

Background

The M-Line has been recognized as one the largest roads within Redwood National and State Parks. The inherent risk to resources from the sheer magnitude of the road has not gone unnoticed. Yet due to the overwhelming volumes, length and location (directly influencing costs), and a host of other administrative and infrastructural issues, the M-Line had essentially fallen out of any planning or prioritizing processes. The New Years day storm of 1997 caused wide spread damage throughout the parks road systems. Approximately 40% of the erosion problems had been identified in the road inventory (completed 1995). Of those sites that were identified, the predicted volumes were often an order of magnitude less than the actual eroded volume. Most of the road failures occurred due to lack of road maintenance, typically failed inboard ditch systems. With a number of these failures occurring along the M-Line, and the respective proximity to the tall trees grove, the M-Line now fell into treatable status.

The New Years Day storm of 1997 caused 4 road fill failures occurred along the M-8 and another 4 failures along the Lower M-Line between the M-8 junction and Tom McDonald Creek.. The junction of the M-8 and M-Line failed, delivering between 10,000 and 15,000 cubic yards of sediment into Redwood Creek. Another large fill failure (approx. 3000 yd³s) occurred near station 11+00 on the M-Line. The M-8 had a several small fill failures (less than 1000 yd³s) and some problems at the Otter Camp stream crossing. A large slope failure (approx. 2000 yd³s), triggered by a culvert on the M-Line, deposited sediment and organic debris on the upstream side of the M-8 crossing at Otter Camp (station 80+75). Otter Camp was a large landing / road junction on the M-8 that had been used for access to Redwood Creek gravel mining, administrative access and camping.

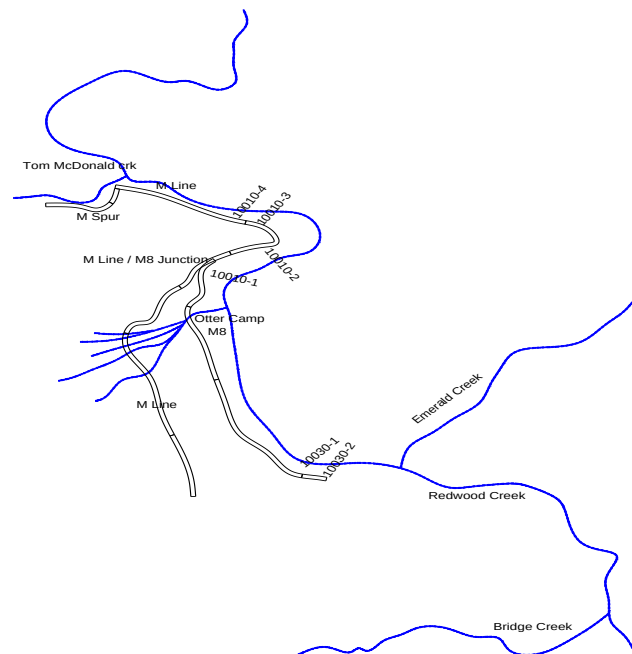


Figure 2. Project 98-2 showing 1997 storm damage sites.

The M-Line from the M-8 junction to station 70+00 caused a number of diversions and stream flow relocations. This section of the M-Line was removed to restore the nature fluvial patterns , there by insuring correct flow courses on the restored slopes below.

Geology

The Redwood Creek basin is almost entirely underlain by the Jurassic-Cretaceous Franciscan formation. This formation is separated into two distinct lithologies by the Grogan fault, which has a surface trace roughly coincident with the valley of Redwood Creek. In general, rocks on the west side of the basin consist of quartz-mica schist (Redwood Creek Schist) whereas the east side is dominantly unmetamorphosed sedimentary. The Grogan fault is more linear than other major NNW faults in the region suggesting a near vertical dip (Hardin et al., 1982). Deformation from tectonic emplacement, predominantly by subduction, and from brecciation along high angle faults, has resulted in intense fracturing and pervasive shearing. The intensity and style of this deformation seems to be the rock characteristic that most influences differences in the erosion rates and landforms (Janda, unknown). This region is subject to high erosion rates due to geologically rapid tectonic uplift, the pervasively sheared and faulted condition of the underlying lithologies and the imprint of the complex, highly disruptive land use activities (Janda and others, 1975).

