

WATERSHED REHABILITATION REPORT

FOR

THE MANEZE CREEK UNIT

(Site 80-2)

RECEIVED
FEB 11 1974

by

Ed Wosika

The work on the Maneze Creek unit was done with the help of my two hydrology technicians, Mark Alpert and Dan Vann, without whose help I would have been in dire straits.

A handwritten signature in dark ink, appearing to read 'Ed Wosika' with a stylized flourish at the end.

Ed Wosika

Table of Contents

INTRODUCTION

Part I: NARRATIVE

Site Location

Timber harvesting history of the site

Observations made during the mapping phase

Part II: HEAVY EQUIPMENT WORK AND COST BREAKDOWN

Heavy equipment used

Time sequence of the work

Synopsis of Equipment Cost and Time Breakdown

Site Specific Equipment Cost and Time Breakdown

Cost Estimates and Guidelines for Future Work

Part III: LABOR INTENSIVE PHASE WORK AND COST BREAKDOWN

Checkdamming of Stream Crossings

Guidelines for Future Checkdam Cost Cutting and Cost Estimates

MAPS.

Map 1: Maneze Creeks rehabilitation site location map

Map 2: Timber harvest history map

Map 3: Erosional features and worksite locations (Upper Maneze Creek)

Map 4: Erosional features and worksite locations (Lower Maneze Creek)

Map 5: Rehabilitation and Photo Point Map (Upper)

Map 6: Rehabilitation and Photo Point Map (Lower)

INTRODUCTION

This report documents the sequence of work and provides a breakdown of the rehabilitation of the Maneze Creek watershed (Site 80-2). It is broken down into three parts:

Part I: Narrative

Part II: Heavy Equipment and its Cost Breakdown

Part III: Labor Intensive Work and its Cost Breakdown

Part I begins with a brief history of road building and timber harvesting within the unit. This is followed by general and site specific observations made during the mapping phase of the project (winter of 1979-1980) including erosional processes and critical sediment yield areas. Finally the erosion abatement prescriptions are discussed, with reference to both general and site specific problems.

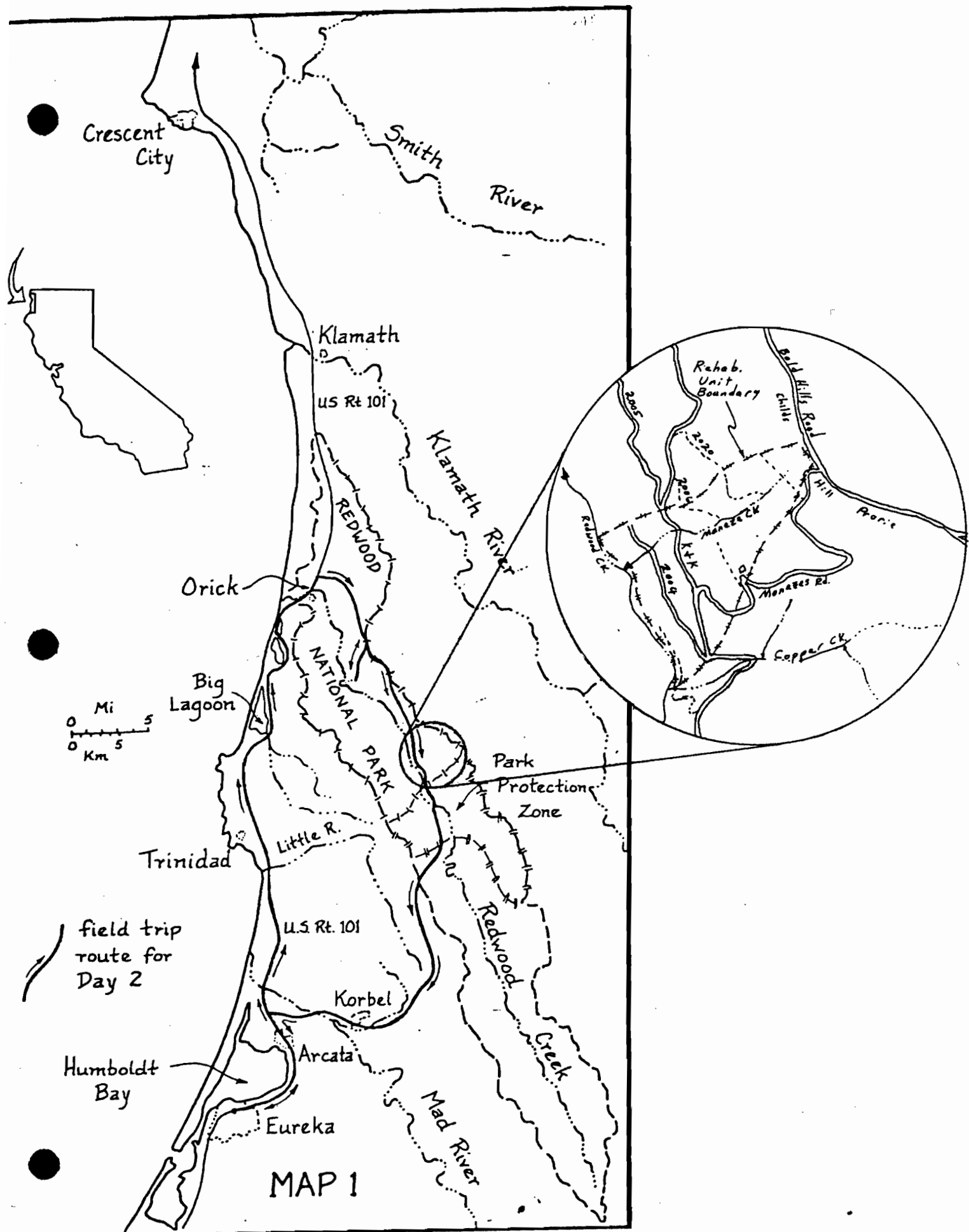
Part II begins with a description of heavy equipment used as well as the reasons for choosing it. The time sequence and site specific cost breakdown are presented, in tabular form, followed by more detailed time and cost analyses for each site. These analyses go into greater detail than the tables and, in addition, contain a verbal synopsis of any special problems encountered or approaches used. Following this is a section which distills this data so as to provide practical guidelines for making future cost estimates and points out the most efficient equipment sequencing approaches. I feel this is the most important part of the report because it encapsulates all that has been learned this year relative to keeping costs to a minimum by using the right equipment and materials at the right place and time.

Part III includes a cost analysis of labor intensive phase of the work, which consisted almost entirely of checkdam installation. This data is presented in tabular form, and is followed by an in-depth look at the relative costs of the various types of checkdams installed.

Part I: NARRATIVE

Site Location

The location of the Maneze Creek rehabilitation unit is shown on Map 1. Maneze Creek is a second order stream on the east side of Redwood, and drains directly into it at a point approximately one mile downstream (northwest) of the mouth of Copper Creek. In addition to Maneze Creek there are four unnamed creeks and major gully systems on the unit which drain directly into Redwood Creek. These may be considered first order streams.



Maneze Creek Rehabilitation Site Location Map

Timber Harvesting History of the Site

Map 2 shows the cutting history of the basin relative to major storm events. Aside from a slight difference in the degree of revegetation, little difference could be seen in the areas that were harvested during the three periods shown. Site quality had a much greater effect on revegetation than cutting history. No erosional differences were discernable that related to time of harvest.

Observations Made During the Mapping Phase

The mapping period for the Maneze Creek Unit (M.C.U.) was nearly three months in duration, due to the extremely dense brush cover. Under more open conditions, this phase could have been completed in less than half the time. To save time, several areas were checked using traverses alone. Erosional features tend to extend downslope from their point of origin. By making horizontal traverses, we could look for signs of disturbance, then map them to their source. Only about 20 percent of the area was mapped in this manner, the remaining 80 percent being thoroughly covered.

The area on the slope above landing #3 and below the S/X-9 channelization, had scoured a 700 foot long gully into blue goo. The gully was up to 40 feet wide and 10 feet deep, and was a quagmire of springs. There was no way to channelize the gully, due to the soft nature of the material, yet something had to be done, due to the obviously high sediment yield. The only reasonable solution was to construct a low gradient channel across the slope to Maneze Creek. This is the present S/X-9 channelization.

Another real problem area was downslope from the section of the 2004 road lying between R/X-23 and R/X-25. This area is the heart of the "quarter section slide" of Harden, Janda and Nolan (1978 Mass Movement and Storms in the Drainage Basin of Redwood Creek, Humboldt County, California - A Progress Report, 162 pp., see pp. 115-117) and it extends from the 2004 road down to Redwood Creek. Lesser disturbed areas associated with this failure extend upslope to just above the K&K road and (laterally) from the large rock outcrop below landing 9 north to Maneze Creek. This area is laced with scarps, some of which are up to 15 feet in height. The heart of the slide was both unmappable and untreatable, due to the high density of erosional features. The sections of the 2004 road and its spur which passed through the failure area were not given intensive treatment, since this would have been a waste of funds. The crossings in this area were given full attention, however, since these sediment point sources could be effectively treated. The only direct work done on the heart of the slide was at R/X-24, where channelization was done across a ponded area to expedite rapid drainage.

The apparent cause of the quarter section slide lies in a series of occurrences which began perhaps several thousand years ago. Just upstream of the slide, and downslope from landing 13 lies an anomalous benched area around which Redwood Creek makes an unusually abrupt meander to the west. This is the remains of a gigantic slump block which came down the east slope of Redwood Creek and may have even dammed off the creek temporarily. The direct cause of this old slump is difficult to determine, but its position and low



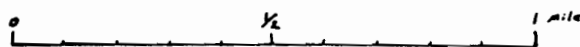
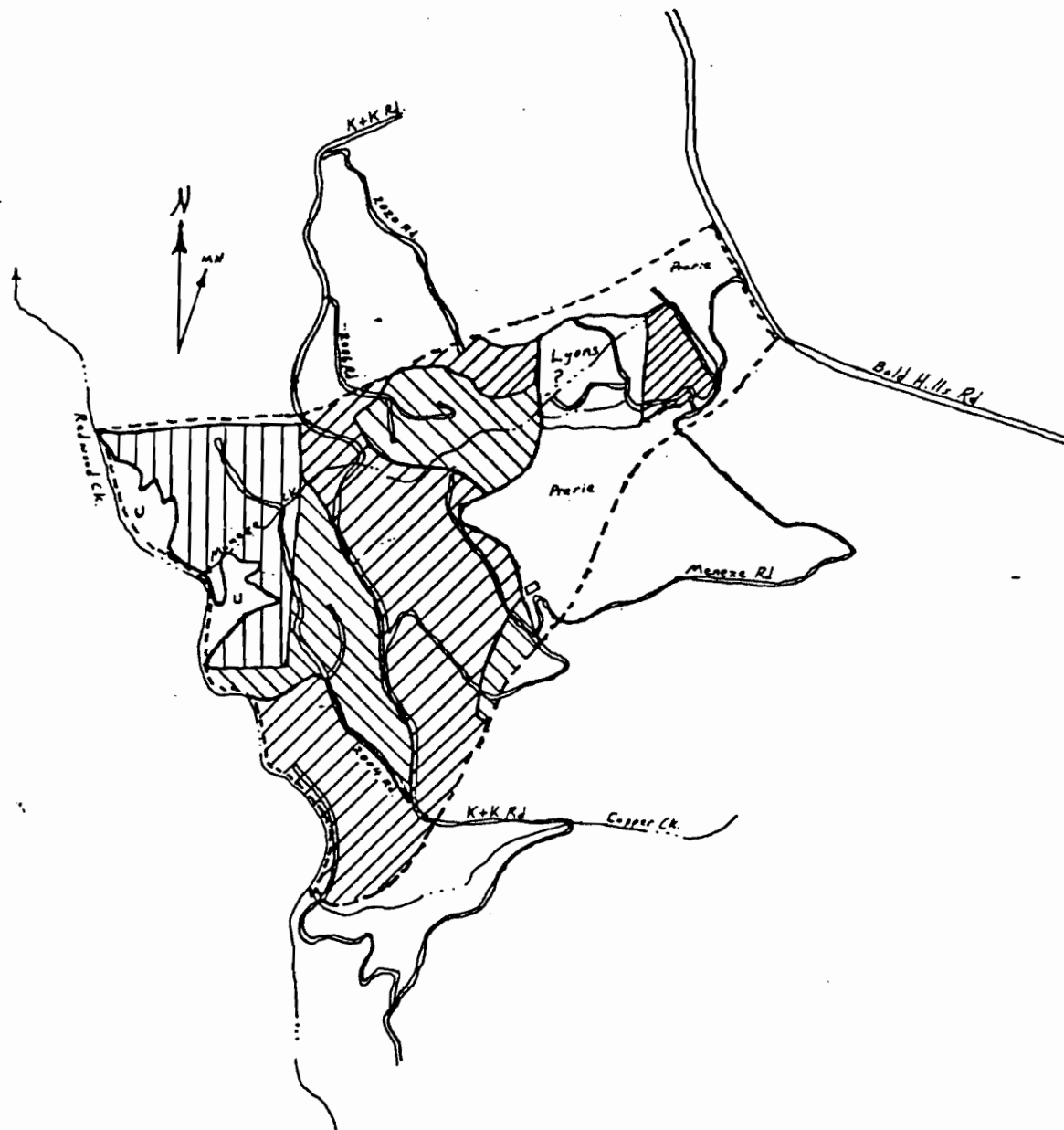
Cut Before The Dec. 22, 1964 Storm



