

Summary Report
Watershed Rehabilitation Unit 03-01
LB500, AA2, and PT1 Road Complexes

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Introduction

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 park boundaries (1968) protected a ½ mile wide corridor of forest along the lower ⅓ of Redwood Creek, while 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 indicate these activities cause unnatural and excessive erosion that result 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 creates severe erosion problems. The cutting of logging roads into steep slopes often results in massive slope failures, causing sediment to be delivered directly into perennial and intermittent stream channels. Surface runoff can be intercepted and concentrated by inboard ditches along these roads, and often discharged onto slopes that have no natural drainage channels, resulting in severe gullying. During major storms, culverts and inboard ditches often become blocked by debris, and water is diverted onto road surfaces, causing new gullies and saturating road fills, which in turn lead 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 are among the results of logging activities in the Redwood Creek basin. These factors lead to increased sedimentation, increased streamside slope failures, greater bank erosion, and loss of anadromous fish-spawning habitat. Further, these events lead to a general degradation of the watershed, including damage to the aquatic and riparian environments in the Redwood Creek basin.

Project Background

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 Park 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 EIS/EIR, 1999). These policies and objectives provided the guidance and

direction for the removal of the AA1/AA2 road complex.

Redwood National Park (RNP) is located in the lower $\frac{1}{3}$ of the 280 square mile Redwood Creek 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 $\frac{2}{3}$ 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).

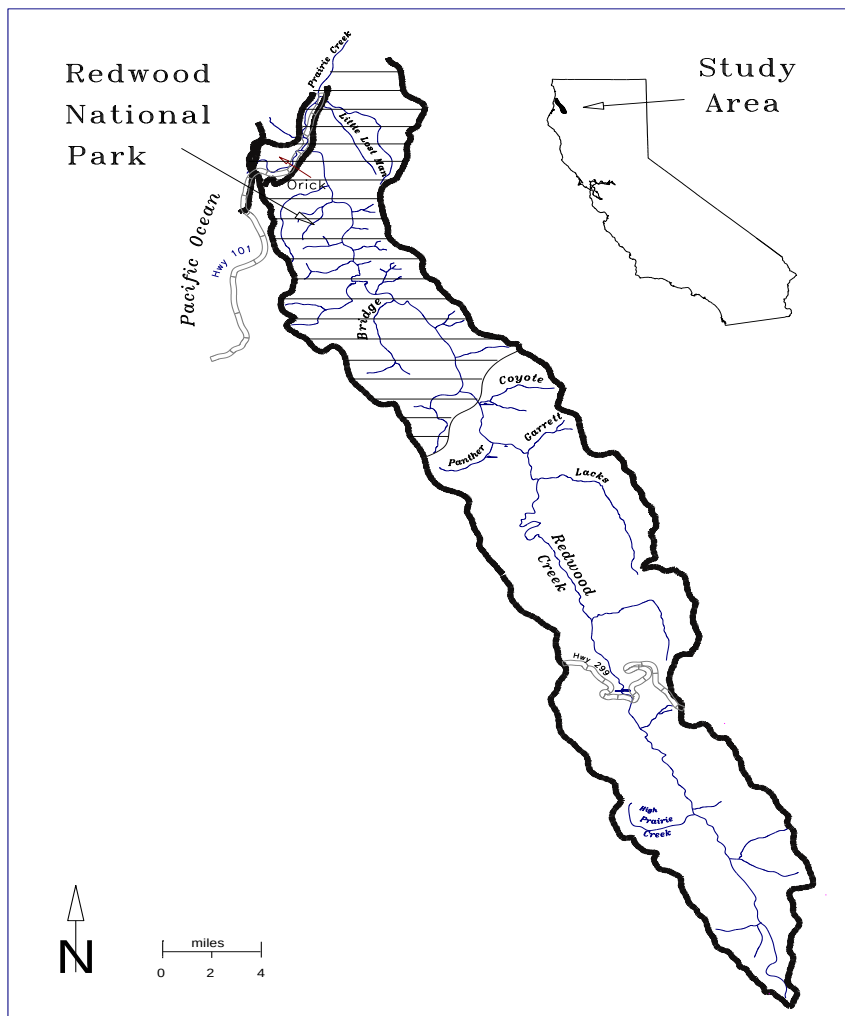


Figure 1. Map of Redwood National Park and the Redwood Creek basin.

"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 re-vegetation process by restoring the hillslope hydrology to conditions that existed prior to man's influence. These policies and objectives provided the guidance and direction for the removal of the AA1/AA2 road complex within the Lost Man Creek sub-watershed of the Redwood Creek basin.

Site Description

Watershed Rehabilitation Unit 03-01 is a part of the final phase of a multi-year strategy to restore watershed health by removing roads and associated crossings along Larry Damm Boulevard (LB500), the major haul road in the watershed. The LB500 was constructed between 1962 and 1966, and was a haul road for Arcata Redwood Company. It is located in the northwestern portion of the Lost Man Creek watershed and runs along the right or northwest bank of Larry Damm Creek, a major tributary to Lost Man Creek. Lost Man Creek flows into Prairie Creek which subsequently flows into Redwood Creek roughly 2 miles upstream of the estuary (Figure 2). Watershed Rehabilitation Unit 03-01 is located approximately 4 miles northeast Orick, California and the terrain is characterized by unconsolidated sediments and soils that are prone to gullying, and landscapes that exhibit mass wasting.

The project addressed accelerated erosion problems along 4685 ft. of the LB500 road, 350 feet of the AA2 road complex, and 1,530 ft. of the PT1 road complex. 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 road complexes. The excavation of the stream crossings uncovered the natural channel bed and banks, and excavated fill was used to re-create the natural topography. Recovered organic and nutrient rich side cast was returned to the surface in order to help speed recovery of native vegetation. Vegetation disturbed during excavation was stockpiled and dispersed along the finished surface in order to provide habitat, simulate natural forest litter, and to impede surface runoff erosion processes. This project involved the excavation of over 99,850 yds³ of fill material, including 62,600 yds³ associated with 13 stream crossings. Methodology for road removal was consistent with past rehabilitation projects, employing heavy equipment for all excavations. Excavations were executed through IDIQ Contract number C848 03 0128, and work was performed by Enviro-Tech of McKinleyville, California. Project costs are summarized in Table 1.

