

Summary Report

WATERSHED RESTORATION UNIT 02-03

Removal of a Portion of The Lower B500 Road

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Introduction

Redwood Creek drains a 280-square-mile watershed in the mountainous, coastal region of northwestern California. The watershed is characterized by high relief, steep unstable slopes, and narrow valley bottoms. Redwood Creek and its tributary streams are subject to frequent flooding from winter storms, and basin soils are naturally unstable and highly erodible. Landslides and earthflows are widespread, and even under natural conditions streams swelled by winter rains transport large volumes of sediment. With over 90% of the forests in the basin harvested, and $\frac{2}{3}$ 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 and State Parks (RNSP) is located in the lower $\frac{1}{3}$ of the Redwood Creek watershed (Figure 1). Redwood National Park was established "in order to preserve significant examples of the primeval coastal redwood (*Sequoia sempervirens*) forests and the streams and seashores with which they are associated for purposes of public inspiration, enjoyment, and scientific study" (Public Law 90-545). Original boundaries protected a $\frac{1}{2}$ -mile wide corridor of forest along the lower $\frac{1}{3}$ of Redwood Creek. Lands located upslope and upstream of this corridor remained in private ownership. Prior to the establishment of the park, much of these lands were forested with old growth mix conifer forests. Subsequent to the park's establishment, these lands were subject to aggressive timber harvesting. This timber harvesting and the related road construction adversely influenced erosion rates, sediment deposition and water quality within the entire basin. Studies indicated these activities caused unnatural and excessive erosion that resulted in adverse impacts to riparian habitat, anadromous fisheries, and amphibian species (Narver, 1971).

The existence of several hundred miles of major haul roads and thousands of miles of tractor trails created severe erosion problems. The cutting of logging roads into steep slopes often resulted in massive slope failures, causing sediment to be delivered directly into perennial and intermittent stream channels. Surface runoff was intercepted and concentrated by inboard ditches along these roads, and often discharged onto slopes that had no natural drainage channels, resulting in severe gullying. During major storms, culverts and inboard ditches often became blocked, and water was diverted onto road surfaces, causing new gullies and saturating road fills, which in turn led to slope failures. The altering of drainage patterns, the resulting loss of top soil, soil compaction, and destruction of ground cover, combined with increased runoff rates were among the results of logging activities in the Redwood Creek basin. These factors led to increased sedimentation, increased streamside slope failures, greater bank erosion and loss of anadromous fish-spawning habitat. These events led to a general degradation of the watershed, including damage to the aquatic and riparian environments of the Redwood Creek corridor.

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

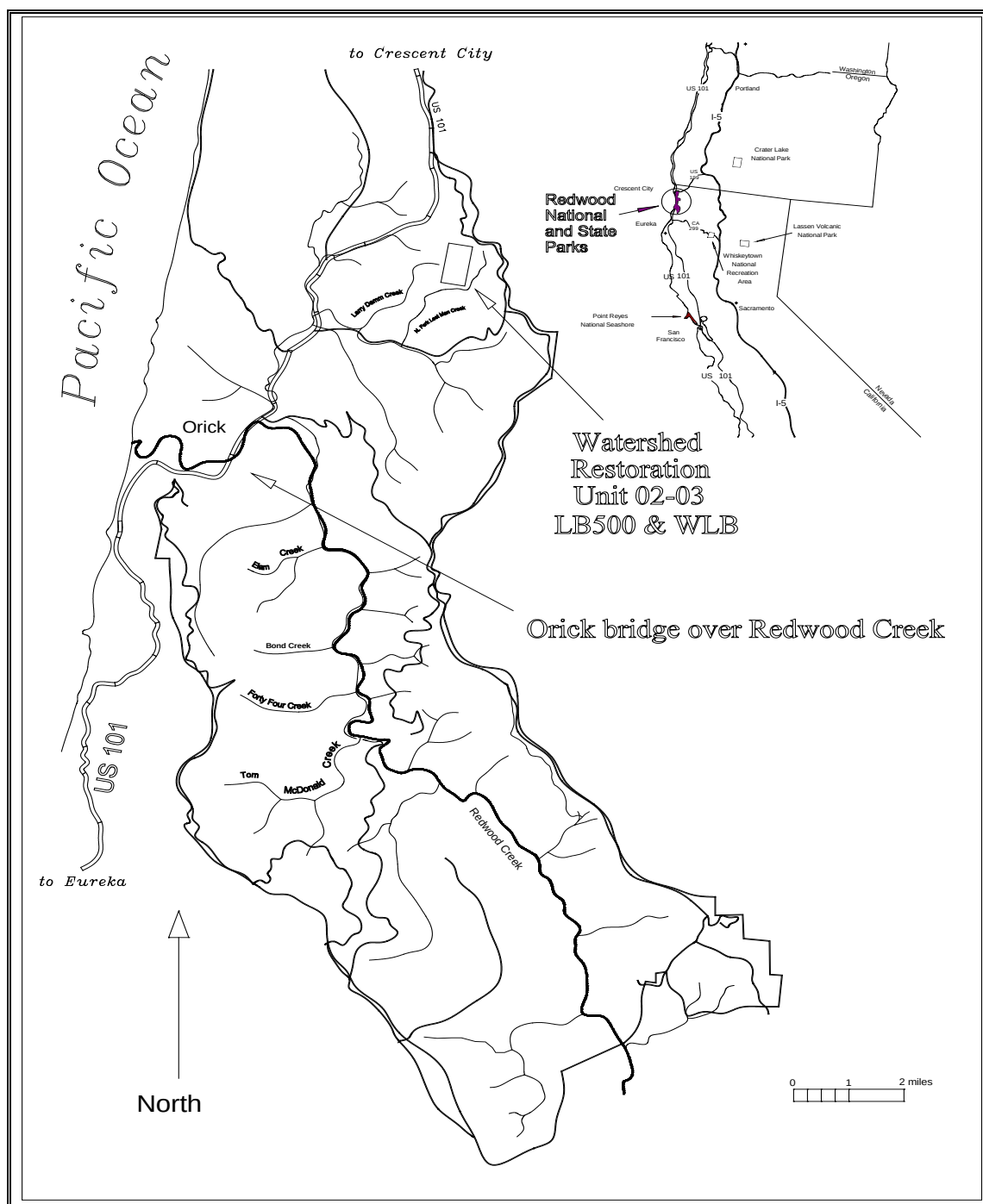


FIGURE 1. Location Map of Watershed Restoration Project 02-03 in Redwood National and State Parks.

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" (National Park Service Management Policies, 2001). It is also Park Service policy that "Landscape and vegetation conditions altered by human activity may be manipulated where the park management plan provides for restoring the lands to a natural condition. Management activities to restore human-altered landscapes may include, but are not restricted to: removing constructed features, restoring natural topographic gradients, and

revegetating with native park species..." (National Park Service Management Policies, 2001). Management objectives of Redwood National and State Parks are "to restore and maintain the RNSP ecosystems as they would have evolved without human influences since 1850 and perpetuate ongoing natural processes" (RNSP, Final General Management Plan / General Plan EIS / EIR, 1999). These policies and objectives provided the guidance and direction for the removal of this portion of the Lower B500 Road.

Project Background and Description

The Lower B500 Road, constructed between 1962 and 1966, was a major haul road for Arcata Redwood Company (ARCO). It is located in the Northwestern portion of the Lost Man Creek watershed in some of the most unstable and erodible terrain in the entire park. This terrain is characterized by soils that are prone to gullyng and landscapes that exhibit large scale mass wasting.

Watershed Rehabilitation Unit 02-03 constitutes the first phase of a multi-year strategy to remove the Lower B500 road from within Redwood National and State Parks. Unit 02-03 is located at the end of the Lower B500 road, near the headwaters of Larry Damm Creek; approximately 5 miles northeast of Orick, California (Figure 1). This initial phase of the Lower B500 road removal included road that was in both the Larry Damm Creek and the North Fork Lost Man Creek watersheds; on both sides of the inferred Lost Man Fault; and in both the mapped geologic units (Lacks Creek Unit of the Franciscan Complex (KJfl) and Gold Bluffs Unit of the Prairie Creek Formation (PPpc)).

The project addressed accelerated erosion problems along 3615 feet of the Lower B500 road and 3125 feet of associated haul roads (LB501, LB502, LB503, WLB, and WLB-2) as well as 1260 feet of skid road treatment. Restoration focused primarily on the removal of the stream crossings and unstable side cast fill, and restoring natural hillslope topography and drainage patterns interrupted by the Lower B500 road. The excavation of the stream crossings uncovered the natural channel bed and banks, and excavated fill was used to re-create the natural topography. Recovered organic and nutrient rich side cast was returned to the surface in order to help speed recovery of native vegetation. Vegetation disturbed during excavation was stockpiled and dispersed along the finished surface in order to inhibit surface erosion, provide habitat and simulate natural forest litter. This project involved the excavation of over 74,500 yds³ of fill material, including 8,506 yds³ associated with 2 haul road stream crossings and 6 skid road stream crossings. Methodology for road removal was consistent with past rehabilitation projects, employing heavy equipment for all excavations. Excavations were executed through an IDIQ Contract (# 1443CX8530-99-006) awarded to Z. Logging L.L.C. (Orick, CA), and the work was subcontracted to, and performed by, Twin Parks of Arcata, California. Project costs are summarized in Table 1.

