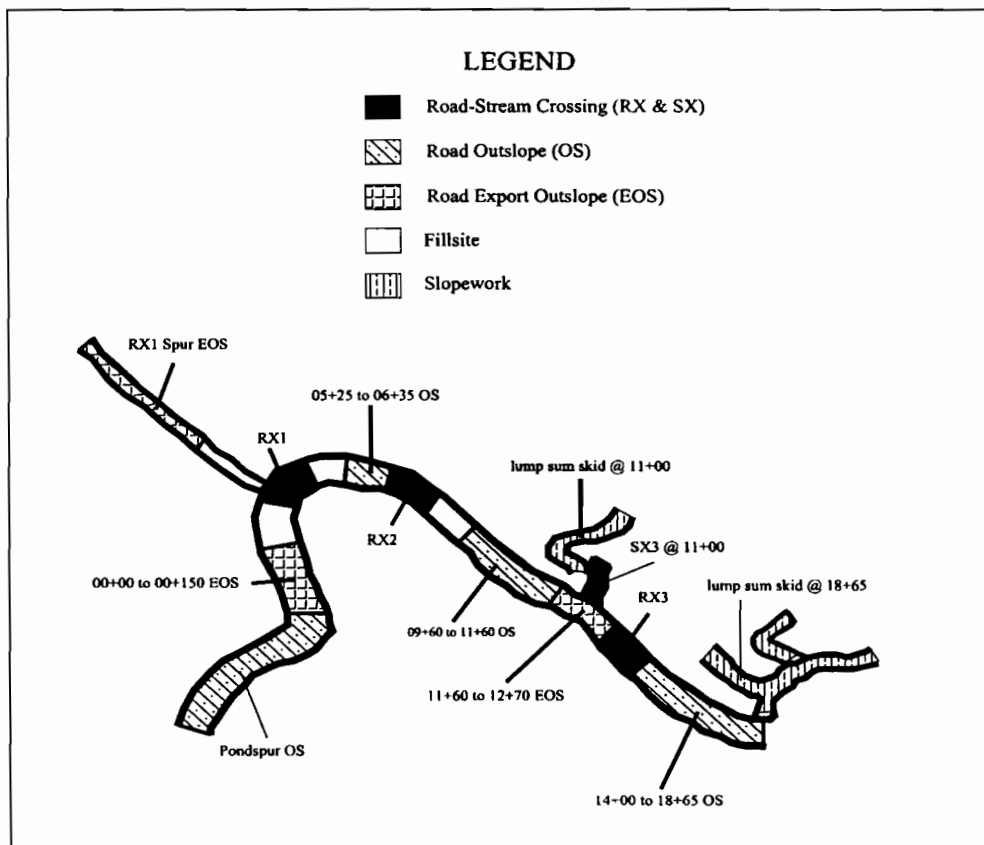


Figure 5. Treatment Prescriptions in the Project Area

Heavy Equipment Phase

The heavy equipment phase included all primary restoration treatments. A total of 0.5 mile of the C-Line North and 0.3 mile of skid roads was removed at a total heavy equipment cost of \$205,000. A total of 57,350 yds³ of material was excavated from 3 haul road stream crossings (42,700 yds³), 1 skid-road stream crossing (900 yds³), 260 feet of haul road export outslope (5,800 yds³), 1075 feet of haul road outslope (5200 yds³), 690 feet of skid road export outslope (2,200 yds³), and 850 feet of skid-road outslope (500 yds³). The haul road surface was ripped to a minimum depth of 18 inches prior to placement of fill on fillsites.

The heavy equipment phase was conducted by "invitation for bid" contract. The contract was split into a base bid and three bid option items. The contract was set up so that the base bid could easily be completed before fall rains inhibited equipment work. Award of option items was contingent on weather forecasts and COTR discretion. Upon completion of all base bid items, option items would be awarded one at a time, given COTR approval. Five bids were received. Table 1 is a summary of the bids received.

Table 1. Summary of Bids Received			
Contractor	Base Bid	Option Items Bid	Total Bid
Barber Construction	\$161,538	\$68,350	\$229,888
Trinity River Construction	\$164,260	\$79,760	\$244,020
George Passage Excavating	\$203,495	\$98,935	\$302,430
Renew-A-Line	\$386,575	\$179,925	\$566,500
Essayons, Inc.	\$386,760	\$186,600	\$573,360

The contract was awarded to the lowest responsive bidder, Barber Construction, Inc., on July 14, 1998. The heavy equipment work began on August 10, 1998 and was completed on October 21, 1998. All base bid items were completed. No option items were awarded as weather had become consistently wet and forecasts indicated continuing rains.