Cut Before The Jan 22 and March 3, 1972 Storms



Cut Before The March 18, 1975 Storm



SCALE 1:24000

Map 2 The Cutting History

erodability caused the creek channel to make the sharp westerly meander we see today. As the water passes the old slump block, it is directed back strongly into the right bank. This process has eroded the toe of the slope, causing numerous failures to develop upslope. This springy, catsteeped mess is the heart of the quarter section slide, while the associated scarps further upslope represent a less severe adjustment to movements at the heart of the slide. This process is still quite active with many of the upper slope position scarps showing evidence of recent adjustment. It is difficult to determine the degree of effect man's activities have had on this failure, since its size is so vast. The failure planes of these scarps surely extend far below the depth of plant roots, so little stability was lost due to clear-cutting. It appears as if the stage was set for this failure so long ago and on such a grand scale that human effort to either retard or accelerate its progress are of little consequence.

Sometimes when a change is prescribed in the drainage pattern of the upper portion of a watershed, other changes become necessary downslope. A good example of this is the construction of the R/X-14 channelization. This new channel was constructed at the Maneze Barn for the purpose of rerouting flow from the prairie. The flow was removed from a bad gully system, which ran by the north side of the barn. The new channel runs by the south side of the barn, crosses the barn road, and dives into the headwaters of a previously dry watercourse (see Maps 5 and 5). This change necessitated work on crossings S/X 12, 13, 14, and 15, within the reactivated watershed. The first three of these crossings just mentioned are small slope crossings, while S/X-15 is a diversion into the headwaters of the stream which crosses the K&K road below S/X-16. The channel just mentioned was being severely eroded at the S/X-16 stream crossing. The addition of more flow, from the barn channelization, seemed unwise yet there seemed to be no alternative. The solution was to create the R/X-18 channelization (located just to the north of S/X-16) to keep the flow from the R/X-18 gully from entering the stream. This was done so as not to overload the stream at S/X-16. The flow from the two channels runs downhill in parallel courses only 150 feet apart. The channel below R/X-18 was dry before the channelization. The activation of this northernmost of the pair of channels required the creation of R/X-30, on the 2004 road spur.

The two drainages form a natural confluence 100 yards downslope of the 2004 road (below R/X-26). The northernmost of the pair of channels is in severely bad shape at the confluence, with springs and massive streambank failures in the infamous "blue goo" (a most despicable substance). The solution to the confluence problem was to avoid it entirely by creating a new confluence at R/X-26, thereby cutting off the offending stream section. Although it is unusual to have such a long series of changes spin off from a single change (the creation of the R/X-14 channelization), it must be kept in mind that all work regardless of magnitude, has an effect downslope.

Cranes were at a premium, since five rehabilitation sites were in operation simultaneously. We opted for a small, 1/4 yd³ capacity, wheel-mounted crane. It worked slowly but, as its hourly rate was low, it was cost efficient. It was necessary to schedule the crane's jobs carefully because its working rate was far too slow to justify the required support equipment (loader or cat) on a full-time basis. Required crane work was given first priority so that, as the crane went from job to job, a project was begun nearby with the other equipment. In this way, support equipment could be made available to the crane as needed, while keeping everyone busy. This did require extra traveling time, but obviated the need to bring in the crane whenever its job site was approached. Instead, it could be used continually for a brief time and then eliminated.

A Case 580B extendahoe was utilized for the excavation of most of off-road job sites (listed as S/X for slope crossing). It is a highly versatile piece of equipment, but is fairly slow in terms of yd³ moved/hour. Backhoe jobs requiring support equipment were scheduled to coincide with work at nearby road crossing sites, so that support equipment could be obtained on an as-needed basis. During those periods when the other equipment was not in close proximity to such a site, the backhoe was kept busy doing jobs which required no support. Backhoe work must be handled in this way to avoid paying extra standby time for support equipment. In addition, the backhoe was used to ferry rock to the excavators, as well as to its own worksites, and to place rock in areas where the excavator lacked maneuvering space.

A 10 yd³ dump truck was retained on site for most of the heavy equipment phase. It was used primarily to help bring in prepared rock, but was also invaluable in distributing straw, fertilizer, and lumber. The use of the dump truck for hauling rock insured that it would always be available on site when other needs for it arose. Often, all or most of the shared rock delivery trucks were busy delivering to other rehabilitation sites. Ideally, having our own dump truck on site meant that we could always have an adequate rock supply to keep ahead of the need, even before our turn with the "fleet" came around again. The truck was also used to haul gravel to three french drain sites. At one site (R/X-27.6) it was used to endhaul excavated material.

Time Sequence of the Work

Table 1 (largest foldout) shows the sequence of work. The horizontal date line is broken up into a column for each of the nine pieces of equipment. The number of hours worked on a given date by each piece of equipment is found in the lower left hand corner of the date box in its column which corresponds to the desired date. The number of unproductive hours, if any, are given in parentheses to the right of the hours worked. The remaining information in a date box consists of a list of site locations where that piece worked during that given day. Heavy horizontal lines correspond to the beginning and ending of work weeks. The amount paid out to a contractor for that weeks work is listed in the lower right corner of the last date box of the work weeks. The rightmost column contains remarks defining the beginning or finishing of work at all crossings.

The original plan was to open the roads with a cat to allow the delivery of all needed rock, straw, lumber, and fertilizer prior to the beginning of heavy equipment excavation. Rock delivery was to begin as soon as the first sites were made approachable by the road opening work. It would have taken six trucks two weeks to deliver the needed 3,700 yds³ of rock, when based on a rate of six deliveries per day. This would have made it possible to begin the main portion of the heavy equipment phase with all the site's personnel concentrating on their work. As it turned out, there were some exasperating delays in rock delivery and the rock was produced so slowly that work was impeded. John Wilson came to the aid of the three "eastside" project leaders by opening another rock pit on Simpson's land, four weeks after our project had begun. By then, all three eastside rehabilitation projects were in such need of rock that the trucks' time had to be divided among us, rather than fully supplying our total needs in turn, as originally planned. These delays forced me to use one of my technicians as a traffic cop, routing rock delivery trucks to various crossings, for nearly the duration of the heavy equipment season. The following is a general overview of how the work was actually accomplished (refer to Table 1).

The "opening up" phase took eight actual working days (June 24 to July 3). The cat work went smoothly, but it soon became apparent that two dump trucks were necessary to deliver all the straw, fertilizer, and lumber by the end of the opening period. The standby time for the loader was fairly high during this period since he had nothing to do but load our one available truck and prepare materials for loading. In the future, I will schedule as many trucks as necessary to keep up the the time table.

The actual "rehabilitation phase" took ten weeks (July 7 to September 12). Ideally, all the required equipment should have been brought on the site as it became available. The rock delivery problem, however, forced a delay while the limited number of sites that either did not need rock, or that could be approached and rocked after excavation, were completed. Prominent among these sites were the crossings at the terminal end of each road, as well as most slope crossings and all landings located on short spurs of the main haul roads. The completion of these few, widely-separated sites, prior to the excavation of the sites needing rock, resulted in a considerable amount of travel time for equipment. Of all the earth moving equipment, only the rubber-tired backhoe had reasonable mobility. The track-mounted loaders, cats, and most especially, the excavators could move at only a snail's pace between work sites.

Normally, work on a drainage channel is sequenced to begin at its most upstream limit and continue downslope. As ideally equipment work begins at the terminal portion of a road and works its way out, travel time should only be incurred by transporting equipment from one road to another and should be at a minimum. The main reason for using this approach, however, is that if an unexpected storm inundates the rehabilitation site, the work accomplished to date is not so subject to destructive flow (in the form of flashy flow or debris torrents), since there is no unrehabilitated land uphill from it. Thus the only pragmatic solution entailed both a considerable added cost and a risk. Fortunately, no storm occurred during the heavy equipment phase.

By July 23, rock was available from both rock pits, though the delivery rate never approached an optimal level. The crane and ripping cat completed their work on August 19 and August 29, respectively. By the later date, the only open road was the 2004, though a portion near its beginning was rather rocky and precluded access by truck. As a result, the dump truck had to be dismissed on September 2, after completing all work accessible to it. The remaining equipment worked until September 11, except for the winching cat. The cat was used to prepare all remaining sites, and was then dismissed on August 28. The backhoe was retained one additional day (September 12) in order to tie up some loose ends, including road maintenance on retained roads.

Synopsis of Equipment Cost and Time Breakdown

The cost and time breakdowns for equipment work completed on this site are presented in Table 2 (large foldout). This table is a synopsis of the more detailed, site-specific breakdowns which are containing in the next section. Please refer to Maps 3 and 4 (large foldouts) for determination of the erosional features associated with each worksite, and to Maps 5 and 6 (large foldouts) for photo point locations as well as a delineation of the disturbed area associated with each worksite.

The following table lists the heavy equipment utilized on this site and their designated abbreviations.

TABLE 3. HEAVY EQUIPMENT ABBREVIATION KEY

<u>Equipment</u>	<u>Abbreviation</u>
IH TD15 Ripping Cat	R.C.
IH TD25 Winching Cat	W.C.
Case 880 Excavator (1/2 yd ³ bucket)	EX880
Case 980 Excavator (1 1/4 yd ³ bucket)	EX980
Bantam Wheel-mounted Crane (1/4 yd ³ bucket)	Crane
Case 580B Extendahoe (1/4 yd ³ bucket)	B
Cat 955 Track-mounted Loader (1 3/4 yd ³ bucket)	955
Cat 977 Track-mounted Loader (2 3/4 yd ³ buckte)	977
Dump Truck	Dump

Site Specific Equipment Cost and Time Breakdown

This section gives detailed data on a site-specific basis. Only the stream crossing data is included herein. The landing and road treatments are dealt with in the next section, since data is sparse on these. Each crossing data listing is followed by a short narrative explaining unusual features, costs, problems encountered, or the techniques used at that crossing. The symbols R/X and S/X are used to designate road crossings and slope crossings, respectively.