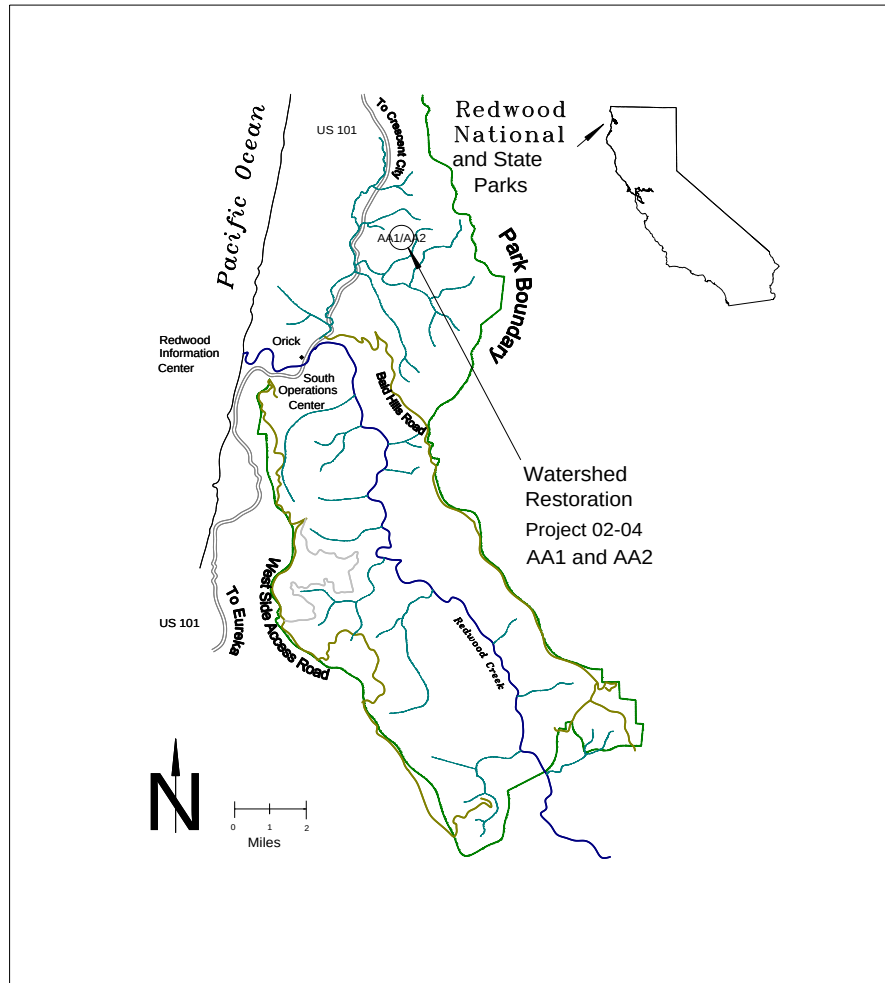


Figure 2. Map of Watershed Restoration Project 03-01, LB500, AA2, and PT1 road complexes locations.

Table 1. Restoration Work Cost Summary for Unit 03-01, LB500, AA2, PT1					
Treatment	Quantity (cubic yards)	Number of Sites	Total Costs (\$)	Percent of Grand Total	Average Unit Costs (\$)
Heavy Equipment					
Road Crossings	62,606	13	\$367,506.85		\$5.87
Export Outslope	32,338	3	\$107,606.60		\$3.33
Outslope	4,926	7	\$14,285.40		\$2.90
Move In	--	--	\$2,176.00		--
Move Out	--	--	\$5,535.00		--
Miscellaneous *	--	--	\$12,342.00		--
Straw Bails	25	--	\$150.00		
Flow Diversions	--	2	\$5,057.50		--
Subtotal	99,870		\$514,662.35		\$6.21
Activity	COTR Hours **	Personnel Hours ***	Total Costs (\$)	Percent of Grand Total	
Project Implementation					
Mapping	63		\$1,214.64		
Brushing/Road Rebuilding	60	130	\$3,756.80		
Prescriptions and Layout	34	10	\$855.52		
Aerial Photo Interpretation	21		\$404.88		
Surveying	89	89	\$,495.92		
Contract Preparation	54		\$1,041.12		
Contract Administration/ Heavy Equipment Supervision	600		\$11,568.00		
Photo Documentation	40		\$385.60		
Report Writing	30		\$578.40		
Subtotal	991	229	\$23,300.88		
Grand Total \$373,975.67					
* Davis Bacon wage adjustment not available at time of printing but less than \$2,000.00.					
** COTR hourly wage \$19.28 per hour					
*** Personnel hourly wage estimated at \$20.00 per hour					

Geology

As mentioned above, the 03-01 project area is in the northwestern portion of the Lost Man Creek watershed and, while there is no specific information about geology in the exact area of the project site, conditions found here were similar to those reported by Kelsey and Trexler (1989), who describe the northern portion of Larry Damm Creek watershed as predominantly underlain by the Gold Bluffs Unit of the Prairie Creek

Formation. The Prairie Creek Formation represents the onshore and nearshore portion of an extensive 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 Trexlor, 1989).

Kelsey and Trexlor (1989) described three sections through the Prairie Creek Formation, one of which is in Larry Damm Creek, near the 560 and 540 roads, and south west of the 03-01 project area. Here, the first 60 meters of sediments deposited on the Franciscan graywacke are medium to fine-grained sands. Above this, the section is dominated by sandstone and mudstone, with some intervals rich in clay and others consisting of massive conglomerate. Above 175 meters, the section becomes more conglomeratic and generally coarser.

Prairie Creek sediments were deposited with angular unconformity on the Jurassic-Cretaceous Franciscan Assemblage. In the project area, the Franciscan is designated as the coherent unit of Lack's Creek (Harden et al., 1982). Harden et al (1982) describes the predominant rock types of the unit as coherent sandstone and interbedded sandstone and mudstone with rhythmic bedding and internal sedimentary structures typical of turbidites. Sandstone occurs as massive beds up to 10 meters thick, but most beds are between 0.1 and 3 meters thick with thinner mudstone 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 and the coherent unit of Lack's Creek are juxtaposed along the Lost Man Fault, a high angle fault trending north-northwest to south-southeast near the eastern 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 Larry Damm Creek. Activity of the Lost Man Fault during the late Pleistocene to Holocene is not known (Kelsey and Trexlor, 1989).

Geomorphology

The geomorphic processes acting within the project area are a direct result of the physical characteristics of the existing 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 where natural drainage patterns have been obliterated by logging disturbances. These sediments are also susceptible to natural and disturbance-induced mass wasting processes.

The 03-01 project area is close to the contact boundary between the Franciscan bedrock and the Prairie Creek Formation, and both these sediments effect the geomorphology of the area. The upper region of the LB500 and sections of the AA2

and PT1 project areas exhibit the steep slopes, narrow, confined canyons, and high energy streams flow associated with the relatively resistant Franciscan bedrock found in the upper reaches of Larry Damm Creek. Other locations in the project area exhibit the gentler terrain and less confined stream reaches of the Prairie Creek Formation, and act as sediment accumulation zones. 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.

Larry Damm Creek may be prone to higher levels of suspended sediments than nearby tributaries as the existing Franciscan graywacke contains abundant fine volcanic detritus (Harden et al., 1982). Volcanic detritus commonly weathers to produce montmorillonite clays in the soil; given the proximity to the coast, salt carried inland by the fog may bind with these clays, resulting in the clay particles repelling each other, and remaining in suspension almost indefinitely (Spreiter, 1979). This may affect the natural turbidity levels of Larry Damm Creek, depending on the proportions of Franciscan graywacke to Prairie Creek Formation in the area, and may complicate comparisons of post-excavation erosion between different areas of Lost Man Creek.

