COLORADO RIVER INVESTIGATIONS III

July-August, 1984

By
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Submitted To

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CHAPTER I

INTRODUCTION

This report presents results of a five-week, six-semester hour course (Geology 538-626) on the geology, hydrology, and biology of the Grand Canyon. Offered through Northern Arizona University (July and August, 1984) in collaboration with the Museum of Northern Arizona and Grand Canyon National Park, the course involved approximately three weeks of classroom and laboratory instruction and about two weeks of field work, most of which was an 11-day research expedition down the Colorado River from Lees Ferry to Diamond Creek (August 1 through August 11).

All field investigations were conducted under the supervision of Dr. Stanley S. Beus, Northern Arizona University, or Dr. Steven W. Carothers, Research Associate, Museum of Northern Arizona.

The research project reports submitted here are all at least partly outlined by students, and present results of a variety of investigations undertaken.

The studies conducted in 1984 are particularly valuable because they document Grand Canyon beach conditions after the exceptional high water flows of 1983. The data collected, when compared to data collected in the previous two years, provides information about the effects of unusually high water discharges on the post-dam downstream (Grand Canyon) environment.

The 1984 investigations included studies of fish distribution and abundance in the Colorado River, beach profile changes, beach sand grain size, growth and vigor of old high water line (OHWL) vegetation, harvester ant densities on camping beaches, and human impact on camping beaches.

CHAPTER II

DISTRIBUTION AND ABUNDANCE OF NATIVE AND EXOTIC FISH SPECIES IN THE COLORADO RIVER, GRAND CANYON, ARIZONA

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INTRODUCTION

> Historically, the primitive Colorado represented a unique aquatic habitat, ranging from a swift-flowing, turbid river to a system characterized by long periods of low flows during droughts. Water temperatures fluctuated seasonally with the water being warmer in spring and summer, and cooler during fall and winter. Physico-chemical regimes varied with the flow regimes, i.e., spring run-off, summer flooding, or conversely, summer drought. It was within this system that one of the most unique North American fish faunas developed, a faunal assemblage which had one of the highest rates of endemism of any river basin in North America (Miller 1958). This fauna included the bizarre appearing humpback chub (Gila cypha) and razorback sucker (Xyrauchen texanus) as well as the roundtail chub (Gila robusta), speckled dace (Rhinichthys osculus), flannelmouth sucker (Catostomus latipinnis) and bluehead sucker (Catostomus discobolus).
>
> (Carothers and Minckley 1981)

This historic Colorado River, however, no longer exists within the Grand Canyon. The silt-laden river flow characterized by seasonal changes in temperature and velocity has ceased as clear cold water is pumped from Lake Powell on energy demand. The operation of the Glen Canyon Dam and the introduction of exotic fish species have proven to be significant. Three native species are now considered extinct in the Grand Canyon: the Colorado squawfish, the bonytail chub, and the roundtail chub.

The razorback sucker is considered extant based on one individual captured in 1978. As to the remaining species, the flannelmouth sucker and bluehead sucker appear to be coping well in the new environment, speckled dace remains populous in the tributaries, and a humpback chub population exists in close proximity to the mouth of the Little Colorado River (Carothers and Minckley 1981).

With the continued proliferation of exotic species, the question remains as to how well the natives will be able to tolerate the new dam-created environment. Information is needed to assess possible trends. As part of ongoing research, the Arizona Game and Fish Department and Northern Arizona University conducted fisheries investigations on a research expedition sponsored by Northern Arizona University from August 1-12, 1984. Information was gathered to determine the effects of fluctuating flows; to determine fish age, growth and food habits; to evaluate reproduction potential and estimate numbers of eggs; and to gain information regarding stocked fish, young of the year, and habitat types. This report will summarize the data gathered on that trip on the distribution and abundance of both native and exotic species.

METHODS

Fish captures were made by electrofishing, seine and trammel nets in the mainstream Colorado. This report will examaine only those species caught by electrofishing.

A two-pontoon, 22 foot, rubber snout catamaran was rigged as the electrofishing vessel. A gas fueled generator powered a Coffelt Variable Voltage Pulsator, Electroshocker Model VVP-15. The VVP-15 was designed to supply AC or DC or pulsed voltages. Output used was 220 AC pulsed with the exceptions of one run in Reach 30 where current output was DC.

RESULTS

A total of 296 fish were captured by electrofishing. The information presented will be analyzed in comparison to data supplied in A Survey of the fishes, aquatic invertebrates and aquatic plants of the Colorado River and selected tributaries from Lees Ferry to Separation Rapids, by Carothers and Minckley, 1981. All raw data is summarized by reach, listing species and their individual lengths in descending order in Tables II-1.1 through II-1.4. Total composition and catch per effort for each reach is summarized in Table II-2. Total collection for both exotic and native species is shown in Table II-3.

Reach 20

The most common fish captured was rainbow trout (80%), with sizes ranging from 77mm to 600mm ($\bar{X}$=340±105). The relative frequency of appearance of adults to juveniles* in the sample was higher than for any other reach. Sixty-four adults comprised 80% of the catch, and eight juveniles, 11%.

The next most common species was humpback chub (11.1%), with sizes ranging from 121mm to 360mm ($\bar{X}$=211±79). Of the ten

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*RBT juveniles were designated as those fish under 200mm in length.

captured, seven (70%) were adults, and three (30%) were juveniles. Researchers have noted that methods other than electrofishing have proven to be more successful in catching humpback chub (Carothers and Minckley 1981), which might indicate that there is a higher population present than these numbers would indicate. Also captured were three adult carp (3.3%), ranging in size from 407mm-531mm ($\bar{X}$=471mm±51).

Three adult flannelmouth suckers comprised 3.3% of the catch, ranging in size from 425mm-469mm ($\bar{X}$=446±18).

Two adult brook trout comprised 2.2% of the catch, with sizes ranging from 436mm-444mm ($\bar{X}$=440±4).

Reach 30

The most common species captured was rainbow trout (33.3%), with sizes ranging from 87mm-444mm ($\bar{X}$=262±126). Of these, eight (57%) were adults, and six (43%) were juveniles.

Carp followed, being 26.2% of the total catch, with sizes ranging from 151mm-580mm ($\bar{X}$=434±115). All 11 individuals collected were adults.

Humpback chub comprised 21.5% of the total catch, with sizes ranging from 46mm-345mm ($\bar{X}$=125±93). Of these, two (22%) were adults, and seven (78%) were juveniles.

Fathead minnows comprised 14.3% of the total catch, with six adults ranging in size from 45mm-67mm ($\bar{X}$=53±7).

One flannelmouth sucker at 482mm and one brown trout at 479mm were also collected in Reach 30, each comprising 2.8% of the total catch for Reach 30.

Reach 40

The most common species captured was rainbow trout (73.1%), with sizes ranging from 81mm-410mm ($\bar{X}$=235±109). Of these, 43 (54%) were adults, and 36 (46%) were juveniles.

The next most common species was carp (22.3%), with sizes ranging from 172mm-561mm ($\bar{X}$=430±86). Of these, 22 (92%) were adults, and two (8%) were juveniles. This was the only reach where juvenile carp were collected.

Three adult brown trout comprised 2.8% of the total catch, with sizes ranging from 288mm-316mm ($\bar{X}$=303±12).

One adult bluehead sucker 166mm long and one humpback chub were also collected, each comprising .9% of the catch. No length was recorded for the humpback chub.

Reach 50

The most common species captured was rainbow trout (44.7%), with sizes ranging from 66mm-337mm ($\bar{X}$=199±89). The relative frequency of appearance in the sample of juveniles to adults was higher than for any other reach. Fifteen juveniles comprised 60% of the catch, and ten adults, 40%.

The second most common fish was carp (39.3%), with sizes ranging from 307mm-482mm ($\bar{X}$=401±54). All 22 collected were adults.

Also captured were three adult speckled dace (5.4%), ranging in size from 77mm to 103mm ($\bar{X}$=11±87). Two adult channel catfish composed 3.6% of the catch, with sizes ranging from 200mm-295mm ($\bar{X}$=248±48). One bluehead sucker at 305mm, one humpback chub at

311mm, one flannelmouth sucker at 373mm, and one fathead minnow at 50mm were also collected, each comprising 1.8% of the total catch for Reach 50.

Summarizing, rainbow trout was the most common species with 64.2% of the total catch for all reaches. The number of adults decreased downstream with the exception of those found in Reach 40. The number of juveniles increased downstream, but decreased slightly in Reach 50. Proportionately, Reach 50 exhibited the highest number of rainbow trout juveniles to adults of any other reach.

In order to compare our data to the Carothers and Minckley 1981 report, percentages of adults only were computed since their report included only adults in the total composition figures. In our study, adult rainbow trout comprised 57.6% of the total mainstream catch. This compares to the 1981 reported distribution of 14.6% in the summer figures, and 13.3% in the overall mainstream and tributaries figures. These data indicate, that since 1978, summer distribution of rainbow trout has increased in the study area (Reaches 20 through 50). Carothers and Minckley also noted that rainbow trout "...usually preferred higher gradient streams and occurred at least 1.6km upstream in Clear, Kanab and Havasu Creeks" (Carothers and Minckley 1981). These creeks occur in Reach 40 where the greatest number of rainbow trout were collected in our study. Most of the rainbows collected in this reach, however, were caught upstream from these creeks between miles 107 and 120. Figures II-1.1 and II-1.2 show length frequencies for rainbow trout.

The second most common species was carp, with 20.3% of the total catch for all reaches. Length frequencies remained relatively stable throughout, with a slight decrease in size downstream. Abundance increased downstream. The absence of young- of-year fish is consistent with earlier findings, and probably indicates unsuccessful breeding. It is presumed that carp have been migrating upstream from Lake Mead (Carothers and Minckley 1981). Carp were the most frequently taken species from the mainstream in the Carothers and Minckley study, comprising 56.1% of the summer mainstream population, and 41.6% of the catch combining mainstreaming and tributaries. Carp comprised 26.7% of our adult total composition. Figures II-2.1 and II-2.2 show length frequencies for carp.

The third most common species was humpback chub, with 7.1% of the total catch for all reaches. Most significant was the fact that almost all of the humpback chub collected were captured in reaches 20 through 30. 1977-78 studies indicate that humpback chub were taken in the vicinity of the Little Colorado River, but rarely downstream, and that adults were taken "...primarily from eddies adjacent to fast currents" (Carothers and Minckley 1981). Our total capture for Reach 30 took place at mile 61, at the mouth of the Little Colorado River, in a back eddy. In Reach 30, three were collected at river mile 62 and six at mile 73. Humpback chub comprised 4.6% of our total adult population, compared to .3% for the summer 1977-78 figures, and 5.8% for the overall 1977-78 figures for mainstream and tributaries. Figure II-3 shows length frequencies for humpback chub.

The fourth most common species was the fathead minnow, with

2.4% of the total catch for all reaches. Carothers and Minckley collected fathead minnows only in river section X and noted that its appearance was sporadic throughout the whole study area (Carothers and Minckley 1981). Six fathead minnows were collected in Reach 30 and one in Reach 50. Fathead minnows comprised 1.8% of our total adult population, as compared to .4% of the summer 1977-78 mainstream catch, and .2% of the 1977-78 overall mainstream and tributary catch.

The fifth most common species was the flannelmouth sucker, with 1.7% of the total catch for all reaches. Flannelmouth suckers have been found to be more populous in tributaries than in the mainstream. Densities are highest in the confluent areas of the Paria and Little Colorado Rivers and Kanab Creek (Carothers and Minckley 1981). Flannelmouth suckers comprised 2.3% of the total adult catch, as compared to 4.9% of the summer 1977-78 catch, and 13.8% of the 1977-78 overall catch combining mainstream and tributaries.

The sixth most common species was brown trout, with 1.4% of the total catch for all reaches. It is presumed that brown trout are limited in their mainstream distribution as previous catches have occurred only in river sections IV through VII (Carothers and Minckley 1981). This compares to our data, as brown trout were collected only in Reaches 30 and 40.

The seventh most common species was speckled dace, with 1% of the total catch for all reaches. Carothers and Minckley found distribution of speckled dace in the mainstream to be sporadic. Summer distribution was limited to river sections VII, X and XI. It is believed that their small size makes collection in the mainstream difficult, thus collections do not represent the actual mainstream population (Carothers and Minckley 1981). Our only three adult captures occurred in Reach 50.