The rehabilitation project is situated on the west side of Redwood creek basin immediately adjacent to Redwood Creek (figure 2). It is entirely underlain by the intensively sheared and complexly folded Redwood Creek Schist. Considerable variation in mineralogy, texture, structure and lithology occur within this unit. However, the intense shearing and complex folding have precluded mapping subunits within the schist.

Within the schist terrain in the Redwood Creek basin, there are a large number of “trough-shaped” first order drainages ranging in area from a few hectares to over a square kilometer. These appear to have been formed by mass-movement rather than fluvial processes. Creep and blocksliding that occur over large, undefined portion of hillslopes have been shown to be important mass-movement processes on areas underlain by schist bedrock (Sonnevill et. al., 1985). Active blocksliding is most common in areas where bedrock is predominately sheared black schist. Several segments of the road have exposed sheared black schist in the cut bank. The morphology of the area of the rehabilitation project is characteristic of the schist terrain; this morphology is represented by an undulating surface of the first order basins.

Land Use History

The lower M-Line and M-8, constructed in the early 1950s by Georgia Pacific Timber Company, were major haul roads in Redwood National Park that lie immediately adjacent to Redwood Creek. The half mile section of the lower M-Line begins at the mouth of Tom McDonald Creek and goes to the ridge dividing Tom McDonald and Bridge Creeks. The M-8 leaves the M line soon after it hits the ridge and goes to the mouth of Bridge Creek. Both the section of the lower M-Line and the M-8 roads are located within the inner gorge of Redwood Creek in some of the most unstable and erodible terrain in the entire park. This terrain is characterized by soils that are prone to gullyng and landscapes that exhibit large scale mass wasting. This terrain has the greatest potential for slope instabilities where roads and skid trails cross steep slopes and wet soils located in headwater swales or along inner gorge slope positions.

Multiple timber harvests were conducted during the early 50's and 60's in the project area. The predominant use of tractor yarding resulted in a dense skid road network and major disruption of natural hydrologic conditions, including large gullies and slope failures due to diversions of surface and stream flows, reactivation of dormant mass wasting features, and in a number of failing roads and road-stream crossings. These conditions have led to an increase in the sedimentation in Redwood Creek, threatened and destroyed old growth redwood trees, and left indelible scars within view of the Tall Trees Grove.



Figure 3. 1954 photo, prior to M-8 construction, M-Spur unit logged.



Figure 4. 1962 photo. M-8 selective logged, Otter Camp and gravel access road in place.



Figure 5. 1968 photo. Point logged above M-Line and residuals removed in Otter Creek bowl (above M-Line)

The remaining vegetation along the M-Line and M8 presently exists similar to what is shown in the 1968 air photo. The unit(s) along the M8 were selectively logged with an intact grove of old growth the can been to the southwest of Otter Camp. Redwood and Douglas Fir with some Hemlock, Tan Oak and Cedar represent second growth trees that have revegetated the project units. As is typical through out the park, Alder trees are prevalent on severely disturbed soils.

Project Description

The work on the M-8 resumed at station 57+10, where project 97-3 ended. The remaining 3290 feet of the M-8, along with over 1000 feet of spur road downslope of Otter Camp and 1000 feet of spur road upslope from station 68+00, were removed. A smaller spur road, running 1650 feet up the south side of Tom McDonald Creek, was removed. Seven thousand feet of the M-Line (00+00 at Tom McDonald Creek), including 1000 feet of additional spur roads used as fillsites or access to fillsites were removed.