Timber Harvest History

Timber harvesting in Unit 03-01 occurred between 1962 and 1966, prior to the establishment of the California Forest Practice Rules. The area was clear-cut logged and heavily tractor-yarded by Arcata Redwood Company. The Arcata Redwood Company lands suffered extreme ground disturbance due to a combination of factors including the recently increased power developments in large bulldozers; old growth logging and tractor-yarding methods of the period; construction of large haul roads and landings with little regard for preserving natural drainage networks; and highly remoldable unconsolidated substrate. Imminent park expansion also influenced the rampant logging activities in the Larry Damm watershed (Franke and others, personal communications, 2002). These land use practices caused major disruptions to the natural hydrologic conditions including the formation of large gullies in stream crossing and sidecast fills, slope failures due to diversions of surface and stream flows, and chronic road slumping of sections of the LB500 road along Larry Damm Creek. These conditions have led to increased sedimentation in Larry Damm Creek and its associated tributaries. This area was prioritized for watershed rehabilitation efforts due to the threat it poses to, and deleterious effects it has on the downstream anadromous fish habitat and other threatened and endangered species.

Erosional Features

The most dominant erosional problems identified in Unit 03-01 were associated with stream crossings on the Larry Damm Creek tributaries. The landings on the AA2 and

the PT1 road complexes were located in stream crossings, burying the stream courses in up to 35 ft. of fill and organic debris. Also, many prominent stream courses were utilized as skidding corridors, destroying the natural stream course form and function. A combination of the high level of ground disturbance from harvest practices with storm events in 1964, 1972, and 1975 resulted in accelerated erosion and the entrainment and deposition of large quantities of sediment in stream systems. Many of the tributary stream crossings conducted subsurface flow, as evidenced by the lack of surface channels, and by numerous sink holes in landing fills. Surface flow that did occur, occurred during high flow periods, cutting large gullies through the landings. Post harvest influxes of sediment from landing failures and gullying caused the channels downstream of these tributary stream crossings to aggrade, and delivered large amounts of sediment to Larry Damm Creek.

Slopes above the LB500, AA2 and PT1 road complexes were characterized by intense skid trail networks that essentially became the new hillslope drainage pattern. Many of these skid trail networks were in an advanced stage of erosion and consequently, the benefits of treating these upslope features were not recognized as warranting the degree of re-disturbance that would result from equipment operations.

Threatened and Endangered Species Concerns and Project Work Schedule

Redwood National and State Parks are home to five species listed as threatened under the Endangered Species Act and that are potentially effected by watershed restoration projects; 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. Unit 03-01 was located entirely outside of the ¼ mile radius for suitable habitat and therefore was excluded from the noise restrictions.

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 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 10 to hours per day, 60 hours per week. Heavy equipment operations on Unit 03-01 began August 20 and were completed October 29, 2003. The NMFS extended the work season past October 15 due to favorable weather in the later part of October.

Restoration Work

Project Implementation

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

The project geologist, Ingrid Corson, mapped geomorphic and hydrologic features, prescribed restoration treatments, surveyed cut and fill volumes before and after excavation, oversaw heavy equipment operations as the contracting officer's technical representative (COTR), photo documented work, and wrote the final report.

Heavy Equipment Phase

The major treatments on the LB500 were five stream crossings on tributaries to Larry Damm Creek, three of which were flowing during the time of excavation, and one main stem Larry Damm Creek stream crossing (Figure 3). Also, 1027 ft. of outsloping and 1734 ft. of export outsloping of the LB500 haul road along Larry Damm Creek were completed. Some sections of the LB500 were not outsloped: instead, they were used as fill site and shaped to drain water. The lower sections of the LB500 past WI13 between stream crossings were treated this way as they were deemed non-threatening and had little erosion potential. The AA2 work involved excavating an approximately 400 ft. long section of a buried tributary to Larry Damm Creek. The major treatments on the PT1 road complex involved excavating two large in-stream landings totaling approximately 1,530 ft. of unburied stream channel. All treatments are described in narrative format below. Volumes, production rates and costs associated with the actual heavy equipment phase of the restoration are detailed in Tables 2, 3, 4, and 5. Variations in production rates were the result of site specific conditions.

Figure 3. See GIS Plan Map

The 03-01 project (LB500/AA2/PT1) was awarded to Enviro-Tech of McKinleyville, California, (contract number C848 03 0128; delivery order number T84850300038)

and heavy equipment work began on August 20 and was completed on October 29, 2003. All equipment used for this contract, except a Caterpillar[®] 330 excavator with a 3.5 cubic yard bucket and a thumb, was owned by the contractor and included a Caterpillar[®] D8H bulldozer with a winch, a Caterpillar[®] D9L bulldozer, a Caterpillar[®] 235 excavator with a 3.5 cubic yard bucket and a thumb, and a John Deer[®] 892 excavator with a 3.5 cubic yard bucket and a thumb. Equipment operators were Warren Larkin primarily on the D8H and D9L, Walter Lara primarily on the 892, and Wendell Larkin primarily on the 330. Operators occasionally switched equipment when the job required.

TABLES 2, 3, 4

Table 5

Stream Crossings

Table 2 summarizes the volumes, equipment hours, and production rates for the thirteen stream crossing work items for the unit 03-01 project. In general, production rates for export outslope sections were comparable to the average production rates for similar work items on other park projects. The higher production rates were associated with LB500 stream crossings and were due to shorter pushes, and the relatively gentle slopes associated with these work items. The stream crossings that were big enough for the highly productive D9L benefited from the dirt moving capacity of that machine at the beginning of the excavations. However, these big stream crossings all became too steep for the D9L and therefore proceeded much more slowly towards the end of the excavation.

LB500

RX1 WI6

Prior to excavation flow in RX1 (WI6) was diverted to the left side of the valley by the LB500 causing active gullying, sediment transport down the road for over 600 feet and subsequent delivery to Larry Damm Creek (LDC). There were a number of buried stumps along the outboard edge of the road (OBR) and in the buried channel of RX1. At the bottom of the stream crossing near the confluence with Larry Damm Creek there was a large buried stump, a number of large sink holes, tension cracks, and a 12 foot wall of fill perched along side LDC. The middle portion of the buried RX1 channel had a gentle gradient, lots of large pushed-in stumps and was not much of an erosional threat in itself. However, once the upper sections of RX1 were excavated it became apparent that the middle section needed to be excavated as well as there was a depression in the channel just below the road crossing. The whole RX1 basin looked like an old landslide and the above mentioned depression was where two landslide lobes joined and continued down slope to form the shallow middle channel of RX1. The final excavated fill volume was approximately 8,200 cubic yards (yds³) and the production rate was 107 cubic yards per hour (yds³/hr). This production rate reflects the relatively short pushes and gentle terrain.



a)



b)

Figure 4. a) A during -excavation view of bottom of RX1 looking upstream from PP6 and b) a post-excavation view from the same photo point.

RX2 WI10

Parking Lot Stream Crossing, or RX2 (WI10) was a small and discreet crossing on the mainstem of LDC. The existing culvert was rotten and the upstream side of the crossing was being undercut as water no longer flowed in through the inlet. Water did flow through the outlet. This crossing was electro-fished by RNSP fish biologists prior to excavation and then de-watered by pumping the flow around the excavation. The excavation was strait-forward; the total volume removed was 745 yds³ with a production rate of 47 yds³/hr. The low production rate reflects the efforts taken to de-water the channel and to finish the channel with alder mulch, locally available LWD, and gravel from inside the culvert.