Brook trout, channel catfish, and bluehead sucker each comprised .7% of our total collection. In the 1977-78 studies, brook trout were most commonly taken 60 miles downstream from Lees Ferry (Carothers and Minckley 1981). Our only brook trout were collected in Reach 20. Brook trout comprised .9% of the total adult catch, as compared to .1% of the 1977-78 summer mainstream catch, and .3% the 1977-78 overall catch combining mainstream and tributaries.

Channel catfish in 1977-78 were collected in sections IX through XI (Carothers and Minckley 1981). Our only collections were in Reach 50. Channel catfish comprised .9% of the total adult catch, as compared to 1.1% of the 1977-78 summer mainstream catch, and .7% the overall 1977-78 catch combining mainstream and tributaries.

Bluehead suckers comprised .9% of the total adult catch, as compared to 12.2% of the 1977-78 summer mainstream catch, and 9.3% the total 1977-78 collection combining mainstream and tributaries. Carothers and Minckley found the highest mainstream densities for bluehead suckers occurred in river sections IV and IX. Densities were also higher in the summer in the fast moving, high gradient tributaries. Only two individuals were collected, one in Reach 40 and one in Reach 50.

CONCLUSIONS

In conclusion, although our population sample was smaller than in previous research trips, it is, nevertheless, representational in terms of distribution and abundance. It should be noted that differences in effort may or may not have effected the abundance data (Appendix II-4 gives percentage of shocking time as compared to percentage of fish caught in each reach). Thus, while no definitive conclusions can be drawn, this report contributes to existing data on the distribution and abundance of both native and exotic fish species of the Colorado River in the Grand Canyon. Its ultimate value lies in its comparison to previous and to future investigations.

LITERATURE CITED

Carothers, Steven W. and C.O. Minckley. 1981. A Survey of the fishes, aquatic invertebrates and aquatic plants of the Colorado River and selected tributaries from Lees Ferry to Separation Rapids. Final report to the Water and Resources Services. Department of Biology, Museum of Northern Arizona.

Table II-1.1.

SPECIES LENGTH LIST

August, 1984
Reach 20 - Colorado River
Grand Canyon

Species	Length
RBT	600
RBT	545
RBT	540
RBT	533
RBT	499
RBT	492
RBT	468
RBT	466
RBT	452
RBT	421
RBT	418
RBT	415
RBT	388
RBT	384
RBT	378
RBT	372
RBT	371
RBT	369
RBT	366
RBT	365
RBT	365
RBT	363
RBT	363
RBT	362
RBT	362
RBT	360
RBT	359
RBT	357
RBT	356
RBT	355
RBT	353
RBT	353
RBT	353
RBT	352
RBT	352

Species	Length
RBT	349
RBT	347
RBT	347
RBT	345
RBT	345
RBT	345
RBT	344
RBT	343
RBT	340
RBT	340
RBT	333
RBT	332
RBT	332
RBT	329
RBT	327
RBT	324
RBT	324
RBT	323
RBT	319
RBT	316
RBT	315
RBT	315
RBT	314
RBT	311
RBT	309
RBT	308
RBT	297
RBT	277
RBT	119
RBT	110
RBT	110
RBT	106
RBT	93
RBT	84
RBT	80
RBT	77
std	105.3421
mean	339.8888

Species	Length
HBC	360
HBC	349
HBC	226
HBC	206
HBC	203
HBC	196
HBC	180
HBC	135
HBC	134
HBC	121
std	79.08855
mean	211

Species	Length
CRP	531
CRP	476
CRP	407
std	50.73022
mean	471.3333

Species	Length
FMS	469
FMS	444
FMS	425
std	18.01850
mean	446

Species	Length
BKT	444
BKT	436
std	4
mean	440

Table II-1.2.

SPECIES LENGTH LIST

Reach 30 - Colorado River
Grand Canyon

Species	Length	Species	Length	Species	Length	Species	Length	Species	Length	Species	Length
RBT	444	CRP	580	HBC	345	FHM	67	FMS	482	BRT	479
RBT	389	CRP	545	HBC	194	FHM	54				
RBT	374	CRP	530	HBC	152	FHM	53				
RBT	365	CRP	490	HBC	147	FHM	50				
RBT	356	CRP	479	HBC	63	FHM	46				
RBT	348	CRP	470	HBC	61	FHM	45				
RBT	341	CRP	441	HBC	60						
RBT	314	CRP	380	HBC	55						
RBT	165	CRP	359	HBC	46						
RBT	157	CRP	346								
RBT	118	CRP	151								
RBT	114										
RBT	91										
RBT	87										
std	125.5050	std	115.1016	std	92.90350	std	7.274384				
mean	261.6428	mean	433.7272	mean	124.7777	mean	52.5				

Table II-1.3.

SPECIES LENGTH LIST

August, 1984
Reach 40 - Colorado River
Grand Canyon

Species	Length	Species	Length	Species	Length	Species	Length	Species	Length	Species	Length
RBT	410			CRP	561	BRT	316	BHS	166	HBC	
RBT	408			CRP	523	BRT	306				
RBT	376	RBT	195	CRP	503	BRT	288				
RBT	373	RBT	170	CRP	502						
RBT	373	RBT	168	CRP	501	std	11.58543				
RBT	363	RBT	151	CRP	498	mean	303.3333				
RBT	361	RBT	150	CRP	488						
RBT	360	RBT	148	CRP	483						
RBT	357	RBT	146	CRP	474						
RBT	357	RBT	140	CRP	468						
RBT	349	RBT	136	CRP	458						
RBT	348	RBT	134	CRP	456						
RBT	347	RBT	127	CRP	451						
RBT	345	RBT	127	CRP	449						
RBT	345	RBT	126	CRP	446						
RBT	343	RBT	125	CRP	445						
RBT	340	RBT	124	CRP	423						
RBT	336	RBT	120	CRP	411						
RBT	336	RBT	119	CRP	405						
RBT	334	RBT	117	CRP	404						
RBT	333	RBT	117	CRP	382						
RBT	332	RBT	117	CRP	344						
RBT	331	RBT	113	CRP	200						
RBT	327	RBT	111	CRP	172						
RBT	325	RBT	110								
RBT	323	RBT	109								
RBT	321	RBT	107	std	86.47626						
RBT	320	RBT	105	mean	429.8260						
RBT	319	RBT	104								
RBT	316	RBT	101								
RBT	311	RBT	100								
RBT	310	RBT	95								
RBT	310	RBT	94								
RBT	308	RBT	92								
RBT	302	RBT	90								
RBT	298	RBT	89								
RBT	296	RBT	84								
RBT	290	RBT	81								
RBT	290										
RBT	288										
RBT	286										
RBT	284	std	108.9143								
RBT	280	mean	235.4810								

Table II-1.4.

SPECIES LENGTH LIST

August, 1984
Reach 50 - Colorado River
Grand Canyon

Species	Length
RBT	337
RBT	335
RBT	325
RBT	320
RBT	303
RBT	303
RBT	292
RBT	285
RBT	284
RBT	224
RBT	184
RBT	181
RBT	160
RBT	151
RBT	145
RBT	142
RBT	139
RBT	132
RBT	123
RBT	115
RBT	115
RBT	108
RBT	104
RBT	90
RBT	66
std	89.21216
mean	198.52

Species	Length
CRP	482
CRP	477
CRP	472
CRP	463
CRP	461
CRP	449
CRP	446
CRP	431
CRP	430
CRP	422
CRP	400
CRP	397
CRP	383
CRP	379
CRP	376
CRP	365
CRP	358
CRP	357
CRP	337
CRP	317
CRP	315
CRP	307
std	54.45925
mean	401.0909

Species	Length
SD	103
SD	81
SD	77
std	11.43095
mean	87

Species	Length
CC	295
CC	200
std	47.5
mean	247.5

Species	Length
BHS	305

Species	Length
HBC	311

Species	Length
FMS	373

Species	Length
FHM	50

Table II-2. Summary sheet of total collection by electrofishing, August 1984. Effort and composition.

Species		Reach 20 f-101m			Reach 30 f=78.6m			Reach 40 f=131.4m			Reach 50 f=116.5m		
		#	c/f	%	#	c/f	%	#	c/f	%	#	c/f	%
RBT	A	64	38.0	71.1	8	6.1	19.0	43	19.6	39.8	10	5.9	17.9
	J	8	4.8	8.9	6	4.6	14.3	36	16.4	33.3	15	8.9	26.8
CRP	A	3	1.8	3.3	11	8.4	26.2	22	10.0	20.4	22	13.0	39.3
	J							2	0.9	1.9			
HBC	A	7	4.2	7.8	2	1.5	4.8				1	.6	1.8
	J	3	1.8	3.3	7	5.3	16.7	1	0.5	0.9			
FMS	A	3	1.8	3.3	1	0.8	2.4				1	.6	1.8
	J												
BHS	A							1	0.5	0.9	1	.6	1.8
	J												
FHM	A				6	4.6	14.3						
	J										1	.6	1.8
BRT	A				1	0.8	2.4	3	1.4	2.8			
	J												
BKT	A	2	1.2	2.2									
	J												
CC	A										2	1.2	3.6
	J												
SD	A										3	1.8	5.4
	J												
Totals		90	53.6	99.9	42	32.1	100.1	108	49.3	100.0	56	33.2	100.2

Table II-3. Relative abundance (expressed in %) of fishes collected from mainstream Colorado, August 1984.

	Reach				Total	%
	20	30	40	50		
EXOTIC						
RBT	72	14	79	25	190	64.2
CRP	3	11	24	22	60	20.3
FHM	0	6	0	1	7	2.4
BRT		1	3		4	1.4
BKT	2				2	0.7
CC				2	2	0.7
TOTAL EXOTIC	77	32	106	50	265	
% EXOTIC	85.6%	76.2%	98.1%	89.3%		89.5%
NATIVE						
FMS	3	1	0	1	5	1.7
HBC	10	9	1	1	21	7.1
BHS	0	0	1	1	2	0.7
SD				3	3	1.0
TOTAL NATIVE	13	10	2	6	31	
%NATIVE	14.4%	23.8%	1.9%	10.7%		10.5%
OVERALL TOTAL	90	42	108	56	296	100%

Figure II-1.1. Length-frequency distribution for rainbow trout.

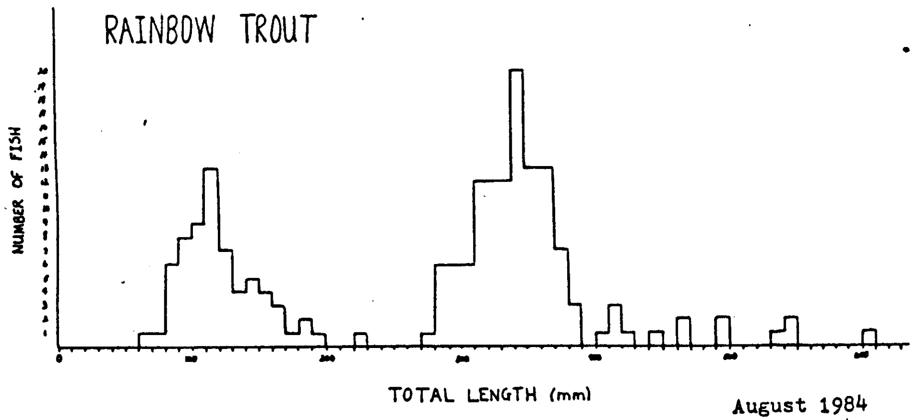
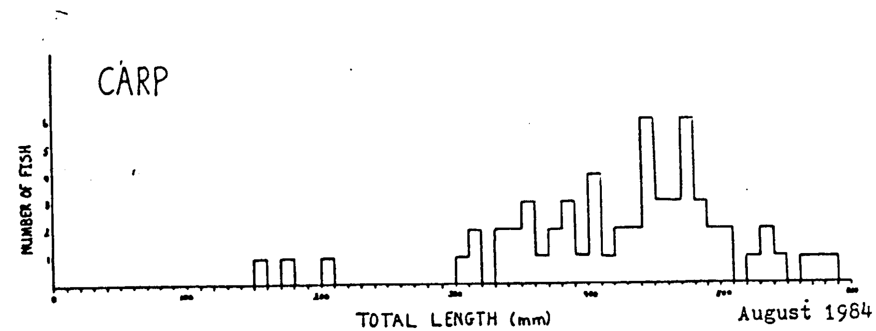


Figure II-2.1. Length-frequency distribution for carp.