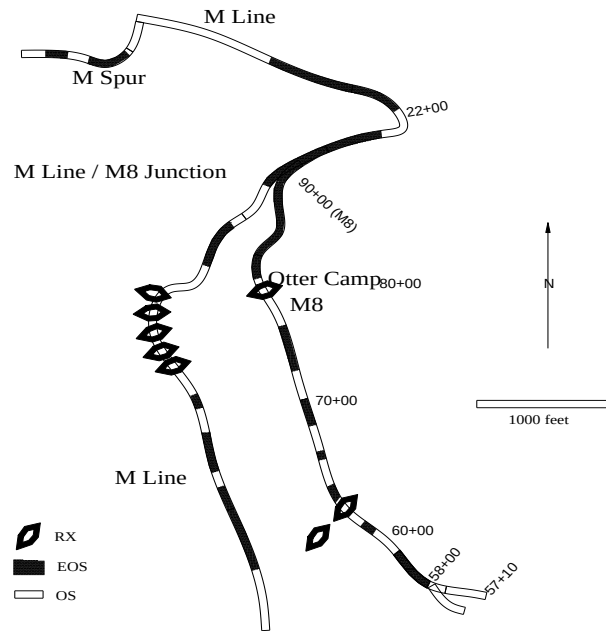


Figure 6. Project 97-2 work plan map.

The project plan map shows three stream crossings along the M-8. RX1 and SX1 were smaller crossings, while Otter Camp was actually a combination of the M-8 crossing, a lower spur road crossing and a small skid road crossing above the M-8. Aggradation at Otter Camp required excavation of the entire length of channel from below the lowest crossing to a few hundred feet above the upper crossing. For better resolution of the survey volume, the area was treated as a single crossing.

Table 1. **General Summary** of 98-2 & 99-2, removal of the remaining M8 and Lower M - Line

Totals		Overall	
Total cubic yards	193,829	Average cost per cubic yard	\$3.27
Total miles (stationed)	2.9	Average cost per mile	\$218,679
Total cost	\$634,169	Average cubic yards per mile	66,838
		Average cubic yards per foot	13

Outslope (OS)		Export Outslope (EOS)	
length (ft)	6,239	length (ft)	7,025
length (mi)	1.2	length (mi)	1.3
volume (yd ³ s)	49,274	volume (yd ³ s)	110,964
average yd ³ s/hr	88	average yd ³ s/hr	95
average \$/yd ³	\$2.22	average \$/yd ³	\$3.43

Stream Crossings (RX)	
volume (yd ³ s)	33,891
average yd ³ s/hr	76
average \$/yd ³	\$3.60

Interlude on Otter Camp

The Otter Camp area appears to be the remnants of an old landslide. There were 5 stream crossings (RX1 Through RX5) on the M-Line that bisected the upper bowl of the slide origin. These 5 channels coalesce immediately above Otter Camp. The landing that had been labeled as Otter Camp by the earlier park researchers and rehab staff, was constructed on a large, relatively flat area just 58 feet in elevation above Redwood Creek. A steep sided channel runs through this flat area in a manner uncharacteristic of other channels in the neighborhood.

The bulk of the flat area (or slide deposit, as it is expected to be) came to a point at Redwood Creek. Upstream of the point is a large hollow in the hillslope with no means of downslope fluvial creation. The consensus from those onsite is that the large slope failure, as indicated by the upslope bowl coalesced at the Otter Camp deposit, blocking Redwood Creek. As the blockage breached, a back eddy on river left scoured the large hollow in the left bank.

Why is this important? That depends on what one feels to be important in the first place. It is certainly an unusual geomorphic feature and would warrant additional exploration into other relative terraces adjacent to the location, should someone be interested in the geomorphic history of the Otter Camp region. More over, the 'hollow' was not identified until the excavation revealed stumps and topsoil buried 30 to 40 feet deeper than expected. When working on structured time frames and budgets, having good estimates of planned work is important. In this particular instance, what should have been one days work ended up taking well over a week. In addition, fill that had been placed in anticipation of a certain 'expected' land form, had to be removed and a significant amount of material had to be reallocated due to the surprise fill. This was not the only surprise fill encountered on this project, keep reading.