Geology

The northern portion of Lost Man Creek watershed is predominantly underlain by unconsolidated sediments representing the Gold Bluffs Unit of the Prairie Creek Formation (PPpc), which is in turn underlain by rocks of the Franciscan Assemblage (KJfs)(Kelsey and Trexler, 1989). The general occurrence of these units is shown in Figure 2. The Prairie Creek Formation represents the onshore and nearshore portion of an extensive Pliocene to Pleistocene age sedimentary sequence deposited near the mouth of the Klamath River. It is dominantly composed of fluvial sediments but also includes nearshore marine, beach, and estuarine deposits. Macro faunal fossils constrain the maximum age of the Prairie Creek Formation to 2-4 Ma (Kelsey and Trexler, 1989). The Franciscan Assemblage is a Jurassic to Cretaceous age complex composed predominantly of marine sediments with associated low-grade metamorphic and minor submarine volcanic rocks. Rocks of the Franciscan Assemblage are typically complexly folded, faulted, and altered due to subduction that was occurring during their formation (Harden et al., 1982). The majority of the restoration work for project 02-03 was in the Franciscan Assemblage, with only 12% of the total road length treated residing on the Prairie Creek Formation. Future projects to remove the Lower B500 road will be almost exclusively in the Prairie Creek Formation.



interbeds; individual beds cannot be traced laterally for more than 100 meters due to complex folding and faulting (Harden et al., 1982).

The Prairie Creek Formation (Gold Bluffs unit) and the Franciscan Assemblage (Lacks Creek unit) (see Figure 2.) are juxtaposed along the Lost Man Fault, a high angle fault trending north-northwest to south-southeast that crosses the western portion of the project area (Kelsey and Trexlor, 1989). According to Kelsey and Trexlor (1989), the Lost Man Fault displaces the Franciscan basement upward along its east-side, exposing it near the headwaters of both tributaries. Activity of the Lost Man Fault during the late Pleistocene to Holocene is not known (Kelsey and Trexlor, 1989).

The geomorphic processes acting within the project area are a direct result of the distinctly different physical characteristics of the two bedrock units, high rainfall and recent disturbance by intensive logging and road building activities. The unconsolidated sediments of the Prairie Creek Formation are readily mobilized by surface runoff, especially where the sediments have been cut and sidecast to construct roads and lay-outs, and natural drainage patterns have been obliterated by logging disturbances. These sediments are also susceptible to natural and disturbance-induced mass wasting processes.

The relatively resistant Franciscan bedrock in the upper reaches of the two tributaries results in steep slopes, narrow, confined canyons and high-energy stream flow in comparison to the gentler terrane and less confined stream reaches of the Prairie Creek Formation. The eastern contact between the Prairie Creek Formation and the Franciscan is a probable hydrologic boundary and a potential zone of instability; groundwater that accumulates in the porous Prairie Creek “cap-rock” is likely to accumulate and move along the buried valleys of the ancient surface of the Franciscan Assemblage, and come to the surface where the fault exposes the contact. The steep slopes of Franciscan graywacke below tend to facilitate the formation of debris flows along this contact.

Land Use History

Logging and road building disturbances in the Larry Damm and the North Fork Lost Man watersheds began in the late 1950’s and culminated in the early 1970’s. Virtually all of the logging occurred prior to the establishment of the California Forest Practice Rules.

Prior to park acquisition Arcata Redwood Company (ARCO) owned the project area. Based on areal photograph analysis, the project area was logged between 1962 and 1966. The ARCO lands suffered extreme ground disturbance from the combination of the old-growth logging and tractor-yarding methods of the period, the recently increased power developments in large bulldozers, and the highly remoldable unconsolidated substrate. In addition, large haul roads and landings were constructed with little regard for preserving the natural drainage network. Imminent National Park expansion also influenced the rampant logging activities in the area (Franke, personal communication, 2002).

Storm events in 1964, 1972 and 1975 in combination with the high level of ground disturbance from recent logging resulted in accelerated erosion and large quantities of sediment being entrained in the stream systems. Aerial photos of the ARCO holdings taken immediately after the 1972 storm show extensive erosion, with numerous washed out roads and diverted streams; many of the skid roads exhibit dual rills, one per bulldozer track. The skid trail network essentially became the new hillslope drainage pattern, particularly in the Prairie Creek Formation, and on the ARCO lands.

Erosional Features

Erosional features associated with the slopes above and below Unit 02-03 were a direct result of the very dense “jackstaw” network of skid roads and harvest layouts. The harvest activities of the early 1960’s essentially redefined the drainage network in this upland area, creating native hillslope gullies, diversion gullies on road fill, moderate shallow debris slides, a large debris torrent, and numerous saturated road fills (potential landslides). In the one existing perennial stream of the project area there were 5 skid road crossings and 1 haul road crossing that exhibited sinkholes and had enough remaining volume to warrant treatment. Two additional skid road crossings on this stream were 80-95% evacuated and the remaining potential erosion volume did not justify the additional disturbance that would have resulted from treatment.

Wildlife Concerns and Work Schedule

Redwood National and State Parks is home to five species listed as threatened under the Endangered Species Act and that are potentially effected by watershed restoration projects. The species of concern are marbled murrelet (*Brachyramphus marmoratus*), northern spotted owl (*Strix occidentalis caurina*), Southern Oregon/Northern California Coasts coho salmon (*Oncorhynchus kisutch*), California Coastal chinook salmon (*Oncorhynchus tshawytscha*), and Northern California steelhead trout (*Oncorhynchus mykiss*).

With respect to terrestrial species, the U.S. Fish & Wildlife Service (FWS), as administrator of the Endangered Species Act, set noise restriction guidelines for management projects that do not remove or degrade suitable habitat for both the northern spotted owl and the marbled murrelet. These noise restrictions are designed to reduce human impact to nesting sites during the breeding season and apply to management projects that are located within a ¼ mile radius of suitable habitat. Additionally, FWS may impose restrictions due to impacts to foraging habitat. Project 02-03 was located entirely outside of the ¼ mile radius for suitable habitat and therefore was excluded from the noise restrictions. The second growth trees in the area are too young (<40 yrs.) to provide suitable foraging habitat.

With respect to aquatic species, the National Marine Fisheries service (NMFS), as administrator of the Endangered Species Act, set restrictions and guidelines for management projects requirements to minimize short-term adverse effects to aquatic habitat and listed, proposed or candidate species of Pacific salmonids (coho, chinook, and steelhead). These restrictions and guidelines include the implementation of erosion control methods (Appendix 2) such as the distribution of woody debris along and in stream channels, and minimizing the disturbance to existing riparian cover along non-fish bearing and fish bearing streams. They also define the work season as June 15 to October 15 of each year. For a complete list of the required measures to be taken to minimize impacts to threatened species, see Appendix 1.

Heavy equipment typically operated 11 hours per day, 55 hours per week. Heavy equipment operations on Unit 02-03 began August 20 and were completed October 24, 2002. The NMFS extended the work season past October 15 due to favorable weather in the later part of October.

Project Implementation

The geologist for this project was G. Gibbs. It was the project geologist's responsibility to perform all formulation and evaluation of rehabilitation prescriptions, complete the surveying and photo-documentation, generate the plansheets and technical specifications for contracting, oversee the heavy equipment operations as the contracting officer's technical representative, and complete the final documentation. Terry Spreiter, supervisory geologist for the Watershed Rehabilitation program, oversaw all work. It should be noted that due to an injury to the project geologist (after equipment season, but before the winter rains) that has prohibited any fieldwork, the traditional post-treatment monitoring has not been completed as of the time of this report.

A summary of the costs associated with restoration treatments is presented in Table 1, as well as a treatment-type specific breakdown in Tables 2-5. Primary rehabilitation treatments included the excavation of two haul road-stream

crossings, six skid road-stream crossings, 3,298 feet of export outslowing, and 3,297 feet of outslowing (Fig 3). Additional bid items included roughly 1,260 feet of “slopework”, which was mostly recontouring of skid roads associated with access to the other prescriptions of the project.