Six pieces of equipment were used on this project, and six operators ran the equipment. Different combinations of equipment and operators were used at different times, depending on the type of work being done, operator availability and equipment breakdowns. Table 2 lists equipment used and the operators who ran the equipment.

Table 2. Equipment Used and Associated Operators	
Equipment	Operator(s)
Caterpillar 245 excavator	Randy Moore Rich Barber
Caterpillar 345BL excavator	Randy Moore
Caterpillar 231D excavator	Randy Moore Rich Barber
Caterpillar D9 dozer	Butch Brundine
Caterpillar D6H LGP dozer	Frank McCallister Dan Reynolds Rich Barber
Caterpillar D6 LGP dozer	Frank McCallister Dan Reynolds Paul Johnson

Stream Crossings:

A summary of stream crossing excavation costs and production rates is shown in Table 4, Appendix 1. A narrative of the excavation of each of the crossings follows.

RX-1

This stream crossing excavation was 384 feet long and 43 feet deep at the outboard edge of the road. The total volume of RX1 was 20,195 cubic yards, making it the largest crossing excavation of this project. The excavation of RX1 proceeded slowly because the majority of the excavated fill had to be pushed 600 feet upstation, around the ridge separating RX1 and the C-Line Pond excavation of 1993. The long push was accomplished through a hand off system from one D6 to another D6 to the D9. As the excavation became deep, fill material was spooned from one excavator to another and then shuttled by the three dozers.

Because RX1 is a large perennial channel, fill material near the bottom of the excavation was saturated, causing the equipment to get stuck several times and limiting the amount of fill material that could be pushed by a dozer in a given turn. But, relative to other crossing excavations carried out in Redwood National Park, this was a very straight-forward job. Stumps, bedrock, topsoil and other geomorphic indicators of original soil surface were numerous and easily interpreted. No obstacle prevented restoration to original channel morphology within excavation boundaries.

RX-2

This stream crossing excavation was 339 feet long and 32 feet deep at the outboard edge of the road. The total volume of RX2 was 11,416 cubic yards. As opposed to RX1, fillsites for the RX2 excavation were relatively close, averaging approximately 200 feet. The stream channel associated with RX2 is also a perennial stream. Fill material near the bottom of the excavation was saturated causing the equipment to become stuck several times. This situation slowed progress of the excavation but did not prohibit complete excavation of fill material and restoration to original stream channel morphology.

There is a confluence of two tributary streams near the top of the RX2 excavation, within the excavation boundaries. The right tributary was used as a skid trail during past timber harvesting activities. Subsequently, this tributary stream channel is choked with sediment and large woody debris (uprooted stumps and logs). When prescribing restoration treatments the COTR chose not to excavate this material from the tributary channel. This decision was based on the lack of access for heavy equipment to the upper reaches of the channel, lack of available fillsites, and the inherent danger to an excavator operator attempting to excavate large woody debris from a channel directly above his/her equipment. The only logical position from which to excavate the channel was in the channel itself, directly below the material being excavated. The resulting finished excavation exhibits an abrupt transition from an excavated channel below to a channel choked with sediment and large woody debris above. Given current technology, methodology, and site conditions this was, in the COTR's opinion, an unavoidable situation.

RX-3

This stream crossing excavation was 280 feet long and 37 feet deep at the outboard edge of the road. The total volume of the RX3 excavation was 11,089 cubic yards. Though it was the smallest of the three road-stream crossing excavations, RX3 was technically the most difficult. Two factors contributed to its difficulty: 1) a channel grade of 24°, as opposed to 15° for RX2, and 13° for RX1; and 2) a confluence of two tributary streams just below the road, within the excavation boundaries.

The extreme channel grade made it difficult, and at times impossible, for the excavators to extract fill from the bottom of the channel and avoid sliding down into the channel where they would be very difficult and costly to rescue. The steepness of the work site also increased the danger to the excavator operators of toppling their machines down into the channel. The steep channel grade also reduced the lateral reach of the excavators, both digging and relaying to other equipment for transport to fillsites. This made it necessary for the excavators to crawl further down into the bottom of the channel, greatly increasing the time and effort to move each yard of fill out of the channel and to the fillsite. The lower portions of the excavation required one excavator to spoon the fill twice and pass it to another excavator, which relayed it to one dozer, which pushed it to another dozer. During this process some of the equipment often had to wait for other equipment to complete its turn.