Chronological Excavation Narrative:

EnviroTech began the removal of the remaining portion of the M-8 on August 18, 1998. Wendell Larkin (owner / operator) ran the John Deere 892 excavator, Warren Larkin (learned how to) run the D8L (Twin Parks) and Ernie Larkin ran the trusty D8H (46A). The Larkin clan has been known for excellence in workmanship, production and stewardship. This project exemplified that reputation.

The excavation of this portion of the M-8 was similar to project 97-3 in that the underlying geology tended to change every few hundred linear feet along the road corridor. The result of the changing geology is evidenced by variations in geomorphology, observed as steep slopes rolling into gentle slopes or narrow gorges with frequent benches at random elevations. These features made predicting final morphology difficult prior to excavation. For the most part, the volumes tended to be reasonably close to the surveyed estimates. The problematic feature of the varying morphology impacted our ability to project appropriate fill space on the M-8. This resulted in additional push distance to fillsites and export of fill that had been prescribed as outslowing.

Otter Camp proved to be much more of a challenge than anticipated. The large landing was intended to be used as a fillsite for the stream crossing(s). As the exhumation of the scoured stream bank began to unfold, the large landing turned into a small point. The small point was quickly overloaded with the addition fill material causing relocation and added transport of the fillsite material. Compounding the dilemma was the loss of room for the stream crossing(s) fill.

Of course the fill material and accumulated sediment in the Otter Camp stream channel was significantly greater in volume than anticipated due to an uncharacteristically wide channel bottom width. Since the anticipated fillsite for the crossing material had disappeared and any available space had been gobbled up by the scoured bank, creative measures were taken. The channel fill was piled as high as possible on the ridge or right lateral morainish feature that had likely been created during the landslide episode. The channel fill was saturated, making the piling process even more difficult. Due to the extreme moisture content of the fill, the pile (now known as Mount Larkin), was left (September 17) to dry for a few weeks before surface finishing could be completed.

The shift down to the M-Line was lead off by Ernie Larkin and his magic 46A (D8H) with Ingrid Corson inspecting. Ernie hogged out most of the fill on the two EOS portions of the M-Spur along the right bank of Tom McDonald Creek. As it turned out, the second EOS (Bid Item 28) lost it's fillsite due to an overabundance of fill from the previous Bid Item (you should notice that this becomes a serious trend), requiring fill from Bid Item 28 to be pushed out to the M-Line, some additional 500 feet. Parts of the M-Spur were very steep and had previous failed. In at least two locations, it was deemed appropriate (for both safety and resource impact) to leave small wads of fill perched above Tom McDonald Creek.

The junction of the M-Spur and the M-Line occurred on the floodplain of Redwood Creek, at the mouth of Tom McDonald Creek. Since the flood plain is a relatively high energy area, compared to the upper hillslope, we did not have the original topsoil or organic layer to interpret as the prior geomorphic condition. We did find an obvious layer of coarse sand which we followed for the renewed floodplain elevation.

The first M-Line reach (Bid Item 30), from the mouth of Tom McDonald Creek (00+00) to station 10+49, was a straight forward outslope - which worked out in text book fasion. This reach saw the development of a new technique for dealing with the vast amount of woody debris that had to be stockpiled and distributed on the finished slope. After some frustration dealing with individual piles of material, they began to shove the woody debris off the outboard edge of the road. As the road fill was brought up – thus lowering the outboard edge of the road – the woody debris was

shoved lower. The end product of this process was a large berm of almost all woody debris at the base of the restored slope. The excavator would then swing the wood upslope and place the remaining fill into a near by disposal site. Additionally, it took a little while for the catskinners to develop techniques for minimizing the amount of dirt that was incorporated with the woody debris.