Road Crossing and Slope Crossing
Table Abbreviation Index

- WC = Winching Cat
- EX990 = Case excavator (model 990) with $1\frac{1}{4}$ yd³ bucket
- EX880 = Case excavator (model 880) with $\frac{3}{4}$ yd³ bucket
- 955 = Case 955 loader (track) with $1\frac{3}{4}$ yd³ 4-in-1 bucket
- 977 = Case 977 loader (track) with $2\frac{3}{4}$ yd³ 4-in-1 bucket
- B = Backhoe (Case 580B extendahoe)

Road Crossing #1 (see p.p.-4)*

This small crossing was in a small drainage in the upper prairie. The high rocking cost reflects the fact that the rock was carried over 250 yards by the backhoe. The hoe operator used the spoil to help outslope the adjacent prairie road.

A. Work Task	Cost	Cost/yd. ³	Time Spent by Equipment (hrs.)
Excavation	\$105.00	\$ 7.50	^B 3 hrs.
Rock (5 yd. ³)	73.00		
Placing rock in channel	78.75	15.75	2½ hrs.
Total Cost =	<u>\$256.75</u>	Total Time =	<u>5.25 hrs.</u>

B. Item	Amount	Cost
Total fill removed	14.0 yds ³	
Total channel length	36.7 ft.	
Draped rocking width	5.3 ft.	
Mean rocking depth	.8 ft.	
Earth/ft. of channel	.38 yds ³	
Rock placed/ft. of channel	.14 yds ³	
Excavation cost/ft. of channel		\$2.86
Rock cost/ft. of channel		1.99
Rock placement cost/ft. of channel		<u>2.15</u>
Total Cost/Foot of Channel =		<u>\$7.00</u>

*pp.-4 refers to photos from Maneze Creek (80-2), photo point #4.

Road Crossing #2 (see p.p.-3)

The backhoe operator used the spoil from this excavation to outslope the adjacent prairie road. He had to transport his rock approx. 130 yards, as we could not find a closer dump site for the rock trucks. This raised the cost of rock placement above what it would have been under normal circumstances.

A. Work Task	Cost	Cost/yd. ³	Time Spent By Equipment (hrs.)
			<u>B</u>
Excavation	\$428.75	\$ 3.54	12.25
Rock (30 yds ³)	438.00		
Placing rock in channel	<u>332.50</u>	11.08	<u>9.5</u>
Total Cost =	<u>\$1199.25</u>	Total Time =	<u>21.75</u> hrs.

B. Item	Amount	Cost
Total fill removed	121 yds ³	
Total channel length	100 ft.	
Length of rocked reach	81.4 ft.	
Draped rocking width	6 ft.	
Mean rocking depth	1 ft.	
Earth/ft. of channel	1.21yds. ³	
Rock placed/ft. of channel	.37yds. ³	
Excavation cost/ft. of channel		\$4.29
Rock cost/ft. of channel		5.38
Rock placement cost/ft. of channel		<u>4.08</u>
Total Cost/Foot of Channel =		<u>\$11.99</u>

Road Crossing #3 (see p.p.-2)

All excavation was done by the big excavator (Case 990), since there was no room to take advantage of the cat for anything but pushing material that was already excavated. The rock was right next to the crossing and easily placed.

A. Work Task	Cost	Cost/yd. ³	Time Spent By Equipment (hrs.)	
			EX990	WC
Excavation	\$773.80	\$ 1.28	8	5
Rock (40 yds. ³)	584.00			
Placing rock in channel	<u>410.50</u>	10.26	<u>5</u>	<u>1.5</u>
Total Cost =	<u>\$1768.30</u>	Total Time=	<u>13 hrs.</u>	<u>6.5 hrs.</u>

B. Item	Amount	Cost
Total fill removed	606 yds. ³	
Total channel length	71 ft.	
Draped rocking width	9 ft.	
Mean rocking depth	1 ft.	
Earth/ft. of channel	8.5 yds. ³	
Rock placed/ft. of channel	.56 yds. ³	

Excavation cost/ft. of channel	\$10.90
Rock cost/ft. of channel	8.22
Rock placement cost/ft. of channel	<u>5.78</u>
Total Cost/Foot of Channel =	<u>\$24.91</u>

Road Crossing #4.

This road crossing is actually more of a fancy crossroad ditch than a true crossing.

A.	Work Task	Cost	Time Spent By Equipment (hrs.)
	Excavation and rock placement	\$70.00	$\frac{B}{2}$
	Rock (5 yds. ³)	<u>73.00</u>	<u> </u>
	Totals =	<u>\$143.00</u>	<u>2 hrs.</u>

B.	Item	Amount	Cost
	Total fill removed	10 yds. ³	
	Total channel length	30 ft.	
	Draped rocking width	8 ft.	
	Mean rocking depth	1 ft.	
	Earth/ft. of channel	.33 yds. ³	
	Rock placed/ft. of channel	.17 yds. ³	
	Excavation cost/ft. of channel plus rocking cost/ft.		\$4.77
	Rock cost/ft. of channel		<u>2.43</u>
	Total Cost/Foot of Channel=		<u>\$7.20</u>

Road Crossing #7 + Slope Crossing #5* (see p.p. 8 & 9)

The high rocking soct at this site (\$19.95), in spite of the abundance of local rock, is partly due to the fact that the excavator was mired in the mud for about 2 hours. The two loaders were involved with extricating the excavator for that period, so the actual cost was more like \$14.68/yd.³ of rock (True hours spent in rocking: EX980 = 9 hrs; 955 = 5.5 hrs; 977 = 2 hrs.).

A. Work Task	Cost	Cost/yd. ³	Time Spent By Equipment (hrs.)		
			EX980	955	977
Excavation	\$1008.70	\$ 2.10	9.5	7	
Rock (40 yds. ³)	584.00				
Placing rock in channel (placed 70 yds. ³)**	1397.10	14.68 (19.95)	11	7.5	4
Total Cost=	<u>\$2989.80</u>	Total Time =	<u>20.5</u>	<u>14.5</u>	<u>4</u> hours

B. Item	Amount	Cost
Total fill removed	480 yds. ³	
Total channel length	174 ft.	
Length of rocked reach	174 ft.	
Draped rocking width	9 ft.	
Mean rocking depth	1.2 ft.	
Earth/ft. of channel	2.8 yds. ³	
Rock placed/ft of channel	.4 yds. ³	
Excavation cost/ft. of channel		\$5.80
Rock cost/ft. of channel		3.36
Rock placement cost/ft. of channel		<u>8.03</u>
Total Cost/Foot of Channel =		<u>\$17.18</u>

* These two crossings are combined, since they form a continuous reach.

**Excavation produced about 30 yds.³ of rock which was added to that brought in.

Road Crossing #8 (see p.p. 6)

This site was at a place where three channels met (channels from S/X3.1, S/X-3, and S/X-2). The relatively small volume of material excavated per foot of channel (0.81 yds.³ of earth/ft) coupled with the long channel length (209 ft.), cramped working area (see p.p.-6) and distant dump site (80 yards from the crossing) elevated the unit excavation cost. The rock supply was 200 yards away, but since there were two loaders to supply the excavator with rock, the cost/yd.³ for rock placement was reasonable (the excavator was kept busy).

A. Work task	Cost	Cost/yd. ³	Time Spent By Equipment (hrs.)		
			EX980	955	B
Excavation	\$1248.80	\$7.35	13	7	
Rock (50 yds. ³)	730.00				
Placing rock in channel	<u>478.30</u>	9.57	<u>3</u>	<u>5</u>	<u>0.5</u>
Total Cost =	<u>\$2457.10</u>	Total Time =	<u>16</u>	<u>12</u>	<u>0.5</u> hours

B. Item	Amount	Cost
Total fill removed	170 yds. ³	
Total channel lengths *	209 ft.	
Length of rock reach	209 ft.	
Draped rocking width	6 ft.	
Mean rocking depth	1 ft.	
Earth/ft. of channel	0.81 yds. ³	
Rock placed/ft. of channel	0.24 yds. ³	
Excavation cost/ft. of channel		\$5.98
Rock cost/ft. of channel		3.49
Rock placement cost/ft. of channel		<u>2.29</u>
Total Cost/Foot of Channel =		<u>\$11.76</u>

* Three channels join into one at this crossing.

Road Crossing #10 (see p.p.-24)

This is the only crossing done exclusively by the crane. The crane's long reach was required in this case. Although it seemed to take an awfully long time to complete, the cost was within bounds because of the lower hourly rate of the crane (\$45.00/hr.) and the fact that the support equipment (cat and loader) could be pulled from a large project nearby (S/X-9) as the need arose, rather than loitering on site (it was planned that way).

A. Work Task	Cost	Cost/yd. ³	Time Spent By Equipment (hrs.)		
			Crane	WC	955
Excavation	\$3327.00	\$6.39	64	2	7
Rock (60 yds. ³)	876.00				
Placing rock in channel	<u>519.00</u>	8.65	<u>7</u>		<u>4</u>
Total Cost =	<u>\$4722.00</u>	Total Time=	<u>71</u>	<u>2</u>	<u>11</u> hours

B. Item	Amount	Cost
Total fill removed	521 yds. ³	
Total channel length	80 ft.	
Length of rock reach	80 ft.	
Draped rocking width	20 ft.	
Mean rocking depth	1 ft.	
Earth/ft. of channel	6.5 yds. ³	
Rock placed/ft. of channel	0.75 yds. ³	
Excavation cost/ft. of channel		\$41.59
Rock cost/ft. of channel		10.95
Rock placement cost/ft. of channel		<u>6.49</u>
Total Cost/Foot of Channel =		<u>\$59.03</u>

Road Crossing #11*

A. Work Task	Cost	Cost/yd. ³	Time Spent By Equipment (hrs.)			
			<u>WC</u>	<u>EX880</u>	<u>955</u>	<u>B</u>
Culvert excavation and placement	\$492.50	--		5	2.5	0.5
Excavating inboard ditch**	<u>45.00</u>		<u>1</u>			
Total Cost =	\$537.50	Total Time=	1	5	2.5	0.5 hours

* This crossing was not on our site, but needed to be dealt with to provide access. It is on the 2020 road, north of the rehab. unit.

** The inboard ditch was needed to drain springs on a steep road stretch near the crossing.

Road Crossing #12 (see p.p.-15)

*The right bank of this crossing was part of landing #1. The unlimited working space gave the cat and loader a chance to show what they could do in an excavating mode. The overall cost/yd.³ of excavated material was \$2.78, while that portion done by the cat and loader cost only \$0.95 per yard. "Support equipment should thus be used as much as possible to do the rough excavating.