Fill was placed on the old AA2 parking lot between RX2 and RX3.



a)



b)

Figure 5. Stream Crossing 2, WI10, looking downstream from PP9 to culvert inlet a) prior to excavation and during electro-fishing, and b) after excavation.

RX3 WI13

Stream crossing three (WI13, Chicken Foot Crossing) was a small crossing on the perennial German Creek, a tributary to LDC. The undersized culvert was failing and the channel upstream of the culvert was aggrading, while the channel below the culvert was scouring. Also, the LB500 was calving off above the culvert inlet. This excavation was terminated on the upstream end near some in-stream LWD. The LWD was deemed a stable channel element and the remaining wedge of fill was of little volume. Leaving the upper wedge of fill also helped to maintain the riparian vegetation in that area. Approximately 1050 yd³ of fill were removed from this crossing. The production rate of 120 yds³/hr reflects the shallow excavation, short pushes and easy excavator reaches. Fill was placed on the old AA2 parking lot between RX2 and RX3.



a)



b)

Figure 6. Chicken Foot Stream Crossing (WI13, RX3). Looking upstream from PP10 a) during excavation of the road prism, and b) at the finished site.

RX4 WI15

Stream crossing four (WI15, Too Hot for Jerry Springer) was another failed culvert on the LB500. Prior to excavation the road bench was sinking through this crossing. The channel was aggraded upstream of the culvert, there were OBR tension cracks, and holes and gullying just upstream of the confluence with LDC. Approximately two feet below the rock road surface the fill became liquid. At one point during the excavation the excavator dropped four feet in elevation as some fill slurried out from under it. The excavator was level during the slurry event and there was no sediment delivery to LDC. The wet fill was mixed with available dry fill, placed on the LB500, and shaped to drain water. Care was taken to save as much of the riparian buffer along LDC as possible, so the bottom of the excavation was not completely excavated: the sides were left with standing trees for shade. The final excavation volume was 1055 yds³. Pushes were wet but short and the total area of the excavation was small, yielding a production rate of 96 yds³/hr.

RX5 WI16

Work Item 16 (RX5, PT1RX) was the largest of the LB500 crossings in Unit 03-01. This crossing was on a perennial tributary to LDC. The channel above the culvert was aggraded and had year-round standing muck with a high organic content, and flowing surface water (Figure 7). Downstream of the LB500 road prism there was a second, older road bench with a two foot deep meandering channel carved into its surface. This meandering channel was only wet during high flows; water flowed subsurface to LDC during the dry months. There were lots of holes and cracks where the ground was being eroded away by the subsurface flow. There were also lots of chunks and LWD between the lower road bench and LDC. Due to the presence of these chunks and the proximity of the LDC, the excavation of the bottom section of this work item was minimal and involved pulling back the wall of perched fill over LDC while not excavating below the LWD or disturbing the riparian buffer zone. The LB500 road prism yielded clean fill (no LWD), indicating the lower road was the first road and the LB500 was pushed in later.

The upper section of WI16 was very wet and very slow. The contractors deflated the LB500 road prism and excavated the bottom section a few weeks before excavating the upper section in an attempt to dry out the upper section. The surface flow was pumped around the excavation but it was difficult to intercept the subsurface flow above the excavation. To intercept the subsurface flow within the excavation, a large hole was dug above the culvert and the water that ponded here was periodically pumped around the excavation and out onto a brush pile on the OBR away from the stream channel. This method helped dry out the crossing and seemed to keep sediment laden water from being pumped into the creek.



a)



b)



c)

Figure 7. PT1RX (WI16, RX5) looking downstream from PP13 to LB500 road prism a) prior to excavation, b) during dishing down of road prism, and c) the final finished slope.

To deal with the watery fill, the contractors dug pits along the inboard edge of the road (IBR) and ladled the watery fill into the pits where it was left to sit for as long as possible (hours to days). The watery fill was then moved from pit to pit away from the excavation and down the LB500 and mixed with dry along the way. The now moist rather than runny fill was again mixed with available dry fill, shaped to drain water, and then mulched with available woody debris. This excavation yielded 3453 yds³ of fill at a production rate of 55 yds³/hr. This low production rate reflects the difficulty of this extremely wet excavation.

RX6 WI18

Work Item 18 (RX6, The Goat) was the last stream crossing on the Unit 03-02 section of the LB500. Similar to some of the other LB500 crossings, the road prism here was also sinking and the undersized culvert was failing. The treatment for this stream crossing was more of a deflation than a full excavation due to riparian buffer concerns and due to time constraints. There were two sections to the excavation, an upper section and a lower section, separated by approximately 200 feet of unexcavated stream crossing. This middle section was not excavated because it was mostly LDW

with fill sprinkled on top.

The bottom section of the RX6 excavation was similar to the bottom of RX5 with hole and cracks in the fill. The lowest section was more trenched than excavated until the channel could be defined by some in-place stumps on either side of the channel. The road prism was removed and the ground above the IBR was blended to drain water. Fill from the lower excavation was placed on the LB500 road bench between WI16 and WI18 and on the far side of WI18.

The upper section of the excavation involved removing the PT1 access road and spoiling the excavated fill on the adjacent landing where it was shaped in preparation for Z Logging to use the landing as a fill site for their nearby excavation. This excavation was not as complete as it could have been but it was impossible to dig to the actual bottom (another two feet or so?) without having to follow the channel through the middle section- something that was deemed not appropriate for the ground disturbance such an excavation would cause with so little dirt actually removed from the channel. This excavation yielded approximately 3400 yds³ at a rate of 125 yds³/hr.

AA2

RX15 WI11

Landslide Creek stream crossing (RX15, WI11) was a continuation of an excavation begun in 2002. Landslide Creek flows into German Creek at the site of a large midstream landing that was excavated in 2002. This season's excavation involved removing a large mound of fill that was part of a landing in the middle of Landslide Creek channel and joining this channel to the already excavated German Creek channel. Prior to excavation water was piping through the middle of the mound of fill along a number of large buried logs. There were active gullies as well as numerous sink holes on the upstream side of the mound where the landing was subsiding and eroding away. There were also seepy wet spots upstream of the mound.

To gain access to the Landslide Creek landing the contractors rebuilt an old skid road that ran along the left side of German Creek below the pond. Then they build a humboldt crossing to cross German Creek below the pond (Figure 8). After deflating the landing the contractors excavated the left side of Landslide Creek up to a mid channel buried stump. A large old log jam was the top of the excavation and flow was subsurface below the logjam for about 40 feet. The excavation was rather slow due to the steepness of the finished slopes, the moisture of the last portion of the fill, the 1000 foot push, and because the each piece of equipment had to wait for fill or for a place to work. There were a number of buried stumps exposed during the excavation and these helped to define the channel. There were also lots of large logs oriented streamwise in the channel. The natural side slopes were steep and wet and were difficult to mulch.



Figure 8. Humboldt access road across German Creek downstream of the AA2 pond. Looking upstream to RX15.

