REPORT OF THE SURVEY OF SEDIMENT BELOW STREAM GAGING SITES 1, 2 AND 3 IN THE H. J. ANDREWS EXPERIMENTAL FOREST WATER YEAR 1982

GEORGE W. LIENKAEMPER

SITE HISTORY

Experimental timber harvest on Watersheds 1, 2, and 3 was an early forest research project in the H. J. Andrews Experimental Forest after its establishment in 1952. Watershed 2 was designed as the undisturbed control. Road building was completed in Watershed 3 during 1959 and after 3 years of monitoring for road building influences on the watershed, logging took place in 1962 and 1963. Approximately 30% of the watershed is in clearcut and road. Extensive road repairs were made in the summer of 1968. Logging in Watershed 1 was accomplished without road building. Cutting continued from 1962-1966, when the entire watershed had been clearcut and slash burning had been completed. No other major management activities have occurred within the watersheds. Large mass movements have been important in the production of bedload in the study watersheds. Swanson (unpublished data) has done a field reconnaissance study of mass movement features and the watershed project field crew have made observations that have generated a partial history of recent mass-movement events in the basins. Dyrness (1967 and unpublished data) and Fredriksen (1963, 1965) have also documented failures in the study watersheds (see fig. 1).

Roadfill failures have frequently delivered sediment to the stream channel in Watershed 3. Such a failure in WY 1962 (S29, fig. 1) entered the channel and eroded 3000 feet of tributary and mainstream. The debris torrent did not reach the gaging station or settling pond (Dyrness, 1967).

In December 1964, heavy rain and melting snow triggered three large (volumes over 500 yd^3) road fill failures (D39 A&B, D40) in Watershed 3. The resulting debris torrents buried the gaging station and sediment basin under tons of mud and debris. Mass movement resulting from road failures also occurred in Watershed 3 in WY 1968 and 1972 (S30, S101).

Storms of WY 1965 also triggered four substantial slides in Watershed 1 (D44, D45, D46, D47). In WY 1968 two large slides (S99, S100) related to earthflow activity began delivering sediment to the stream in Watershed 1. This area continues to be active. Heavy rainfall in 1972 triggered two slides (S97, S98) on the south slope, low in the watershed that continued to be a source of bedload material. Mass movement in Watershed 2 has been rare during the length of the study.

Figure 1 - Mass Movement Reference Map

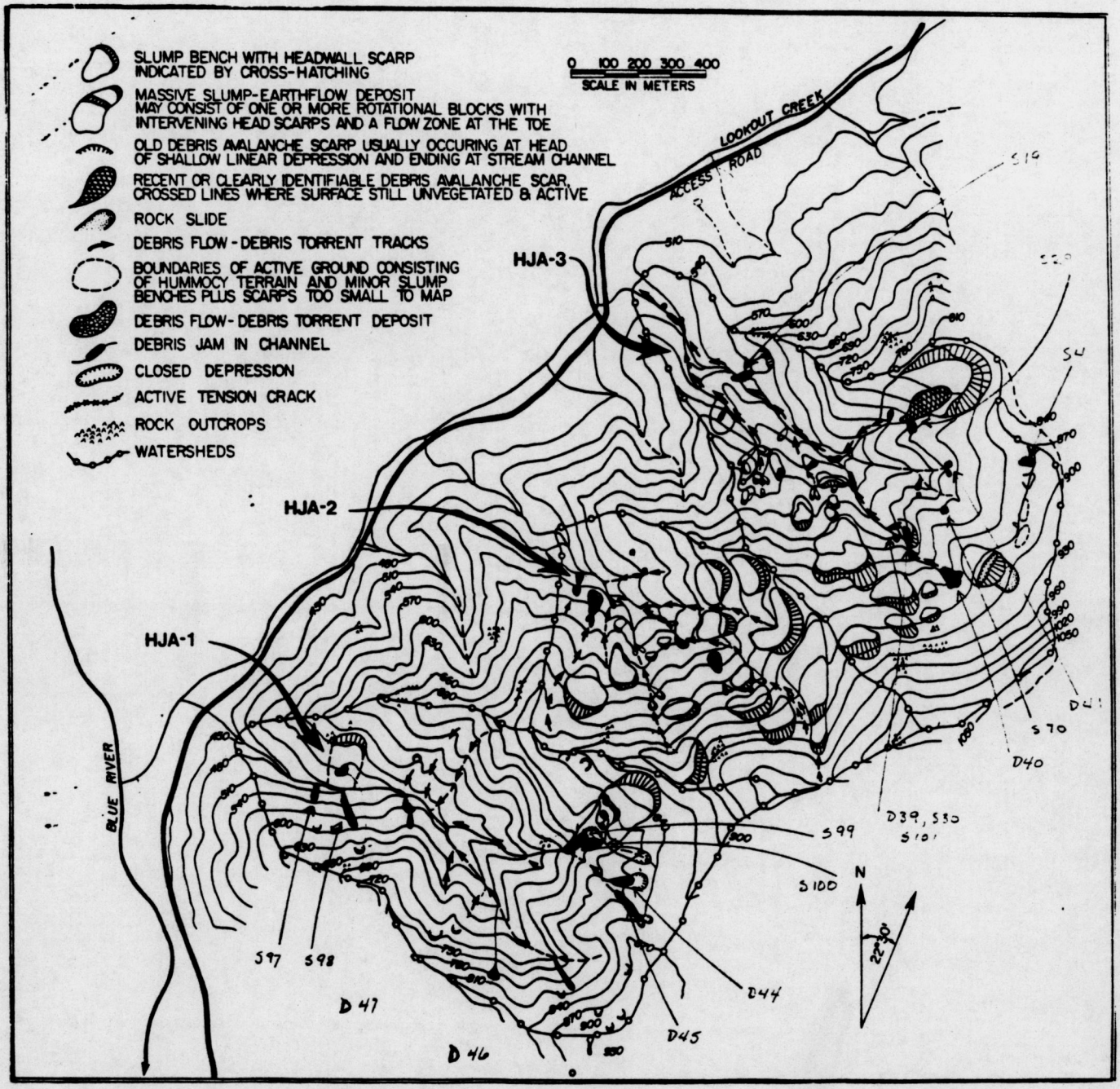


Figure 1 - Unpublished map of mass movements in HJA 1, 2, and 3 (Fredriksen, personal communication). Colored areas indicate mass movement contributing to bedload (Dyrness, 1967; F. J. Swanson, unpublished data).

MEASUREMENTS

Basin surveys have been designed to determine a change in average bottom elevation between annual surveys. Monumented cross sections are spaced at regular intervals along a primary control line, which runs the length of the basin dam. Survey points are spaced at intervals along the cross section lines, three-foot intervals at Watershed 1 and Watershed 2 and two-foot intervals at Watershed 3.