A1. <u>Crossing Work Task</u>	Cost	Cost/yd. ³	Time Spent By Equipment (hrs.)		
			<u>EX980</u>	<u>WC</u>	<u>977</u>
Excavation	\$1958.50	\$ 2.78	10	9.5	13
Rock (40 yds. ³)	584.00				
Placing rock in channel	<u>668.00</u>	16.70	<u>5</u>	<u> </u>	<u>5</u>
Total Channel Cost =	<u>\$3210.50</u>	Total Time=	<u>15</u>	<u>9.5</u>	<u>18</u> hours

B1. <u>Crossing Item</u>	Amount	Cost
Total fill removed	704 yds. ³	
Total channel length	100 ft.	
Length of rocked reach	53 ft.	
Draped rocking width	12 ft.	
Mean rocking depth	1.7 ft.	
Earth/ft. of channel	7.0 yds. ³	
Rock placed/ft. of channel	0.76 yds. ³	

Excavation cost/ft. of channel	\$19.59
Rock cost/ft. of channel (rocked portion only)	11.02
Rock placement cost/ft. of channel (rocked portion only)	<u>12.60</u>
(Rocked Portion) Total Cost/Foot of Channel =	<u>\$43.21</u>
(Overall Average) Total Cost/Foot of Channel =	<u>\$32.11</u>

A2. <u>French Drain Work Task</u>	Cost	Cost/yd. ³	Time Spent By Equipment (hrs.)		
			<u>Dump</u>	<u>B</u>	<u>955</u>
Excavation	\$ 70.00	\$ 3.50		2	
Gravel (20 yds. ³)	321.96	16.10	4		4
Placing gravel in drain	<u>35.00</u>	1.75	<u> </u>	<u>1</u>	<u> </u>
Total Drain Cost =	<u>\$426.96</u>	Total Time =	<u>4</u>	<u>3</u>	<u>4</u> hours

(continued on next page)

Road Crossing #16

The water flowing through the culvert under the K&K road at Meneze Creek, had a fall of over 20 ft after exiting. Last year's rainfall was not marked by many high intensity storms, yet the creek had an average flow of over 4 cfs. The erosive power of the water, after a 20 ft. vertical fall, was undercutting the soft rock and fill of the streamcrossing under the culvert exit. Large diameter rock (about 2 feet in diameter) was used and it looks like the crossing is now well protected. No access was possible, so the rock was dumped in until the eroding portion of the crossing was adequately riprapped.

A. Work Task	Cost	Cost/yd. ³	Time Spent By Equipment (hrs.)
No Excavation	--	--	--
Rock (80 yds. ³)	\$1168.00	\$14.60	(truck cost & time included in rock unit cost)
No Placing (just dropped)	--	--	--

Road Crossing #20 -- Eliminated

Road Crossing #21.1

This job entailed dumping rocks over the outboard edge of the road, using a loader. Trucks could not do this job directly, due to limited access and the need for exact placement. This work fortified the outfall area of the culvert.

A. Work Task	Cost	Cost/yd. ³	Time Spent By Equipment (hrs.)
			<u>977</u>
Excavation	---	---	---
Rocks (50yds. ³)	\$730.00		
Placing rock in channel	<u>487.50</u>	\$9.75	<u>7.5</u>
Total Cost=	<u>\$1217.50</u>	Total Time =	<u>7.5</u> hours

Road Crossing #22 -- Eliminated

Road Crossing #24

About half of the rock used in this channelization had to be transported over adverse terrain for distances of up to 200 yards. This greatly increased the unit cost of the rock placement.

A. Work Task	Cost	Cost/yd. ³	Time Spent By Equipment (hrs.)					
			WC	B	EX980	EX880	955	977
Excavation	\$3677.15	\$ 3.15	2.75	59.5	6.5	5	5	6.5
Rock (40 yds. ³)	584.00							
Placing rock in channel	<u>1547.00</u>	38.68		<u>7</u>	<u>8.5</u>	<u>3</u>	<u>3</u>	<u>5.5</u>
Total Cost =	<u>\$5808.25</u>	Tot. Time=	<u>2.75</u>	<u>63.5</u>	<u>15.0</u>	<u>8</u>	<u>8</u>	<u>12.0</u>

B. Item	Amount	Cost
Total fill removed	1167 yds. ³	
Total channel length	500 ft.	
Total rock channel length	190 ft.	
Draped rocking width	9 ft.	
Mean rocking depth	0.6 ft.	
Earth/ft. of channel	2.3 yds. ³	
Rock placed/ft. of channel	0.21 yds. ³	
Excavation cost/ft. of channel		\$7.35
Rock cost/ft. of channel		3.07
Rock placement cost/ft. of channel		<u>8.14</u>
(In Rocked Reach) Total Cost/Foot of Channel	=	<u>\$18.56</u>
(Overall Mean) Total Cost/Foot of Channel	=	<u>\$11.62</u>

Road Crossing #25 (see p.p.-38, 39)

All excavation was done by the cat and 977 loader. In addition, the dump sites were immediately adjacent to the channel. These factors produced an extremely inexpensive unit excavation cost. The rock was located over 200 yards from the site. This increased the rocking cost, as well as the cost of transporting the dam materials. Some of the boards for the dams were over half a mile away, due to the impossibility of driving a dump truck over ripped portions of the road.

A1. Work Task	Cost	Cost/yd. ³	Time Spent By Equipment (hrs.)				
			WC	EX980	955	977	B
Excavation	\$980.00	\$ 0.58	5			10	
Rock (30 yds. ³ placed at upper and lower ends of channel only)	438.00						
Placing rock (as described above)	<u>578.65</u>	19.29		<u>2.75</u>		<u>6</u>	
Sub-Total Cost =	<u>\$1996.65</u>	Tot. Time=	<u>5</u>	<u>2.75</u>	<u>0</u>	<u>16</u>	<u>0</u> hours
A2. Dam Preparation							
Rock (40 yds. ³)	\$584.00				2	3.5	2
Bringing Rock & Boards	<u>411.36</u>						
Sub-Total Cost =	<u>\$995.96</u>	Tot. Time=	<u>0</u>	<u>0.0</u>	<u>2</u>	<u>3.5</u>	<u>2</u>
Grand Totals:	Cost= <u>\$2992.01</u>	Time=	<u>5</u>	<u>2.75</u>	<u>4</u>	<u>7.0</u>	<u>2</u>

B.	Item	Amount	Cost
	Total fill removed	1674 yds. ³	
	Total channel length	203 ft.	
	Rocked channel length	66 ft.	
	Draped rocked width	17 ft.	
	Mean rocking depth	0.7 ft.	
	Earth/ft. of channel	8.25 ft.	
	Rock placed/ft. of channel	0.45 ft.	

(continued on next page)

R/X #25 (Continued)

<u>B.(Continued)</u>	<u>Item</u>	<u>Amount</u>	<u>Cost</u>
	Excavation cost/ft. of channel		\$ 4.83
	Rock cost/ft. of rocked reach		10.95
	Rock placement cost/ft. of rocked reach		<u>14.66</u>
	Total Cost/Foot Of Rocked Reach	=	<u>\$30.25</u>
	Overall Cost/Foot Of Channel	=	<u>\$14.74</u>

Road Crossing #26 (see p.p.-35,36)

Both the new and the rehabed channels were worked on sumultaneously, so there is no way to determine the cost per foot of each channel seperately, since the total time spent by each piece of equipment on each of the two channels could not be determined. The majority of the excavation was accomplished by the cat and the two loaders. Rock had to be carried 200 to 300 yards to this site. The two loaders and the backhoe were working together to bring the rock. This kept the cost as low as possible by keeping the excavator busy.

A. Work Task	Cost	Cost/yd. ³	Time Spent By Equipment (hrs.)					
			WC	EX980	EX880	955	977	B
Excavation	\$1938.00	\$ 1.69	13.5	5	7	6	3	
Rock (150 yds. ²)	2190.00							
Placing rock in channel	<u>1930.25</u>	12.87		<u>5</u>	<u>5.5</u>	<u>5</u>	<u>13</u>	<u>3</u>
Total Cost =	<u>\$6058.25</u>	Tot. Time=	<u>13.5</u>	<u>10</u>	<u>12.5</u>	<u>11</u>	<u>16</u>	<u>3</u>

B. Item	Amount	Cost
Total fill removed (new channel)	512 yds. ³	
Total fill removed (rehabed. channel)	190 yds. ³	
Total fill removed (between channels)	445 yds. ³	
Grand total of all fill removed	1150 yds. ³	
New Channel length (all rocked)	122 ft.	
Rehabed channel length (all rocked)	96 ft.	
Total channel length (sum of above)	218 ft.	
Draped rocking width (both channels)	11 ft.	
Mean rocking depth (both channels)	1.6 ft.	
Earth/ft. of new channel	4.2 yds. ³	
Earth/ft. of rehabed channel	2.0 yds. ³	
Mean Earth/ft. of channel (including both channels and area between)	5.28 yds. ³	
Rock placed/ft. of channel (both channels are the same)	0.69 yds. ³	

(continued on next page)

R/X #26 (continued)

B. (Continued)	Item	Amount	Cost
	Excavation cost/ft. of channel (both)		\$ 8.89
	Rock cost/ft. of channel (both)		10.05
	Rock placement cost/ft. of channel (both)		<u>8.85</u>
	Total Cost/Foot of Channel =		<u>\$27.79</u>

Road Crossing #28 (see p.p.-29)

A. Work Task	Cost	Cost/yd. ³	Time Spent By Equipment (hrs.)			
			EX980	EX880	955	977
Excavation	\$189.10	\$1.26	1	1	1	
Rock (15 yds. ³)	219.00					
Placing 25 yds. ³ of rock in the channel*	<u>133.60</u>	5.34	<u>1</u>	<u>—</u>	<u>—</u>	<u>1</u>
Total Cost =	<u>\$541.70</u>	Total Time =	<u>2</u>	<u>1</u>	<u>1</u>	<u>1</u> hours

B. Item	Amount	Cost
Total fill removed	150 yds. ³	
Total channel length	57 ft.	
Total length of rockd reach	30 ft.	
Draped rocking width	10 ft.	
Mean rocking depth**	2.3 ft.	
Earth/ft. of channel	2.6 yds. ³	
Rock placed/ft. of channel	0.83 yds. ³	

Excavation cost/ft. of channel	\$3.32
Rock cost/ft. of channel (rockd reach only)	7.30
Rock placement cost/ft. of channel (rockd reach only)	<u>4.45</u>
(Rockd Reach Only) Total Cost/Foot of Channel =	<u>\$15.07</u>
Mean Overall Total Cost/Foot of Channel =	<u>\$ 9.50</u>

* 10 yds.³ of rock were produced on site and used.

** thick rock layer was used, due to steep gradient of lower channel.

Road Crossing #29

The excavation of this long channelization was accomplished primarily by the cat, thus this unit cost was low. Lateral access to this steep channel was better than for R/X-27.6, and this is reflected by a lower unit rocking cost.

A. Work Task	Cost	Cost/yd. ³	Time Spent By Equipment (hrs.)		
			WC	EX980	977
Excavation	\$1208.20	\$ 0.83	10.5	5.75	5.25
Rock (50 yds. ³)	730.00				
Placing 90 yds. ³ of rock*	<u>999.30</u>	11.10		<u>6.75</u>	<u>8.25</u>
Total Cost =	<u>\$2937.50</u>	Total Time=	<u>10.5</u>	<u>12.5</u>	<u>13.5</u> hours

B. Item	Amount	Cost
Total fill removed	1450 yds. ³	
Total channel length (all rocked)	265 ft.	
Draped rocking width	9 ft.	
Mean rocking depth	1 ft.	
Earth/ft. of channel	5.5 ft.	
Rock placed/ft. of channel	0.34 yds. ³	
Excavation cost/ft. of channel		\$4.56
Rock cost/ft. of channel		2.76
Rock placement cost/ft. of channel		<u>3.77</u>
Total Cost/Foot of Channel =		<u>\$11.09</u>

* 40 yds.³ of rock were produced on site and used

Road Crossing #30 (see p.p. 32)

This channel was dug by the excavator, with the loader serving in a support role. Unit excavating cost is low in spite of this for the reason that no obstructions were encountered and little transport of waste material was necessary.