Prior to excavation there was much discussion concerning the riparian zone on German Creek below the pond, and the fate of the pond; some Interdisciplinary Team (IDT) members wanting to spare the riparian vegetation even if it meant leaving fill in the channel. There was also IDT discussion concerning the fate of the pond at the confluence of German and Landslide Creeks. As the excavation proceeded, it became apparent that if the riparian vegetation was to remain below the pond and above the excavated area of WI13, then the pond would also have to remain. It was also apparent that if the pond remained, then the Landslide Creek channel would have to be cheated and forced to flow more to the left and into the pond rather than following its natural course close to the right bank. So the Landslide Creek channel was cheated to the left at the confluence with German Creek, allowing the pond to remain and allowing the excavation to terminate at the pond to preserve the downstream riparian vegetation. The newly built Humboldt was removed to the elevation of the logs and fill creating the pond and the access road was outsloped. All the fill from this excavation was pushed 1000 feet to the ridge nose fill space between RX2 and RX3 as there was no closer fill space due to the steep slopes.

The final volume for this crossing, 3931 yds³, was much smaller than the original estimate of 8152 yds³ because the channel was not as deep as designed and because some of the original estimate turned out to be a ridge nose that was not necessary to excavate (Figure 9). The production rate for RX15 was 58 yds³/hr, reflecting the long push and, tight working conditions and steep finished slopes.



a)



b)



c)



d)

Figure 9. Work item 11, (RX15, Landslide RX). Looking upstream to RX15 from PP1 a) prior to 2003 excavation, b) and c) during excavation, and d) finished work item.

RX12 WI12

Because the pond and the riparian zone remained there was no need to excavate RX12.

PT1

RX7 WI19

Work Item 19 (RX7, ULARX) was the largest of four swales/streams that entered the large landing, WI20. This tight stream valley had cut banks, leaning trees, lumpy ground, tension cracks and sink holes, but was not much of an erosional threat in itself. However, as this channel flowed into WI20 which had high erosion potential, it was necessary to survey and excavate WI19 so as not to leave a wall of fill at the top of WI20. Approximately 300 yds³ of fill were removed from WI19 and pushed to a stable fill site 200 feet away. The production rate for this work item was 50 yds³/hr and reflects the tight working conditions and the fact that equipment had to wait during this excavation.

RX8 WI20

The upper landing (RX8, WI20) on PT1 Creek was a large in-stream landing similar to those excavated on German and Landslide Creeks (Figure 10). There were four swales/streams that entered WI20, two in the upper end and one on each side in the middle of the work item. There was a high-flow channel carved onto the landing surface extending from WI9 to the outer edge of the landing where there was evidence of both old and new erosion, but most of the flow was subsurface. At the bottom of the downstream wall of fill at the outer edge of the landing there was a landslide deposit from right bank landslide caused by water diverted down a skid road. This landslide probably occurred in 2000-2001 given the size of the alders and the fern ground cover. There were holes, tension cracks, gullies and leaning trees all along the outer edge of the landing as well as along the lower right and left banks where the fill

was failing. There were also a handful of buried stumps visible on the lower right bank above the landslide scar.



a)



b)

Figure 10. Work item 20, (RX8, ULRX). Looking downstream from PP2 a) prior to excavation and b) after excavation. Same camera, lense and frame, 17,159 yds³ later...

There was one very odd landscape feature worth mentioning; a 20 foot high bank with a thick growth of lady finger ferns (Figure 11). At first glance it looked like a cutbank, but on second glance one noticed the clump of three in-place stumps at the bottom of the bank, making it impossible for this to have been a cut bank as the stumps were too close to the bank for a dozer blade to pass between the stumps and the bank. Also, there were no blade marks on the bank as there are on all the other cutbanks in the valley. An interesting feature.



a)



b)

Figure 11. Work item 20 (RX8, ULRX). Looking to fern covered vertical bank from PP2 prior to excavation, and to the same bank from PP3. Note the triple in-place stumps at the bottom of the vertical bank, and PP2 on top of the in-place stump just to the right of center at the top of the channel.

The excavation began by dishing down the landing with the D9 and the D8. The fill was used to fill in the left bank cutbank. As the excavation progressed however, more fill space needed to be opened up so the fill from the landing went into a push ramp that allowed the contractors to push the fill up to a series of fill site along the ridge above WI20. While the push was steep the D9 was able to bring fill up the hill until the fill space was no longer needed. Push distances for this work item ranged from 800 feet to 20 feet and the finished slopes along the channel were almost vertical in places. Some of the fill from the lower part of the landing was pushed across the top of the landslide debris pile to a cutbank on the right side of the channel. The rest of the channel fill was pushed up the channel to the push ramp or up the channel and out of the hole to the lower left side of the channel. There were lots of chunks and LWD in the bottom of this channel and due to the steepness of the channel banks it was difficult to impossible to get the chunks out of the channel or to stay on the banks as mulch.

There were three or four exceptionally large pushed in chunks at the bottom of the excavated channel. Because of the size and positioning of these chunks it was impossible to move them so they remain at the bottom of the channel wedged on the upstream side of a large in-place stump. There were also many stumps exposed on the right bank that aided in determining the natural topography of the banks and channel. Exposed in-place veg mats were also helpful in defining the original topography, especially on the steep left banks.

The finished channel was considerably deeper and had steeper side banks than originally estimated (Figure 12). The final volume for WI20 was 17,159 yds³ (compared to an estimated volume of 9888 yds³) and the production rate was 53 yds³/hr. This production rate is low and represents the difficulty of the excavation despite the fact that there was a lot of easy cat dirt in the early stages of this excavation.



a)



b)

Figure 12. Work Item 20 (RX8, ULRX). Looking upstream from PP3 a) during excavation, and b) at finished excavation.

The excavation proceeded smoothly except for one event worth mentioning. Walt Lara rolled the 892 while spreading brush on the last day of work on WI20, October 20, 2003. Thankfully, he was not hurt. Again, thankfully, despite the fact the he was not wearing hi seat belt, he was not hurt. However, the 892 burned up and was almost a complete loss (some new track motors may have been salvageable) (Figure 13). Apparently, Walt was sitting on an almost flat surface helicopter spreading brush. On the third swing he began to tip down slope, tried to arrest the tip by swinging his bucket back under him but caught some bucket teeth on the ground and accelerated the flip. The machine came to rest on the arm side and Walt was able to jump out of the cab quickly. As the ground was sloped below the work pad Walt had been sitting on, both tracks were off the ground. The machine caught on fire before Walt was free of the cab and despite his efforts with the onboard fire extinguisher, was unable to control the flames. Wendell and Warren Larkin arrived on site moments after the flip and buried the burning excavator to smother the flames. The next morning the excavator was unburied, righted, disassembled and towed off the hill to the LB500. More than 50 gallons of diesel fuel were recovered from the 892 and pumped into the D8. The ground around the excavator was dry and it is presumed that all the volatiles that may have leaked out of the engine were burned up. Later on the 21st Walt reshaped the fillsite where the 892 was buried and finished mulching WI20. In hind site, getting the 892 off the hill was perhaps more dangerous than the actual flip

considering the number of pieces of heavy equipment it took, how steep the ground was, and how far it was to the LB500 and the vulnerability of those few assisting on the ground.



a)



b)



c)



d)



e)



f)



g)



h)

Figure 13. Work Item 20 (RX8, ULRX). Pictures depicting the October 20, and 21 892 excavator roll accident. Photos depict a) the burning excavator on its side, b) burying the excavator to smother the flames, c) the early morning unburying, d) righting, e) disassembling, f) pumping warm diesel from the burned excavator, and g) pushing and pulling the excavator to the LB500. Figure 13h is a bonus picture featuring the extremely lucky 2002 and 2003 excavator rollers comparing notes.