TABLE 1 WATERSHED RESTORATION COSTS SUMMARY FOR UNIT 02-03: REMOVAL OF A PORTION OF THE LOWER B500 ROAD						
TREATMENT	QUANTITY	# of JOBS	TOTAL COSTS	% OF GRAND TOTAL	AVERAGE UNIT COSTS	
HEAVY EQUIPMENT						
STREAM CROSSINGS ^(a)	8,506 yds ³	8	\$39,761.40	11.0%	\$4.67	
EXPORT OUTSLOPING	50,903 yds ³	17	\$241,958.90	66.8%	\$4.75	
OUTSLOPE	12,804 yds ³	18	\$31,174.45	8.6%	\$2.43	
MISC. BID ITEMS ^(b)	2,360 yds ³	7	\$30,159.26	8.3%	---	
<i>SUB-TOTAL:</i>	74,573 yds ³	50	\$343,054.01	94.7%	\$4.60	
PROJECT IMPLEMENTATION						
	COTR ^(c)	PERSONNEL ^(d)				
MAPPING	100 hrs	0 hrs	---	\$1,800	0.5%	---
PRESCRIPTIONS AND LAYOUTS	120 hrs	60 hrs	---	\$3,060	0.8%	---
SURVEYING	150 hrs	210 hrs	---	\$5,850	1.6%	---
CONTRACT PREP	25 hrs	0 hrs	---	\$450	0.1%	---
HEAVY EQUIPMENT SUPERVISION	360 hrs	3 hrs	---	\$6,525	1.8%	---
PHOTO DOCUMENTATION	6 hrs	0 hrs	---	\$108	0.1%	---
REPORT	50 hrs	0 hrs	---	\$900	0.2%	---
CONTRACT ADMINISTRATION	30 hrs	0 hrs	---	\$540	0.2%	---
<i>SUB-TOTAL:</i>	841 hrs	273 hrs	---	\$19,233	5.3%	
GRAND TOTAL:			\$362,287.01	100.0%	\$4.86 ^(e)	

^(a) Stream Crossing figure includes Skid Road crossings as well as Haul Road crossings.

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

^(c) COTR costs are based on the salary of one GS-9 employee (@ \$18/hr)

^(d) Personnel costs are based on the salary and benefits for one GS-5 employee (@ \$15/hr).

^(e) Grand Total Unit Cost is \$/yd³ based on total project cost (including implementation) and total cubic yards excavated.

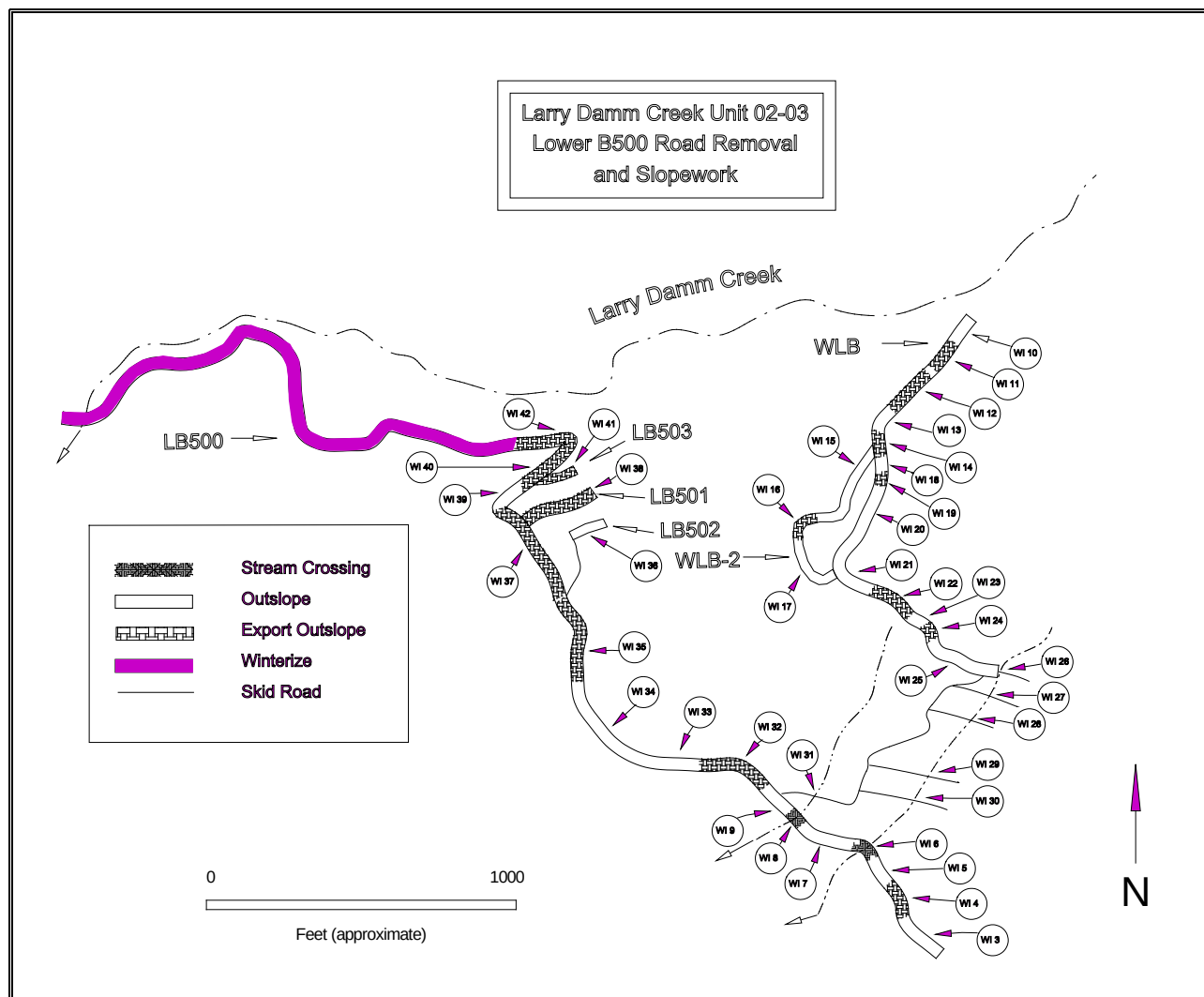


FIGURE 3. Treatment map for Watershed Restoration Unit 02-03. Roads treated include: LB500, LB501, LB502, LB503, WLB, and WLB-2.

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). Therefore, prevention of human-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. All stream crossings, including skid road crossings, for project 02-03 drain to the North Fork Lost Man Creek. A summary of stream crossing excavation costs and production rates is shown in Table 2. A narrative description of each stream crossing work item is provided below.

Stream crossing excavation rates varied significantly (Table 2). These rates are mainly attributed to site-specific conditions, but some variability is the result of intrinsic errors in time keeping. Predominately the time keeping errors are associated with the difficulty in distinguishing which prescription the equipment is working.

TABLE 2
STREAM CROSSING EXCAVATION COSTS FOR UNIT 02-03:
REMOVAL OF A PORTION OF THE LOWER B500 ROAD

WORK ITEM	WORKSITE	VOLUME (yds ³)	HEAVY EQUIPMENT HOURS					ACTUAL COSTS		TOTAL HOURS	EXCAV RATE ^(a) (yds ³ /hr)
			D8 H	D8L	D8K	400	228	TOTAL	UNIT		
6	RX 2	2727	0	10.75	0	15.25	22.5	\$11,998.80	\$4.40	48.5	56.2
8	RX 3	1547	0	1.25	8.25	14.25	8.25	\$6,961.50	\$4.50	32	48.3
30	SX 1 ^(b)	1646	0	0	6	6	19.25	\$7,407.00	\$4.50	49.25 ^(b)	33.4 ^(b)
29	SX 2 ^(b)	0 ^(b)	0	0	3	7	8	\$0 ^(b)	---	--- ^(b)	---
28	SX 3	503	0	0	4.5	0	4.25	\$2,414.40	\$4.80	8.75	57.5
27	SX 4	847	0	0	0	5.75	17	\$5,078.50	\$4.30	22.75	37.2
26	SX 5	715	0	2	0.75	8.5	4.5	\$2,931.50	\$4.10	15.75	45.4
31	SX 6	521	0	0	0	0	5.5	\$2,969.70	\$4.30	5.5	94.7
	Total	8506	0	14	22.5	56.75	89.25	\$39,761.40	\$4.67 ^(c)	182.5	46.6 ^(c)

^(a) 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.

^(b) SX-1 and SX-2 were designed to be two discrete sites, however, during excavation the stream reach between these sites required additional work to be done. This resulted in one, long continuous excavation. Pre-excavation surveys were joined, and post excavation surveys were used to calculate the total volume for both SX-1 and SX-2 that is reported as SX-1. Thus there is no volume for SX-2. Likewise, the equipment hours recorded for SX 2 were applied to SX 1 and used to calculate an overall Production Rate for the combined SX 1 and SX 2.

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

Haul road stream crossing RX-2 was the largest volume of all the stream crossing excavations. Located on the same perennial stream as skid road crossings 1-5, this crossing had the most obvious evidence of active sediment contribution. The crossing was originally a humboldt with some apparent crib logs or log stringers (i.e. logs perpendicular to stream flow) positioned on top of the humboldt logs. The road was also exceptionally wide through the crossing as a long backfill area was leveled off behind (upstream of) the ordinary road tread. The crossing had substantial (4-6 ft diameter) holes that were 3 to 12 ft deep running the length of the crossing along the path of the subsurface stream. At the outboard edge of the remaining road (pre-excavation), it appeared that an approximately 3-foot width of road had eroded a length of 20 feet down to the stream (approx 20 ft. deep).

The excavation of RX-2 proceeded without any major delays or logistical pitfalls. The finished excavation turned out to be smaller than the design excavation because it did not run as long as designed, and the sideslopes were steeper than designed for the entire length of the excavation. Neither the design TOP nor the design BOT was reached for this excavation. Bedrock was encountered at the upstream limit of excavation, below the design TOP; the downstream limit of excavation was reduced after consultation with the equipment operators and revaluation of disturbance vs. benefit for the lowest reach of the design excavation. The lowest reach of RX-2, below the finished excavation was a shallow grade and incised 1 to 3 feet, and it was determined that the configuration actually mimicked a 'natural' setting. Moreover, the likely disturbance caused to access this stream-bank fill would not be justified by the few tens of yards of material retrieved.