The confluence near the bottom of the excavation and the steep ridge between the two tributaries made it physically difficult for the operators to position the equipment to excavate fill material while protecting the integrity of the original soil surface. As the excavation deepened and the fill became saturated the pads on which the excavators sat while working would soften and slide down the channel. The excavators would have to escape quickly from each pad they constructed or become stuck. In the steepest sections of the channel, it was impossible for the excavators to sit in the channel while working, so the COTR allowed the operator to dig his pad into original ground in two locations on the center ridge. Digging through the original ground surface was deemed justified by the COTR as a trade off to remove fill material from the channel where its potential to deliver sediment to downstream resources was 100%, and accept the lesser potential of surface erosion from the ridge delivering sediment to downstream resources.

Two unfortunate incidents further exacerbated the difficulty of the RX3 excavation. First, a miscommunication between the contractor and his excavator operator resulted in the excavation being started at the top of the channel. Customarily all excavations begin at the bottom of the channel so that any water uncovered during excavation flows freely down the channel and does not saturate unexcavated fill. Starting at the top of the channel led to immediate decommission of the culvert and a pond at the top of the excavation. Consequently, all future stream flow increased the moisture content of the remaining 95% of the fill to be excavated. The COTR advised the operator not to start the excavation at the top of the channel, but the operator was convinced that his boss told him to do so, and the advice was disregarded. It was later discovered there was a miscommunication between contractor and operator.

The second unfortunate incident was the collapse of a bench of unexcavated fill material. On October 13th the contractor cancelled work due to rain. On October 14th, when we returned to the site, we discovered 50-100 cubic yards of fill had slid down to the bottom of the excavation from a collapsed excavator work pad. The fill was well out of reach from any of the remaining work pads. This caused a good deal of consternation on the part of the contractor and the excavator operator. They understood that the material had to be retrieved from the channel, but they wouldn't go back down the channel to do it, because the channel was too wet and they figured they would never be able to get back out. The COTR's alternatives were to either leave 50-100 cubic yards of fill in the channel or allow the excavator operator to again cut into the nose of the center ridge where he could access the material from solid ground.

The COTR chose to allow the operator to cut into the ridge and retrieve the fill from the channel. The operator cut into the nose of the ridge considerably more than the COTR had understood he would. But the damage was done before the COTR could intervene. When the excavator operator cut deep into the original soil surface he exposed considerable ground water flow. The COTR instructed the operator to remove the material cut from the nose of the ridge and send it down station to a fillsite, rather than rebuild the ridge to its original shape with fill material which would quickly saturate and ooze into the channel. This reduced the length and increased the slope gradient of the ridge. The fill was retrieved from the channel and the crossing excavation was eventually completed. After the first winter the amount of material eroded from the nose of the ridge was comparable to the amount which was retrieved from the bench failure. In retrospect the COTR would have chosen to write off the material which slid to the bottom of the channel during excavation and leave the nose of the ridge intact.

SX-3

A summary of skid road-stream crossing excavation costs and production rates is shown in Table 5, Appendix 1. There was only one skid road-stream crossing excavation on this project. Skid road-stream crossing SX3 was located on the right tributary of RX3, above the C-line. The bottom of SX3 blended with the top of the export outslope of bid item 12. The excavation was 214 feet long and 10 feet deep at its maximum depth of cut. The total volume of the excavation was 906 cubic yards. The fillsite for this bid item was located directly adjacent to the excavation. The entire length of the channel was excavated from the right side of the channel. It was a relatively small, straight-forward excavation.

Export Outsloping:

A summary of export outslope excavation costs and production rates is shown in Table 6, Appendix 1. Export outslope treatments were done on two road reaches and on one skid road. Export outsloping was prescribed when there was not sufficient space against the cutbank within the bid item to store all the fill material. The fill was exported to other fill sites by dozers.

Export outslope 00+00 was performed extremely well. The excavator operator made an extra effort to reach sidecast fill well down the fill slope. Dark, rich topsoil was located and followed throughout the entire bid item. Several stumps and two old growth redwood trees also assisted in identification of the original soil surface. Export outslope 11+60 also turned out quite nicely.