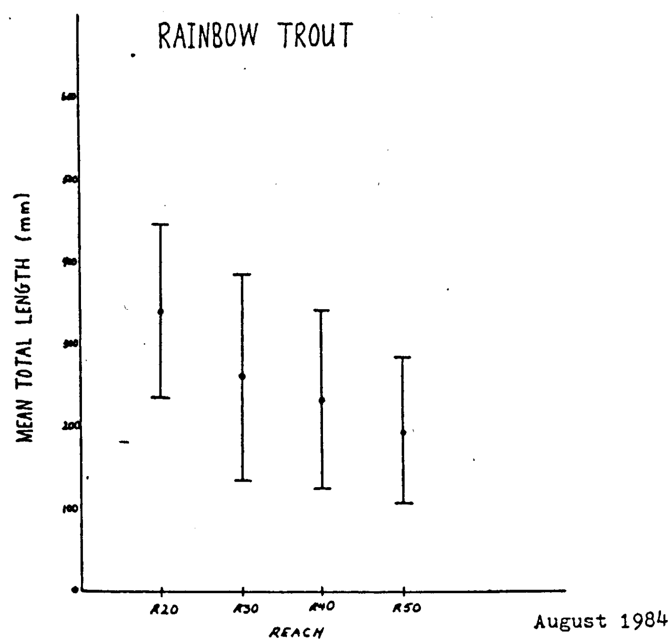


Figure II-1.2 $\overline{X}$ and standard deviation by reach for rainbow trout.

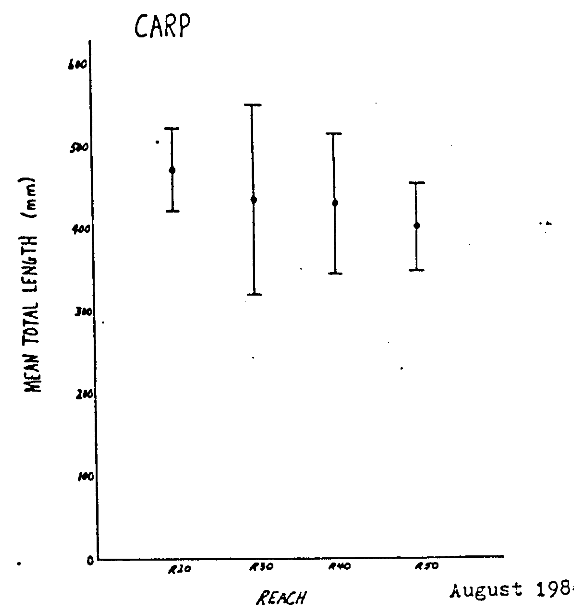
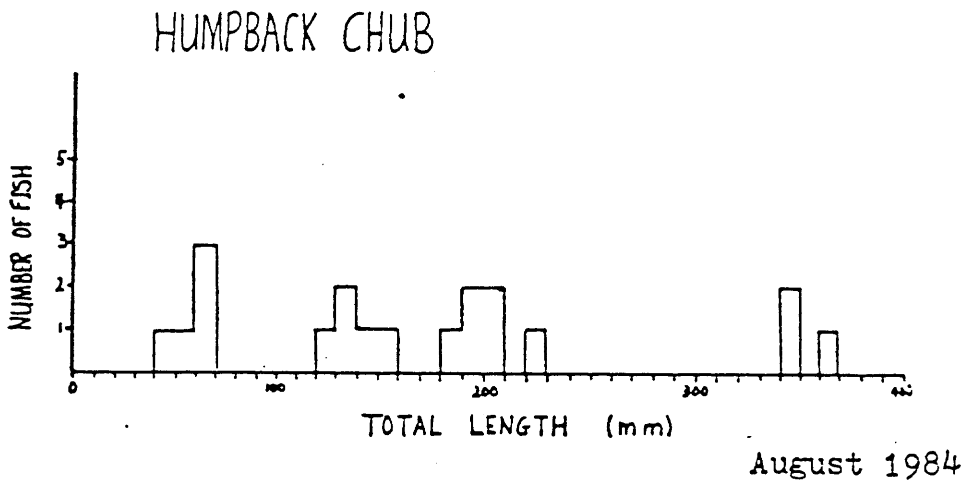


Figure II-2.2. $\overline{X}$ and standard deviation by reach for carp.

Figure II-3. Length-frequency for humpback chub.



APPENDICES

Appendix II-1. Species abbreviations.

RBT	rainbow trout	BHS	bluehead sucker
CRP	carp	BKT	brook trout
HBC	humpback chub	BRT	brown trout
FHM	fathead minnow	CC	channel catfish
FMS	flannelmouth sucker	SD	speckled dace

Appendix II-2. Arizona Game and Fish reach designations.

Reach 10	Dam to Lees Ferry
Reach 20	Lees Ferry to the Little Colorado River
Reach 30	Little Colorado River to Bright Angel
Reach 40	Bright Angel to National
Reach 50	National to Separation

Appendix II-3. Comparison of AG&F River reaches to river sections used by Carothers and Minckley, 1981.

AG&F	C&M, 1981
Reach 20	Sections I-III
Reach 30	Sections IV-V
Reach 40	Sections VI-IX
Reach 50	Sections X-XII

Appendix II-4. Percentage of shocking time as compared to percentage total catch.

	% of total shock time	% of total catch
Reach 20	23.6%	30.4%
Reach 30	18.4%	14.2%
Reach 40	30.7%	36.5%
Reach 50	27.3%	18.9%

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CHAPTER III

TOPOGRAPHIC CHANGES IN FLUVIAL TERRACE DEPOSITS USED AS CAMPSITE BEACHES ALONG THE COLORADO RIVER IN GRAND CANYON

S. S. Beus, F. Lojko, M. L. Holmes, D. Penner and S. Renken

INTRODUCTION

Sandy alluvial terraces and bars along the Colorado River in Grand Canyon are locally used as beaches by river recreationists. The beaches serve for campsites and lunch stop sites for some 15,000 river runners per year and thus constitute a major recreational resource in the national park. Most of the recreational use is concentrated on about 100 commonly used beaches out of the more than 200 beach campsites recognized along the river corridor through Grand Canyon National Park (Howard and Dolan 1981; Brian and Thomas 1984).

The terrace deposits were formed by a dynamic river system which deposited sandy sediment over alluvial fans, talus debris, and bedrock along the river corridor (Figs. III-1 and III-2). Deposition was accomplished mainly during seasonal high water floods of the river before the completion of Glen Canyon Dam in 1963. Prior to the dam, flow of the Colorado River through Grand Canyon fluctuated between a mean monthly high of about 58,000 cubic ft per second (cfs) and a mean monthly low of about 5,000 cfs (Table III-1). The lowest flows occurred during the winter months and the highest during the spring runoff from the high mountainous part of the Colorado watershed in May and June. The annual high water level during the spring runoff commonly reached 86,000 cfs. Extreme high flows were estimated at 300,000 cfs in 1884, and measured at 200,000 cfs in 1921.

During the pre-dam years, when the river was monitored by the U.S. Geological Survey for discharge and sediment load (1914-1962), the suspended sediment load of the river was high (average of 0.38 million tons per day). The sediment load was even higher during the seasonal high water flood stages and was adequate to maintain the terrace deposits along the shoreline by periodic deposition, even though specific locations experienced both erosion and deposition from the flood waters through time.

Since the completion of Glen Canyon Dam in 1963, the river regimen has changed dramatically. Discharge rates fluctuate on a daily basis between about 28,000 and 5,000 cfs. The rate is carefully controlled by the Bureau of Reclamation at the dam, and varies in response to hydroelectric power needs. The sediment load has also been dramatically reduced (Table III-1). Most of the sediment load of the Colorado River now settles out in Lake Powell above the dam. Because the water allowed through the dam is essentially free of suspended sediment, the reduced sediment load of the river below the dam must be acquired entirely from the local tributaries when in flood,, and from reworking of existing sediment stored in the river bed, as suggested by Howard and Dolan (1981). The overall sediment load of the river through Grand Canyon now appears to be at least an order of magnitude less than it was before the dam.

In the absence of periodic high-water floods of sediment-enriched water through Grand Canyon, gradual depletion of some existing terraces, and thus of campsite beaches, has occurred in the past 20 years (Dolan and others 1974; Beus and others 1984). Some of the erosion is by the main Colorado during daily fluctuations, and some, at the higher terrace levels, is by flash flooding of tributaries, wind transport, and gravity. Under the present controlled flow of the river, the higher terrace levels never receive new sediment from the river. The lower terrace levels are, in places, eroding more than they are aggrading, even though flooded in part almost daily by the river. There is concern that what the Colorado and other agents now erode from these alluvial terraces may never be put back. Laursen and Silverton (1976) have predicted that the beaches in Grand Canyon will be gone in 200 years.

POST-DAM SPILLS

In the 21 years since the closing of Glen Canyon Dam, the river discharge has exceeded the 28,000 cfs high (level for maximum power generation at the dam) only rarely. In 1955, and again in 1980, unusually high water releases of 55,700 cfs and 49,000 cfs occurred for brief periods of less than one day. The latter was at the time Lake Powell first filled to design level.

In the spring and summer of 1983, unexpectedly high and rapid runoff filled Lake Powell above design level by early June and produced an exceptional "spill" through Grand Canyon. The discharge rate at Glen Canyon Dam reached 96,000 cfs for a few days in late June. During July the rate decreased gradually from about 80,000 cfs to 40,000 cfs with only very minor daily fluctuations. In June and July of 1984, a similar, though lesser, "spill" occurred, during which discharge through the dam reached 56,000 cfs in late June and decreased gradually during July to 25,000 cfs by early August, 1984.

These two "spills" were the first major departure from the normal 1963-1984 discharge levels in 20 years. All the campsite beaches along the river corrider in Grand Canyon were flooded for periods of several days to several weeks and the surficial alluvial terrace deposits were actively reworked.

BEACH PROFILE SURVEYS

In an attempt to monitor and to some degree quantify the rates of change (erosion and deposition) of campsite beaches in Grand Canyon, a series of survey sites were established at 20 selected beaches in 1974-75 by Howard (1975). Semi-permanent bench marks were established at each site and from one to three topographic profiles were measured by tape and transit across the terrace from the campsite area to the shoreface at the river´s edge.The profile traverse lines were oriented approximately perpendicular to the beach and river bank trend. Some of these sites were resurveyed in 1980 (Dolan 1981), and two beaches were resurveyed in 1982 (Beus and others 1982). In the summer of 1983, immediately following the high water "spill," and again in late summer, 1984, following the second high water "spill," the beaches were resurveyed by Northern Arizona University field parties at the request of the National Park Service.

Of the 20 campsite beaches originally surveyed in 1974-75, 15 were resurveyed in 1980-82, 18 were resurveyed in 1983, and 19, plus three new beaches, were resurveyed in 1984 (Table III-2). The combined 1983-1984 surveys provide data on 43 profiles covering 19 of the original 20 beaches, plus three new sites (Figs. III-3 through III-45). The 1983-1984 surveys were all done with a transit, rod, and tape, except in two instances when a hand-held Brunton compass was used as the surveying instrument because the transit station was still underwater.

The availability of survey data both before and immediately after the high water "spills," particularly the 1983 data, provides a means for assessing the effect of the "spills" on the existing campsite beaches. It also permits some quantitative evaluation of the changes in surface elevation of the 20 beaches sampled over a 10-year period, including eight years of normal controlled discharge and two years during which unexpected "flood" events occurred.

RESULTS OF THE BEACH PROFILE SURVEYS

The results of all the survey data covering a 10-year period are summarized in Table III-3, and Figure III-3. It is clear that, during the 10-year period of the surveys, the most dramatic changes occurred immediately after, and presumably as a result of, the 1983 "spill."

Data from 22 vertical profiles on 15 beaches during the eight-year period before 1983 indicate only modest changes. Nine profiles showed a build-up of one to two vertical feet of sand,

and nine profiles showed a loss of up to three vertical feet of sand. Eight profiles on eight beaches showed essentially no change (Fig. III-3). Ten profiles on seven of the original beaches surveyed were not adequately monitored. On balance there was slightly more loss than gain, suggesting a gradual depletion of beach sand from the terraces studied.

Following the 1983 high water "spill," 19 profiles on 12 beaches showed an increase of at lease one vertical foot, and up to 13 vertical feet of sand added by deposition on the terraces. This includes a newly-measured beach campsite at Forster, mile L122.8, where the pre-1983 level is marked by a buried vegetation-covered surface exposed at the edge of the beach. Nine profiles on eight beaches showed a loss of from one to five vertical feet of sand. Ten profiles on seven beaches could not be adequately measured because they were still under high water in August, 1983.Three beach sites that were under water during the 1983 surveys--R109-mile, L124 1/2-mile, and the Ledges (mile R151)--were almost entirely depleted of sand by erosion during the 1983 high water, although this was not adequately documented until 1984, when they were no longer submerged. Even with incomplete data, it is clear that the beaches monitored gained more than they lost during the 1983 high water (Fig.III-3).