A1. Crossing Work Task	Cost	Cost/yd. ³	Time Spent By Equipment (hrs.)	
			<u>EX880</u>	<u>955</u>
Excavation	\$811.00	\$1.35	8	5
Rock (40 yds. ³)	584.00			
Placing 15 yds. ³ of rock in the channel*	<u>120.00</u>	8.03	<u>1</u>	<u>1</u>
Sub-Total Cost =	<u>\$1515.50</u>	Sub-Total Time=	<u>9</u>	<u>6</u> hours
A2. Dam Prep. Work Task				
Bringing and arranging 25 yds. ³ of rock for check dams	<u>\$102.00</u>		<u>0</u>	<u>2</u>
Sub-Total Cost =	<u>\$102.00</u>		<u>0</u>	<u>2</u> hours
Grand Total - - - -	<u>\$1617.50</u>		<u>9</u>	<u>8</u> hours

B. Item	Amount	Cost
Total fill removed	599 yds. ³	
Total channel length	180 ft.	
Total length of rocked reach	50 ft.	
Draped rocking width	14 ft.	
Mean rocking depth	0.6 ft.	
Earth/ft. of channel	3.3 yds. ³	
Rock placed/ft. of channel	0.3 yds. ³	
Excavation cost/ft. of channel		\$4.51
Rock cost/ft. of channel		4.38
Rock placement cost/ft. of channel		<u>2.41</u>
(Rocked Reach Only) Total Cost/Foot of Channel =		<u>\$11.30</u>
Mean Overall Total Cost/Foot of Channel =		<u>\$ 8.99</u>

* rocked only upper and lower ends

Road Crossing #31 (see p.p. 31)

The dam materials (boards and posts) were already delivered to the site while the road was still useable, thus no cost was incurred in their transport (other than normal costs for "opening up" the rehab unit).

A.	Work Task	Cost	Cost/yd. ³	Time Spent By Equipment (hrs.)	
				<u>EX880</u>	<u>955</u>
	Excavation	\$806.50	\$0.87	5	9
	Rock (20 yds. ³)	292.00			
	Placing 10 yds. ³ rock in channel*, and stockpiling 10 yds. ³ rock for dams	<u>542.25</u>	not avail.	<u>4.5</u>	<u>4.5</u>
	Total Cost =	<u>\$1640.75</u>		<u>9.5</u>	<u>13.5</u> hours

B.	Item	Amount	Cost
	Total fill removed	927 yds. ³	
	Total channel length*	67 ft.	
	Draped rocking width	22 ft.	
	Mean rocking depth	0.7 ft.	
	Earth/ft. of channel	13.8 yds. ³	
	Rock placed/ft. of rocked reach	0.28 yds. ³	
	Excavation cost/ft. of channel		\$12.03
	Rock cost/ft. of channel (overall, incl. dam rock)		4.36
	Rock cost/ft. of rocked reach		4.17
	Rock placement cost/ft. of channel (overall, incl. dam)		27.11
	Rock placement cost/ft. of rocked reach		<u>7.75</u>
	Total Cost/Foot of Rocked Reach Only	=	<u>\$23.95</u>
	Overall Mean Cost/Foot of Channel	=	<u>\$24.49</u>

* Rocked at top and bottom of reach only

Road Crossing #32 - Eliminated
(20 yds.³ of rock delivered prior to its being dropped)

Road Crossing #33 - Eliminated

Road Crossing #34

This job entailed filling in a headcut produced by a culvert outfall at the beginning of the 2005 road, on the northernmost boundary of the rehab. unit. The work was a fairly low priority item and was saved till the last part of the season. Due to a mix up, the excavator which was to place the rock was dismissed prior to starting this job. The backhoe did it, but couldn't reach far enough to use all the rock.

A. Work Task	Cost	Cost/yd. ³	Time Spent By Equipment (hrs.)
Excavation	--	--	<u>B</u> --
Rock (50 yds. ³)	\$730.00		
Placing 30 yds. ³ of rock in the channel	<u>70.00</u>	\$2.33	<u>2</u>
Total Cost =	<u><u>\$800.00</u></u>	Total Time =	<u><u>2</u></u> hours

Road Crossing #35 (see p.p.-43)

This channel was hand-rocked by a Redwoods United crew after the heavy equipment season.

A.	Work Task	Cost	Cost/yd. ³	Time Spent
				By Equipment (hrs.)
	Excavation	\$208.50	\$2.09	<u>EX880</u> 3 hours

B.	Item	Amount		Cost
	Total fill removed	100	yds. ³	
	Total channel length	197	ft.	
	Earth/ft. of channel	0.5	yds. ³	
	Excavation cost/ft. of channel			\$1.06

Slope Crossing #1

Eliminated due to low priority and poor access.

Slope Crossing #2

A. Work Task	Cost	Time Spent by Equipment (hrs.)	
		B	955
Excavating & Rocking	\$441.00	7.5	3.5
Rock (10 yds ³)	<u>146.00</u>		
Total Cost =	\$587.00		

B. Item	Amount	Cost
Total fill removed	60 yds ³	
Total channel length	62 ft.	
Draped rocking width	6 ft.	
Mean rocking depth	.73 ft.	
Earth/ft. of channel	.97 yd ³	
Rock placed/ ft. of channel	.16 yd ³	
Excavation cost/ft. of channel		\$9.46
Rock cost/ft. of channel		\$2.36

Rock had to be transported 200 yards to the site up a steep grade in adverse terrain.

Slope Crossing #3 (see p.p.7)

A. Work Task	Cost	Cost/yd ³	Time Spent by Equipment (hrs.)		
			<u>B</u>	<u>955</u>	<u>977</u>
Excavation	\$306.25	\$ 3.40	8.75		
Rock (10 yds ³)	146.00				
Placing rock in channel	<u>272.00</u>	27.20	<u>3</u>	<u>2</u>	<u>1</u>
Total Cost =	\$724.25		11.75	2	1

B. Item	Amount	Cost
Total fill removed	90 yds ³	
Total channel length	54 ft.	
Draped rocking width	9 ft.	
Mean rocking depth	.55 ft.	
Earth/ft. of channel	1.7 yd ³	
Rock placed/ft. of channel	.19 yd ³	
Total cost/ft. of channel		\$13.41
Excavation cost/ft. of channel		5.67
Rock cost/ft. of channel		2.70
Rocking placement cost/ft. of channel		5.03

Bringing rock to this site was expensive, since it was over 250 yards from the site, over steep, adverse terrain. This escalated the rocking cost.

Slope Crossing #3.1

A. Work Task	Cost	Cost/yd ³	Time Spent by Equipment (yd ³)	
			<u>B</u>	<u>955</u>
Excavation	\$113.50	\$ 3.78	3.25	
Rock (10 yds ³)	146.00			
Placing rock in channel	<u>207.00</u>	20.70	<u>3</u>	<u>2</u>
Total Cost =	\$466.75		6.25	2

B. Item	Amount	Cost
Total fill removed	30 yds ³	
Total channel length	43 ft.	
Draped rocking width	6 ft.	
Mean rocking depth	1.0 ft.	
Earth/ft. of channel	.70 yds ³	
Rock placed/ft. of channel	.23 yds ³	
Excavation cost/ft. of channel		\$2.64
Rock cost/ft. of channel		3.40
Rocking placement cost/ft. of channel		4.81

As with adjacent sites S/X-3 and S/X-2, this sites was hard to bring rocks to. The backhoe had to be winched up to these sites.

Slope Crossing #4

A. Work Task	Cost	Cost/yd ³	Time Spent by Equipment (hrs.)
Excavation	\$34.40	\$1.72	<u>EX980</u> .5
No rock			
B. Item	Amount	Cost	
Total fill removed	20 yds ³		
Total channel length	20 ft.		
Earth/ft. of channel	1.0 yd ³		
Cost/ft. of channel			\$1.72

This crossing is more a large cross-road drain than a crossing. It conveys a small gully across the road.

Slope Crossing #5

This job was combined with R/X-7, since the two together represented a continuous reach.

Slope Crossing #6

A. Work Task	Cost	Cost/yd ³	Time Spent by Equipment (hrs.)
Excavation	\$35.00	\$4.38	<u>B</u> 1
No rock			
B. Item		Amount	Cost
Total fill removed		8 yds ³	
Total channel length		15 ft.	
Earth/ft. of channel		.53 yd ³	
Cost/ft. of channel			\$2.33

Part of the expense of this crossing was just the problem of getting to it (up a 45 percent grass covered slope).

Slope Crossing #7

A. Work Task	Cost	Cost/yd ³	Time Spent by Equipment (hrs.)
			<u>B</u>
Excavation	\$ 70.00	\$ 4.67	2
Rock (5 yds ³)	73.00		
Placing rock in channel	<u>70.00</u>	\$14.00	<u>2*</u>
Total Cost =	\$213.00		4

B. Item	Amount	Cost
Total fill removed	15 yds	
Total channel length	35 ft.	
Rocked** channel length	25 ft.	
Draped rocking width	6 ft.	
Earth/ft. of channel	.42 yds ³	
Rock placed/ft. of channel	.2 yd ³	
Mean rocking depth	.9 ft.	
Total cost/ft. of channel		\$8.52
Excavation cost/ft. of channel		2.00
Rock cost/ft. of channel		2.92
Rock placement cost/ft. of channel		2.80

*This time represents both placing and carrying in the rock. Carrying distance was about 250 yards.

**Only the steep upper section and lower section of this little crossing needed rock.

Slope Crossing #9 (see p.p. 21, 22, 23)

This gigantic channelization was the largest project on the Maneze Creek rehabilitation site. Please refer to the text for a full justification and explanation of this operation. Due to the depth of the excavation, very little use could be made of the cat and loaders except as support equipment for the 980 Case excavator, although the cat did do some excavation.

A1. <u>Channel</u> Work Task	Cost	Cost/ yd ³	Time Spent by Equipment (hrs.)					
			<u>WC</u>	<u>EX980</u>	<u>955</u>	<u>977</u>	<u>B</u>	<u>Crane</u>
Excavation	\$14,323.50	\$2.85	97.75	97.5	50			15.25
Rock (250 yds ³)	3,650.00							
Placing rock in channel	<u>1,355.70</u>	5.42		<u>2</u>	<u>12.25</u>	<u>2</u>	<u>13.25</u>	
Sub-Total	= \$19,329.20		97.75	99.5	62.25	2	13.25	15.25

B1. Channel Item	Amount	Cost
Total fill removed*	5,016 yds ³	
Total channel length	627 ft.	
Rocked channel length**	477 ft.	
Mean draped rocking width***	12 ft.	
Mean depth of rocking	1.2 ft.	
Earth/ft. of channel	7.5 yds ³	
Rock placed/ft. of rocked reach***	.52 yds ³	
Total cost/ft. of channel (not incl. rip rap)		\$ 30.83
Excavation cost/ft. of channel		21.44
Rock cost/ft. of rocked reach		7.80
Rock placement cost/ft. of rocked reach		2.90

A2. <u>Rip Rap</u> Work Task	Cost	Cost yd ³	Time Spent by Equipment (hrs.)					
			<u>WC</u>	<u>EX980</u>	<u>955</u>	<u>977</u>		
Excavation	\$1,160.20	not avail.	5	7			7	
Rip rap (120 yds ³)	1,752.00	\$14.60						
Placing rock in channel	<u>1,024.45</u>	8.53		<u>7</u>	<u>1.25</u>	<u>7</u>		
Sub-Total	= \$3,936.65		5	14	1.25	14		
Total Cost	= \$23,265.85	Totals	<u>WC</u>	<u>EX980</u>	<u>955</u>	<u>977</u>	<u>B</u>	<u>Crane</u>
			104.75	113.5	63.5	16	13.25	15.25

B2. Rip Rap Item	Amount	Cost
Rip rapped channel length	75 ft.	
Rip rap/ft. of rip rapped reach****	1.6 yd ³	
Estimated mean thickness of rip rap	5 ft.	
Total cost/ft. of channel (incl. rip rap)		\$37.10
Total cost/ft. of rip rapped reach		52.49
Rip rap excavation cost/ft. of rip rapped reach		16.57
Placing rock in channel/ft. of rip rapped reach		14.64
Rock cost/ft. of rip rapped reach		25.02
Total Rip Rap cost/ft. of rip rapped reach		56.24

*Includes both channel and rip rap excavation

**The low gradient center reach was left unrocked, due to lack of rock.

***Does not include rip rap.

****Rip Rapping was incomplete by ~ 50 percent due to our rock source being cut off.

Slope Crossing #9.1

This was basically a channelization of an existing gully down an abandoned skid trail, connecting to the S/X-9 channelization. Access was a problem, due to the fact that the only safe way to the top of the treated reach was up the gully channel. This required the backhoe operator to literally dig his way up 340 feet of gully before he could really begin the job. Rocking costs were kept to a minimum, since the loader was working nearby and would bring rock as needed instead of waiting around.