As shown in Table 6, Appendix 1, excavation of the RX1 Spur was accomplished with only the 245 excavator. Volume surveys prior to excavation indicated a fillsite deficit on the RX1 Spur. The excess fill material was contained within the sidecast fill on the lower 200 feet of the skid road. This was explained to excavator operator. The COTR expected the excavator operator to request the assistance of a dozer to export the surplus fill when he reached the last 200 feet of the excavation. When the excavator operator reached this section of the excavation the COTR was monitoring the progress of another excavator on a different bid item. The site inspector monitoring the RX1 Spur excavation in the COTR's absence did not recognize the extent of the excavation and allowed the operator to pass over the last 200 feet of the job without excavating all the sidecast fill. The operator excavated only what could be stored directly against the cutbank. When the COTR returned the bid item was nearly complete, but a large lobe of sidecast fill had not been excavated 200 feet upstation.

The COTR decided it would be unfair to the contractor to incur considerable cost backtracking over his completed work and re doing the job, given that a designated site inspector had been present during the excavation. The cost of removing large woody debris, rebuilding the road, excavating the remaining fill, and spreading the large woody debris back over the surface would indeed have been considerable. Erosion of the unexcavated fill will likely be limited to some minor bank erosion and minor sediment delivery. The actual volume excavated was 700 cubic yards less than the pre excavation volume estimate.

Outsloping:

A summary of outslope excavation costs and production rates is shown in Table 7, Appendix 1. Production rates were quite low across the board for all the outslope bid items. This may be contributed to the sequence in which road segments were removed. As the project proceeded, the contractor opened many bid items simultaneously to keep all of the equipment busy. This led to a lot of moving time between bid items. It also resulted in work being done twice.

Each of the outslope bid items was completed in the same general sequence. A short segment of the road surface was cleared of trees and ripped by the excavator. Then the excavator would excavate a short segment of sidecast fill, spoil the fill in a pile on the ripped road surface, and cover the completed slope with large woody debris. Then the excavator would move downstation and repeat the process on the adjacent segment of road. The spoil piles would accumulate on the remaining road surface, to be shaped later when the fillsite was full. Without the assistance of a dozer (pushing the fill away and distributing it along the designated fill site) the excavator could only spoil so much fill before it began to bury itself, or ravel the spoils back down the hill from where they had just been excavated. Wherever the road surface was narrow (i.e. where the top of cut became close to the cutbank) the excavator would run out of available spoil site and leave the sidecast fill partially unexcavated.

The excavator and all the other equipment would have to travel back and forth over the spoil piles, so they would build a road over the top of the spoils. As fill material became available from adjacent crossings the fillsite would fill up, but a road had to be maintained over the fillsite to access incomplete bid items upstation. Inevitably, a considerable amount of fill would ravel down from the fillsite and bury the completed outslope below. After all upstation bid items were complete the outslope bid items would have to be re worked. The sidecast portion of the road segment would have to be re excavated, uncovering previously completed work buried by ravel, and completing the excavation on narrow segments of road where the excavator had run out of spoil site. This was extremely slow and difficult because the fillsite above was full, leaving nowhere for the excavator to position itself to do the work. Excess fill would have to be pushed downstation to the nearest available fillsite, sometimes not at all near. Production rates suffered.

The quality of the finished product was compromised in these situations. The large, heavy excavators were limited as to how much they could move around on top of the fillsites to smooth the surface and blend the seems. Large woody debris stockpiled on the lower portion of the outslope could not be retrieved and spread evenly over the entire outslaped surface. Also, sidecast fill was not excavated completely along several sections of the road.

Miscellaneous Bid Items

Miscellaneous bid items include ripping and two skid road outslopes. See Table 3, Appendix 1 for costs associated with these bid items. All miscellaneous bid items were lump sum items.

Ripping (road surface decompaction) was performed by digging up the road surface to a minimum depth of 18 inches with the 245 excavator. A unit price relative to cubic yards could not be associated with ripping. The contractor submitted his bid based on the total length of road

to be ripped, in this case 2,350 feet. The actual time spent on ripping was not recorded, and therefor no H.E.R.E rate was calculated for this bid item.

Skid roads 11+00 and 18+65 were also lump sum bid items. These two skid roads were treated as lump sum bid items because the COTR felt the cost of treating them was not well represented by cubic yards of material excavated. Relative to unit price bid items, these two skid roads required much more equipment time per cubic yard of fill excavated, mainly due to the amount of trees and brush to be handled. The contractor submitted his bids based on his own investigation of each bid item. Excavation volumes associated with these two bid items (as seen in Table 3, Appendix 1) were based on ocular estimates by the COTR. Therefor, the average unit costs derived from volume of material excavated may not be accurate.