RX9 WI22

Stream crossing nine (WI22, LSRX) was a steep stream crossing where the upper PT1 access road crossed a tributary to PT1 Creek. There was a blown-out log stringer bridge above the access road crossing that was not treated. Prior to excavation the lower crossing had a series of active gullies, OBR tension cracks, a few small sink holes, and leaning trees. Less fill was removed from this crossing than originally estimated because it was tight and became too steep for the dozer and the excavator to safely operate (perhaps some post-flip caution too). The final volume for this work item was approximately 890 yds³ with a production rate of 60 yds³/hr. The rather low production rate is due in part to the steepness of the crossing and due in part to the fact that this crossing was partially excavated prior the 892 flipped and had to be

filled in order to get the burned up machine off the hill.

RX10 WI23

SBRX (RX10, WI23) was a skid crossing on a steep tributary to PT1 Creek and joined PT1 Creek directly across from the RX9 tributary (Figure 14). The top of this excavation was a large pushed in stump in the narrow channel. This work item was also very steep. Because of this, some fill was not excavated from the channel in the lower middle section where there was a considerable change in slope. The post-excavation volume was 1128 yds³ at a production rate of 53 yds³/hr; think steep and slow!



Figure 14. Work Item 23 (RX10, SBRX). Looking downstream from PT1 PP4 to finished RX10 and RX11 channels.

RX11 WI24

Work Item 24 (RX11, LLRX) was the last big landing in Unit 03-01 and was separated from WI20 on PT1 Creek by a 150 foot patch of riparian vegetation and the landslide debris pile. Approximately 350 feet downstream of the bottom bounds of WI24 was the top of WI16 on PT1 Creek. Stream crossings nine and ten join PT1 Creek about 30 feet from the top of the WI20 excavation.

Prior to excavation WI20 was a big flat landing that sloped slightly downstream from the halfway point to the edge of the landing (roughly 300 feet) (Figure 15). The whole landing was covered in standing water during the winter rains with areas of

flowing water. There were even areas of standing water in June. There was a gully down the middle of the landing that grew from two feet deep at the halfway point to over 12 feet deep approximately 300 feet downstream. There were tension cracks, slumping, leaning trees and an amazingly active sinking hole that grew from 6 feet in diameter to 9 feet in diameter in three weeks with no rain and appeared bottomless.



a)



b)



c)



d)



e)



f)

Figure 15. Work Item 24 (RX11, LLRX). Photos take from PT1 PP1 looking upstream and down stream respectively a) and d) prior to excavation, b) and e) during excavation, and c)and f) after excavation.

This excavation began with easy cat dirt and relatively short pushes, much like WI20. And like WI20, there were lots of chunks in the bottom of the channel and the left bank was almost vertical. There were good buried stumps to help define the natural topography too. Per the suggestion of the ID Team the contractors left small holes or ponds in the LWD at the bottom of the channel to allow for channel development and more varied habitat. The upper section of the excavation tapers to some mid channel LWD and the bottom section of the excavation tapers flat back from a small flood plane to the original channel bottom. Most of the fill was pushed to a through cut on the lower access road and to rebuild the ridge nose on the right side of the crossing (Figure 16). The final excavation volume of 18,788 yds³ was more than twice the estimated volume of 8782 yds³ as the channel was much deeper and the side banks much steeper than originally estimated. The production rate was 87 yds³/hr. While the shape of WI20 and WI24 were similar, the pushes were much shorter and easier on WI24.



Figure 16. Work Item 24 (RX11, LLRX). The D9L backing out of the access road throughout fill site used for much of the fill from WI24.

Export Outslope

Table 3 summarizes the volumes, equipment hours, and production rates for the five export outslope work items for the unit 03-01 project. In general, production rates for export outslope sections were higher than those for stream crossings. The higher production rates were due to drier fill, shorter pushes and the relatively gentle slopes associated with these work items. Most export outslope sections were in areas where the D9L could be used.

WI3 EOS1

Pat's Parking Lot EOS (WI3, EOS1) extended from approximately the hairpin landslide that marked the end of 2002 LB500 work to the down-road end of a roadside landing. This section of road was perched high above Larry Damm Creek and the road had already outsloped it self to some extent with gullies coming off the OBR, leaning alder trees and general slumping (Figure 17). On the outboard edge of the landing there were large tension cracks and active gullies.



a)



b)

Figure 17. Work Item 3 (EOS1, Pat's Parking Lot). Looking down road from LB500 PP1 to Pat's Parking Lot landing a) before, and b) after excavation.

The excavation of this work item went well. There were local fill sites on the upslope side of the excavation and in adjacent WI4. There were many exposed stumps that aided in defining the natural topography. One interesting stump feature was an old burned-out stump ring exposed on the down slope edge of the excavation. This area also had some rock out crops that formed low ridges between swale or undulations topography. These rock outcrops and undulations indicated the EOS area was an old landslide or slump that had been filled in by logging operations.

The final excavated volume for this work item, 10,233 yds³, was considerably larger than estimated, 5,917 yds³. The work item became larger than expected due to the deeper and wider than expected swale feature. Despite the increased volume, the production rate of 116 yds³/hr was relatively high. This higher production rate was due to the short pushes, the dryness of the fill, the wideness of the work area and the fact that the D9L was able to operate easily in this area.

WI5 EOS2

Work Item five involved removing a skid road from a swale that intersected the LB500. Prior to excavation the upslope skid road the road itself was a water diversion, causing the ground to be highly fractured with tension cracks and there were shallow gullies from high flow events. This swale was one of the two upslope lobes that joined to form the stream course exposed in WI6 (RX1). It is interesting to note that two test excavation pits dug 15 feet apart, down slope of the LB500 and down slope of a large clump of in-place redwood trees yielded two entirely different subsurface geologies. One test pit revealed sandy light yellow/gold subsoil approximately 3 feet bellow the surface with a fine orange-red soil layer on top. Deeper digging revealed the same yellow/gold sandy subsoil with hints of green-blue at greater depth. The other test pit was closer to the redwood clump an digging exposed a fine loose uniform orange-red soil to the deepest depth the 892 could dig. The difference in these soils is supporting evidence that this area is highly faulted.

The final volume for this work item was approximately 2,500 yds³ and was more than twice the estimated volume. The production rate of 126 yds³/hr was high in part due to the short and sometimes downhill pushes.

WI8 EOS3

Work Item eight (EOS3) had a large and active IBR gully created from water diverted by the LB500 (Figure 18). The gully was over 10 feet deep and 8 feet wide where it cut through a ridge nose on the boundary of WI8 and WI9 (see below). There were also some OBR sink holes that indicated active sediment transport and delivery to LDC. This road reach ran along the east or left bank of LDC and had large fill pockets that overhung LDC, posing a high erosion potential. There was also a section

of this road reach that ran along an old log jam in LDC. Through this road reach the excavation was minimal, in part to protect the riparian, but mainly because to go back to natural topography in that area would have involved disturbing the LDC channel; something that was not within the scope of this project. The road reach immediately adjacent to RX2 was also minimally treated. In this area the road bench was closer to the level of the LDC, and therefore the erosion potential was much less than other higher road reaches in this work item. The minimal treatment through this road reach preserved the riparian buffer, a goal of the IDT.



a)



b)

Figure 18. Work Item 8 (EOS3). Looking up road from LB500 PP8 a) before and b) after excavation. Note the gully in the before picture.