Haul road crossing RX-3 was located on an ephemeral stream just west of RX-2, and downstream of SX-6. This site was interpreted as a fill crossing that experienced very intermittent seasonal flow primarily accommodated by infiltration beneath the road. No culvert was present, no subsurface logs were evident, and there were not any holes present in the road tread. Above the inboard edge of the road was evidence of ponded water, and at the outboard edge of the road there was a 5 foot wide by 4 foot deep gully through the fillslope. Upstream of the crossing, the channel

was subtle and well vegetated, but a bed and bank morphology was observable. Downslope of the crossing there exists a jackstraw network of skid trails and harvest layouts, and a gully that appears to be accepting the surface flow that goes over the road, but no clear stream channel. The site was dry at the time of excavation.

During excavation, a large log was uncovered along the predicted stream path situated on top of mottled gray clay, indicative of subsurface flow. This bucked log was about 4 feet in diameter and 25 to 30 feet long and oriented almost exactly perpendicular to the road tread, which implies that it was intentionally placed here to accommodate flow. It could be argued that less water reaches this site now than at the time of road construction. The left bank of the flow course was readily defined by a bedrock exposure in the cutbank and an in situ stump near the outboard edge of the road, however, the right bank was more elusive and not well-defined. In its final post-excavation configuration the right bank, and indeed the crossing in general, was left unconfined and subtle. The absence of a channel downslope combined with the elimination of any diversion potential at the road contributed to the decision to leave the crossing broad and undefined in order to promote infiltration of water and deposition of any sediment.

Skid road stream crossings SX-1 through SX-5 are all on the same perennial stream as RX-2, located upstream between the Lower B500 road and the WLB road (See figure 3 & Table 2). All five of these crossings were similar in nature, designed as temporary crossings with no drainage structures and obvious signs of decay and sediment delivery (collapse). All except for SX-3 and SX-5 are deeply incised (steep sideslopes) and the channel is at a steep grade: SX-5 was located at a break-in-slope on the hillside, and was thus at a milder hillslope grade and has a gentler sideslope angle. SX-3 appears to be at a localized stream channel knickpoint. SX-6 was anomalous to the other skid crossings because it is located on the ephemeral stream associated with RX-3, and there was no water in the stream during the excavation.

SX-1 and SX-2 were designed as two discrete work sites, but after excavation was begun on SX-1 it was realized that one long continuous excavation, encompassing both SX-1 and SX-2, would be more restorative with a minimum of added disturbance. It was obvious after the vegetation was cleared from SX-1 that the left bank of the channel, between the two sites (above SX-1), was skid fill that could be easily retrieved. For excavation volume bookkeeping the original design surveys were joined, and the 15 feet of unsurveyed length between them inserted, to make one long excavation design encompassing both sites. The lower reaches of the excavation were confined by a bedrock knocker on the right bank and sheared bedrock on the left bank. The upstream extent of the excavation was more ambiguous, and the sideslopes were designed to have a gentle grade and blend original channel bottom with inferred probable original ground.

Sx-3 is the smallest of the crossing excavations. The ease of excavation here was due in part to the prominence of bedrock within the crossing. This crossing appeared to be at an underlying knickpoint. The upper and lower extents of the excavation were defined by bedrock, and the natural stream gradient is unusually shallow through this crossing. Therefore, because the channel was not significantly incised at this site, the majority of the fill was efficiently removed using a bulldozer.

Sx-4 was the most complicated of the Skid Crossings. The factors contributing to the complexity at this site were: a very narrow upper end, a very confined, narrow channel with steep sideslopes, and the presence of a thick gooey clay lens that contributed to almost 75% of the material to be excessively wet. In addition, a fifty foot length of skid road approaching the crossing required removal, something not encountered at the other skid crossing sites. The general confinement of the site eliminated any substantial use of a bulldozer. In fact, the confinement coupled with the excessive moisture required the use of two excavators (and a triple-swing) for most of the work. The position of the skid road approaching the site dictated that the spoils from the site be transported further offsite than at the other skid crossing sites.

SX-5 is located at the highest elevation of all the stream crossings and coincides with the general position of the WLB road. Along the entire hillslope at this elevation there is a decrease in slope steepness from here to the peak, observable on a topographic map, that may be the morphological expression Prairie Creek Formation above the contact with the Franciscan Formation. This site is noteworthy because of its long flat aggraded sediment wedge upstream of the crossing, which is more commonly observed in the lowermost hillslope position elsewhere in the basin. Because of the channel morphology upstream of the skid road, the top of the excavation could not be reasonably placed so as to uncover the pre-disturbance channel bottom upstream of the road. Consequently, the excavation at the upper end of the crossing began in unconsolidated gravels and tapered gently to the natural channel bottom beneath the skid road. Some adjustment is expected to occur in this portion of SX-5.

SX-6 was a very straightforward excavation that was done almost entirely with a bulldozer. Moreover, there was absolutely no water encountered on this site. This accounts for the abnormally high excavation rate for this site.

Export outslope (EOS) treatments are performed where the road fill cannot be stored locally and needs to be endhauled to a stable fillsite. A bulldozer performed all endhauling on this project, pushing material to its storage site. There were a number of EOS treatments performed on project 02-03. The noteworthy EOS sites are described below. Project costs for EOS treatment are summarized in Table 3.

TABLE 3 EXPORT OUTSLOPE EXCAVATION COSTS FOR UNIT 02-03: REMOVAL OF A PORTION OF THE LOWER B500 ROAD											
WORK ITEM	WORK SITE ^(a)	VOLUME (yds ³)	HEAVY EQUIPMENT HOURS					ACTUAL COSTS		TOTAL HOURS	EXCAV RATE ^(b) (yds ³ /hr)
			D8H	D8K	D8L	228	400	TOTAL	UNIT		
4	2+25 to 4+25	1,716	0	4.0	15.0	5.0	17.5	\$5,662.80	\$3.30	40.5	42.4
MOD 1	9+50 to 11+35	1,573	0	0	0	7.0	13.5	\$6,763.90	\$4.30	20.50	76.7
11	4+20 to 5+80	833	0	4.75	8.50	4.75	4.25	\$3,345.30	\$4.02	22.25	37.4
12	5+80 to 8+05	1,833	0.5	8.0	5.50	5.75	19.75	\$6,598.80	\$3.60	39.5	46.4
14	9+80 to 11+40	2,453	0	14.0	0	15.25	18.0	\$8,830.80	\$3.60	47.25	51.9
16	4+71 to 5+65	152	0	2.75	0	2.5	3.0	\$509.20	\$3.35	8.25	18.4
19	12+11 to 12+41	168	0	0.75	0	0	0.5	\$604.80	\$3.60	1.25	134.4
22	15+60 to 17+75	1,831	0	4.5	3.75	0	10.5	\$6,042.30	\$3.30	18.75	97.7
24	18+71 to 19+60	176	0	0	1.0	0	1.75	\$580.80	\$3.30	2.75	64.0
32	11+35 to 14+45	6,918	0	0	16.5	1.0	18.5	\$24,904.80	\$3.60	36.0	192.2

TABLE 3 EXPORT OUTSLOPE EXCAVATION COSTS FOR UNIT 02-03: REMOVAL OF A PORTION OF THE LOWER B500 ROAD											
WORK ITEM	WORK SITE ^(a)	VOLUME (yds ³)	HEAVY EQUIPMENT HOURS					ACTUAL COSTS		TOTAL HOURS	EXCAV RATE ^(b) (yds ³ /hr)
			D8H	D8K	D8L	228	400	TOTAL	UNIT		
35	21+50 to 25+10	14,060	0	34.5	45.25	25.25	38.75	\$79,291.50	\$5.64	143.75	97.8
37	25+10 to 30+40	6,904	0.5	28.5	32.25	57.25	33.25	\$26,974.00	\$3.91	151.75	45.5
38	0+00 to 3+40	2,092	2.5	4.0	1.5	4.75	25.75	\$7,531.20	\$3.60	38.5	54.3
MOD 7	30+40 to 31+45	300	0	3.5	0	0	2.5	\$1,005.00	\$3.35	6.0	50.0
40	31+45 to 34+00	2,657	0	9.0	7.5	8.0	8.75	\$10,224.60	\$3.85	33.25	79.9
41	0+00 to 1+15	709	0	1.0	0	9.5	0	\$2,481.50	\$3.50	10.5	67.5
42	34+00 to 36+15	6,528	0	35.5	32.75	7.25	24.5	\$50,607.60	\$7.75	100	65.3
Total		50,903	3.5	154.75	169.5	381.25	640.75	\$241,958.90	\$4.75 ^(c)	720.75	70.6 ^(c)

^(a) Work Sites are referred to by station number, but may be located on either the Lower B500 or the WLB road. For specific site location, cross reference the Work Item # with the treatment map (Figure 3).