The survey is conducted using a level or a transit, a tape, and a leveling rod. The tape is run between cross section end posts and the rod is placed on the basin bottom at each of the prescribed survey points. At each point a level reading is made with the surveying instrument and recorded.

Permanent bench marks have been established near all three gage houses and in 1977 auxiliary bench marks (1/4" bolts set in concrete) were established near each catchment basin. These new bench marks replace nails or spikes driven into stumps or trees as reference points. Annual checks, monitoring elevational distance between bench marks and reference points, showed unexpected changes. The reference point on the Watershed 3 dam was actually sinking, while at Watershed 1 and Watershed 2 stumps containing the reference spikes were deteriorating and reliable measurements became increasingly difficult. The elevational difference between auxiliary bench marks and permanent bench marks continues to be monitored.

As part of the sediment basin survey, a check on the auxiliary bench mark elevation is made at the end of alternate cross-section transects. This procedure reveals any change in the elevation or level of the surveying instrument.

When catchment basins near or reach capacity, they are emptied. Local contractors are employed and usually a front-end loader or clam-shovel is used to clean the basin. After emptying, the basin is resurveyed--this survey being used as the baseline for comparison.

Following debris torrents and subsequent burial of the gaging station and sediment basin at Watershed 3 (see 1965 report), the catchment basin was remodeled in December of 1965. Details can be found in the 1966 report. A new survey was made in that month, but further modification was done in April 1966, followed by a new base survey in August 1966.

In 1976, the channel between the flume and the sediment basin at Watershed 2 was excavated to reduce the entrainment of bedload material in this seciton. In order to detect any accumulation or degradation in the channel several survey lines were extended.

The excavation (in 1976) of the channel between the WS#2 flume and sediment had raised questons regarding the reliability of sediment accumulation measurements. No distinction could be made among sediment generated in this section, sediment trapped in this section, or material that moved through it. In August 1980 the Blue River YACC lined the channel with concrete. We now expect that all sediment accumulated in the sediment basin will have come from the watershed study area.

In an effort to reduce confusion over the timing and volume of material delivered to the WS#1 sediment basin during individual storm events, a device for measuring the profile of the sediment pile was installed in September, 1981. Pulleys were fixed to two trees which were growing in strategic positions at either end of the long axis of the sediment delta. A nylon rope (later replaced by a plastic coated wire) was run between the two pulleys - washline style. A hook was tied into the rope and a tape weighted with a lead clock weight was run through the hook. A nail driven into one of the trees was used as a measurement point. The rope was run out one meter at a time and at each meter interval the weight was lowered to the water surface, tape distance recorded, lowered to the bottom and a second tape distance recorded. This procedure was repeated at each meter interval along the axis of the delta. A meter stick, partly submerged, attached to another basin-side tree served as a staff gage and was used to normalize water surface differences between any two surveys.

CALCULATIONS

The determination of sediment accumulation is based on the average change in bottom elevation between two annual surveys. This is accomplished by comparing the change for the same survey points between any two surveys. Originally all points between cross section end posts were included in the calculations, but in years of little or no bedload accumulation small errors began to compound and led to negative values for bedload accumulations. Errors in rod placement or instrument readings are difficult to quantify, however some potential errors can be eliminated. One such potential error is rod placement on steep slopes at the edges of the sediment basin. These slopes accumulate virtually no sediment and may provide some very misleading rod readings. The entire cross section line is surveyed to monitor bank slumping. However, during years of low sediment yield, in an attempt to hold errors to a minimum only points on the bottom are used in calculations--slope points are eliminated. When slope points have been eliminated, the area they represented is less than 10 percent of the sediment basin area.

The number of points included in any calculation is variable, depending on the amount of filling. The catchment basins often fill to, and sometimes beyond, capacity. When a basin is filled near capacity, points on the bottom may have been on a steep slope in a previous survey and are included in the calculations. Therefore, all points along the survey line must be recorded.

Rod measurements for survey points used are totaled and averaged; yielding an average rod reading. A line of sight is determined by adding the mean of the bench mark readings to the elevation of the auxiliary bench mark (designated as 100.000 meters) and adjusting further by any change in the elevational difference between the permanent bench mark and the auxiliary bench mark. The average rod reading subtracted from the line of sight provides an average bottom elevation. By subtracting the previous bottom elevation from the current value and multiplying by sediment basin area, the volume of sediment accumulation is determined. This volume divided by watershed area determines yield of bedload per unit area of watershed.

Example

$$\frac{\text{rod readings}}{\#\text{ of points}} = \text{average rod reading}$$

Elevation of auxiliary bench mark + $\bar{X}$ bench mark reading
+correction value = line of sight

Line of sight - average rod reading = average bottom elevation

Current average bottom elevation - previous bottom elevation = change in bottom elevation

Δ Bottom elevation x sediment basin area = accumulation

Accumulation - watershed area = accumulation/unit Watershed area

Sediment Basin Summary WY1982

The annual sediment accumulation at WS#1 and a five year accumulation of material at WS#2 were removed from the basins on 8-5-81 and both basins were surveyed the following day. Resurveying was conducted on WS#1 and WS#3 on 8-18-82 and on 8-17-81 at WS#2.

WY1982 was a wet year. Precipitation was nearly 125% of the long term average (see Table 1), making WY1982 the wettest year since 1974. Seven major storm events were recorded in the study watersheds (see Table 2). Early season storms of 12-2 and 12-6-81 were quite intense,but snow melt played a limited role in stream discharge. The following storms of December and storms in January were probably rain on snow events at the higher elevations of the watersheds, but peak discharges were relatively low. In Febuary, an extensive strom from 2-13 to 2-21-82 produced nearly 320mm of precipitation. The peak flows of 2-14-82 were quite high (see Table 2) and had a snow melt component. All three study streams stayed high through the week and a secondary peak on 2-19-83 was likely almost entirely rainfall related.

The sediment monitoring device (see Measurement section) installed last year proved to quite useful in estimating the timing of sediment input in the WS#1 basin. Our measurements indicate that approximately 80% of the annual bedload discharge into the WS#1 basin was produced by the storms of 12-2 and 12-6-81. Another 10% was attributed to the less intense events on 12-14/15-81, 1-17-82 and 1-24-82. The remaining 10% was deposited during the week long storm in Febuary.

Field observations of sediment piles at WS#2 and WS#3 also suggest that the early storms produced the bulk of annual bedload production. Notes from the watershed check on 12-9-81 indicate that an estimated $6m^3$ had accumulated in the WS#2 basin and that $5m^3$ had been deposited at WS#3.