The next reach of the M-Line was an EOS (Bid Item 31) that had partially failed into Redwood Creek during the 1997 storm. It was at this region that fillsite trouble began. What appeared to be a small swale, became a medium sized swale. This increase in size required that the fillsite that was to be shared with the following OS was completely used. Not really a big deal if everything else went to spec, but this is rehab.

The outslope labeled Bid Item 32, transformed into a large void from a past slide or creek migration, requiring almost all the fill to be exported. The volume more than doubled, and had to be transported across the following OS to a fillsite that was supposed to be used by two road reaches nearly 1000 feet ahead. You should be able to guess what's coming next.

Here is where the plan truly headed south. Bid item 33 looked to be a fairly benign outslope blending into a broad through cut ridge. As the excavation proceeded, a nice layer of topsoil was uncovered along the inboard center of the road. The outboard edge did not provide generous clues, and in turn yielded an unfathomable morphological suggestion. Within a couple of days (the whole reach should have taken less than two days) Ernie and Ingrid thought that we were uncovering an old landslide scarp. Wendell and I – being all knowing experts in watershed restoration / road removal – knew that that was ridiculous, some kind of voodoo must be at hand. This reach became known as the “Silly Monkey EOS” (review your South Park collection). As it turned out, we indeed found in place topsoil and stumps, abutting a vertical wall with intact topsoil at the top of the wall. Compounding the frustration of now being weeks behind the timeline due to the overages and increased push distances, all the fillsites for the upcoming EOS's had been usurped by the 5 time increase in volume from the Silly Monkey.

Once again, the OS at Bid Item 34 became a hole in the hillside, causing the fill to be exported. But now, instead of pushing it into the adjacent throughcut as intended, the fill had to be pushed 1200 feet. The push ended up re-filling the hogged out portion of Bid Item 35, then half way through the M-Line / M-8 junction to a 170 degree turn to be pushed up onto a landing atop the ridge. Ernie hogged and pushed away from Wendell to Warren in this manor for three weeks. They moved a tremendous amount of fill and left a beautifully restored slope above Redwood Creek, and we were all glad to end the season on November 4th, 1998, as the rains came.



Figure 7. M Line / M8 junction following 1997 storm.



Figure 8. M Line / M8 junction removal in progress during 1999 season.

Continuation of M-Line / M-8 removal re-initiated July 12, 1999.

The 1999 season began much like the 1998 season ended. Wendell finishing the lower berm that was left at Bid Item 35, Ernie pushing the remaining fill away from Wendell or hogging out of the M-Line / M-8 junction and Warren taking the fill up to the ridge top landing.

The junction:

The upstation end of the junction was consistent with the adjacent bid items producing a somewhat benchy topography with a number of small 'holes'. The holes appear to be related to springs that had been buried during road construction. This type of topography followed suit until the M Line came to a series of stream crossings.

The Crossings:

A series of five stream crossings upslope of the M8 (bid items 41 to 45) were added to the original storm related road removal. Most of these crossings were diverting flow from their original channel to the next down road channel (or further). The culvert outflow location for RX2 had caused a small slope failure that deposited approximately 1000 cubic yards of material at the Otter Camp stream crossing. All five of the channels coalesced above Otter Camp and are likely the fluvial product of the ancient slope failure that created the Otter Camp feature.

After the series of stream crossings another 1400 feet of M – Line was removed to correct surface flows that were being captured by the inboard ditch. A number of small swales that only had surface flow in extreme events were addressed in this stretch. The remaining 6 bid items shared some of the same fillsites. This made for some difficulty in gauging which fill eventually reached a particular fillsite. Adding to the confusion, either dozer would be sporadically pulled from a given task to help the excavator or would move to another bid item that might have been more productive at that moment. The shifting of equipment and the over lapping of fill seemed to be more productive in an overall sense, but the problems with project tracking are evidenced in the production numbers on the final tables for the last few bid items (note BI 50 has 214 yd³/hr while similar items adjacent have much lower rates). The M–Line removal ended at this point (station 70+00) for this project.