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

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

Work Item #4 was a very interesting site. The setting was a flowing spring at the inboard edge of the road that had saturated a 50' section of road, but no obvious flow course was evident. About 100 feet down road (towards 0+00), and downslope about 150 feet, there is an incised v-shaped channel with flow originating underneath a skid road. Moreover, there was no evidence of a channel upslope of the Lower B500 road. So, it appeared that the flow course crossed the road (and 2 skid roads) at an oblique angle, which is uncharacteristic. The final, restored, configuration was a large meander from the spring downslope to the v-shaped channel.

Work Item #14 is located on the WLB road near the headwall of a swale that eventually drains to Larry Damm Creek. It is positioned in the concave hillslope morphology adjacent to a ridge that has prominent bedrock outcrops. The fill volume at this site was large relative to the length of road treated because the site is also located at the edge of a landing, which is much wider than the average road reach. Upslope of this site there is no watercourse, but there is a skid road that has evidence of some minor periodic flow potentially contributing to the hydrologic input. Downslope of this site water had been diverted out of the axis of the swale, and down a skid road that runs parallel to the ridge. In addition, there was surface erosion on the landing that indicated some percentage of water had diverted across the landing, eroded the outer edge of the landing, and flowed into an alternate drainage. Compounding the problem is a jackstraw network of skid roads in the subdrainage below the site that continue so far downslope as to be cost/disturbance prohibitive.

The strategy for restoration at this site was to remove the landing fill from the swale and eliminate the diversion potential at the road, and to manipulate the skid road immediately below the site enough to eliminate the diversion along the ridge.

Work Item #35 is the largest EOS treatment of this restoration project with just over 14,000 yd³ excavated. The excavation of this section of road resulted in a very broad headwall to a swale that is undefined upslope of the Lower B500 road. The extensive ground disturbance upslope of the road has generated numerous undefined and intermittent potential flow paths, which suggested that a broad headwall in the position of the road would be the best strategy for controlling the water course and eliminating diversion potential. The bulk of the excavation actually came from below the Lower B500 road proper in order to retrieve fill associated with skid roads and harvest layouts that were creating multiple diversions. It should be noted that about 100' below the bottom of the excavation there is a large gully (~ 3'w x 5'd). Another point of interest is that the majority of the fill for this site was spoiled on a skid road upslope of the Lower B500 road at approximately station 24+50. Spoil was used to control flow at the upper most extent of the skid, and to fill a 15' high throughcut about midway up the skid.

This site was referred to as “the landslide-switchback” site. Before the project began, this section of road was impassable due to a saturated and slumped reach about 80 feet long. Moreover, it was apparent from air photo analysis that a large hillslope debris slide had deposited on this section of road (and the skid immediately downslope) in the early 1970s. The erosion/transport zone of the slide (upslope of the LB500 switchback) was greater than 300 feet long and an average of 80 feet wide; the lateral scarps are on the order of 3-6 feet high. The morphology of the feature (pre-treatment) on the road proper was analogous to a depositional fan in that there were multiple anastomosing gullies through the deposit and road fill. The evidence suggested that the subsurface flow had saturated the fill/deposit to a threshold that induced surface flow at slightly different locations since 1972. An alternate interpretation is that the erosion/transport zone of the slide scar carries surface flow seasonally and that this flow may or may not be redirected at the interface with the deposit/road zone; or conceivably redirected somewhere in the transport zone.

The strategy for restoration at this site was to remove the road fill and the landslide deposit in order to relieve the oversteepened burden above Larry Damm Creek and to direct the upslope water into a single flowcourse. No topsoil was discovered at this site. The switchback area was excavated down to the “sheared black schist” bedrock (Franciscan).

Outsloping (OS) treatments are used to reconstruct the original contours along a road corridor. This involves the removal of fill from the outboard edge of a road and placing it along the cutbank. Recontouring restores natural drainage patterns and results in the recovery of original side cast soil elements. Recovering the original sidecast topsoil from the outboard edge of the road and distributing it across the finished excavation enhances the process of revegetation dramatically (Popenoe and Martin, 1990). In addition, the dispersal of organics (i.e. trees, sidecast logs and rootwads, etc.) along the finished slopes is believed to provide additional organic material for revegetation as well as provide suitable habitat for wildlife. Excavation costs for outslope treatments are summarized in Table 4.

TABLE 4 OUTSLOPE EXCAVATION COSTS FOR UNIT 02-03: REMOVAL OF A PORTION OF THE LOWER B500 ROAD											
WORK ITEM	WORK SITE ^(a)	VOLUME (yds ³)	HEAVY EQUIPMENT HOURS					ACTUAL COSTS		TOTAL HOURS	EXCAV RATE ^(b) (yds ³ /hr)
			D8H	D8K	D8L	228	400	TOTAL	UNIT		
3	0+00 to 2+25	447	0	1.5	0	0	7.0	\$1,139.85	\$2.55	8.5	52.6

TABLE 4
OUTSLOPE EXCAVATION COSTS FOR UNIT 02-03:
REMOVAL OF A PORTION OF THE LOWER B500 ROAD

WORK ITEM	WORK SITE ^(a)	VOLUME (yds ³)	HEAVY EQUIPMENT HOURS					ACTUAL COSTS		TOTAL HOURS	EXCAV RATE ^(b) (yds ³ /hr)
			D8H	D8K	D8L	228	400	TOTAL	UNIT		
5	4+25 to 5+30	354	0	0	3.0	4.0	3.0	\$902.70	\$2.55	10.0	35.4
7	6+50 to 8+70	424	0	0	0	0	3.5	\$1,017.60	\$2.40	3.5	121.1
9	9+50 to 11+35	395	0	0	0	1.5	3.5	\$1,007.25	\$2.55	5.0	79.0
10	3+00 to 4+20	194	0	1.5	0	0	1.5	\$465.60	\$2.40	3.0	64.7
13	8+05 to 9+80	1,381	0	0	0	9.5	7.75	\$3,521.55	\$2.55	17.25	80.1
15	0+00 to 4+71	2,524	0	2.5	0	0	10.0	\$6,183.80	\$2.45	12.5	201.9
17	5+65 to 7+10	474	0	0	0	0	7.0	\$1,137.60	\$2.40	7.0	67.7
18	11+40 to 12+11	333	0	0.75	0	2.0	2.0	\$849.15	\$2.55	4.75	70.1
20	12+41 to 15+10	1,110	0	0	0	0	5.5	\$2,719.50	\$2.45	5.5	201.8
21	15+10 to 15+60	328	0	0.75	1.25	0	1.5	\$738.00	\$2.25	3.5	93.7
23	17+75 to 18+71	286	0	0	0	0	3.25	\$729.30	\$2.55	3.25	88.0
25	19+60 to 21+50	713	0	0	2.5	0	3.5	\$1,604.25	\$2.25	6	118.8
27a	SX-4	204	0	0	6.5	0	0	\$499.80	\$2.45	6.5	31.4
33	14+45 to 18+60	966	0	0	0	0	18.0	\$2,173.50	\$2.25	18.0	53.7
34	18+60 to 21+50	1,492	0	0	0	0	17.75	\$3,655.40	\$2.45	17.75	84.1
36	0+00 to 1+10	127	0	0	0	1.25	0	\$304.80	\$2.40	1.25	101.6
39	30+40 to 31+45	1,052	0	8.0	3.0	0	6.0	\$2,524.80	\$2.40	17.0	61.9
	Total	12,804	0	15	16.25	18.25	100.75	\$31,174.45	\$2.43 ^(c)	150.25	85.2 ^(c)

^(a) Work Sites are referred to by station number, but may be located on either the Lower B500 or the WLB road. For specific site location, cross-reference the Work Item # with the treatment map (Figure 3).

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

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

Miscellaneous bid items on this project included Move In and Move Out costs. Additional bid items were “To Be Negotiated” slopework and winterization of the access road at the end of the work season. All of these miscellaneous bid items were Lump Sum items. Table 5 provides a cost breakdown for miscellaneous bid items.

TABLE 5: MISCELLANEOUS BID ITEM COSTS FOR UNIT 02-03: REMOVAL OF A PORTION OF THE LOWER B500 ROAD									
WORK ITEM	JOB	QUANTITY	HEAVY EQUIPMENT HOURS					ACTUAL COSTS	
			D8H	D8L	D8K	400	228	TOTAL	UNIT
1	MOVE IN ^(a)	1 JOB	---	---	---	---	---	\$5,586.13	---
1a	MISC Move In ^(b)	1 JOB	2	9	2	9	9	\$8,027.00	---
2	MOVE OUT ^(c)	1 JOB	---	---	---	---	---	\$5,586.13	---
2a	Winterization ^(d)	1 JOB	1	1	1	5	12	\$5,060.00	---
31a	SLOPEWORK ^(e)	2210 yds ³	---	---	---	---	---	\$5,525.00	\$2.50
MOD 6	SLOPEWORK ^(e)	50 yds ³	---	---	---	---	---	\$125.00	\$2.50
37b	SLOPEWORK ^(e)	100 yds ³	---	---	---	---	---	\$250.00	\$2.50
	TOTAL	2360 yds³						\$30,159.26	

^(a) Move In is actual expenses incurred by the Contractor to mobilize heavy equipment to the lowboy drop-off point.