There was a large rock out crop on the ridge that separated RX1 from EOS3 that extended towards the creek through EOS3. It is interesting to note that there were no such rocks or rock outcrops exposed on the other side of LDC during the 2002 work season, supporting other evidence suggestion the location of a fault along this reach of LDC.

The final volume of this work item was 8,370 yds³, and was smaller than estimated due to the rock outcrops and to the minimal treatment of the road bench adjacent to RX2. While most pushes were level, there were some long pushes and some steep sections of road and the production rate was 110 yds³/hr.

WI9 EOS4

Bobby Brady EOS (WI9, EOS4) was the excavation of an upslope landing that was failing onto the LB500 road bench. This landing was above the deepest and largest gullied section in WI8 and included an odd piece of ground that was melting but with no clear reason why prior to excavation. This piece of ground was complete with leaning trees, big tension crack along the outer edges and as mentioned above, slumping and melting ground.

Approximately 5,450 yds³ of fill were excavated from this work item and spoiled to a series of adjacent gentle upslope through cuts. The excavation exposed a steep wet swale that began on the ridge that was the base of the landing (Figure 19). The swale had ponding water and very wet soil during the excavation. There were lots of buried chunks and a couple of buried stumps exposed. The swale did not connect to the LDC, and instead, shallowed out and dried up about halfway across the road bench. The fill was pushed up a steep hill and to the adjacent through cuts on the upslope side of the excavation. The production rate of 70 yds³/hr reflects the long steep push.



a)



b)

Figure 19. Work Item 9 (EOS4, Bobby Brady). Looking down slope from LB500 PP7 a) during, and b) after excavation.

WI17 EOS5

Utah EOS (WI17, EOS5) was another above-road landing excavation and, like Bobby Brady, Utah was failing onto the LB500. The LB500 was also sinking in one area though this work item. On a broad landscape scale this area looked like an old massive slump forming a shallow bowl. Prior to excavation there were areas of ponding water on the landing, and an active but shallow head cut where the ponding water flowed down onto the LB500. There were a number of skid roads entering the landing from the upslope side bringing diverted water with them. These skids were both shallow swales that were skidded and regular skids that focused surface flow onto the landing. These areas were shaped to drain so as to pose less of a threat to slope stability.

The sinking section of the LB500 turned out to be a narrow steep stream channel that had flowing water in it from just above the road prism to the confluence with LDC (Figure 20). There was a small plugged culvert in the road fill and the bottom of the channel was about 12 feet below the road surface. Except for the narrow channel excavation that went to the flood plane just above LDC, the downstream extent of this excavation was minimal and most of the adjacent riparian buffer was left intact.



a)



b)

Figure 20. Work Item 17 (EOS5, Utah). Photos looking down slope from LB500 PP12 a) during and b) after excavation. Note the narrow channel on the left side of Figure 20b.

Aside from the channel excavation, the rest of the EOS was simple and strait forward.

Fill was pulled back from the bottom of the road bench and the fill was pushed upslope to fill in the high cutbanks that bounded the landing. Some of these pushes were long but not that steep. Some fill was also placed on the adjacent LB500 road benches and shaped to drain waster. The total excavated volume of Utah was 8,363 yds³; 5,777 yds³ of EOS dirt and 2,586 yds³ of RX dirt. The production rate was 103 yds³/hr.

Outslope

Table 4 summarizes the volumes, equipment hours, and production rates of the four outslope work items for the 03-01 project. In general, production rates for outslope sections were higher than other prescriptions. The higher production rates were due to dry fill, shorter pushes, and the relatively gentle slopes associated with the

outslopes. Most outslope prescriptions were adjacent to wide areas in the road where the D9L could easily access the fill.

WI4 OS1

Work item four (OS1) was a straight forward outslope involving the excavation of approximately 1,880 yds³ of dry fill. The road bench was pulled back and the fill was placed on the ridge nose between WI4 and WI5. There was a lower skid road that was left in tact as it was narrow and did not seem to pose much of an erosional threat. There was a rock outcrop exposed on a short section of the OBR where some redwood stumps were still in place. The pushes were short and the production rate was 118 yds³/hr.

WI7 OS2

Work Item seven was also a straight forward outslope excavation. This short outslope reshaped the ridge nose between RX1 and WI8. There was a small springy area adjacent to RX1 that was left unburied. The OBR through this work item was bounded by a number of large redwood stumps. The final volume for this work item was 852 yds³. The fill was placed along the ridge on the upslope side of the LB500. While the fill site was close, for some unknown reason the fill was moved back and forth through the work item a number of times before the work item was closed and the production rate only 76 yds³/hr.

WI14 OS3

Work Item 14 (OS3, AA2 Access Road) was the reshaping of the 2002 AA2 access road. This road was winterized rather than removed at the end of the 2002 heavy equipment because it was one possible route to the AA2 2003 work site. This road was removed because it was diverting surface water and was failing on the OBR just above German Creek. Approximately 1,350 yds³ of fill was easily outsloped to the IBR and the area was shaped and mulched per usual. The production rate was quite high, 200 yds³/hr, and reflects the simplicity of completing this work item with the D9L as the dirt hog and the 330 as the finishing tool.

WI21 OS4

Work Item 21 (OS4, ULRX Access Road) involved outsloping the ULRX access road. This road was a narrow haul road running parallel to and up slope of PT1 Creek. The road connected ULRX to LLRX and was intersected by RX9. Prior to excavation there were buried OBR stumps, tension cracks, and many OBR leaning trees. The finished slopes were relatively steep as was the over all restored topography. The final volume was 841 yds³ with a production rate of 160 yds³/hr. The road reach that entered LLRX was not as excavated as it might have been in an ideal world and less than 20 yds³ of perched fill was left behind. This fill was left behind because the ground became too steep for the equipment to safely operate. The effort and amount of additional stream-side ground disturbance required to retrieve the fill did not balance the positive gained by retrieving this sediment, so it was left there as an eye sore and possible source of sediment to PT1 Creek.

Documentation Phase

The final phase of this watershed restoration project was the documentation process. This includes post-heavy equipment volumetric surveys and volume estimates, photo point documentation, cost and data compilation, and writing the restoration project report. This work was done by the COTR, Ingrid Corson.

Discussion

The removal of the AA1/AA2 road complex met the goals of National Park Service Management Policies from the 2000 General Management Plan, 1992 Statement for Management, and the 1981 Watershed Rehabilitation Plan. The implementation of this project effectively eliminated unnatural sediment sources associated with the road and disturbed hillslopes. Diversion potentials were eliminated through the restoration of natural hillslope topography and drainage patterns. This restoration minimized the potential for both hillslope and sidecast failures and delivery of unnaturally large quantities of sediment to Larry Damm Creek and systems farther downstream. The recovery of nutrient and organic-rich soil should greatly speed the recovery of native vegetation. The thorough treatment of the LB500, AA2 and PT1 road complex has reduced the impacts to downstream resources in the Lost Man Creek watershed, most importantly salmonid habitat, and eliminated the costly drain on maintenance resources.