DISCUSSION

In spite of the numerous storms in WY1982, some of high intensity, no mass movements in the watersheds were reported. Bedload production during this period was higher in all three watersheds than in recent years. The apparent trend toward reduced, or at least stable, bedload production is likely a function of reduced precipitation amounts and intensity levels. We should expect that winters featuring high precipitation, especially rain on snow events early in the year, will continue to deliver large amounts of material to the sediment basins.

The estimates of timing of bedload material entering the sediment basins has been a riddle for some time. Field observations have been found to underestimate the amounts by as much as 50% and turbidity or water depth in the basin often makes observation of the pile impossible. The sediment monitoring apparatus installed last year has given us an opportunity to make some much better estimates at WS#1. The cross section line runs the length of the mostly inorganic pile that develops at the mouth of the stream that enters the basin. The development of this delta during WY1982 is shown in Figure 3. The organic material tends to drift past this area and settles in a different part of the basin. This organic pile does not fall along the cross section line and estimates of timing and amount of this material have not been attempted.

While monitoring the sediment pile at WS#1 provides information needed to estimate bedload input, any extension to the other study watersheds should be avoided. Each basin behaves differently in any storm event and must be monitored individually. For the time being, at least, we must rely on ocular estimates at WS#2 and WS#3.

The nagging problem of the loss of material through the sediment basin outflow remains. The early development of the sediment delta in the basin has the potential to divert material entering later in the year toward the outflow channel. In order to alleviate the problem the field crew plans to redirect the flow of the stream entering the basin to a more extensive and deeper area. A new alignment of the sediment monitoring apparatus will also be done at that time.

LITERATURE CITED

Dyrness, C. T. Mass soil movements in the H. J. Andrews Experimental Forest. USDA For. Serv. Res. Pap. PNW-42. Portland, Oreg.; PNW For. and Range Exp. Stn.; 1967.

Fredriksen, R. L. A case history of a mud and rock slide on an experimental watershed. USDA For. Serv. Res. Note PNW-1. Portland, Oreg.; PNW For. and Range Exp. Stn.; 1965.

Fredriksen, R. L. Christmas storm damage on the H. J. Andrews ExperimentalForest. USDA For. Serv. Res. Note PNW-29. Portland, Oreg.; PNW For. and Range Exp. Stn.; 1965.

Table 1 Storm Season (October through April) Precipitation

Water Year	PPT (mm)	PPT (in)	# Major* Storms	% of Storm Season $\bar{x}$
1976	2302	90.63	3	116
1977	860	33.86	0	43
1978	1996	78.58	3	101
1979	1588	62.52	2	80
1980	1776	69.94	1	90
1981	1742	68.59	3	90
1982	2474	97.42	7	125

Mean of storm season precipitation 1958-1981
$\bar{x}$ = 1989 mm
* = A storm during which the discharge at Watershed 2 exceeds 7.6 cfs

Table 2 Major storms WY/1982, peak flow

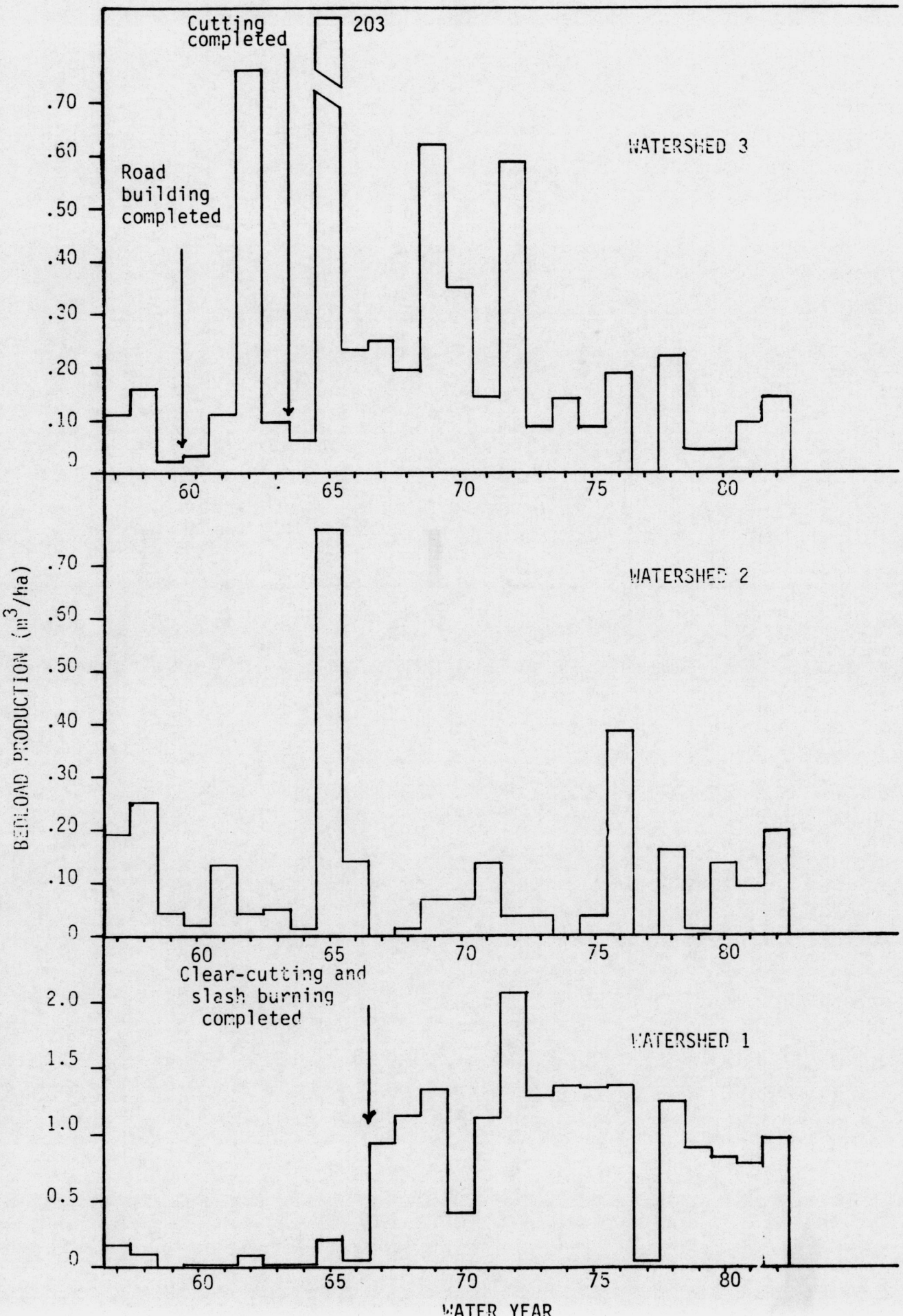
WY	Date	Watershed 1 (ft)	Watershed 1 (cfsm)	Watershed 2 (ft)	Watershed 2 (cfsm)	Watershed 3 (ft)	Watershed 3 (cfsm)
1982	12-2-81	1.164	91.03	.737	49.20	1.060	59.67
	12-6-81	1.273	109.00	.965	83.84	1.309	87.57
	12-14/15-81	1.042	72.84	.764	52.83	.945	48.42
	1-17-82	.796	42.36	.620	34.95	.554	18.34
	1-24-82	1.013	68.82	.602	33.15	.858	40.62
	2-14-82	1.209	98.25	.843	64.17	1.092	62.98
	2-19-82	.952	60.73	.756	51.74	.962	50.02