^(b) Miscellaneous Move In includes road opening (brushing and minor rebuilding), fuel and maintenance equipment set-up, as well as the walk-in time from the lowboy drop-off point to the first work site.

^(c) Move Out is actual expenses incurred by the Contractor to mobilize heavy equipment from the lowboy drop-off point to “home”.

^(d) Winterization is road and slope work intended to minimize any potential erosion on untreated road that was left in the project area. This cost includes the installation of 12 rolling dips, fuel and maintenance equipment tear-down, as well as the walk-out time from the last work site to the lowboy pick-up point.

^(e) Slopework is negotiated “lump sum” treatments that are outside the bounds of the road fill (and therefore, the surveyed work items). The approach on this project was to negotiate an agreeable volume and unit cost (for each slopework site) in order to arrive at a lump sum cost. Thus, equipment times were not recorded, and volumes are only estimates.

Rolling dips were constructed as a winterization treatment at various locations along the remaining Lower B500 Road from the project stopping point down to the Larry Damm Creek stream crossing. These were installed to prevent the possibility of diversions running on the untreated road, and to minimize the impacts to the watershed in the event of a large storm occurring prior to possible treatment

Discussion

The removal of this portion of the Lower B500 Road (including the WLB secondary haul road) and associated road-stream and skid trail crossings was the action most consistent with 2001 National Park Service Management Policies, the 1999 RNSP General Management Plan, PL 95-250 Section 101(6), and the 1981 RNSP Watershed Rehabilitation Plan. The implementation of this project effectively eliminated unnatural sediment sources associated with the road and disturbed hillslopes. Diversion potentials were eliminated through the restoration of natural hillslope topography and drainage patterns. This restoration minimized the potential for both hillslope and sidecast failures and delivery of unnaturally large quantities of sediment to North Fork Lost Man and Larry Damm Creeks (as well as their tributaries). The uncovering of nutrient-rich soil and the spreading of organic debris on finished surfaces should greatly speed the recovery of native vegetation. The thorough treatment of this portion of the Lower B500 and surrounding hillslopes has reduced the potential impacts to downstream resources in the Redwood Creek watershed.

Typically, outslope and export outslope treatments were quite successful. The uncovering of original soil elements will allow for quick revegetation of grasses and small plants. The placement of recovered organics atop the finished slopes will help minimize surface erosion. Restoring natural drainage patterns eliminated concentrated surface flow thereby reducing the erosion to the finished slopes.

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

Finally, the most important skill acquired during the administration of this project was the ability to maintain flexibility in the design. Unlike typical contracted work, watershed restoration aims at recovering a product, not constructing it. Because the pre-existing features are initially covered, all designs are based upon extrapolation of the surrounding conditions. Consequently, these surrounding conditions provide guidance towards meeting the ideal but by no means provide a total map to reaching it. Because there is no way to know what lies under a road until it is excavated, there must be flexibility towards guiding the excavation by what is uncovered. This flexibility is what makes the difference between creating an engineered product and restoring a natural condition.

Acknowledgements

The restoration work accomplished by the completion of Unit 02-03 is the result of the dedication and hard work of numerous individuals. This report is a compilation of those efforts.

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Appendix 1

(Biologic Considerations)

From: A Biological Assessment of Impacts to Aquatic Threatened Species from the Watershed Restoration Program in the Northern Portion of Lost Man Creek Watershed, Redwood National and State Parks, 2002.

Post Excavation Monitoring

All completed projects are visited a number of times during the first winter, and photo-points established prior to excavation are re-photographed. The distribution of woody debris and rock in the excavated channel may be rearranged using hand tools, to minimize post-excavation erosion. Additional on- and off-site monitoring is described in the Post-excavation Erosion Control Plan in the appendix 2.

Measures Taken to Minimize Impacts to Threatened Species

- 1) RNSP geologists will continue to plan and design all excavation work. The geologist that planned and designed the work will continue to directly oversee all excavation work on the ground as it proceeds and follows the POST-EXCAVATION EROSION CONTROL GUIDELINES as written in Appendix 2.
- 2) A detailed, final project summary report, similar to those normally prepared by the parks, will be submitted to NMFS by the end of the July following project completion.
- 3) RNSP will ensure that erosion control measures are used to minimize short-term adverse effects to aquatic habitat and listed, proposed, or candidate species of Pacific salmonids.
- 4) Woody debris will be concentrated on finished slopes adjacent to stream crossings to reduce surface erosion, contribute to amounts of organic debris in the soil, encourage fungi, provide immediate cover for small terrestrial species and to speed recovery of native forest vegetation.
- 5) Large woody debris will be placed in the streams when completing crossing excavations. This will provide storage locations for trapping sediment that moves through the channel from natural upstream and post-excavation erosion, and provide immediate cover for aquatic/riparian species.
- 6) Riparian cover on fish-bearing streams and non fish-bearing (where non-fish bearing streams lead immediately into fish-bearing waters) will be protected wherever reasonably feasible, balancing quality and benefits of the riparian cover against risks of sediment delivery. Proposed treatments in riparian areas will be reviewed by an interdisciplinary team prior to implementation; the team will include a park restoration geologist and a park fishery biologist.
- 7) All non-emergency project work will be completed during the normal operating season (NOS), that is, between June 15 and October 15 of each year. If more than 0.5 inches of rain is forecast during the dry season, project operations will temporarily cease and sites will be winterized. If periods of dry weather are predicted outside of the NOS, additional small work items may be done, if they can be completed within the window of predicted dry weather. Only those repairs needed to reduce risks from active erosion will be undertaken outside of the NOS, in coordination with NMFS.
- 8) Work sites will be winterized at the end of each day when significant rains are forecast that may cause unfinished excavations to erode. Winterization procedures are supervised at all times by RNSP geologists and involve taking measures necessary to minimize erosion on unfinished work surfaces. Winterization includes the following: smoothing unfinished surfaces to allow water to freely drain across them without concentrating or ponding; compacting unfinished surfaces where concentrated runoff may flow with an excavator bucket or similar to minimize surface erosion and the formation of rills; and installation of culverts, silt fences and other erosion control devices where necessary to convey concentrated water across unfinished surfaces, and trap eroded sediment before it leaves the work site.
- 9) Equipment, both hand tools and heavy equipment, will be inspected daily to check for leaks. Equipment that may leak lubricants or fuels into drainage will not be used until leaks are repaired. All equipment will be stored, serviced and fueled outside of riparian areas and away from stream crossings. Heavy equipment will be cleaned (e.g., power washed, steam cleaned) prior to use below the ordinary high water mark.

10) A spill plan and materials for spill containment will be available to onsite personnel and all personnel shall know how to use them. In the event of a spill, work shall be stopped immediately, clean up shall begin and the appropriate authorities will be notified.

11) Petroleum products, chemicals, fresh cement, deleterious materials, or water contaminated by the aforementioned shall not be allowed to enter flowing waters.

12) Disruption of natural hydrologic flow paths, including diversion of streamflow and interception of surface and subsurface flows, shall be minimized during excavation.

13) Adequate erosion control supplies (gravel, straw bales, shovels, etc.) shall be kept at all restoration sites to ensure materials are kept out of water bodies.

14) Water drafting from fish-bearing streams will be conducted only at sites approved by a park fishery biologist, and shall be done in accordance with NMFS's "Water Drafting Specifications".

15) Any disturbed ground must receive appropriate erosion control treatment prior to the beginning of the wet season. (See Appendix 2)

16) Streams with significant surface flow capable of sediment transport off-site must be diverted around excavation areas. The diverted flows shall be returned to their natural streamcourse as soon as restoration is complete and prior to the rainy season. Any turbid wastewater from project activities and de-watering is disposed of off-site in a location that will not drain directly into a stream channel or carry sediment laden water into a stream channel.

17) Listed salmonids that would be in the area shall be removed prior to and during stream flow diversion and de-watering. Listed salmonids will be relocated to a suitable instream location immediately up or down stream of the work area. This will be done by qualified fishery biologists using nets to capture and relocate listed salmonids when practical. When it is necessary to use electroshockers, the Park will follow and be consistent with NMFS guidelines. The Parks' section 10 permit does not cover the capture and relocation of listed salmonids during culvert replacement and installations activities, therefore take coverage is necessary. All efforts shall be taken to neither exhaust nor kill listed salmonids during the capture and relocation process.

18) Effective erosion control measures shall be in place at all times during restoration activities. Activities within the 5-year floodplain will not begin until all temporary erosion controls (e.g., straw bales, silt fences that are effectively keyed in) are in place, downslope of project activities within the riparian area. Erosion control structures shall be maintained throughout, and possibly after, activities. Erosion control devices such as check dams, silt fences, and other acceptable techniques, shall be used when the potential exists to have sediment or other materials entering water bodies. Note: The maintenance of all roads used to access work sites for the North Fork of Lost Man and Larry Damm Creeks are listed and covered in the current Routine/Non-Routine Road Maintenance BA.