A. Work Task	Cost	Cost yd ³	Time Spent by Equipment (hrs.)	
			<u>B</u>	<u>955</u>
Excavation	\$ 945.00	\$ 6.70	27	
Rock (80 yds ³)	1,168.00			
Placing rock in channel	<u>1,022.00</u>	12.78	<u>19</u>	<u>7</u>
Total Cost =	\$3,135.00		46	7

B. Item	Amount	Cost
Total fill removed	141 yds ³	
Total channel length	340 ft.	
Earth/ft. of channel	.42 yd ³	
Rock placed/ft. of channel	.24 yd ³	
Draped rocking width	12 ft.	
Mean rocking depth	.53 ft.	
Total cost/ft. of channel		\$9.22
Excavation cost/ft. of channel		2.78
Rock cost/ft. of channel		3.44
Rock placement cost/ft. of channel		3.01

Slope Crossing #10 (see p.p. 20)

This job entailed laying back and rocking a 10 foot headcut in a large gully. Material was excavated by the cat from the top of the headcut and used to fill it in, thus creating a smooth gradient. The area was then heavily rocked to protect the easily eroded fill material.

A. Work Task	Cost	Cost yd ³	Time Spent by Equipment (hrs.)		
			WC	EX980	955
Excavation	\$ 159.50	\$2.25	2	1	
Rock (80 yds ³)	1,168.00				
Placing rock in channel	<u>591.88</u>	7.40	<u>1</u>	<u>4.75</u>	<u>4.25</u>
Total Cost =	\$1,919.38		3	5.75	4.25

B. Item	Amount	Cost
Total fill removed	71 yds ³	
Total channel length	30 ft.	
Earth/ft. of channel	2.4 yds ³	
Rock placed/ft. of channel	2.6 yds ³	
Draped rocking width	25 ft.	
Mean rocking thickness	1.8 ft.	
Total cost/ft. of channel		\$63.98
Excavation cost/ft. of channel		5.32
Rock cost/ft. of channel		38.93
Rock placement cost/ft. of channel		19.73

Slope Crossing #11

The channel of Maneze Creek at this point was choked with debris and had 8 foot high vertical banks. The debris was pulled out and the right bank (the only accessible one) was laid back, then the channel was rocked. The rock had to be brought in 300 yards over a steep skid trail.

A. Work Task	Cost	Cost yd ³	Time Spent by Equipment (hrs.)				
			RC	WC	EX980	955	B
Excavation	\$ 438.30	\$3.27	1	3.5	3		
Rock (40 yds ³)	584.00						
Placing rock in channel	<u>344.00</u>	8.60	—	—	—	<u>4</u>	<u>4</u>
Total Cost =	\$1,366.30		1	3.5	3	4	4

B. Item	Amount	Cost
Total fill removed	134 yds ³	
Total channel length	47 ft.	
Draped rocking width	15 ft.	
Mean rocking depth	1.5 ft.	
Earth/ft. of channel	2.85 yds ³	
Rock placed/ft. of channel	.85 yd ³	
Total cost/ft. of channel		\$29.07
Excavation cost/ft. of channel		9.33
Rock cost/ft. of channel		12.43
Rock placement cost/ft. of channel		7.32

Slope Crossing #12

Rock for this channelization had to be transported 250 yards down a steep skid trail, thus the higher unit rocking price.

A. Work Task	Cost	Cost yd ³	Time Spent by Equipment (hrs.)	
			<u>B</u>	<u>977</u>
Excavation	\$382.50	\$ 2.52	10	.5
Rock (20 yds ³)	292.00			
Placing rock in channel	<u>370.00</u>	18.50	<u>5</u>	<u>3</u>
Total Cost	= \$1044.50		15	3.5

B. Item	Amount	Cost
Total fill removed	152 yds	
Total channel length	176 ft.	
Rocked channel length	89 ft.	
Draped rocking width	10 ft.	
Mean rocking depth	.6 ft.	
Earth/ft. of channel	.86 yd ³	
Rock placed/ft of rocked channel	.22 yd ³	
Total cost/ft. of channel		\$5.93
Excavation cost/ft. of channel		2.17
Rock cost/ft. of rocked reach		3.28
Rock placement cost/ft. of rocked reach		4.16

Slope Crossing #13

Rock for S/X-13, S/X-14, and S/X-15 channelization was transported 600 yards up a steep skid trail. The excavation work was done in rather steep terrain and with extremely limited working space. This accounts for the relatively high unit excavation price.

A. Work Task	Cost	Cost yd ³	Time Spent by Equipment (hrs.)	
			<u>B</u>	<u>977</u>
Excavation	\$297.50	\$ 8.50	5.25	1.75
Rock (15 yds ³)	219.00			
Placing rock in channel	<u>182.90</u>	12.19	<u>4</u>	<u>.66</u>
Total Cost =	\$699.40		9.25	2.41

B. Item	Amount	Cost
Total fill removed	35 yds ³	
Total channel length	106 ft.	
Draped rocking width	6 ft.	
Mean rocking depth	.6 ft.	
Earth/ft. of channel	.33 yds ³	
Rock placed/ft. of channel	.14 yds ³	
Total cost/ft. of channel		\$6.60
Excavation cost/ft. of channel		2.81
Rock cost/ft. of channel		2.07
Rock placement cost/ft. of channel		1.73

Slope Crossing #17

This crossing was excavated to apparent original grade (a somewhat arbitrary base level, considering the violent erosion this reach and the reach upstream have sustained) and left to its own devices, without any channel or bank protection. This was done in an effort to ascertain whether or not such protection is worth the high price that must be paid for it. Before excavation, the reach was characterized by vertical banks of from 6 to 20 feet in height. The site's suitability to an "excavation only" approach was based upon the fact that there was enough room that the fill could be removed to a safe distance and the banks could be laid back to a stable angle. The cost per cubic yard is the result of extensive use of the cat (WC) for excavation.

A. Work Task	Cost	Cost yd ³	Time Spent by Equipment (hrs.)		
			WC	EX980	955
Excavation	\$2,429.90	\$1.31	20.5	21.5	.5
No Rock					
Total Cost	= \$2,429.90				

B. Item	Amount	Cost
Total fill removed	1,850 yds ³	
Total channel length	199 ft.	
Earth/ft. of channel	9.3 yds ³	
Total cost/ft. of channel		\$12.21

Slope Crossing #18 (see p.p. 34)

A. Work Task	Cost	Cost/yd ³	Time Spent by Equipment (hrs.)			
			<u>WC</u>	<u>EX980</u>	<u>EX880</u>	<u>955</u>
Excavation	\$4,752.50	\$4.44	33.5	25		30
Rock (160 yds)	2,336.00					
Placing rock in channel	<u>1,845.15</u>	9.71	<u>2</u>	<u>2.75</u>	<u>13</u>	<u>13</u>
Total Cost =	\$8,933.65		35.5	27.75	13	43

B. Item	Amount	Cost
Total fill removed	1,070 yds ³	
Total channel length	392 ft.	
Rocked channel length	277 ft.	
Draped rocking width	8.0 ft.	
Mean rocking depth	2 ft.	
Earth/ft. of channel	2.73 yds ³	
Rock placed/ft. of channel	.75 yd ³	
Total cost/ft. of channel		\$22.79
Excavation cost/ft. of channel		12.12
Rock cost/ft. of rocked channel		8.43
Rock placement cost/ft. of rocked channel		6.66

Slope Crossing #18.1 (see p.p. 33)

A. Work Task	Cost	Cost yd ³	Time Spent by Equipment (hrs.)			
			<u>WC</u>	<u>EX980</u>	<u>EX880</u>	<u>955</u>
Excavation	\$ 397.60	\$ 1.78	3.5	3.5		
Rock (70 yds ³)	1,022.00					
Placing rock in channel	<u>723.00</u>	10.33	<u> </u>	<u> </u>	<u>3</u>	<u>3</u>
Total Cost	\$2,142.60		3.5	3.5	3	3

B. Item	Amount	Cost
Total fill removed	223 yds ³	
Total channel length	61 ft.	
Draped rocking width	26 ft.	
Mean rocking depth	1.2 ft.	
Earth/ft. of channel	3.7 yds ³	
Rock placed/ft. of channel	1.2 yds ³	
Total cost/ft. of channel		\$35.13
Excavation cost/ft. of channel		6.52
Rock cost/ft. of channel		16.75
Rock placement cost/ft. of channel		11.85

Slope Crossing #19 (p.p. 42)

A. Work Task	Cost	Cost yd ³	Time Spent by Equipment (hrs.)			
			WC	EX980	EX880	955
Excavation	\$3,389.70	\$2.51	23.5	19.5		19.5
Rock (80 yds ³)	1,168.00					
Placing 90 yds of rock*	<u>723.00</u>	8.03	<u> </u>	<u> </u>	<u>6</u>	<u>6</u>
Total Cost =	\$5,280.70		23.5	19.5	6	25.5

B. Item	Amount	Cost
Total fill removed	1,353 yds ³	
Total channel length	248 ft.	
Draped rocking width	11.7 ft.	
Mean rocking depth	.7 ft.	
Earth/ft. of channel	5.5 yds ³	
Rock placed/ft. of channel	.32 yd ³	
Total cost/ft. of channel		\$21.29
Excavation cost/ft. of channel		13.67
Rock cost/ft. of channel		4.71
Rock placement/ft. of channel		2.92

*10 yds³ of rock produced and used on site.

Slope Crossing #20

A. Work Task	Cost	Cost yd ³	Time Spent by Equipment (hrs.)		
			<u>WC</u>	<u>EX980</u>	<u>955</u>
Excavation No Rock	\$878.10	\$2.91	3	6	6.5

B. Item	Amount	Cost
Total fill removed	302 yds	
Total channel length	75 ft.	
Earth/ft. of channel	4 yds ³	
Excavation cost/ft. of channel		\$11.71

Slope Crossing #21

A. Work Task	Cost	Cost yd ³	Time Spent by Equipment (hrs.)
			<u>WC</u>
Excavation	\$56.25	\$1.13	1.25
B. Item		Amount	Cost
Total fill removed		50 yds ³	
Total channel length		50 ft.	
Earth/ft. of channel		1.0 yd ³	
Excavation cost/ft. of channel			\$1.13

Slope Crossing #22

Eliminated due to poor access.