Table 3 Sediment Accumulation WY 1982

Site	Year	Number of points	Line of sight (m)	Avg. Rod Reading (m)	Mean bottom elev.(m)	Δ bottom elev.(m)	Total accum (m^3)	Prod. (m^3 /ha)	Ratio
WS 1	1981	200	101.17	3.17	98.00				
	1982	200	101.22	2.74	98.48	.48	94.98	.99	5.18
WS 2	1981	200	101.15	2.94	98.22				
	1982	200	101.22	2.94	98.28	.06	11.50	.19	
WS 3	1981	221	100.34	2.82	97.53				
	1982	222	100.20	2.50	97.70	.17	14.04	.14	.73

	WS#1	WS#2	WS#3
Watershed area (ha)	96	60	101
Sediment basin area (m^2)	198	175	83

Figure 2. Annual bedload production in sediment basins watersheds 1, 2, and 3, H. J. Andrews



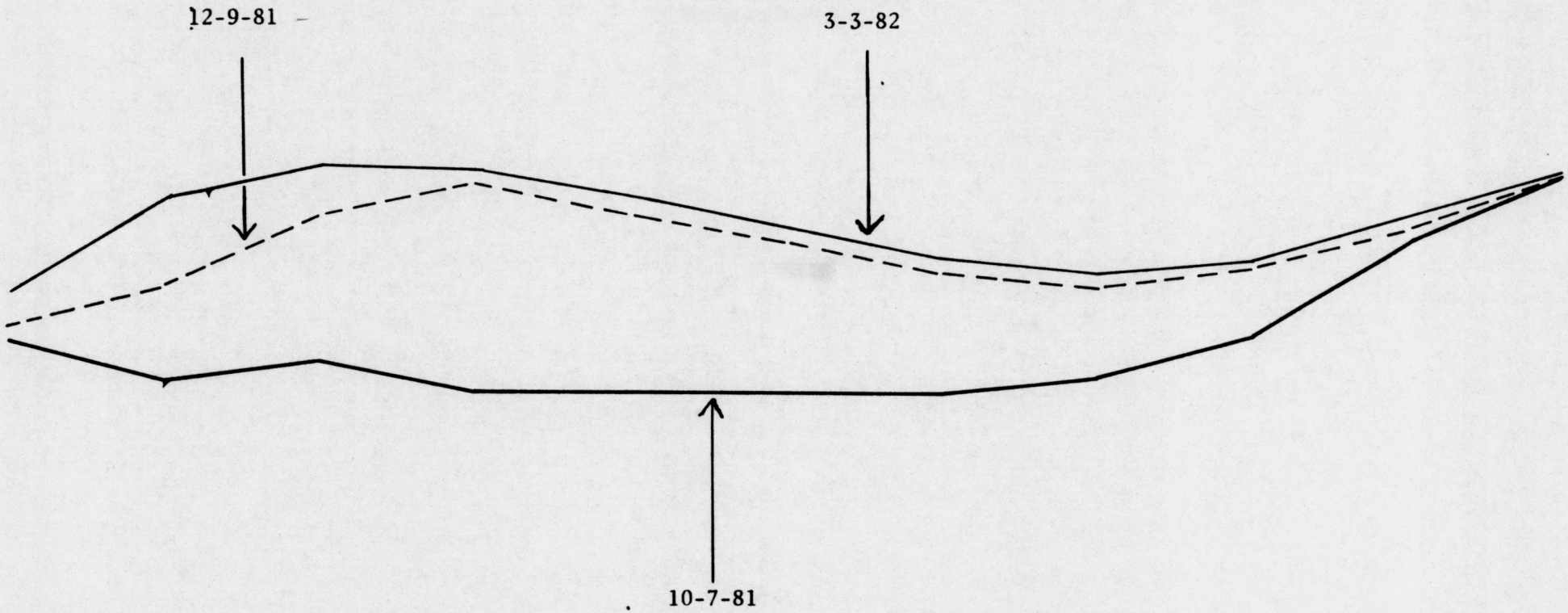


Figure 3. Development of bedload delta at WS#1 during WY1982.

.I - NW
SOIL STABILIZATION
Watersheds

ELEVATIONS OF SEDIMENT ACCUMULATED IN CATCHMENT BASINS

FORM RI-2

Benchmark: 1.169
H.I.
Elev.

EMPTY SURVEY

Experimental Area: HJA
Basin Location: WS #1

Date: 8-5-81
Party: Level GL
Rod AL
Notes KM

Station*	Transects (Designated in ft. starting at crest of dam)													
	1		2		3		4		5		6		7	
	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.
0														1.23
3						1.35		1.17		1.03		1.01		1.11
6		1.34		1.37	BE 8'	1.41	BE	1.18	BE 8.5'	1.19		1.53		1.63
9	BE	1.81		2.60	SLOPE	2.71	BE	2.58		2.49	BE	2.44		2.45
12		3.02		3.23	↑	3.49		3.31		3.53		3.17	Slope	3.19
15	Slope	3.03	bottom	3.51		3.79		3.75		3.79		3.70		3.67
18		3.15		3.60		3.76		3.75		3.87		3.78		3.69
21	Bottom	3.14		3.51		3.78		3.79		3.88		3.82		3.69
24		3.20		3.63		3.71		3.77		3.80		3.75		3.74
27		3.15		3.41		3.69		3.71		3.79		3.77		3.80
30		2.94		3.36		3.64		3.66		3.67		3.71		3.72
33		2.67		3.12		3.46		3.58		3.61		3.61		3.55
36	Slope	2.56		2.95		3.46		3.52		3.57		3.54		3.51
39		2.20		2.71		3.08		3.41		3.44		3.44		3.46
42	B.E.	1.49		2.68		3.04		3.37		3.40		3.37		3.44
45	BASIN	1.10		2.67		2.82		3.32		3.30		3.34		3.38
48				2.50		2.76		2.99		3.27		3.35		3.38
51				2.29	BOTTOM	2.48	Bottom	2.81		3.18		3.26		3.37
54			B.E.	1.81	↑	2.39		2.70		3.00		3.20		3.32
57			OUT of BASIN	1.48	SLOPE	1.95		2.18		2.79		3.13		3.33
60					↑	1.54	ROCK	2.03		2.50		2.70		3.21
63					ROCK	1.59		1.89		2.06		2.45		2.91
66						1.82	INLET	1.92	BOTTOM	1.85		2.13	Hole	2.47
69					INLET	1.82			ROCK	1.30	Bottom	1.87		1.99
72											BE	1.40	BE	1.66
75														1.46
78														
		BM	START		1.170									
		LINE	3		1,176	?								
		LINE	5		1,169									
			7		1.170									
Total		34.80		50.43		63.54		64.39		68.31		71.47		75.56
Average		14		18		23		22		23		24		26

*Numbered to right starting with 0 at borderline which extends upstream from left end of dam.