Appendix 2
POST-EXCAVATION EROSION CONTROL GUIDELINES

POST-EXCAVATION EROSION CONTROL GUIDELINES

INTRODUCTION

Studies have shown that erosion from roads is a primary cause of the decline in salmonids throughout the Pacific Northwest. In Redwood National and State Parks (RNSP), the erosion and resultant sedimentation downstream is also threatening streamside ancient redwoods by increased bank erosion and flooding. The parks are actively involved in watershed restoration work, with the goals of reducing unnaturally accelerated erosion, restoring natural geomorphic and hydrologic processes, and speeding the recovery of native forest vegetation in areas disturbed by the logging and road building that occurred before park acquisition.

These goals are achieved by:

- completely excavating stream crossing fills,
- excavating potentially unstable sidecast road fills,
- uncovering buried topsoil where reasonably feasible,
- placing native vegetative debris and large woody debris on the finished surfaces, and
- transplanting native plant species on finished slopes where a boost to re-establishment of vegetation is needed.

During the restoration process, large volumes of road fill are excavated using heavy equipment, and re-distributed to stable locations. The potential exists for post-excitation erosional adjustments to occur, particularly if the excavations do not uncover the original channel beds and banks, or where roads are located on unstable slopes. Generally the total volume of post-excitation erosion is small in comparison to the volumes being prevented from eroding by moving road fill from removed stream systems. However, new information on the effects of turbidity and suspended sediment on the survival of young salmonids has raised concerns about the surface erosion that may occur during the first winter post-excitation. This document describes measures that will be taken to control this erosion, and minimize management-related contributions to downstream turbidity and suspended sediment.

BACKGROUND

The watershed restoration program goals of erosion control and restoring geomorphic/hydrologic processes focus on removing road fill from stream crossings, minimizing failure of sidecast road fill into streams, and reducing driving forces on management-related mass movements. Initial adjustments and potential for continued post-treatment erosion were generally most pronounced in the early years of the watershed restoration program before more effective excavation techniques were developed. Myriad combinations of ground cover and vegetation were used to reduce surface erosion from treated areas. Various methods were tried to reduce fluvial erosion following the stream channel treatments, including building check dams and placing rock armor in the flow courses. As heavy equipment techniques were improved, more complete excavations became cost-effective, and the need for secondary erosion control treatments declined. Extensive monitoring and cost-effectiveness analyses were undertaken during this period, providing feedback to the restoration project leaders. This information is described in RNSP's technical report series and numerous other papers.

SURFACE EROSION CONTROL

In the early years of the restoration program, the park relied on imported mulch and other surface erosion control blankets reduce post-excitation surface erosion. At that time, there was little vegetation that had to be removed in order to do the work, or to spread on finished surfaces, and there was little choice but to import mulch or other blanket materials. In the late 1980's, approximately \$50,000, or 10% of the erosion control and watershed restoration implementation budget, was being invested in straw mulch (includes purchase, delivery and spreading costs).

In 1989, the cost-effectiveness of controlling surface erosion was reviewed, particularly in light of the improving efficiency of heavy equipment excavation techniques. The \$50,000 spent on straw would also move 25,000 cubic yards of sediment from the stream system, or completely recontour 5 miles of road. Minimizing the small volume of sediment generated from surface erosion post-excitation was not viewed as cost-effective in addressing the large-

scale problems associated with abandoned logging roads. The decision was made to greatly reduce straw mulching, and concentrate on more complete excavations of stream channels and sidecast road fills (Spreiter, personal communications).

Aside from the benefit of removing more sediment from the stream system, other restoration goals were addressed by the additional earthmoving. Natural hillslope drainage patterns were restored, potentially unstable sidecast fills were stabilized, and buried topsoil was uncovered beneath the fill. Native forest species quickly re-established on the organic and nutrient rich soil. Meanwhile, the heavy applications of straw most effective at controlling surface erosion were found to slow the re-establishment of native forest species, and straw, although certified weed-free, generally introduced exotic species. The additional earthmoving also eliminated long term maintenance and potential future failures associated with inboard ditch and cross-road ditch systems that had been constructed along many of the treated roads in the early years.

At the same time, the density and size of vegetation along the road corridors was increasing. On a few projects, large amounts of vegetative debris were buried in fillsites. This practice was quickly discontinued, with the realization that large voids would develop as the debris decayed, potentially affecting slope drainage and stability. Vegetative debris began to be stockpiled and scattered on the finished slopes. Benefits to re-establishment of vegetation were quickly noted, as many of the first successful plants were those protected by the cover of the debris. It was also noted that where shallow slumping occurred on finished slopes, the vegetative debris acted as a “binder”, trapping much of the mobilized material. This has been the standard practice for the last 10 years.

New Developments

Recently, concerns have been raised about post-excavation surface erosion potentially contributing to turbidity and suspended sediment in the fish-bearing streams, impacting young salmonids. These concerns have caused RNSP to re-evaluate the importance of surface erosion control measures.

In order to address these new concerns, the parks propose to alter the distribution of the vegetative debris. Rather than random scattering of debris, vegetative material will be collected and concentrated on slopes adjacent to live streams and other locations where fine sediment may be mobilized and enter the stream system. If there is not enough on-site vegetative debris to achieve the desired level of ground cover, additional materials may be imported to the site. Materials will be selected to comply with NPS guidelines to minimize introduction of exotics and interference with re-establishment of native forest species. Shredded redwood bark is the current preferred material.

Guidelines have been established to help determine where surface erosion control materials will be most useful, and in what quantities, based on the factors that affect erosion and transport of fine sediment, described below. Interactions between these factors are often complex and somewhat unpredictable. Best professional judgement will be used in analysis of these factors in the field.

The potential for surface erosion from a completed watershed restoration project is largely a function of:

Material properties (e.g., texture, cohesion, coarse fragment content, etc.) of the soil subject to erosive forces.

Slope length of the finished area (in a downslope direction).

Slope steepness of the of the finished area (in a downslope direction)

Slope form or convergence of the finished slopes.

Surface treatments applied to control erosion following earthmoving activities (ground cover type and degree of cover or rate of application).

The potential for sediment delivery to a stream channel is largely a function of buffer characteristics:

Slope steepness of the hillslope between the treated area and the stream.

Slope length from the treated road segment down to a stream channel

Surface conditions of the intervening slope (e.g., slope form, ground cover) that control the ability of the intervening slope to trap sediment delivered from upslope prior to reaching the channel.

A chart (Figure 1) has been developed to help plan the surface erosion control efforts. The rationale for the chart is that the potential for sediment delivery from finished slopes to streams is largely a function of the ability of the intervening ground to trap eroded sediment as it moves downslope. In general, excavated stream crossing side slopes have the highest risk of sediment delivery if not treated with preventative measures. Adjacent recontoured road segments that approach a stream crossing will have a relatively moderate to high sediment delivery risk, depending on the buffering factors. Road segments that are not near a stream crossing will have relatively low risk of sediment delivery, except: 1) where such segments are crossed by fluvial transport features (rills, gullies, swales), and 2) where such segments are located low on the hillslope, in close proximity to stream channels. Low risk areas may be left bare in order to insure adequate cover at the higher risk locations.

Controlling post-earthmoving erosion and sediment delivery from watershed restoration projects in a cost-effective manner requires balancing erosion and sedimentation risks with treatment costs and site logistics. While the chart provides guidance, site-specific conditions both on the finished slope and within the buffer will affect the amount of ground cover actually needed to achieve the goals of reducing downstream turbidity and suspended sediment. For example, the greater the levels of duff, live vegetation, downed woody debris and micro-topography within the buffer, the greater the natural trapping efficiency, and the less ground cover needed on the finished slope directly above. Where particularly vulnerable species or habitat are located immediately downstream, or where highly erodable soils are found, the guidelines shall be adjusted to favor more complete surface erosion control. Conversely, some areas may allow relaxing of guidelines, for example where buffer zones have atypically high sediment trapping efficiency due to topographic benches or particularly dense understory and litter accumulations or where excavated materials contain large coarse fragment content that would readily form an erosion pavement.

These guidelines will be used and adapted as needed to actual field conditions to insure that fine sediment is prevented from entering the stream systems as much as is reasonably possible. Best professional judgement of an interdisciplinary team including a park geologists and park biologist will be used in analysis of these factors in the field.