Documentation Phase

The final phase of this watershed restoration project 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 the COTR, Jim Howard.

DISCUSSION

Project 98-4 met the goals of Redwood National Park's watershed restoration program by removing a portion of the C-Line North road, restoring the natural landscape and natural hydrologic patterns, and minimizing human-caused erosion in the Tom McDonald Creek watershed. A total of 57,350 cubic yards of fill material was excavated from unstable locations and moved to stable fillsites. The project's total heavy equipment cost was \$165,458. The average cost per cubic yard was \$2.88/cubic yard.

The original goal of this project was to move 87,000 cubic yards of dirt. This included one more large crossing, one export outslope, two outsoles, and two skid outsoles. However, midway through the project, the contractor removed his operators and equipment from the site and transferred them to another job. This constituted a 17-day shut down and a failure to achieve the original goal of the project.

REFERENCES

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Appendix 1

Table 3. Restoration Work Costs Summary for Unit 98-4, C-line North Road							
Treatment	Quantity (cubic yards)	Number of Sites	Total Cost		Percent of Grand Total	Average Unit Cost	
			Actual	H.E.R.E.*		Actual	H.E.R.E.* (\$/cu. yd.)
Heavy Equipment							
Road Crossings	42,700	3	\$ 109,026	\$ 105,660	53.2	\$2.55	\$2.44
Export Outslope	5,829	2	\$ 15,215	\$ 14,090	7.4	\$2.61	\$2.49
Outslope	5,228	4	\$ 10,735	\$ 19,421	5.2	\$2.05	\$3.83
Skid Road Crossings	906	1	\$ 2,718	\$ 1,478	1.3	\$3.00	\$1.63
Skid Road Export Outslope	2,188	1	\$ 6,564	\$ 2,850	3.2	\$3.00	\$1.30
Move in	—	—	\$ 10,000	\$ 10,000	4.9		
Move out	—	—	\$ 5,000	\$ 5,000	2.4		
Ripping	2350 feet	—	\$ 5,000	\$ 5,000	2.4		
Miscellaneous Bid Items	500	2	\$ 1,200	\$ 2,891	0.6	\$2.40	\$5.78
Miscellaneous Non-Bid Items	—	—	—	—	—		
Subtotal	57,351	13	\$ 165,458	\$ 166,390			
Project Implementation							
Mapping	256	—	\$ 5,010		2.4		
Prescriptions and Layout	152	200	\$ 6,595		3.2		
Aerial Photo Interpretation	25	—	\$ 489		0.2		
Surveying	270	254	\$ 8,525		4.2		
Contract Preparation	260	—	\$ 5,180		2.5		
COTR Training	30	—	\$ 587		0.3		
Contract Administration/ Heavy Equipment Supervision	550	80	\$ 11,865		5.8		
Photo Documentation	23	10	\$ 550		0.3		
Report Writing	34	—	\$ 665		0.3		
Subtotal	1600	544	\$ 39,466				
Grand Total			\$ 204,924				

* H.E.R.E. = heavy equipment rental equivalent. The cost to complete each bid item based on the hours worked. Calculated using the monthly rental rate of each machine (or a comparable machine) divided by 180 hours to derive the hourly rental rate, added to Bacon-Davis operator wages for each machine, then that total multiplied by 1.4 to account for a 40% overhead. Overhead includes maintenance, fuel, profit, insurance, etc...

Appendix 1 (continued)

Table 4. Road-Stream Crossing Excavation Costs and Production Rates for Unit 98-4, C-line North Road

Bid Item	Description	Volume (cu yds)	heavy equipment hours				Caterpillar D9	Caterpillar D6LGP	Caterpillar D6H	Total Cost Actual (\$)	Unit Cost Actual (\$/cubic yard)	H.E.R.E.* (\$/cubic yard)	Original Bid (\$/cubic yard)	Average Fillsite Distance (feet)	Total Hours per Bid Item (hours)	Excavation Rate (cu yds/machine*hr)
			Caterpillar 245	Caterpillar 345	Caterpillar 231D	Caterpillar D6H										
7	RX1	20195	36.75		72.25	117	95.75	60.25		\$55,536	\$2.75	\$2.61	\$2.75	400	382	53
9	RX2	11416	12.25	15.75	39.25	36.75	35.25	34.25		\$28,540	\$2.50	\$2.22	\$2.50	200	173.5	66
13	RX3	11089	2.5	44.25	12.75	66	59.5	20		\$24,950	\$2.25	\$2.48	\$2.25	150	205	54
total/average		42700	52	60	124	220	191	115		\$109,026	\$2.50	\$2.44	\$2.50	250	254	58