Slope Crossing #23 (see p.p. 16)

A. Work Task	Cost	Cost yd ³	Time Spent by Equipment (hrs.)	
			<u>EX980</u>	<u>977</u>
Excavation	\$ 666.20	\$3.45	4.5	5.5
Rock (80 yds ³)	1,168.00			
Placing rock in channel	<u>568.70</u>	7.11	<u>4.5</u>	<u>4</u>
Total Cost =	\$2,402.90		9	9.5

B. Item	Amount	Cost
Total fill removed	171 yds ³	
Total channel length	77 ft.	
Rocked channel length (dug)	105 ft.	
Draped rocking width	14 ft.	
Mean rocking depth	1.5 ft.	
Earth/ft. of channel (105 ft.)	1.6 yds ³	
Rock placed/ft. of channel (105 ft.)	.76 yd ³	
Total cost/ft. of channel (105 ft.)		\$22.88
Excavation cost/ft. of excavated reach (77 ft.)		8.65
Rock cost/ft of channel (105 ft.)		11.12
Rock placement cost/ft. of channel (105 ft.)		5.42

Cost Estimates and Guidelines for Future Work

As mentioned in the "Heavy Equipment Used" section, our pieces of equipment were carefully chosen and matched so as to be both flexible in application and mutually complimentary in size. The work on the Maneze Creek Unit represents an improvement in efficiency over the work on Copper Creek last year. The first portion of this section will discuss the philosophy of approach used (with examples), followed by some basic guidelines for making cost estimates.

The following are some basic suggestions for the proper excavation and treatment of a stream crossing reaches, as based on observations of work done on this site. During excavation, the channel itself should be made wider at the stream crossing than it is at its widest point within 200 yards up and downstream. This will lower the depth and velocity of flow through the sensitive stream crossing, ensuring that this disturbed reach can recover rather than being subjected to a new sequence of erosion. Checkdams should be used only on small streams, as the large dams needed in major streams are quite costly (per foot of rise) and require careful maintenance. A properly rocked and excavated crossing will adjust to dissipate energy below a headcut, should one develop, while a checkdammed crossing is in serious difficulty if even one dam fails (particularly one of the lower dams in a sequence). On this site one experimental crossing (S/X-17) was fully excavated to grade and given no channel or bank protection, except for some native rocks which were moved to the lower end of the excavated reach. It was given a wide (10 foot) channel and gently sloping banks. On December 2, a storm dropped six inches of rain on the Maneze Creek watershed. While the rocked channels experienced little erosion this unprotected stream channel degraded an average of three feet and developed several 6 foot headcuts. Theoretically, a properly excavated channel should not downcut significantly. In reality this is not always a dependable theory. Ideally, all major crossings should be thoroughly rocked. If rock is not available in the proper size distribution or quantity, then checkdams may be contemplated. It is our opinion that the crossing should be completed properly (fully excavated and rocked) or should be left until the rock is available, even if it means waiting a year.

An excavator should be utilized whenever possible to place rock into excavated stream channels. The rock should be placed all the way up to the highest expected water level (as determined by runoff calculations), and should be 1.5 times thicker than the smallest rock that would not be moved by such a flow. This would mean spreading one foot diameter rock to a depth of 1.5 feet for most first and second order streams.

The most important pieces of equipment utilized on this site were the two hydraulic excavators. All work was scheduled so as to maximize their efficiency. An excavator can work very quickly and can prepare its own bench on a slope to work from. Most track-mounted excavators can operate on a 35 percent slope (track aligned with the slope) and can climb grades as steep as 70 percent. They can be maneuvered down steep channel sideslopes and, thus, can dig or place rock from nearly all locations in or out of the channel.

Unfortunately, one problem they do have is that they bog down easily under wet surface conditions, such as those commonly encountered in a stream crossing excavation that is nearing final depth. The easiest solution to such a problem is to cut a narrow access road with a cat which parallels the nearly completed channel and is just above the expected high water line. The excavator can easily complete the excavation and rock the channel from this temporary road. It then pulls the road as its final channel treatment is complete, leaving uniform, outsloped sideslopes.

An hydraulic excavator is only as efficient as its support equipment. The support piece should be able to remove waste material to a distance of at least 100 yards, without significant spillage, and still keep up with the excavators' progress. In addition, it must be able to support the excavator even during in-channel work (must be able to operate over steep, uneven terrain). The piece of equipment that can best fulfill these prerequisites is a track-mounted loader with a 4-in-1 bucket. The 4-in-1 bucket permits it to "bite" and lift rock or waste material, including brush and logs, without having to push the bucket into the pile. The track-mounting permits operation over rough terrain. This combination of a 4-in-1 bucket and tracks permits the loader to function as a small cat when needed, the only disadvantage being its inability to tilt its blade. A loader of this type can also serve an excavating function when not needed to remove spoil material from a worksite. Loaders were used to excavate, in part, the following stream crossings: R/X-6; R/X-12; R/X-25; R/X-26; and S/X-16. They were particularly useful for pulling back the side slopes of stream channels without side casting. This was accomplished by backblading with a down-tilted, open bucket, using both portions of the bucket simultaneously in soft material and the upper lip alone in hard material.

In order to assure a good match between a loader and an excavator, the loader should have a bucket capacity of at least twice that of the excavator. The loader should also have an adequate cooling system, which is best determined before choosing equipment so that the owner has time to make any necessary repairs.

The sequence of work must be laid out in advance to minimize travel distance for all equipment. As excavators travel at a relatively slow speed, the faster support equipment begin preparation work while waiting for the excavator to catch up. Each road should be pulled in its entirety prior to going on to the next road.

When two excavators (and loaders) are available there are several efficient ways to use them, as outlined below:

1. One excavator conducts preliminary excavations of stream crossings while the other one completes them. This is feasible only where the portions above and below the road can be completed while leaving an escape route for the other excavator.
2. The two excavators may "leap-frog" each other. If one begins to fall behind, then;
3. Both excavators work on the same stream crossing.
4. Each excavator works on a separate road.

The first three options have the advantage of keeping the less utilized support equipment (winching cat and backhoe) within easy reach of both excavators at all times. The fourth option, however, assures that the individual pieces of equipment do not get in each other's way. In general, equipment pieces should concentrate in one area up to the point where they begin to have mutual interference.

Cranes are not cost efficient in terms of excavation rates and should only be used only where a very long reach is essential. Support equipment should work near the crane site so that it will remain available to serve the crane as the need arises. This means that while the crane is on site, the work schedule for other equipment must revolve around it instead of following the four suggested options outlined above. Although this procedure results in extra travel time while the other equipment hopscotches around to the various crane sites, it is most efficient overall for it expedites the work at crane sites. Crane work should be done at each site only to the point where the excavator can take over and easily complete the job (in proper sequence). Do all crane work over the entire rehabilitation unit as soon as possible, then you may follow the more efficient procedure outlined above.

One excellent use for a crane is to pull large volumes of fill, such as landings, that are perched directly over a perennial stream. In this case, a cat should assist by blading the excavated material to a safe location. The crane should dig the lip of the fill back locally to a slope angle upon which the cat can operate, leaving a berm extending downhill on either side of the slot. At this point, the cat can go down to the bottom of the fill and move it out by cutting it off with the side of his blade, while pushing uphill. At the same time, the crane can begin cutting slots in other portions of fill in the same manner. This procedure works well, as the crane only excavates ~20 percent of the fill while the cat removes the rest. In addition, this procedure keeps both pieces of equipment busy at what they do best, while the cat remains available at all times to blade away the crane's waste.

Where a landing is not sitting over a stream or critical area, it can be outsloped most efficiently by a large cat. They can "quarter" the edge of the landing, blading the fill towards the cutbank. A berm is left at the edge that can then be gently pushed downhill, providing footing for a yet deeper cut along landing's edge. A large cat, such as a TD-25, can completely outslope a normal-sized landing in about four hours, while the same job could take a crane one to two weeks! [Beware of these deep fills, as they are usually very wet at depth, even in the summer, and the cat may become mired. Usually the edge of the landing can be taken down at least eight feet without any problem.]

The winching cat should be the first piece of equipment to arrive on the site, since the roads and crossings must be reconstructed to afford access. All rock storage sites should be located as close to their final crossing destinations as possible, without interfering with waste spreading. They should be prepared by the cat as it opens the roads. This is most efficiently done by cutting further into the cutbank. While this may temporarily destabilize the cutbank, it greatly lowers rocking costs. The offended cutbank can be given extra care when the rock is removed and the road is pulled to that point. In addition, the cat should prepare generous turn-around places for the rock trucks so that they won't have to backup more than 50 yards to their dump site. These trucks will be needed in rapid sequence, if the rock is to be delivered on site in time, and traffic bottle-necking is to be avoided.

The winching cat needs to be of a moderate size, for good maneuverability. As a consequence, this cat will not have sufficient power and blade size to efficiently outslope a landing, and a larger ripping cat should be utilized. Our one attempt to outslope a landing (Landing 3) with the winching cat alone was ineffective and the TD-25 ripping cat was eventually substituted. The winching cat was found to be most useful as an excavating piece for smaller jobs, however, as it works at a faster rate than the excavator. In general the rough, preliminary excavations should be done by a cat, while utilizing the excavator for more critical or delicate finish work.

Another piece of equipment that should be brought in right at the beginning of the equipment phase is a dump truck. [Preferably, it should have a "U" shaped bed, so that large rocks and heavy logs may be hauled without damaging the truck. A tailgate is unnecessary in a "U" bedded truck, as the rear of the bed is tilted up slightly, effectively containing even a nearly full load. In contrast, much time can be lost by having a dump truck with a conventional bed, since a tailgate is necessary for hauling dirt and rock but must be removed when large logs or rip rap are transported]. The truck should also be used to bring logs to the cat for humboldt crossings and to distribute straw, fertilizer, and checkdam materials in its "free" time. These functions alone will occupy the truck for at least the duration of the "opening up" period. Rock hauling should begin right away, using as many trucks as necessary to complete the delivery by the end of the "opening up" period (any regular dump truck will serve well). If this is not possible, the delivery should start at the top of the watershed and work its way down. If at any time the work catches up to the rock delivery, shut down the whole show and wait for rock. There is no excuse for poor planning.

Backhoes are extremely flexible in their application, yet somewhat slow in their excavation rates. In confined stream channels and crossings, they can be driven down (or let down on a bull line, where safety permits) into the actual channel where rocking is easily completed. Backhoes should be used wherever possible to dig keyways for checkdams (positions flagged in advance), for which purpose they should be equipped with a narrow trenching bucket. [In addition, they can be used to enplace prefabricated sections of concrete and wire mesh dams into the keyways. There, sections are placed so that their overlapping bare wire mesh (vertical) edges overlap. The hoe holds each piece in place until it is stabilized by rocks and stakes, then lowers down the next section. Once in place, laborers can complete the dam by building up ferro-cement in and over the over-lapping mesh.] In this way, checkdam construction would be expedited and the total cost of checkdams could be greatly reduced.

Road outslowing was tried with every piece of excavating equipment but the crane. For shallow outslowing (by simply cutting down the outboard edge of the road approximately two feet while placing the waste against the cutbank, the use of an unassisted ripping cat was found to be the cheapest method (\$.13/ft.), followed by the 977 loader (\$.26/ft.); the winching cat (\$.27/ft.); the excavator (\$.29/ft.); and finally the backhoe (\$.48/ft.). The unassisted loader, however, was found to have only limited capabilities for outslowing roads because they lack the ability to tilt their buckets. The average cost for shallow outslowing using a cat or excavator (\$1,478.40/mile) was low enough to justify the wide spread use of this method on non-critical and less-steep road reaches. Heavy outslowing of roads was best accomplished by the 880 excavator, with the assistance of the winching cat and 955 loader to blade away the fill to a stable portion of the road for storage. For example, just south of R/X-23 (2004 road), the entire road prism was removed by the excavator to a maximum depth of nine feet at the outboard edge. The average cost/length was \$1.70 per foot to outslope this road reach. Long stretches of deep outslowing, however, are not possible at this cost because of the extensive amount of endhauling that would be required.