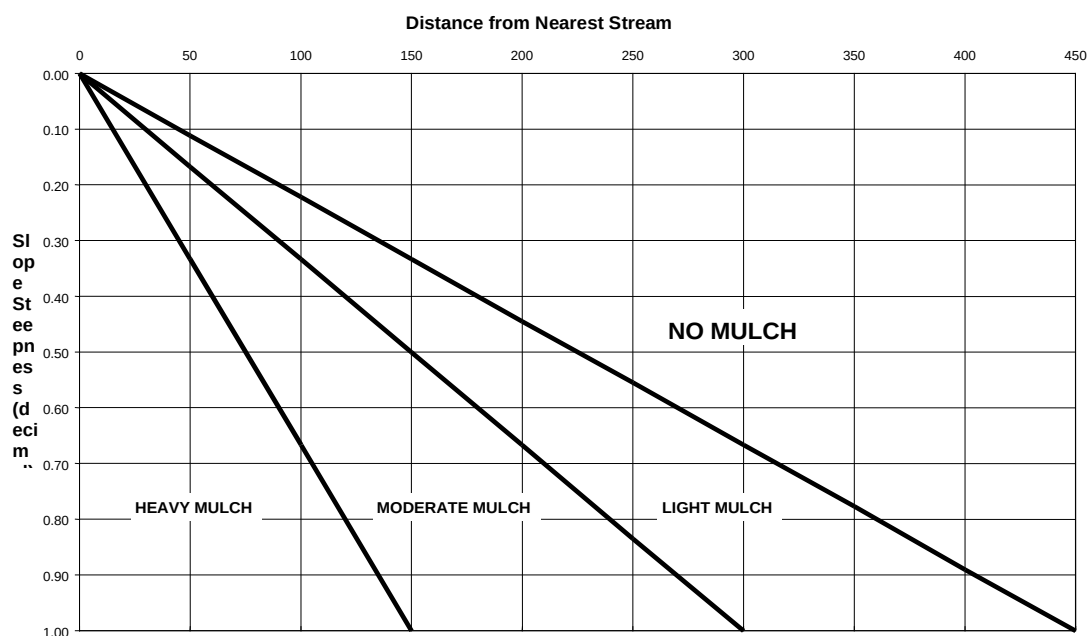


Figure 1. Mulching Guidelines

In planning ground cover needs, the site geologist will estimate the finished slope steepness and length along road segments with potential to contribute surface erosion to streams, and use the guidelines to determine appropriate ground cover rates. Where flow is expected to cross the finished slopes, ground cover will be increased to reduce erosion and trap sediment. Small swales that may not exhibit signs of surface runoff will also be covered with vegetative debris to reduce erosion and sediment delivery. Ground cover in both cases will be done to “moderate” specifications. As excavations proceed, and slopes are finished, final adjustments to ground cover rates will be made to insure the intent of reducing downstream turbidity and suspended sediment is achieved.

There is abundant vegetation that must be disturbed in order to get to the fill that needs to be excavated, and this material provides a good source of on-site, native material that can be used as ground cover. Recently, this material has been spread relatively evenly over all finished slopes, but observations show that this often results in insufficient ground cover to control surface erosion adjacent to streams. Practices are being changed to collect this material and concentrate the vegetative debris on finished slopes leading directly to streams, and on recontoured slopes where the downslope buffer is inadequate to catch mobilized fine sediments.

Where surface erosion control is critical equipment operators will be asked to “mash” the woody debris to increase ground contact. If needed, hand crews will cut and lop debris that is suspended to further increase ground contact, following placement of the debris with the heavy equipment. Woody debris scattering may have to be supplemented with imported mulching material (shredded bark, wood chips, etc.) to achieve the needed ground coverage. This would consist of applying the imported mulch over small bare areas that compose gaps in woody debris application.

From previous monitoring studies, surface erosion from bare areas is greatest the first winter following earthmoving, then declines exponentially in subsequent years as erosion pavements and leaf litter accumulate and revegetation proceeds. To speed re-establishment of vegetation, and provide long-term surface erosion control, seed bearing vegetation may be collected and scattered on the slopes to spread native seed. Similarly, duff, laden with seed, nutrients and fungi may be collected and scattered. Care will be taken not to impact source areas.

Figure 2 represents a hypothetical application of the surface erosion control guidelines to a watershed restoration project to be implemented in 2002 (note that this was a map exercise as would be used in project planning; actual ground-based prescriptions will vary somewhat).

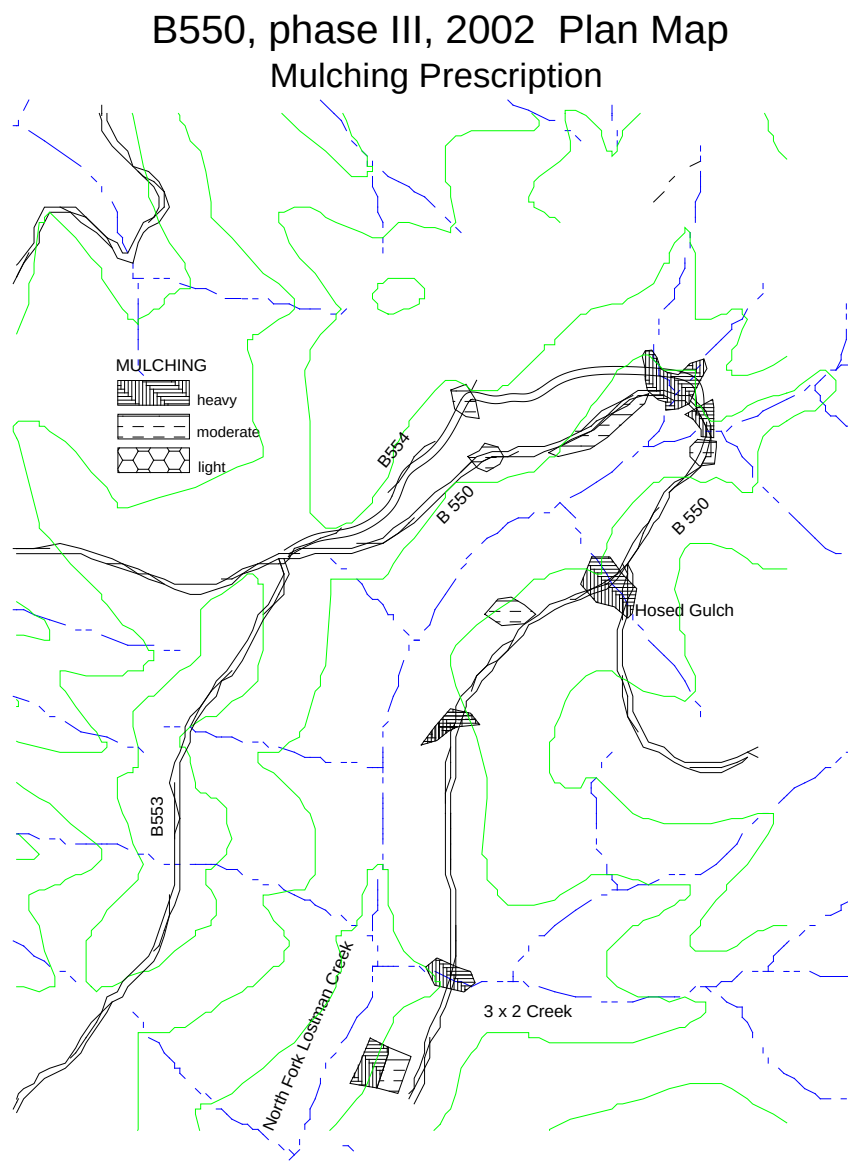


Figure 2. Hypothetical application of surface erosion control guideline to a planned 2002 rehabilitation site. Roads, streams, and contour lines are shown.

Figure 3. Vegetative debris mulching on excavation sideslopes provides for control of surface and fluvial erosion (this depicts a heavy rate of mulch application). Note the excavated stream channel with large woody debris placement in the foreground.



CHANNEL EROSION CONTROL

With the parks' goal of re-exposing the natural channel bed and banks, stream channel adjustments following excavation are generally small in volume (less than 5%), relative to the amount of material removed from the stream system during excavation. Adjustments are most pronounced during the first winter, but the erosional response is also affected by the sequence of high flow events following excavation.

The potential for channel erosion from a completed stream crossing excavation is largely a function of:

Stream power during storm runoff events (proportional to drainage area and channel gradient).

Material properties (e.g., texture, cohesion, coarse fragment content, etc.) of the soil subject to erosive forces.

Length of the excavated channel.

Steepness of the excavated channel.

The degree to which intact **original channel structure** (woody debris, boulders, bedrock) was exhumed upon completion of the excavation.

The type and degree of **treatments** applied to control channel scour following earthmoving activities.

Sediment delivery resulting from scour processes in stream channels is immediate and total. While many types of channel erosion control measures might be considered (and have been used in the past at RNSP), the park relies on finding original channel structure, supplemented by large woody debris placement. Check dams or import rock riprap to armor channels were tried and abandoned primarily due to the high cost, high maintenance and questionable ecological consequences of using non-native materials and structures. The best case scenario for avoiding significant channel adjustment (scour) is successful excavation of original channel beds and banks.

Fortunately this is usually possible. In addition, large woody debris encountered during excavation is placed in arrangements that mimic natural accumulations observed in stream channels. In most cases, abundant woody debris is available for placement in stream crossing excavations. Figure 4 shows a completed stream crossing excavation with extensive woody debris placement as it appeared in spring, 2001, following a relatively mild winter. While channel scour will occur even with woody debris placement, the extent of scour will be minimized, much of the sediment is trapped within the excavated reach, and the channel will have the structural elements needed to re-establish a natural morphology relatively quickly with this approach.

Figure 4. A stream crossing excavation with extensive woody debris placement. This photo was taken after the first winter following excavation.



Adaptive Management

It is anticipated that the guidelines for preventing surface and fluvial erosion included herein will be sufficient for achieving the desired level of protection for downstream resources. However, the monitoring program included in this biological assessment will provide feedback on the performance of these guidelines through time. Insights gained through monitoring will be used to adapt these criteria as may be required to achieve the desired level of protection in a cost-efficient manner.