RI - NW
SOIL STABILIZATION
Watersheds
Benchmark: 1.169
H.I.
Elev.

ELEVATIONS OF SEDIMENT ACCUMULATED IN CATCHMENT BASINS

FORM RI-2

Date: 8-5-81
Party: Level GL
Rod AL
Notes KM

Experimental Area: HJA
Basin Location: WS #1

Station*	Transects (Designated in ft. starting at crest of dam)													
	8		9		10		11		12		13		14	
	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.
0		1.36												1.25
3		1.07		1.11		1.16								1.37
6		1.55		1.22		1.03		1.11		1.10			SLOPE	1.94
9	B.E 6'S	2.17	BE 8'0	1.96	B.E	1.68	BE10	1.36	BE10	1.34				2.57
12	Slope	2.92		2.60	↑	2.18		2.11		1.95				2.59
15		3.59	SLOPE	3.24	SLOPE	2.91	SLOPE	2.56	H20 S.E SLOPE	2.52				2.70
18		3.68		3.64		3.51		3.07	SLOPE	2.68				2.67
21		3.68		3.69		3.72		3.15		2.83			BE	2.38
24		3.70		3.68		3.66		3.00		2.68				1.49
27		3.74		3.65		3.64		3.09	SLOPE	2.72			R	1.43
30		3.64		3.61		3.56		3.07	P	1.61				
33		3.51		3.52		3.46		2.99	P	1.71		1.47		
36		3.45		3.48		3.40		2.96	P	1.66	SLOPE	2.33		
39		3.43		3.43		3.37		2.74		2.65		2.87		
42		3.39		3.28		3.12		2.91		2.94		2.91		
45		3.42		3.32		3.11		3.18		3.10		3.03		
48		3.35		3.32		3.29		3.26		3.19		3.13		
51		3.32		3.33		3.27		3.26		3.13		2.82		
54		3.38		3.33		3.31		3.20		3.16		2.61		
57		3.35		3.33		3.28		3.20	Bottom	2.99	SLOPE	2.21		
60		3.29		3.29		3.24		2.97		2.55	H20 Ridge	1.61		
63		3.07		3.04		3.11	MUD	2.48	BE 6.5	2.26	TRAIL	1.50		
66		2.65		2.67		2.50	BE	1.73		1.53				
69		1.96		2.11		2.04	TRAIL	1.58						
72	BE 70.0	1.75	BE 70.0	1.73		1.70		1.36						
75		1.60		1.55		1.46								
78														

TOTAL ROD READINGS 805.88
TOTAL PTS 291
AVG. ROD READING 2.769

BM LINE 9 1.170
BM 11 1.169
BM END OF 1.169

LINE OF SIGHT 101.169
AVG BOTTOM ELEV 98.40

Total		76.02		73.13		70.71		60.34		50.30		26.49		20.39
Average		26		25		25		23		21		11		10

*Numbered to right starting with 0 at borderline which extends upstream from left end of dam.

RI - NW
SOIL STABILIZATION
Watersheds
Benchmark:
H.I.
Elev.

ELEVATIONS OF SEDIMENT ACCUMULATED IN CATCHMENT BASINS

FULL

FORM RI-2

Date: 8-18-82
Party: Level GSO
Rod RM
Notes GW

Experimental Area: HJA
Basin Location: WS #1

Station*	Transects (Designated in ft. starting at crest of dam)													
	1		2		3		4		5		6		7	
	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.
0														1.27
3						1.35		1.21		1.08		1.13		1.14
6		1.27		1.29		1.34		1.19		1.22		1.44		1.64 x
9		1.50		2.63		2.64		1.69		2.61		2.41 x		2.39
12		2.78		3.13		3.35		3.36		3.33		3.21		3.19
15		2.98		3.44		3.62		3.63		3.32		3.40		3.31
18		3.06		3.49		3.62		3.60		3.18		3.22		3.31
21		3.09		3.44		3.62		3.42		3.16		3.15		3.22
24		3.02		3.39		3.63		3.39		3.09		3.12		3.21
27		2.92	rock	3.30		3.57		3.34		3.13		3.17		3.10
30		2.88		3.21		3.49		3.33		3.15		3.06		3.16
33		2.82		3.05		3.31		3.41		3.13		3.06		3.18
36		2.37		2.92		3.25		3.40		3.30		3.17		3.22
39		2.17		2.70		3.05		3.33		3.34		3.31		3.01
42		1.72		2.63		2.95		3.24		3.25		2.81		2.48
45		1.23		2.58		2.79		3.16		2.90		2.39		2.08
48				2.44		2.64		2.86		2.59		2.20		2.20
51				2.24		2.44		2.75		2.49		2.43		2.43
54				2.07		2.25		2.60		2.53		2.59		2.51
57				1.46		1.94	rock	2.19		2.52		2.47		2.37
60						1.56	"	2.02		2.38		2.40		2.39
63					rock	1.53	st. stump	2.08		1.95		2.17		2.52
66						1.88	"	1.88		1.79		1.97		2.21
69						1.74			rock	1.30		1.84 x		1.85
72												1.48		1.63 x
75														1.45
										RD PT TOTAL		674.79		
										TOTAL PTS		285		
										$\bar{x}$ RD READING		2.368		
					Line of sight = 100 m + 1.217 =			101.217						
								- 2.368						
			AVG BOT ELEV							98.849				
Total	(14)	33.51												
Average		2.39												

*Numbered to right starting with 0 at borderline which extends upstream from left end of dam.

RI - NW
SOIL STABILIZATION
Watersheds
Benchmark:
H.I.
Elev.