Table 5. Skid Road-Stream Crossing Excavation Costs and Production Rates for Unit 98-4, C-line North Road

Bid Item	Description	Volume (cu yds)	heavy equipment hours				Caterpillar D9	Caterpillar D6H	Caterpillar 231D	Total Cost Actual (\$)	Unit Cost Actual (\$/cubic yard)	H.E.R.E.* (\$/cubic yard)	Original Bid (\$/cubic yard)	Average Fillsite Distance (feet)	Total Hours per Bid Item (hours)	Excavation Rate (cu yds/machine*hr)
			Caterpillar 231D	Caterpillar D6H	Caterpillar 345	Caterpillar 245										
12A	SX3	906	9.25	0.5	0.5					\$2,718	\$3.00	\$1.63	\$3.00	30	10.25	88

* H.E.R.E. = heavy equipment rental equivalent. The cost to complete each bid item based on the hours worked. Calculated using the monthly rental rate of each machine (or a comparable machine) divided by 180 hours to derive the hourly rental rate, added to Bacon-Davis operator wages for each machine, then that total multiplied by 1.4 to account for a 40% overhead. Overhead includes maintenance, fuel, profit, insurance, etc...

Appendix 1 (continued)

Table 6. Export Outslope Excavation Costs and Production Rates for Unit 98-4, C-line North Road

Bld Item	Description	Volume (cu yds)	heavy equipment hour					Total Cost Actual (\$)	Total Cost H.E.R.E.* (\$)	Unit Cost Actual (\$/cubic yard)	Unit Cost H.E.R.E.* (\$/cubic yard)	Original Bid (\$/cubic yard)	Average Fillsite Distance (feet)	Total Hours per Bid Item (hours)	Excavation Rate (cu yds/machine*hr)
			Caterpillar 245	Caterpillar 345	Caterpillar 231D	Caterpillar D6H	Caterpillar D6LGP	Caterpillar D9							
HAUL ROAD	5	00+00 to 01+50	15.25			22.5	24		\$7,749	\$3.00	\$3.10	\$3.00	400	61.75	42
	12	11+60 to 12+70	4.75	9	1	16.25	15.75		\$7,466	\$2.30	\$1.87	\$2.30	200	46.75	69
	total/average		20	9	1	39	40	0	\$15,215	\$2.65	\$2.49	\$2.65	300	54	56
SKID ROAD	6	RX1 Spur, 690 ft	15						\$6,564	\$3.00	\$1.30	\$3.00		15	146

Table 7. Outslope Excavation Costs and Production Rates for Unit 98-4, C-line North Road

Bld Item	Description	Volume (cu yds)	heavy equipment hour					Total Cost Actual (\$)	Total Cost H.E.R.E. (\$)	Unit Cost Actual (\$/cubic yard)	Unit Cost H.E.R.E. (\$/cubic yard)	Original Bid (\$/cubic yard)	Average Fillsite Distance (feet)	Total Hours per Bid Item (hours)	Excavation Rate (cu yds/machine*hr)
			Caterpillar 245	Caterpillar 345	Caterpillar 231D	Caterpillar D6H	Caterpillar D6LGP	Caterpillar D9							
4	Pondspur (C-line) 500 ft	1116	15.75			3	3.25	1.5	\$2,511	\$2.25	\$3.57	\$2.25	0	23.5	47
8	05+25 to 06+35	471	3.75	5.5	1.5	1			\$942	\$2.00	\$4.16	\$2.00	0	11.75	40
10	09+60 to 11+60	1271	14.25	8	3	5.5	1		\$2,542	\$2.00	\$4.09	\$2.00	30	31.75	40
14	14+00 to 18+65	2370	26.75	7.5	3	13.25	0.5		\$4,740	\$2.00	\$3.50	\$2.00	0	51	46
total/average		5228	61	21	8	23	5	2	\$10,735	\$2.06	\$3.83	\$2.06	8	67	44

* H.E.R.E. = heavy equipment rental equivalent. The cost to complete each bid item based on the hours worked. Calculated using the monthly rental rate of each machine (or a comparable machine) divided by 180 hours to derive the hourly rental rate, added to Bacon-Davis operator wages for each machine, then that total multiplied by 1.4 to account for a 40% overhead. Overhead includes maintenance, fuel, profit, insurance, etc...