Table 2. **Outslope** excavation costs and production rates for unit 98-3, M8/M Line roads

Bid Item	dirt moved (yd ³)	hours 892	D8H	D8L	Actual cost	H.E.R.E. cost**	Actual (\$/yd ³)	H.E.R.E. (\$/yd ³)	production yd ³ /hr*
3	250	3	0.25	0	\$500.00	\$487.50	\$2.00	\$1.95	77
10	700	3	10.75	0	\$1,400.00	\$2,062.50	\$2.00	\$2.95	51
15	250	2.25	2.75	0	\$500.00	\$750.00	\$2.00	\$3.00	50
17	2626	17.5	8	7.75	\$7,221.50	\$5,103.75	\$2.75	\$1.94	79
18	350	3	1.75	0	\$700.00	\$712.50	\$2.00	\$2.04	74
25	4700	15.5	6	0	\$9,400.00	\$3,225.00	\$2.00	\$0.69	219
27	114	1.75	0.5	0	\$228.00	\$337.50	\$2.00	\$2.96	51
29	275	1.25	2.25	0	\$550.00	\$525.00	\$2.00	\$1.91	79
30	14425	51.25	75.5	31.5	\$28,850.00	\$24,210.00	\$2.00	\$1.68	91
37	10408	35.5	41.25	12.5	\$23,666.00	\$13,575.00	\$2.00	\$1.30	117
39	6693	18.75	5.5	31.75	\$16,732.50	\$8,876.25	\$2.00	\$1.33	120
40	5615	17	7.25	7.5	\$14,037.50	\$4,875.00	\$2.00	\$0.87	177
47	596	1.75	8	2.5	\$1,192.00	\$1,875.00	\$2.00	\$3.15	49
49	1224	4.5	12.5	10	\$2,448.00	\$4,200.00	\$2.00	\$3.43	45
51	1048	10.5	8.5	2	\$2,096.00	\$3,180.00	\$2.00	\$3.03	50
TOTALS		49274			\$109,521.50	\$73,995.00			
AVERAGES							\$2.22	\$2.15	88

* production rates do NOT reflect time spent on discussion or breakdowns. Discussion time during this project would be expected to reduce production rate by a few yards per hour at the most

** rental rates were calculated with \$150/hr for both the 892 excavator and the D8H dozer and \$165/hr for the D8L dozer

Table 3. **Export Outslope** excavation costs and production rates for unit 98-3, M8/M Line roads