The 1984 survey data provides 39 profiles on 22 beaches. This includes three beaches--Awabuti (R59.8), Nevills (L75), and Forster (L122.8)--that were not in the original surveys, but, excepting Nevills, had received considerable new sand deposition during the 1983 high water. Two beaches from the original survey--L19-Mile and Suspension Bridge (L87.1)--were not measured. The former appeared on visual observation to have no significant change from 1983.

The 1984 results do show that some of the beach sands newly deposited in 1983 were substantually eroded in a one-year period (Fig. III-3). Among these are Little Colorado (R61.8), parts of Upper Unkar (R72.2), Upper Granite (L93.2), Lower Lava (R180.9), and Granite Park (L208.8). Most of the beach at Unkar (R72.2) and part of Nautiloid (L34.7) were removed by local flash floods in tributaries from a heavy storm in late August, 1983. The other three appear to be losing sand to the normal river flow and a combination of other local factors, such as the lack of vegetation to help anchor the sand and slumping of steep cutbacks left by erosion during the 1983 high water.

SUMMARY OF TEN YEAR PROFILE DATA

The lowermost bar graph in Figure III-3 shows the net vertical changes in beach profiles during the ten-year period from 1974-1984. Five of the original 20 beach sites monitored are essentially depleted of sand--Unkar (R72.2), R109-Mile, Waltenberg (R112), L124 1/2-Mile, and Ledges (R151). These sites are no longer adequate or even available for camping where originally surveyed, although some camping is done just downstream from Unkar and on the higher sand-covered terrace levels at Ledges. In all, 15 profiles, at 14 beaches, show substantial (more than 1 vertical foot) net loss of sand over the 10-year period. On the positive side, 15 profiles on 12 beaches show a substantial net gain (more than 1 vertical foot) of sand during the same period. Moreover, some new beaches exist where before the 1983 high water there was either no beach or very limited beach sand adequate for camping. Two of these, Awatubi (R59.8) and Forster (L122.8) are included in the 1983 and/or 1984 surveys.

Brian and Thomas (1983) did an extensive beach campsite inventory of the entire Marble Canyon and Grand Canyon segment of the river corridor and recognized 50 new sand deposit sites adequate for camping that had been added by the 1983 high water. They also recognized 86 pre-existing beaches that had been increased in size by the 1983 high water deposition or vegetation removal. Conversely, they reported a loss of 24 campsites, out of 227 sites being monitored, by erosion of sand during the 1983 high water.

DISCUSSION OF RESULTS

All of the selected campsite beaches monitored in this study have experienced some changes in vertical beach profiles in the past 10 years. During the period 1974-1982, at least half of the 20 beaches had some deterioration owing to erosion by the river and other dynamic erosive processes. Normal controlled flow of the river through Grand Canyon, as now carefully regulated at Glen Canyon Dam, precludes high water and heavy sediment-loaded floods that might periodically restore beach sand lost by erosion. The unexpected high water discharge through the dam in summer, 1983, actively reworked sediment on all the beaches being monitored. More measurable changes occurred in the beach profiles as a result of the 1983 high water than in the preceding eight years. Because there was substantially more gain than loss of beach sand during the 1983 high water, it appears that the unexpected "spill" had a positive effect on beach maintenance, much as the peak floods of pre-dam days must have done before 1963.

The net sand gain added to the beaches by the 1983 high water must have come from sediment already along the river bed. Preliminary assessment of the sediment stored in the river bed through eastern Grand Canyon by Howard and Dolan (1981, p.293-294) indicates that there has been local post-dam aggradation. The river apparently has more sediment stored now at some sites along its channel than before the dam. The source of the sediment must be primarily input from tributaries entering the Colorado Rivcer below Glan Canyon Dam. If, as seems likely, the periodic flooding of tribuitaries continues to provide sediment to the main stem of the Colorado, a limited but perhaps adequate sediment supply for future maintenance of the beaches in Grand Canyon may be assured. Perhaps occasional high water "spills" through Glen Canyon Dam will be beneficial and necessary to effectively maintain sufficient sand on the campsite beaches.

Loss of some beach sands newly deposited by the 1983 high water seems to have been locally accelerated by a lesser but substantial high water "spill" in summer, 1984, and local intensive flash floods of some tributaries. It may be that the new beach deposits are so unstable as to be only very temporary additions to the terrace deposits along the river. However, the net changes recorded in the beach profiles over the past ten years show that, on balance, there was slightly more gain than loss of sand on the 20 beaches being monitored.

RECOMMENDATIONS

Additional beach profile monitoring of the original 20 beaches, plus some of the newly-formed beaches and others added to this study in recent years, may be expected to provide more definitive data on the questions of long-term beach stability and maintenance. Plane-table mapping and soil auger measurements of beach sand surfaces and beach sand thicknesses may also provide more quantified data regarding future changes in critical beach campsites. There is also the need for more adequate data on long-term sediment transport and storage along the Colorado below Glen Canyon Dam. An intensive study currently underway by the U.S. Geological Survey (personal communication 1983), though interrupted by the 1983 and 1984 "spills," is expected to provide this data in the near future.

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Table II-1. Discharge rate and sediment load for the Colorado River in Grand Canyon.

	1921-1963 Pre-Dam	1963-1982 Post-Dam	1983
Measurements at Lees Ferry 14 miles below Glen Canyon Dam			
Mean discharge (cfs)	16,610	12,200	12,450
Mean monthly high (cfs)	58,000	28,000	
Mean monthly low (cfs)	5,000		
Mean annual flood (cfs)	86,000	27,000	96,000
Maximum flood (cfs	220,000	60,200	96,000
Measurements near Phantom Ranch about 102 miles below Glen Canyon Dam			
Sediment load (ppm)	1,250	350	

Table III-2. Beach profiles surveyed.

River Mile	Beach Name	Number of Profiles Measured 1974	1975	1980	1982	1983	1984
L18.2	Upper 18 Mile Wash		2			2	2
L19.3	19 Mile Wash		2	1		2	
L34.7	Nautiloid Canyon	2	2			2	2
R53.0	Lower Nankoweap	3	3	1		1	3
R59.8	Awatubi (New 1984)						1
R61.8	Mouth of Little Colorado	1		1		1	1
L65.5	Tanner Mine	2		2		2	2
R72.2	Unkar Indian Village	1	1	3		2	1
L75	Nevills Rapid (New 1984)						2
L81.1	Grapevine	2		2		2	1
L87.1	Lower Suspension Bridge		2	1			
L93.2	Upper Granite Rapid	2		1		2	2
R109.4	109 Mile	2				1	2
R112.2	Waltenberg Canyon	1		1		1	1
R120.1	Blacktail Canyon	2		2	1	2	2
L122.8	Forster Canyon (new 1983)					3	3
L124.4	Upper 124 1/2 Canyon	2				1	1
R131	Bedrock Rapid	2		2		2	2
R151	The Ledges	2	2			1	2
L166	National Canyon		2	1		1	2
L180.9	Lower Lava Falls	2		2		2	2
L190.2	190 Mile		1	1			1
L208.8	Granite Park	2	2	2	1	2	2

1974, 1975 data from Howard (1975)
1980 data from Dolan (1981)
1982 data from Beus and others (1982)
1983 data from Beus and others (1984)
1984 data from this report

Table III-3. Beach profile data from Grand Canyon campsite areas.
Numbers indicate gain (+) or loss (-) in vertical feet.
__ Indicates no survey.
? Indicates measurements uncertain.

River Mile	Beach	Cross Sect.	1974/75 to 1982 Inner	1974/75 to 1982 Outer	1980/82 to 1983 Inner	1980/82 to 1983 Outer	1983 to 1984 Inner	1983 to 1984 Outer	NET 10 yrs. Inner	NET 10 yrs. Outer	Remarks
L18.2	18 mile	1	__	__	-2	-3	-4	-1	-6	-4	1983-84 loss by local flash floods
L18.2	18 mile	2	__	__	+5	+11	+2	+1	+7	+12	Major gain '83, minor gain '84
L19.3	19-mile	1	__	__	+2	0	__	__	+2	0	Appears similar to 1983
L19.3	19-mile	2	+1	0	+2	-2	__	__	0	-2	
L34.7	Nautiloid	1	__	__	+2	+4	-2,+3	0	0,+5	+4	Channel cut by flash flood '83
L34.7	Nautiloid	2	0	0	+3	+3	-1	+1	+2	+4	
R53	Nankoweap	1	-1	-2	__	__	?	?	+1	+1	
R53	Nankoweap	2	0	0	0	?	+1	+3	+1	+3	Minor change
R53	Nankoweap	3	__	__	__	__	__	__	-1	+3	
R61.8	LCR	1	+1	+1	+1	+3	+1,-1	+4	+3	0	1983 gain lost in 1984, outer Beach
R59.	Awatubi	1	__	__	__	__	+	+	+	+	New beach, new survey
L65.5	Tanner Mine	1	0	-3	+2	+5	-1	+	0	+3	1/2 1983 gain lost in 1984
L65	Tanner Mine	2	+1	-2	-2	0	-1	0	-2	-2	
B72.2	Unkar	1	-1	0	+5	0	-2	-6	+2	-6	Loss by flash flood

(continued)

Table III-3 continued.

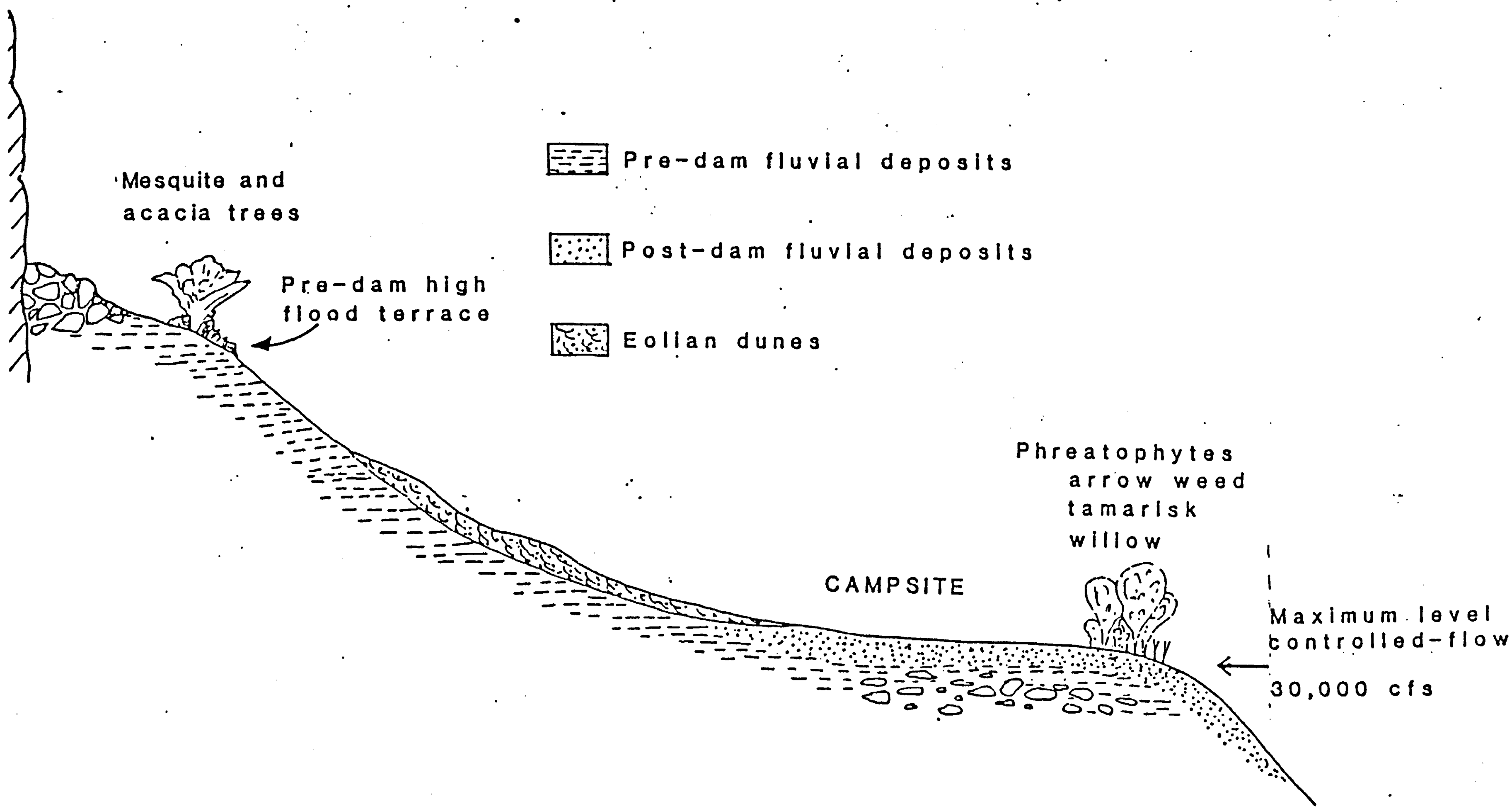
River Mile	Beach	Cross Sect.	1974/75 to 1982 Inner	1974/75 to 1982 Outer	1980/82 to 1983 Inner	1980/82 to 1983 Outer	1983 to 1984 Inner	1983 to 1984 Outer	NET 10 yrs. Inner	NET 10 yrs. Outer	Remarks
R72.2	Unkar	2	0	0	-1	+1	Removed by flood		—	—	Loss by flash flood each gone
L75	Nevills Rapids	1,2	—	—	—	—	—	—	—	—	New survey
L81.1	Grapevine	1	-2	+2	+4	+2	0	0	+2	+4	
L81.1	Grapevine	2	0	0	+5	+5	-2	0	+3	+5	
L93.2	Upper Granite	1	—	—	+4	-4	-1/2	-4	+3½	-8	Beach nearly gone
L93.2	Upper Granite	2	0	+1	+3	-5	-1	-7	+2	-11	Beach nearly gone
R109.4	109-mile	1	—	—	Under Water		?	?	-2	-1/2	Beach sand gone - only rocks left
R109.4	109-mile	2	—	—	?	?	?	?	-3	-?	" " " "
R112.2	Walthenberg	1	—	—	-1	?	-2	?	-3	?	" " " "
R120.1	Blacktail	1	+1/2	0	+2	+3	-1/2	0	+2	-3	Beach front cut back 8'
R120.1	Blacktail	2	0	0	+6	?	0	?	+6	+3	6' added is still there
L122.8	Forster	1	—	—	—	—	0	0	—	—	No change - more Tamarisk growth
L122.8	Forster	2	—	—	—	—	0	+2	—	—	Filled in gully - otherwise no change
L122.8	Forster	3	—	—	—	—	0	+2½	—	—	Outer beach built up more
L124.3	124½-mile	1	—	—	Under Water		?	?	-1	-3	Beach nearly gone, too narrow for use
L124.3	124½-mile	2	Measurements Uncertain				—	—	?	?	
R131	Bedrock	1	0	+1/2	+1	0	0	-1/2	+1	0	Very minor change