ELEVATIONS OF SEDIMENT ACCUMULATED IN CATCHMENT BASINS

FORM RI-2

Date: 8-18-82
Party: Level Geo
Rod RM
Notes GW

Experimental Area: HJA
Basin Location: WS#1

Station*	Transects (Designated in ft. starting at crest of dam)													
	8		9		10		11		12		13		14	
	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.
0								1.25				1.55		1.32
3		1.13		1.18		1.27		1.18						1.43
6		1.60		1.26		1.09		1.32		1.6				2.03
9		2.22 x		2.00 x		1.71 x		3.21		1.44				2.57 x
12		3.02		2.69		2.25		2.54		2.00				2.47
15		3.43		3.21		2.94		3.09		1.72				2.49
18		3.27		3.46		3.52		3.32		2.65				2.63
21		3.27		3.32		2.55		3.30		2.76				1.23 x
24		3.03		3.20		3.53		3.23		2.67				1.49
27		3.02		3.15		3.45		3.01		2.68				
30		3.06		3.11		3.42		2.85		1.60				
33		3.03		3.26		3.34		2.63		1.72		1.48		
36		3.35		3.10		2.96		2.18		1.72		1.56		x
39		2.85		2.58		2.38		1.96		2.37 x		2.69		
42		2.30		2.05		1.95		1.87		2.06		2.45		
45		2.17		2.02		1.93		1.83		1.99		2.38		
48		2.31		2.09		1.93		1.82		2.03		2.45		
51		2.45		2.13		1.89		1.88		2.15		2.71		
54		2.45		2.09		1.91		2.00		2.28		2.55		
57		2.28		2.02		1.95		2.39		2.56		NS		
60		2.43		2.28		2.23		2.68		2.68		1.52		
63		2.56		2.68		2.65		2.59		NS		1.55		
66		2.29		2.46		2.54		2.05		NS				
69		1.88 x		2.10		2.19		1.83		1.57				
72		1.65		1.82 x		1.87 x		x NS		1.33				
75				1.66		1.69								
78														

BENCH MARK SURVEY

PERM BM → SURVEY STA	1.157	1.157	1.157
SURVEY STA 1 → TURNING PT	4.296	4.296	4.297
SURVEY STA 2 → TURNING PT	0.157	0.156	0.157
SURVEY STA 2 → AUX. BENCH MARK	4.468	4.467	4.467

BM START		1.217
END 10		1.218
END 8		1.217
END 6		1.217
#7	3	1.216
		1.216

INSTRUMENT HEIGHT

1. 1.060
2. 1.580

Total
Average

*Numbered to right starting with 0 at borderline which extends upstream from left end of dam.

Slip this column down one line.

RI - NW
SOIL STABILIZATION
Watersheds
Benchmark: 1.214
H.I.
Elev.

ELEVATIONS OF SEDIMENT ACCUMULATED IN CATCHMENT BASINS

FORM RI-2

Date: 8-17-82
Party: Level GL
Rod GW
Notes RM

Experimental Area: HJA
Basin Location: WS# 2

Station*	Transects (Designated in ft. starting at crest of dam)													
	1		2		3		4		5		6		7	
	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.
0										1.707		1.717		1.609
3				1.757	BE 5'	1.900	BE 4'	1.945	BE 5.3	2.080	BE 4'	2.123	BE 3.6'	1.974
6				2.124	S	3.535	S	2.578	S	2.615	S	2.550	S	2.528
9				2.420	S	2.871	S	3.225	S	3.189	S	3.128	S	3.085
12			S	2.793		3.194		3.415		3.421		3.404		3.341
15			S	2.848		3.350		3.496		3.445		3.375		3.335
18		1.960		3.199		3.450		3.430		3.336		3.356		3.353
21	BE S	2.150		3.362		3.428		3.424		3.339		3.094		3.070
24	S	2.607		3.379		3.405		3.361		3.053		2.894		2.863
27	S	2.952		3.469		3.524		3.360		3.054		2.885		2.927
30	S	3.168		3.410		3.465		3.346		3.156		2.915		2.950
33	S	2.967		3.416		3.463		3.236		3.083		2.883		2.803
36	BE			3.391		3.425		3.281		3.216		3.006		2.990
39				3.330		3.330		3.186		3.223		3.163		3.200
42				3.164		3.105		3.060		3.126		3.056		3.005
45			S	2.640		2.846		2.928		3.027		2.915		2.807
48			BE S	2.251		2.572		2.770		2.691		2.705		2.630
51			S	1.857		2.506		2.660		2.636		2.565		2.447
54			S	1.725		2.431		2.555		2.429		2.286		2.172
57					BE	1.164		2.162	BE 5.7'	1.876	BE 5.6'		BE 5.5'	
60							BE 5.8'							

BENCH MARK SURVEY

PERM BM → SURVEY STA 0.933
INT AUX BM → SURVEY STA 4.092 4.090
LOWER AUX BM → SURVEY STA

HI₁ = 1.332

SS₂ – AUX BM 1.213 1.214 1.215
SS₂ – AUX BM 1.871 1.870 1.871

HI₂ 1.545

BM START OF SURVEY 1.214
BM END OF LINE 2 1.213
" " 4 1.213
6 1.213
8 1.215
10 1.214
12 1.213
14 1.214
18 1.213

Total
Average

*Numbered to right starting with 0 at borderline which extends upstream from left end of dam.

RI - NW
SOIL STABILIZATION
Watersheds
Benchmark:
H.I.
Elev.

ELEVATIONS OF SEDIMENT ACCUMULATED IN CATCHMENT BASINS

FORM RI-2

Date: 8-17-82
Party: Level
Rod
Notes

Experimental Area: HJA
Basin Location: WS#2

Station*	Transects (Designated in ft. starting at crest of dam)													
	8		9		10		11		12		13		14	
	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.
0		1.639		1.640		1.598		1.600		1.656		1.732		1.845
3	BE 4.7'	1.875	BE 4.8'	1.935		1.615	BE 6.5'	1.445		1.519	BE 4'	1.855	.5	2.250
6	.5	2.556	.5	2.222	BE 6'	2.202	.5	2.070	BE 6'	2.287	.5	2.450	BE 3.5'	2.688
9	.5	3.050	.5	3.006	.5	2.832	.5	2.552	.5	2.832		2.935		2.803
12		3.324		3.170		3.249		3.082		3.050		2.963		2.872
15		3.295		3.252		3.227		3.170		3.056		2.961		2.909
18		3.306		3.282		3.232		3.160		3.085		2.981		2.844
21		2.956		3.062		3.125		3.187		3.104		2.936		2.825
24		2.825		2.775		3.115		3.266		3.106		2.901		2.764
27		2.936		2.800		3.270		3.209		3.126		2.945		2.770
30		2.809		2.940		3.261		3.276		3.105		2.945		2.782
33		2.880		3.146		3.275		3.230		3.100		2.876		2.575
36		3.233		3.307		3.270		3.185		2.968		2.779		2.382
39		3.159		3.186		3.055		3.039		2.812		2.547	BE 37.5'	2.143
42		3.036		2.924		2.849		2.820		2.611		2.338		1.929
45		2.722		2.683		2.583		2.572		2.423	BE 43.6'	1.928		
48		2.587		2.335		2.401		2.351		2.015				
51		3.296	ROCK	2.050		2.161		2.070	BE 50'	1.757				
54	BE 53.4'	1.767	BE 54'	1.821	BE 51.5'		BE 51'							
57														
60														
Total														
Average														

*Numbered to right starting with 0 at borderline which extends upstream from left end of dam.