This project excavated approximately 99,870 yd³ of fill material from stream crossings and failing road benches. The project's total heavy equipment cost was approximately \$515,512 with an average cost per cubic yard of \$5.01.

One of the most interesting developments of this project was the depth, width and bank steepness of tributary channels. Both the AA2 and PT1 tributary excavations yielded areas with almost vertical banks. These banks often had intact and still moist veg mats and in-place root masses. It is interesting to note that there was usually one steep bank and one more gradual bank.

As this was the second park heavy equipment season during which there was a tipped or capsized excavator, it drives home points such as wearing seat belts and no ground is too flat!

That's all I can think to say at the moment. That's all I am going to say. Good luck making this into something. Cheers, icc.

Acknowledgements

The restoration work accomplished by the completion of Unit 03-01 is the result of the dedication and hard work of numerous individuals. This report is a compilation of those efforts. Thanks to Neal Youngblood, Mike Sanders, and Greg Gibbs, geologists at Redwood National Park, for assisting in contractual preparation, site investigation, and idea development. Thank you to Chris Heppe for his continued support and interest in the successful completion of this project and the well being of those involved. Thank

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APPENDIX 1

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.

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" (attached in Appendix 4)

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 eletroshockers, 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.

POST-EXCAVATION EROSION CONTROL GUIDELINES

APPENDIX 2

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.

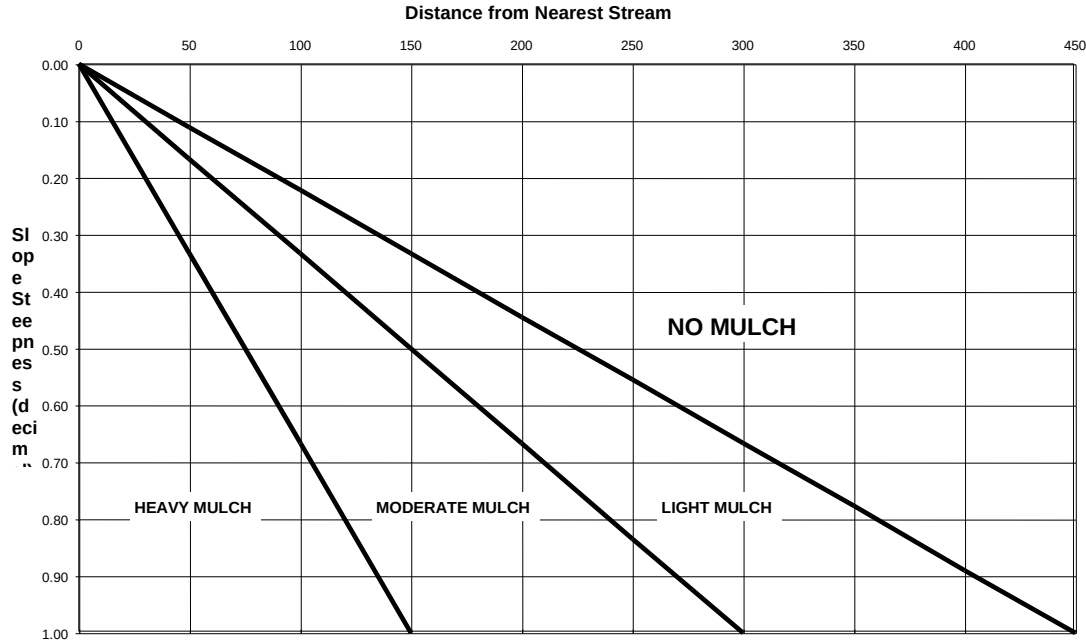


Figure 1. Mulching Guidelines

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).

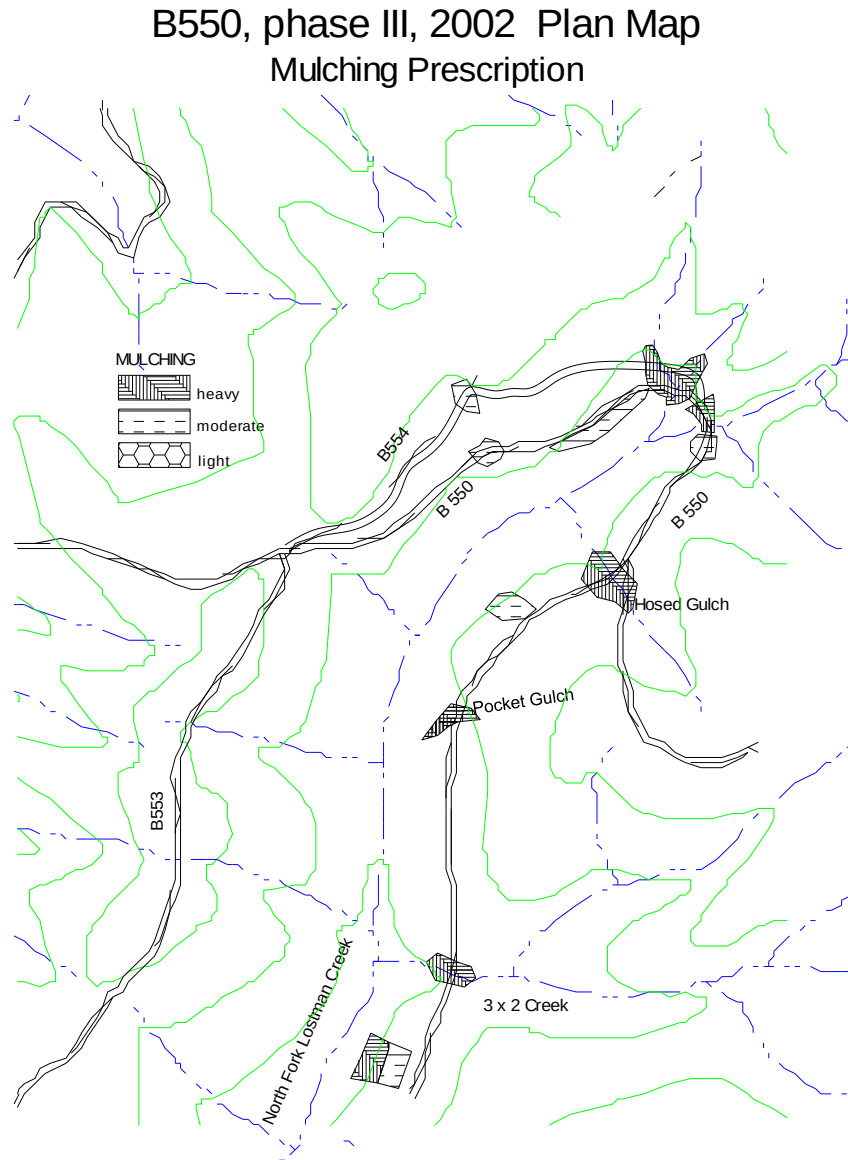


Figure 2. Hypothetical application of surface erosion control guideline to a planned 2002 rehabilitation site. Roads, streams, and contour lines are shown.



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.