(continued)

Table III-3 continued.

River Mile	Beach	Cross Sect.	1974/75 to 1982 Inner	1974/75 to 1982 Outer	1980/82 to 1983 Inner	1980/82 to 1983 Outer	1983 to 1984 Inner	1983 to 1984 Outer	NET 10 yrs. Inner	NET 10 yrs. Outer	Remarks
R131	Bedrock	2	0	0	+1	-1	0	0	+1	-1	Very minor change
R151.6	The Ledges	1	—	—	?	?	?	?	-3	-8+	Sand all gone
R151.6	The Ledges	2	—	—	—	—	—	—	0	-2½	Sand all gone
L165.5	National	1	0	?			0	—	-2½	?	
L165.5	National	2	+1	0	-1	?	0	—	0	-3	Much of outer beach gone
R180.9	Lower Lava	1	0	0	+1	0	-1	0	0	0	Not much change - gullying by local flood
R180.9	Lower Lava	2	-1	+1	+7	?	-2	-2	+5	-1	1/3 of 1983 gain lost in 1984
L190.2	190-mile	1	0	-1	—	—	—	—	-2,+1	-1	Part of outer beach face gone
L208.8	Granite Park	1	0	0	+3	+2	0	-3	+3	-1	Some of outer beach removed 1983-1984
L208.8	Granite Park	2	0	3	+5	+7	0	-2	+5	+2	" " " " "

Figure III-1. Cross-section of a typical beach.



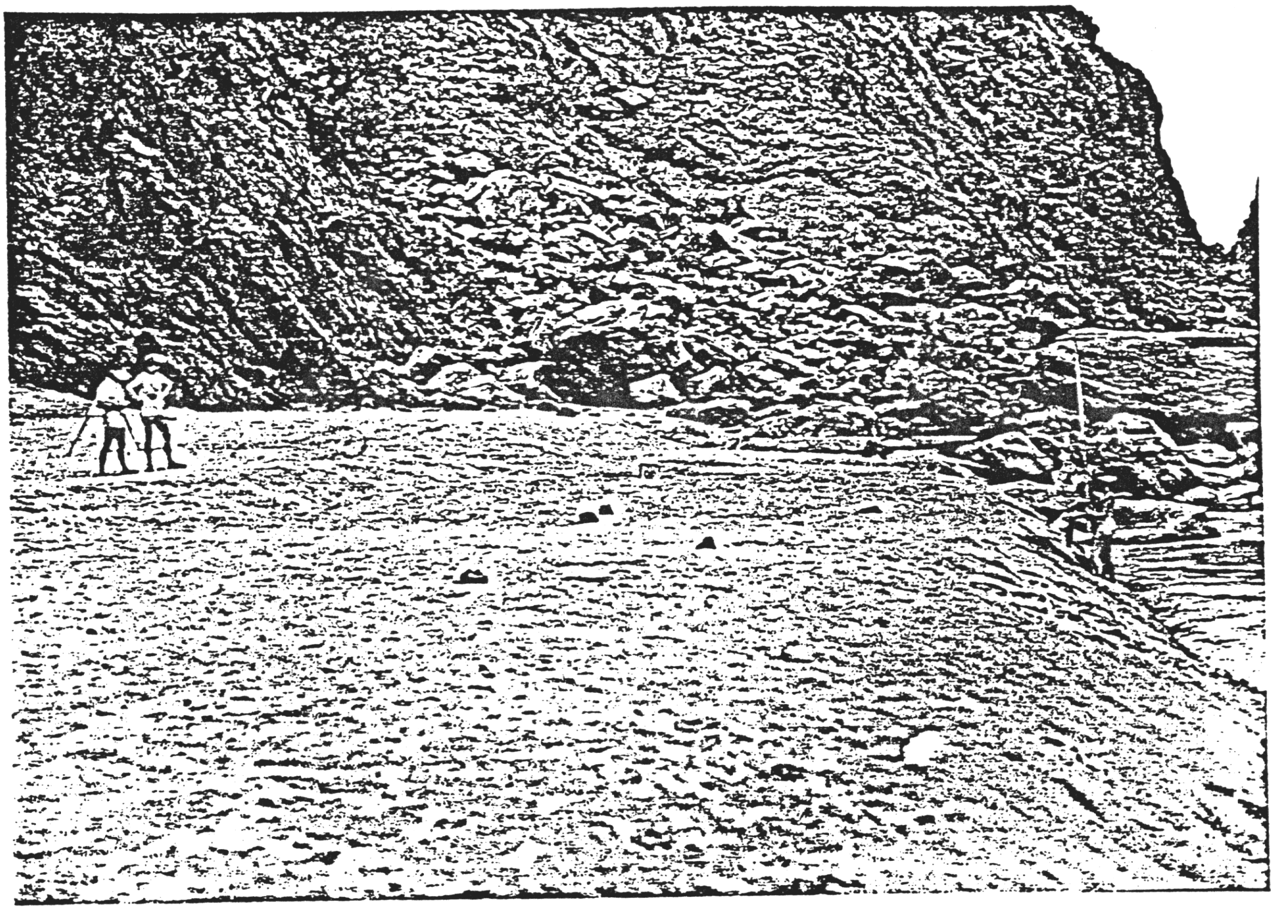


Figure 2. Campsite beach at Grapevine, L81.1, at cross-section 1.

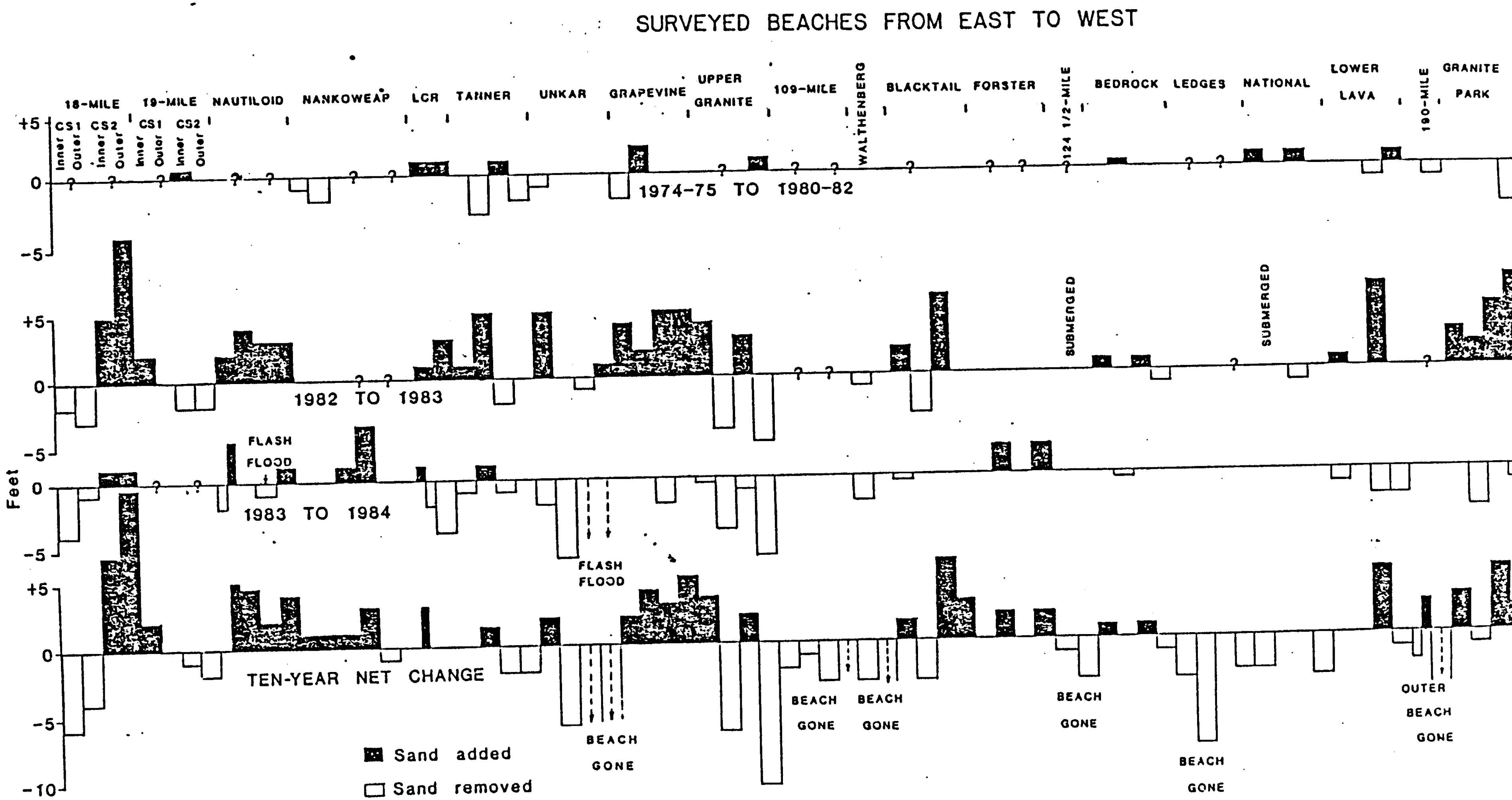


Figure III-3. Graphic summary of vertical changes in beach profiles over a ten-year period (1974-1984). For each campsite one to three profiles were measured (CS numbers). Two bars for each profile (CS) represent data from the inner (shoreward) and outer (riverward) half of the profile as indicated at the first two campsites listed. Half-width bars indicate data from approximately 1/4 of the profile. ? indicates no measurement at the site that year.