RI - NW
SOIL STABILIZATION
Watersheds
Benchmark:
H.I.
Elev.

ELEVATIONS OF SEDIMENT ACCUMULATED IN CATCHMENT BASINS

FORM RI-2

Date: 8-17-82
Party: Level
Rod
Notes

Experimental Area: HJA
Basin Location: WS#2

Station*	Transects (Designated in ft. starting at crest of dam)													
	15		16		17		18							
	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.
0	S	1.875		1.957		2.390								
3	BE 3'S	2.225	BE 3	2.346		2.410								
6	S	2.500		2.534		2.467								
9		2.810		2.608		2.333								
12		2.783		2.657		2.417		2.184						
15		2.748		2.579		2.343		2.415						
18		2.680		2.432		2.162								
21		2.686	BE 21.8'	2.340	BE 21'									
24		2.594		2.139										
27		2.410		1.975										
30		2.292		1.900										
33	BE-33	2.076												
36														
39														
						Spillway		2.308						

1981 : TOTAL ROD READINGS 584.130
TOTAL ROD POINTS 199
X ROD READING 2.935

INT. BM = 100.000 m
BM READING + 1.148 m
BM CORR + .002

LINE OF SIGHT 101.150 m
X ROD READING 2.935

X BOTTOM ELEV 98.215

1982: TOTAL ROD READINGS 584.128
TOTAL ROD POINTS 199
X ROD READING 2.935

INT BM = 100.000 m
BM READING = 1.214 m
BM CORR = +.002 m

LINE OF SIGHT 101.216
X ROD READING 2.935

X BOTTOM ELEV 98.281

1982 X BOTTOM ELEV 98.281
1981 X BOTTOM ELEV - 98.215

Δ = .066 m

Total
Average

*Numbered to right starting with 0 at borderline which extends upstream from left end of dam.

RI - NW
SOIL STABILIZATION
Watersheds
Benchmark: 1.148 EMPTY
H.I.
Elev.

ELEVATIONS OF SEDIMENT ACCUMULATED IN CATCHMENT BASINS

FORM RI-2

Date: 8-6-81
Party: Level KM
Rod GL
Notes AL

Experimental Area: HJA
Basin Location: WS #2

Station*	Transects (Designated in ft. starting at crest of dam)													
	1		2		3		4		5		6		7	
	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.
0										1.62		1.60		1.55
3				1.66	BE 5'	1.84	BE 4	1.88		2.01	BE 4	1.98	BE 5	1.87
6			BE 6'	1.98	S	2.55	S	2.55	BE 5.5 S	2.50	S	2.45	S	2.33
9			6 "	2.28	S	2.75	S	3.13	S	3.08	S	2.99	S	2.90
12			S	2.41	B	3.11		3.31	B	3.35		3.34		3.36
15			S	2.51		3.28		3.40		3.35		3.31		3.30
18		1.91	S	2.94		3.35		3.36		3.32		3.33		3.30
21	BE	2.20		3.12		3.33		3.32		3.33		3.36		3.29
24	S	2.84		3.22		3.34		3.29		3.33		3.32		3.28
27	S	2.82		3.39		3.40		3.36		3.28		3.30		3.29
30	S	2.60		3.30		3.38		3.37		3.34		3.28		3.28
BE 33 34	S-R	2.34		3.25		3.37		3.31		3.31		3.26		3.25
36	S-R			3.18		3.32		3.35		3.28		3.27		3.22
39			B	3.09		3.31		3.23		3.15		3.13		3.18
42			S	2.63		3.10		3.07		3.06		3.02		3.02
45				2.53		2.83		2.95		2.95		2.87		2.82
48			BE 5.0	2.19		2.67		2.81		2.80		2.63		2.66
51			1.6	1.75		2.51		2.68		2.62		2.63		2.48
54			1.6	1.63	BE 5.6	2.20	↑	2.64		2.52		2.47		2.15
57			1.4	1.42		1.71	2.0 B	2.27		2.17			X	X
60			X	X	X	X	X	X	X	X	X	X		
63														
66														
69														
72														
75														
78														
81														
		BM Start of Survey				1.150		Aug BM		1.770				
		BM End Line			2	1.148				1.800				
		"		"	4	1.145								
					6	1.147								
					8	1.148								
					10	1.148								
					12	1.147								
					14	1.148								
						1.148								
Total		14.61		48.48		55.35		57.28		58.37		55.54		54.53
Average		6		19		19		19		20		19		19

*Numbered to right starting with 0 at borderline which extends upstream from left end of dam.

RI - NW
SOIL STABILIZATION EMPTY
Watersheds
Benchmark:
H.I.
Elev.

ELEVATIONS OF SEDIMENT ACCUMULATED IN CATCHMENT BASINS

FORM RI-2

Date: 8-6-81
Party: Level KH
Rod GL
Notes AL

Experimental Area: HJA
Basin Location: WS#2

Station*	Transects (Designated in ft. starting at crest of dam)													
	8		9		10		11		12		13		14	
	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.
0		1.55		1.66		1.57		1.54		1.53		1.63		1.73
3 BE 5.0		1.78	B.E 5	1.85		1.56	BE 5	1.37		1.37	S	1.64	S	2.09
6	S	2.37	S	2.43		2.16	S	2.13	S	2.08	S	2.35		2.56
9	S	2.96	B	2.92	S	2.67	↓	2.43		2.84		2.87		2.68
12		3.25		3.10		3.18		2.98		2.93		2.96		2.74
15		3.24		3.18		3.24		3.09		3.01		2.94		2.80
18		3.29		3.24		3.27		3.11		3.07		2.93		2.86
21		3.26		3.20		3.29		3.17		3.06		2.91		2.79
24		3.30		3.25		3.26		3.20		3.06		2.92		2.78
27		3.28		3.20		3.29		3.15		3.05		2.93		2.69
30		3.29		3.25		3.23		3.20		3.04		2.91		2.67
33		3.25		3.33		3.30		3.16		3.06		2.84	S	2.57
36		3.27		3.28		3.23		3.12		2.91		2.79	BE	2.39
39		3.14		3.13		3.03		2.87		2.76	X	2.60		2.04
42		3.01		2.88		2.81		2.71		2.56	BE 43	2.26		1.85
45		2.67		2.62		2.58		2.50		2.37		1.86		
48		2.57		2.23		2.34		2.13	BE	1.95				
51		2.19	B.E	2.16	BE 52	2.10	BE	1.98		1.95				
54	B.E	2.00	X	1.80	X	X								
57	X	X												
60														
63														
66														
69														
72														
75														
78														
81														
84														
87														
90														
93														
96														
99														
102														
Total		53.67		52.66		50.11		47.84		46.60		41.34		37.24
Average		19		19		18		18		18		16		15

*Numbered to right starting with 0 at borderline which extends upstream from left end of dam.