Bid Item	dirt moved (yd ³)	hours 892	D8H	D8L	Actual cost	H.E.R.E. cost	Actual (\$/yd ³)	H.E.R.E. (\$/yd ³)	production yd ³ /hr
4	2001	7.25	12.25	0	\$5,002.50	\$2,925.00	\$2.50	\$1.46	103
5	1416	8.25	4	0	\$3,894.00	\$1,837.50	\$2.75	\$1.30	116
6	675	3.5	1.5	0	\$1,687.50	\$750.00	\$2.50	\$1.11	135
9	567	1.75	3.25	0	\$1,417.50	\$750.00	\$2.50	\$1.32	113
11	180	1.25	2.5	2	\$450.00	\$892.50	\$2.50	\$4.96	31
12	1851	11.75	3	5.75	\$5,090.25	\$3,161.25	\$2.75	\$1.71	90
13	700	3.25	3.25	0.5	\$1,750.00	\$1,057.50	\$2.50	\$1.51	100
14	2000	9.75	6	9.5	\$5,000.00	\$3,930.00	\$2.50	\$1.97	79
16	500	6.25	7.75	1	\$1,250.00	\$2,265.00	\$2.50	\$4.53	33
19	200	1.75	1	0	\$500.00	\$412.50	\$2.50	\$2.06	73
20	12057	55.5	43.75	37	\$42,199.50	\$20,992.50	\$3.50	\$1.74	88
21	1000	3.75	0	3.75	\$2,500.00	\$1,181.25	\$2.50	\$1.18	133
23	2205	13	2.5	0	\$6,063.75	\$2,325.00	\$2.75	\$1.05	142
24	1964	18.25	1.25	0.5	\$5,401.00	\$3,007.50	\$2.75	\$1.53	98
26	2354	12.5	14.25	13.5	\$7,062.00	\$6,240.00	\$3.00	\$2.65	58
28	2650	15.5	13.25	11.25	\$6,625.00	\$6,168.75	\$2.50	\$2.33	66
31	4929	11.5	17.5	16	\$16,413.57	\$6,990.00	\$3.33	\$1.42	110
32	10584	30.50	34.50	22.25	\$37,044.00	\$13,421.25	\$3.50	\$1.27	121
33	16769	81	101.25	90.5	\$58,691.50	\$42,270.00	\$3.50	\$2.52	61
34	8492	27.75	30	26.75	\$55,198.00	\$13,076.25	\$6.50	\$1.54	100
35	5673	41.25	25.25	11.25	\$14,182.50	\$11,831.25	\$2.50	\$2.09	73
36	21198	72.25	120.5	151	\$52,995.00	\$53,827.50	\$2.50	\$2.54	62
38	1559	5.5	8.75	0	\$3,897.50	\$2,137.50	\$2.50	\$1.37	109
46	246	2	1.5	1.25	\$615.00	\$731.25	\$2.50	\$2.97	52
48	3145	15	5	9.5	\$7,862.50	\$4,567.50	\$2.50	\$1.45	107
50	6049	5.5	18.25	4.5	\$15,122.50	\$4,305.00	\$2.50	\$0.71	214
TOTALS	110964				\$289,673.82	\$172,080.00			
AVERAGES							\$2.86	\$1.93	95

* production rates do NOT reflect time spent on discussion or breakdowns. Discussion time during this project would be expected to reduce production rate by a few yards per hour at the most

** rental rates were calculated with \$150/hr for both the 892 excavator and the D8H dozer and \$165/hr for the D8L dozer

Table 4. **Stream Crossing (RX)** excavation costs and production rates for unit 98-3, M8/M Line roads

Bid Item	dirt moved (yd ³)	hours 892	D8H	D8L	Actual cost	H.E.R.E cost	Actual (\$/yd ³)	H.E.R.E. (\$/yd ³)	production yd ³ /hr
7	1100	11.75	5.75	0	\$4,400.00	\$2,625.00	\$4.00	\$2.39	63
8	300	2.25	3	0	\$1,050.00	\$787.50	\$3.50	\$2.63	57
22	14278	81.75	79.25	80.75	\$60,681.50	\$37,473.75	\$4.25	\$2.62	59
41	1561	0	2.5	20	\$5,463.50	\$3,675.00	\$3.50	\$2.35	69
42	3518	8	8	21	\$12,313.00	\$5,865.00	\$3.50	\$1.67	95
43	2203	8.75	6	13.25	\$7,710.50	\$4,398.75	\$3.50	\$2.00	79
44	9296	31	17.5	46.75	\$32,536.00	\$14,988.75	\$3.50	\$1.61	98
45	1635	7.25	4.5	7	\$5,722.50	\$2,917.50	\$3.50	\$1.78	87
TOTALS	33891				\$129,877.00	\$72,731.25			
AVERAGES							\$3.66	\$2.13	76

* production rates do NOT reflect time spent on discussion or breakdowns. Discussion time during this project would be expected to reduce production rate by a few yards per hour at the most

** rental rates were calculated with \$150/hr for both the 892 excavator and the D8H dozer and \$165/hr for the D8L dozer