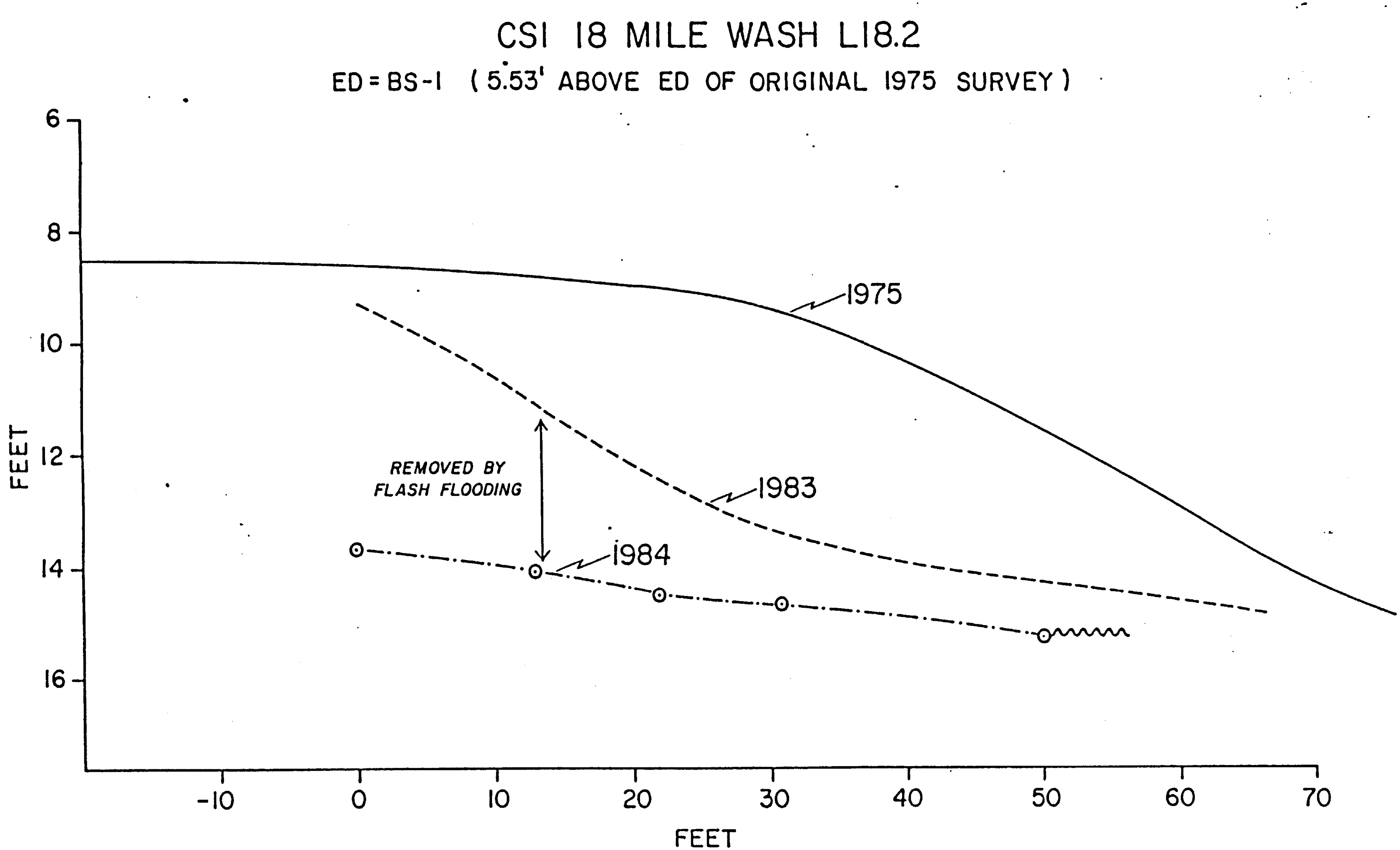

CSI 18 MILE WASH L18.2
ED = BS-1 (5.53' ABOVE ED OF ORIGINAL 1975 SURVEY)
1975
1983
1984
REMOVED BY FLASH FLOODING
FEET
FEET
6
8
10
12
14
16
-10
0
10
20
30
40
50
60
70

Figure III-4.

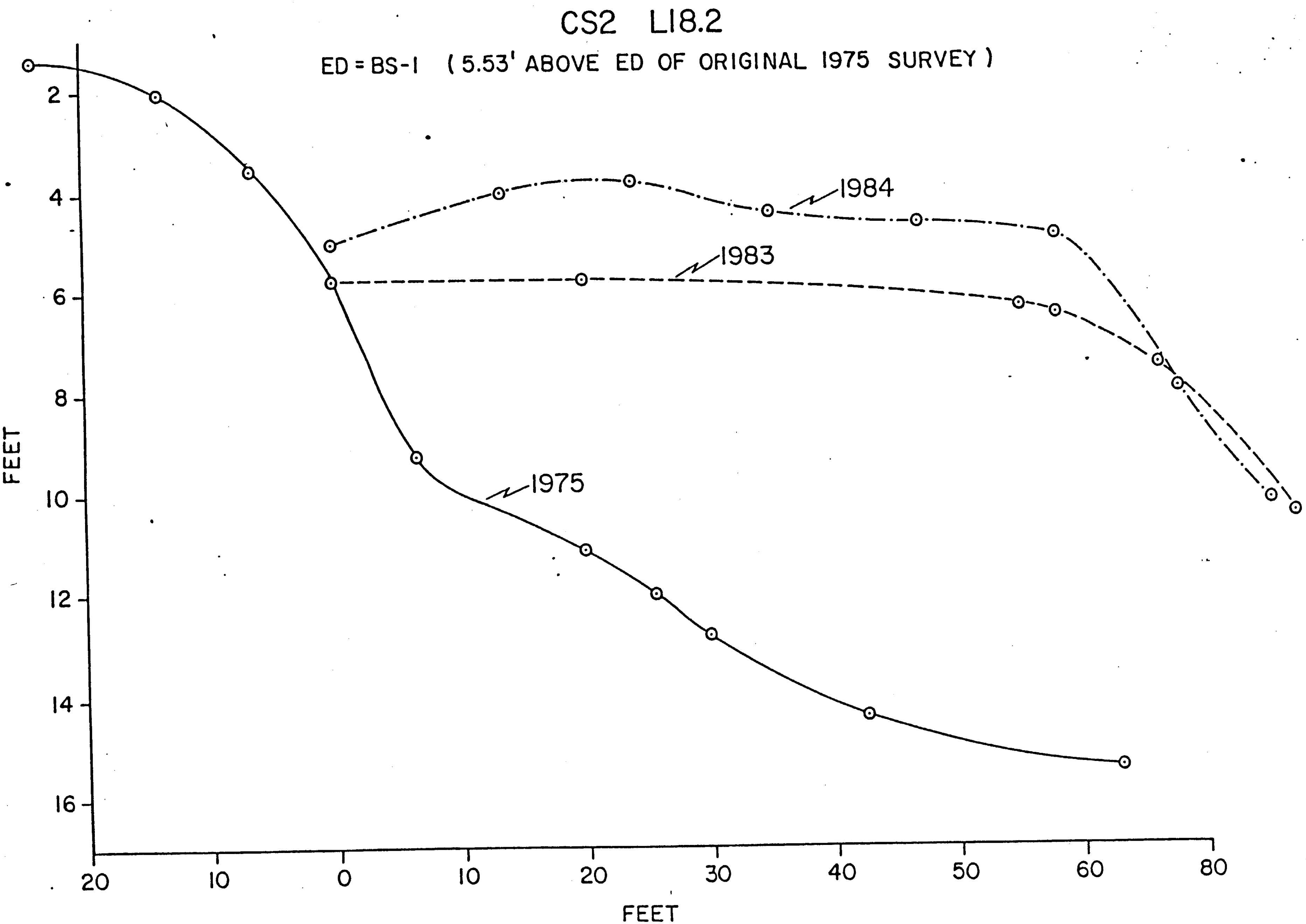

CS2 L18.2
ED = BS-1 (5.53' ABOVE ED OF ORIGINAL 1975 SURVEY)
1984
1983
1975
FEET
2
4
6
8
10
12
14
16
20
10
0
10
20
30
40
50
60
80
FEET

Figure III-5.

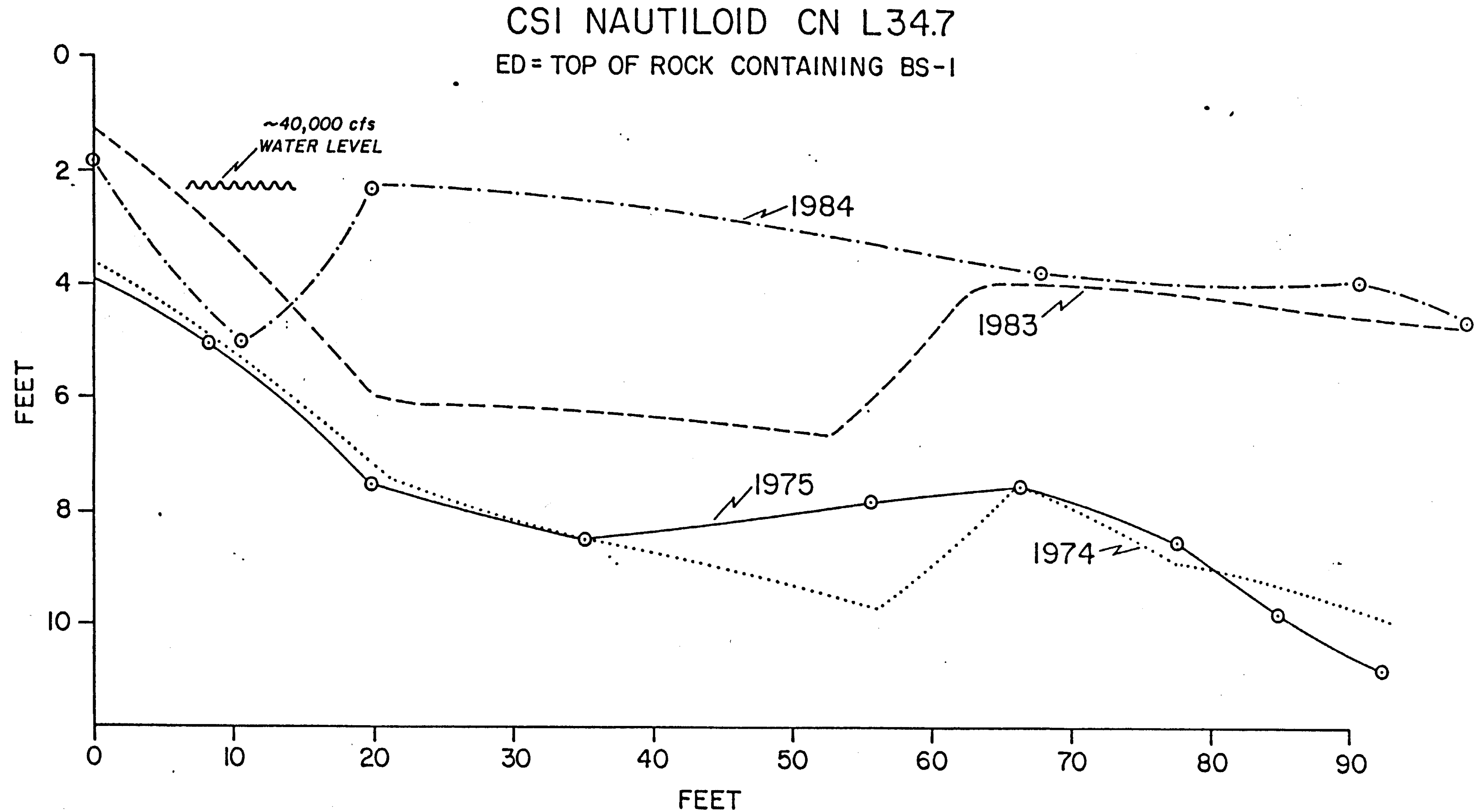

CSI NAUTILOID CN L34.7
ED = TOP OF ROCK CONTAINING BS-1
~40,000 cfs
WATER LEVEL
1984
1983
1975
1974
FEET
0
2
4
6
8
10
0
10
20
30
40
50
60
70
80
90
FEET

Figure III-6.