RI - NW
SOIL STABILIZATION
Watersheds
Benchmark:
H.I.
Elev.

ELEVATIONS OF SEDIMENT ACCUMULATED IN CATCHMENT BASINS

EMPTY

FORM RI-2

Date: 8-6-81
Party: Level GR.KM
Rod GL
Notes AL

Experimental Area: HJA
Basin Location: WS#2

Station*	Transects (Designated in ft. starting at crest of dam)													
	15		16		17		18							
	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.
0	6	1.74	5	1.93		2.30								
3		2.20		2.30		2.30								
6		2.49		2.43		2.32								
9		2.67		2.50		2.28								
12		2.72		2.58		2.10		2.08						
15		2.65		2.48		2.17	X	X						
18		2.61		2.33	BE	1.86								
21		2.65		2.22	X	X								
24		2.51	X	2.06										
27		2.44	BE26	1.97										
30	5 X	2.29		1.81										
33	BE31	2.26												
36														
39														
42														
Total		29.23		24.61		15.43		2.08						
Average		12		11		7		1						

TOTAL ROD READINGS 744.97
TOTAL PTS 275
Avg Rod Reading 2.709
Line of sight 101.148
Avg Bottom Elev 98.439

*Numbered to right starting with 0 at borderline which extends upstream from left end of dam.

RI - NW
SOIL STABILIZATION
Watersheds
Benchmark: 0.199
H.I.
Elev.

ELEVATIONS OF SEDIMENT ACCUMULATED IN CATCHMENT BASINS

FULL

FORM RI-2

Date: 8-18-82
Party: Level
Rod
Notes

Experimental Area: HJA
Basin Location: WS #3

Station*	Transects (Designated in ft. starting at crest of dam)													
	1B		1A		1		2		3		4		5	
	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.
0		X		X										
2.5		X		X		2.75		2.83		3.10		3.47		3.53
4		X		X		2.73		2.66		2.93		3.30		3.47
6		X		X		2.80		2.65		2.86		3.15		3.35
8		X		X		2.77		2.74		2.94		3.19		3.33
10		X		X		2.76		2.77		2.96		3.19		3.25
12		X		X		2.79		2.79		2.95		3.09		3.19
14		X		X		2.79		2.96		3.06		3.12		3.18
16		X		X		2.80		2.75		2.93		2.94		3.04
18		X		X		2.75		2.62		2.65		2.79		2.87
20		X		X		2.54		2.54		2.53		2.58		2.66
22		X		X		2.60		2.41		2.31		2.29		2.49
24		X		X		2.56		2.14		2.07		2.08		2.26
26		X		X		2.45		1.85		1.94		1.90		2.06
28		X		X		2.28		1.93		1.87		1.90		1.91
30		X		X		1.99		1.86		1.88		1.87		1.89
32		X		X		1.88		1.89		1.84		1.84		1.79
34		0.91		1.61		1.79		1.89		1.83		1.82		1.72
36		1.20		1.61		1.79		1.74		1.78		1.76		1.78
38		1.38		1.78		1.78		1.70		1.76		1.70		1.76
40		1.58		1.77		1.76		1.71		1.75		1.72		1.70
42		1.33		1.76		1.74		1.62		1.77		1.80		1.68
44		1.65		1.70		1.70		1.64		1.72		1.67		1.69
46		1.64		1.69		1.70		1.64		1.65		1.75		1.65
48		1.63		1.63		1.63		1.63		1.71		1.79		
50		1.64		1.58		1.61		1.76		1.76		1.74		
Total														
Average														

Found that upstream end of tape was on wrong stake. Apparently we got off at #7 and put 7 on upstream point #6. When we found out I put #2 on Point 2

*Numbered to right starting with 0 at borderline which extends upstream from left end of dam.

RI - NW
SOIL STABILIZATION
Watersheds
Benchmark:
H.I.
Elev.

ELEVATIONS OF SEDIMENT ACCUMULATED IN CATCHMENT BASINS

FULL

FORM RI-2

Date: 8-18-82
Party: Level
Rod
Notes

Experimental Area: HJA
Basin Location: WS#3

Station*	Transects (Designated in ft. starting at crest of dam)													
	6		7		8		9		10		11		12	
	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.	H.I.	Elev.
0														
2.5		3.63		3.61		3.64		3.62		3.52		3.49		3.42
4		3.59		3.61		3.63		3.60		3.58		3.52		3.47
6		3.43		3.44		3.40		3.32		3.30		3.39		3.52
8		3.36		3.34		3.23		2.96		3.04		3.14		3.38
10		3.26		3.25		3.06		2.86		2.82		2.94		3.16
12		3.22		3.14		2.92		2.70		2.65		2.81		2.87
14		3.15		3.12		2.81		2.59		2.56		2.67		
16		3.07		3.07		2.86		2.70		2.56		2.59		
18		2.99		3.01		2.93		2.81		2.70		2.79		
20		2.86		2.93		2.88		2.88		2.90				
22		2.74		2.84		2.81		2.88		2.86				
24		2.58		2.69		2.79		2.80						
26		2.42		2.61		2.80								
28		2.25		2.48										
30		2.24		2.41										
32		2.06												

BM Beginning of Survey 0.198 0.198

End Line	16 =	0.197
" "	8	0.198
" "	6	0.202
" "	4	0.200
" "	2	0.201
" "	1B	0.201

1981: TOTAL ROD READINGS 622.34
TOTAL ROD POINTS 221
$\bar{X}$ ROD READING 2.816

LINE OF SIGHT 100.344
$\bar{X}$ ROD READING 2.816

$\bar{X}$ BOTTOM ELEV 97.528

1982: TOTAL ROD READINGS 555.42
TOTAL ROD POINTS 222
$\bar{X}$ ROD READING 2.502

LINE OF SIGHT 100.199
$\bar{X}$ ROD READING 2.502

$\bar{X}$ BOTTOM ELEV 97.697

1982	97.697
1981	97.528
Δ	0.169

Total
Average

*Numbered to right starting with 0 at borderline which extends upstream from left end of dam.