Cross-road drains were dug by the backhoe and both of the excavators. The mean unit cost per drain for these techniques were as follows: the backhoe at \$15.22 (.44 hrs); the 880 excavator at \$18.06 (.28 hrs); and the 980 excavator at \$11.64 (.17 hrs). Ripping costs averaged \$1,378.48 per mile of road and to cross-road drain a road was approximately \$4,013.79 (using the mean cost of the three techniques of cross-road draining, which came to \$14.97 per drain or \$2,635.31 per mile of drained road). This costs substantially more than it would to shallowly outslope the same road reach and is not as effective at keeping flow from concentrating. In the future, we recommend shallow outslowing as the most cost effective road treatment, using cross-road drains only at spring locations and where small gullies cross the road. Deep outslowing will be done in critical areas, such as near stream channels, where the entire road prism is in danger of failing.

Generally speaking, the lowest unit cost per excavated cubic yard was achieved at the larger stream crossings ($>1,000 \text{ yd}^3$ excavations) where there was enough room for the cats and loaders to do excavation work themselves, as well as to support the hydraulic excavator. This is evidenced by the data in Table 2. The mean excavation cost per cubic yard for all the crossings in which the cat and/or loader completed some of the excavation was $\$1.59/\text{yd}^3$, with a standard deviation of $\$.817$ (this includes R/X-12, R/X-14, R/X-18, R/X-25, R/X-26, R/X-27, R/X-27.6, R/X-29, S/X-9, S/X-17 and S/X-21). The two crossings in this group with the highest unit cost are R/X-12 ($\$2.78/\text{yd}^3$) and S/X-9 ($\$2.85/\text{yd}^3$). R/X-12 is the smallest crossing of the group (generally, the smaller the size, the greater the increase in unit cost), while at S/X-9, the cat could only occasionally be used for excavation. The right bank of R/X-12 was excavated by the cat and the 977 loader at a cost of only $\$.95/\text{yd}^3$, showing the greater efficiency of these pieces in doing the rough cut work. By contrast, the average mean unit cost and standard deviation for all excavated crossings were $\$3.09/\text{yd}^3$ and $\$2.283$, respectively. The smaller crossings 1000 yds^3 , where neither a cat nor a loader could be utilized for excavation, showed a higher mean unit cost of $\$3.60/\text{yd}^3$ ($s=\$2.516$). That a larger size alone does not give a great advantage is proven by the unit costs at our large crossings where no cat or loader excavation occurred. Here, the mean excavation cost was $\$2.86/\text{yd}^3$ ($s=\$1.289$), which is only slightly cheaper than the overall average previously stated. In general, it seems that the use of cats and loaders to do the preliminary, rough out excavations will cut unit costs at least in half.

There are two ways to estimate costs for future stream crossing rehabilitation sites using the data in this report. Before using either method, the following must be known: 1) Channel length; 2) the proposed channel width; 3) the proposed rocked wetted perimeter; 4) an estimate of the volume of fill to be removed; and 5) whether or not support equipment may be used for a significant portion of the excavation. The two methods of cost estimation are described below.

The first method utilizes direct comparison with similar crossings on Table 2. The photo point documentation should be noted to eliminate unsuitable crossings. The initial group of crossings to be observed is obtained by selecting all those with comparable "yds³ earth removed/ft. of channel" values from Table 2. Of this group, only those which utilized a similar heavy equipment approach are retained. A mean value of any desired parameter may then be taken for this group.

The second method more roughly estimates crossing costs, using Tables 4 and 5 (see page). Table 4 utilizes the proposed rocked wetted perimeter of the channel as a basis for estimating rock needs and costs, while Table 5 uses the number of cubic yards of earth removed per foot of channel to estimate general excavation costs. The entries in these tables represent mean values of the desired parameter within each class (of wetted perimeter or yds³/ft. of channel). Behind each mean value is the standard deviation associated with it, which has been provided only for the purpose of gross comparison. (In actuality, simple standard deviations may not be taken of ratios since the limits and distribution of such a population are not normal). For example to estimate the overall cost per yard³ of an excavation and the cost per foot of excavated channel excavated for a crossing that will have three cubic yards of earth removed per foot of channel, one merely enters the $2 \rightarrow <4$ column of Table 5 and reads $\$2.32$ and $\$6.08$.

This second method of cost estimation averages figures from crossing excavations that required all the various heavy equipment approaches used. While it may give only a rough cost estimate for a given crossing, it should yield a good overall value for the predicted cost of an entire rehabilitation site. The first method may be used at individual crossing or channelization sites of interest.

TABLE 4

ROCK ESTIMATES BASED ON MEAN VALUES

	Rocked Wetted Perimeter (Mean Values)		
	0→<10'	10→<20'	20→<32'
Percent of total crossings (with data available)	47.6%	40.5%	11.9%
Number of crossings	20	17	5
Yds ³ rock/ft. of channel	.276(.154)	.521(.213)	1.21(.867)
Draped rocking width (ft.)	7.4(1.37)	12.5(2.30)	25.0(4.58)
Rocking depth (ft.)	.85'(2.70)	1.12'(.490)	1.19'(.465)
\$/yd of rocking (not incl. rock cost)	\$15.55(7.69)	\$11.69(5.06)	\$7.92(2.20)
\$/ft of channel length rocked (rocking cost only)	\$3.86(1.74)	\$5.68(3.03)	\$9.26(6.79)

TABLE 5

MEAN #YDS³ OF EARTH/FT.

OF CHANNEL

Mean number yds³ of earth/ft. of channel
(Mean Values)

	0→<2	2→<4	>4
Percent of total crossings (with data available)	46.8%	21.3%	31.9%
Number of crossings	22	10	15
\$/yd ³ of excavation	\$4.26(2.68)	\$2.32(.976)	\$1.92(1.47)
\$/ft of channel excavated (excav. only)	\$3.39(2.77)	\$6.08(2.38)	\$10.60(5.27)
Yds ³ earth/ft. of channel	.92(.563)	2.67(.489)	7.78(3.52)

Part III: LABOR INTENSIVE WORK AND COST BREAKDOWN

Checkdamming of Stream Crossings

The labor intensive costs for checkdams are shown in Table 6 (see page 77). The cost effectiveness of checkdams in any size channel (using present techniques) is very poor when compared with that of premium quality rocking for the same size channel. R/X-13 is a small channelization which cost \$131.08 per foot of rise for installing checkdams of one foot effective height. This channel has a mean slope of 25 percent and a width of 4 feet. It would have cost \$15.44 to rock (using \$3.86/ft. of channel taken from Table 3) the reach of channel protected by one \$131.08 dam. The dam, in this case is over eight times as expensive.

R/X-31 is a large crossing at which three 5-foot effective height (very large) checkdams were placed. It also had a 25 percent channel gradient. An average dam cost \$1,420.00, while the same area could have been protected by rocking for a cost of only \$113.60 (less than one-twelfth the cost of checkdamming). Neither of the above examples considers material costs (rock and lumber).

In addition to their greater cost, checkdams are not nearly as effective at controlling erosion in a stream channel as rocking and require quite a bit of maintenance. The greatest cost was incurred in digging the keyways. If these could have been dug by a backhoe, the cost would have been greatly reduced. In addition, the use of inhouse labor greatly inflates the cost as compared to similar size dams produced by a contractor. For example, large dams such as those mentioned above (at R/X-31), would only cost \$300 to \$400 each, if done by a contractor who used a backhoe to dig the keyways (based on a recent verbal estimate by contractor, Ralph Naylor). While this is still not exactly comparable with rocking costs for a similar reach, it represents an improvement over this year costs.

Checkdams are much more cost effective in wide, low gradient stream channels, because while a dam's unit cost is independent of gradient, the length of stream channel protected by it is inversely proportional to the gradient (expressed as percent slope). So a 4 foot dam will protect 11 feet of reach in a stream with a 36 percent gradient, but the same dam will protect 40 feet of reach if the gradient is 10 percent. These dams may then be even more cost effective than rock for low gradient reaches.

Labor Intensive Phase of Checkdams
Table 6

Channel	Mean Dam Height (ft.)	# Dams	Total Rise (ft.)	Person hours		Total	Cost	
				RNP	RWU		per dam	per foot of rise
S/X-9.1	1.5'	7	9.5'	140		\$ 994.00	\$ 142.00	\$104.63
R/X-13	1.0	26	26	480		3408.00	131.08	131.08
R/X-31	.5	3	15	600		4269.00	1420.00	284.00
R/X-25								
Dams only	4	13	52	1050		7455.00	573.46	143.37
R/X-25								
Splashboards	—	12	—	Ralph Naylor Purchase Order		1215.00	101.25	25.31
Total								
R/X-25	4	13	52	1050		8670.00	666.92	166.73
R/X-30	1.5	12	18	280	140	2478.00	206.50	137.67
R/X-18	1	29	29	210	390	2856.00	98.48	98.48
Grand Total=						\$31336.00		

Guidelines for Future Checkdam Cost Cutting and Cost Estimates

The following is a projected cost estimate for protecting a hypothetical channel that is 100 feet long, 15 feet wide, with a 21 feet wetted perimeter and 25 percent slope (25 feet of rise). The purpose is to contrast known rocking costs of large channels with hypothetical checkdammings costs when a backhoe is used to excavate the keyways.

<u>Rocking</u>	<u>Cost</u>
Rock (1.5' deep @ \$14.60/yd ³ = 116 yds ³)	\$1,703.33
Rocking (estimated at \$11.69/yd ³ from Maneze Creek data)	<u>1,356.04</u>
Total	= \$3,059.37
\$/ft of rise	= <u>\$122.38</u>
 <u>Checkdams</u> (4' high with 6" of water depth at base of dam = 3.5' effective height)	
Backhoe (1.5 hrs to dig each keyway @ \$35/hr.)	\$52.30 per dam
Labor (3 person days @ \$7.10/hr.)	\$213.00 per dam
Rock (2 yds ³ per dam @ \$14.60/yd ³)	<u>\$29.20 per dam</u>
Total	= \$294.70 per dam
\$/ft of rise	= <u>\$84.20</u>

It may be seen from the above estimate that large checkdams could be very cost effective, if the keyway were dug by machine. A test of this idea should be made prior to writing off large dams as a waste of effort.

Another situation in which large checkdams may be useful is encountered where a large stream has a very steep gradient. In this case, big dams with board energy dissipation maybe used if rock is unavailable or if the hydrologist feels that the available rock is too small to withstand the plucking forces expected on that reach. In this case cost effectiveness would not be a consideration.



Unit: 80-2 PP 1-A PP#31 6-11-80 Meneze. E.W.



Unit: 80-2 1-B PP#31 11-12-80 Meneze E.W.



Unit: 80-2 1-C PP#31 6-15-81 M.S.S.



Unit: 80-2 1-D PP#31 07-12-82 L.T.



Unit: 80-2 1-E PP#31 07-25-83 L.T.



Unit: 80-2 2-A PP#40 06-11-80 E.W.



Unit: 80-2 2-B PP#40 11-12-80 E.W.



Unit: 80-2 2-C PP#40 06-15-81 M.S.S.



Unit: 80-2 2-D PP#40 07-12-82 L.T.