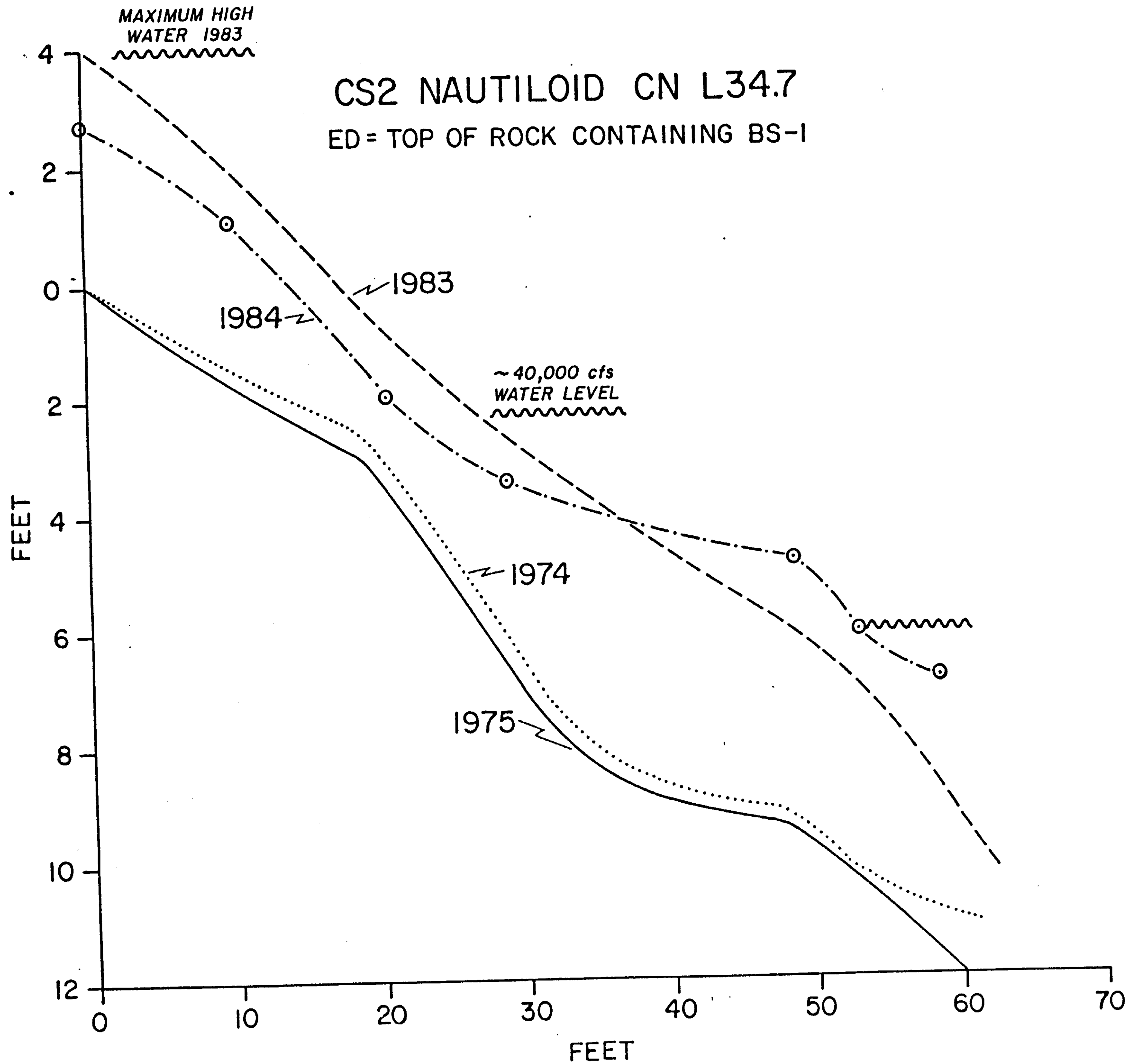

MAXIMUM HIGH
WATER 1983
CS2 NAUTILOID CN L34.7
ED = TOP OF ROCK CONTAINING BS-1
1983
1984
~40,000 cfs
WATER LEVEL
1974
1975
FEET
4
2
0
2
4
6
8
10
12
0
10
20
30
40
50
60
70
FEET

Figure III-7.

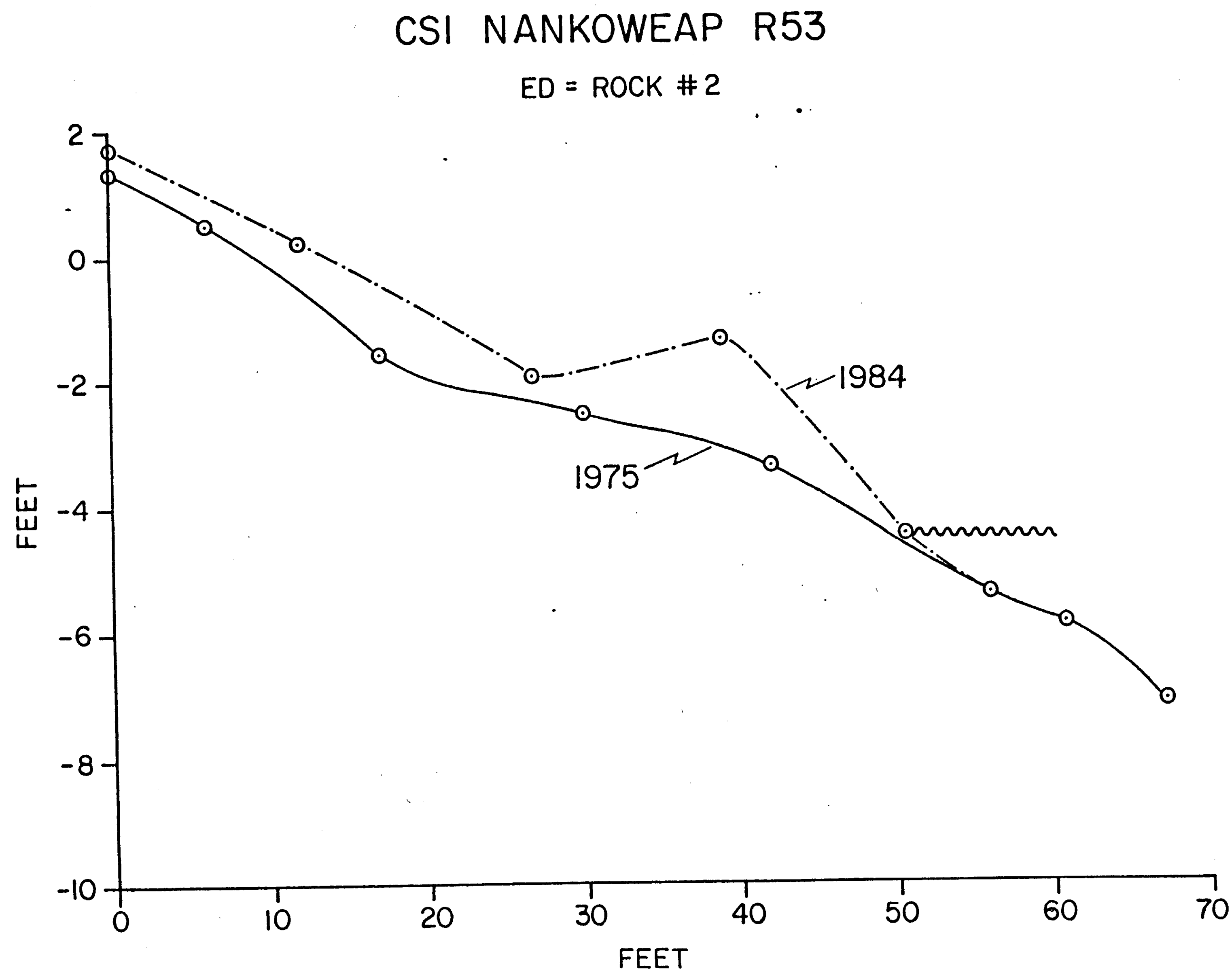

CSI NANKOWEAP R53
ED = ROCK #2
2
0
-2
-4
-6
-8
-10
FEET
0
10
20
30
40
50
60
70
FEET
1984
1975

Figure III-8.

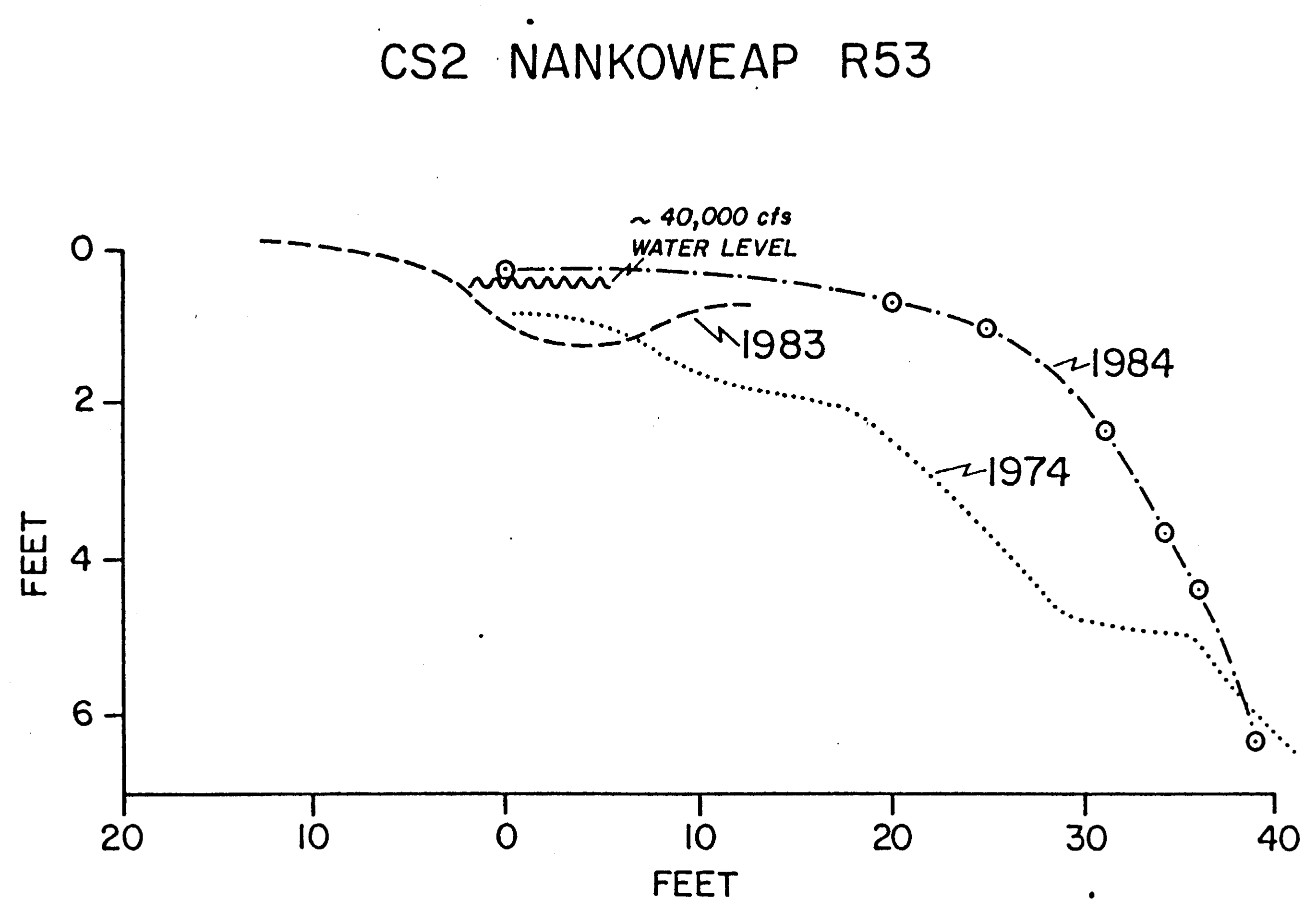

CS2 NANKOWEAP R53
~ 40,000 cfs
WATER LEVEL
1983
1984
1974
0
2
4
6
FEET
20
10
0
10
20
30
40
FEET

Figure III-9.

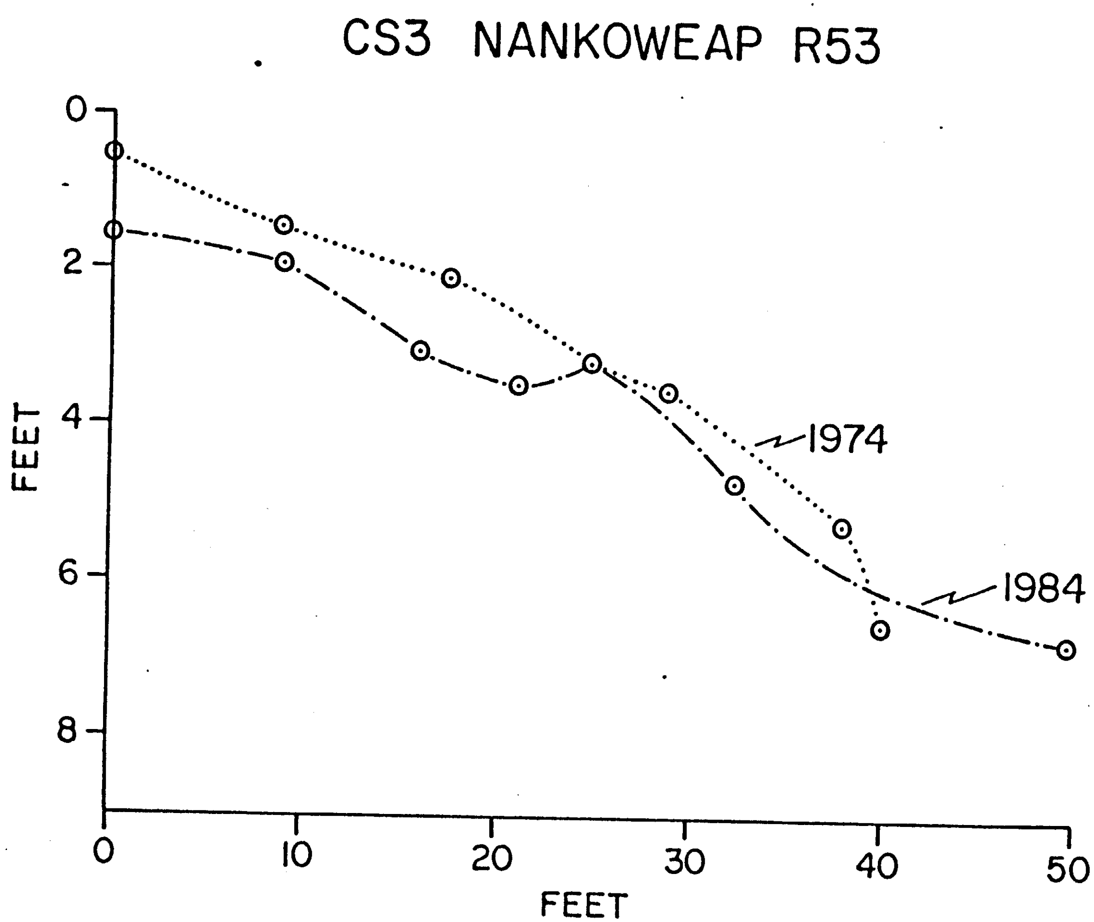


Figure III-10.

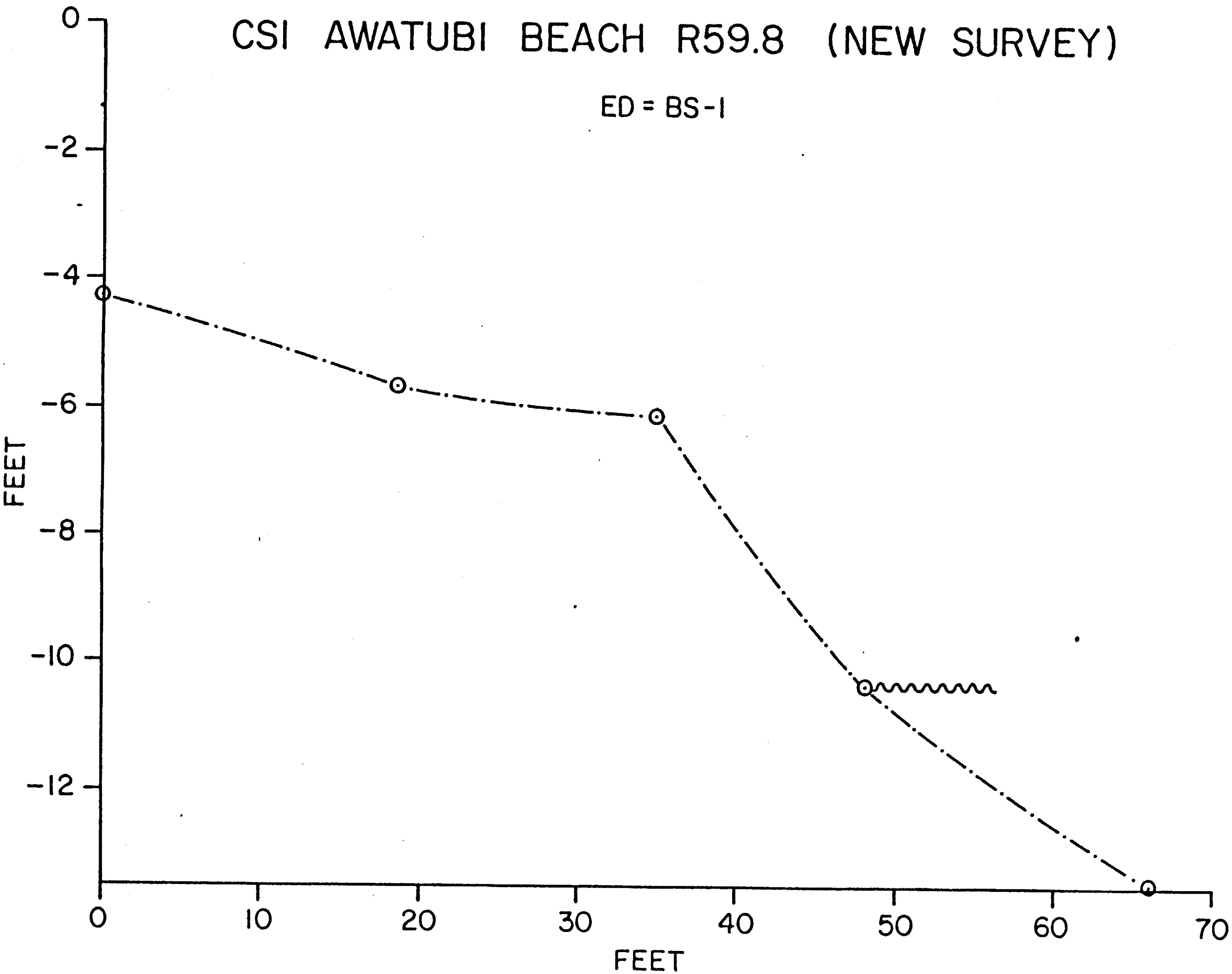


Figure III-11.

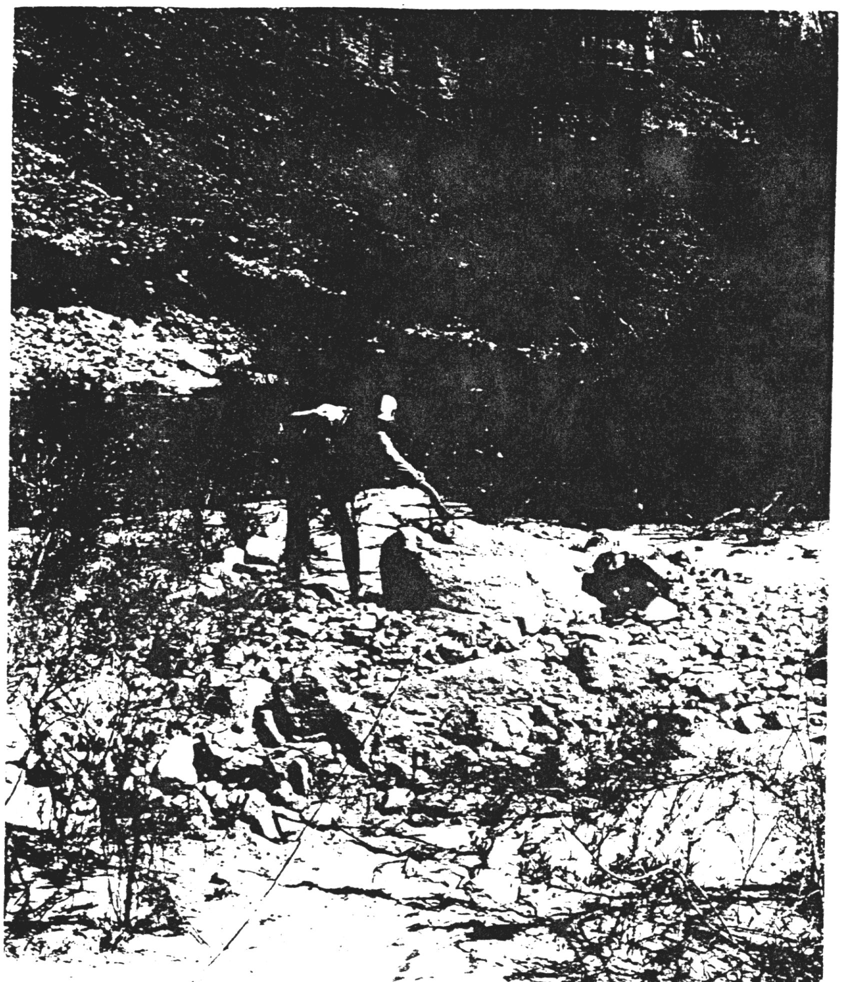
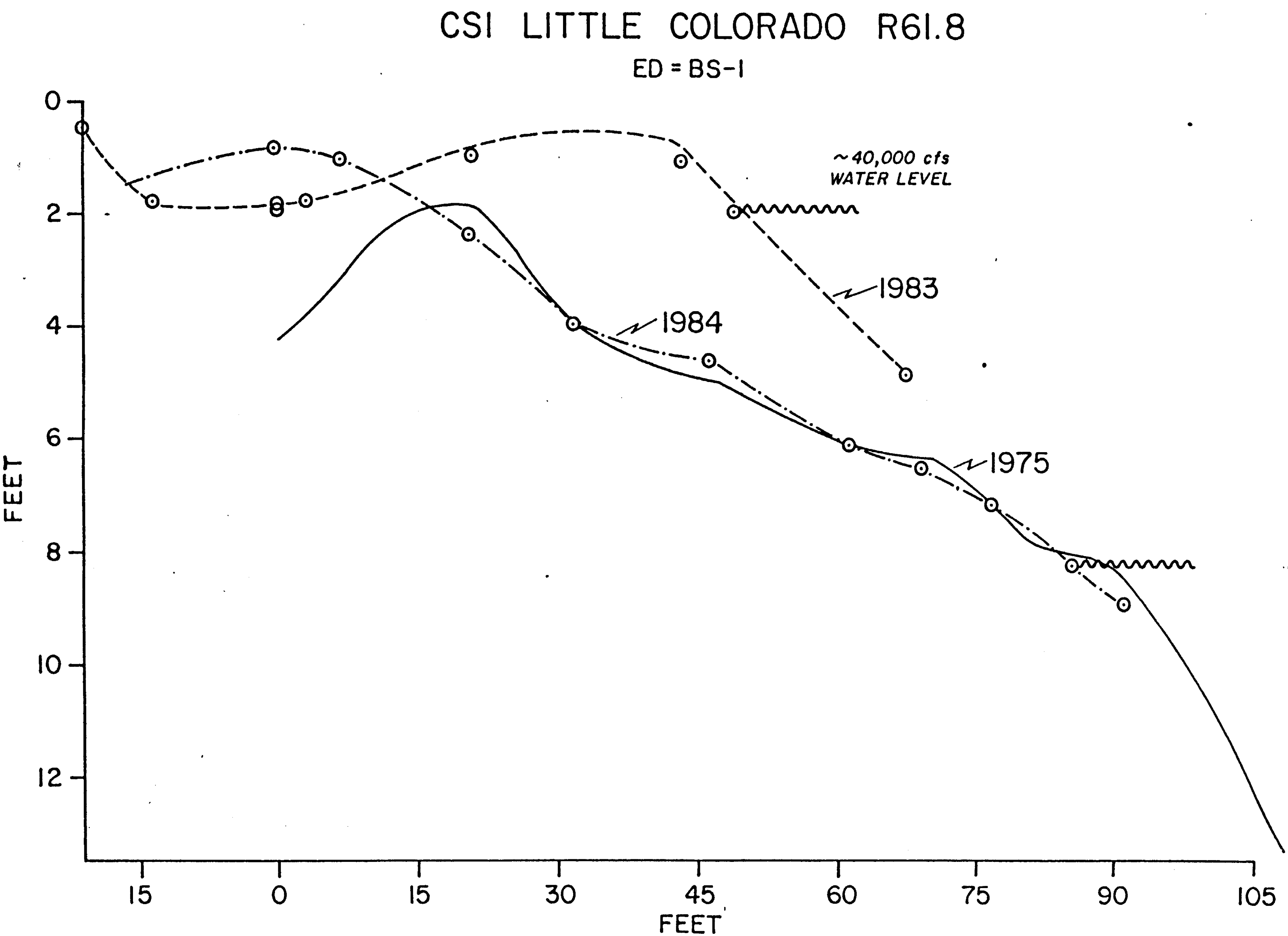


Figure III-14. Base station 1 at Awatubi Beach, R59.8

Figure III-15. Base station 2 at Awatubi Beach, R59.8



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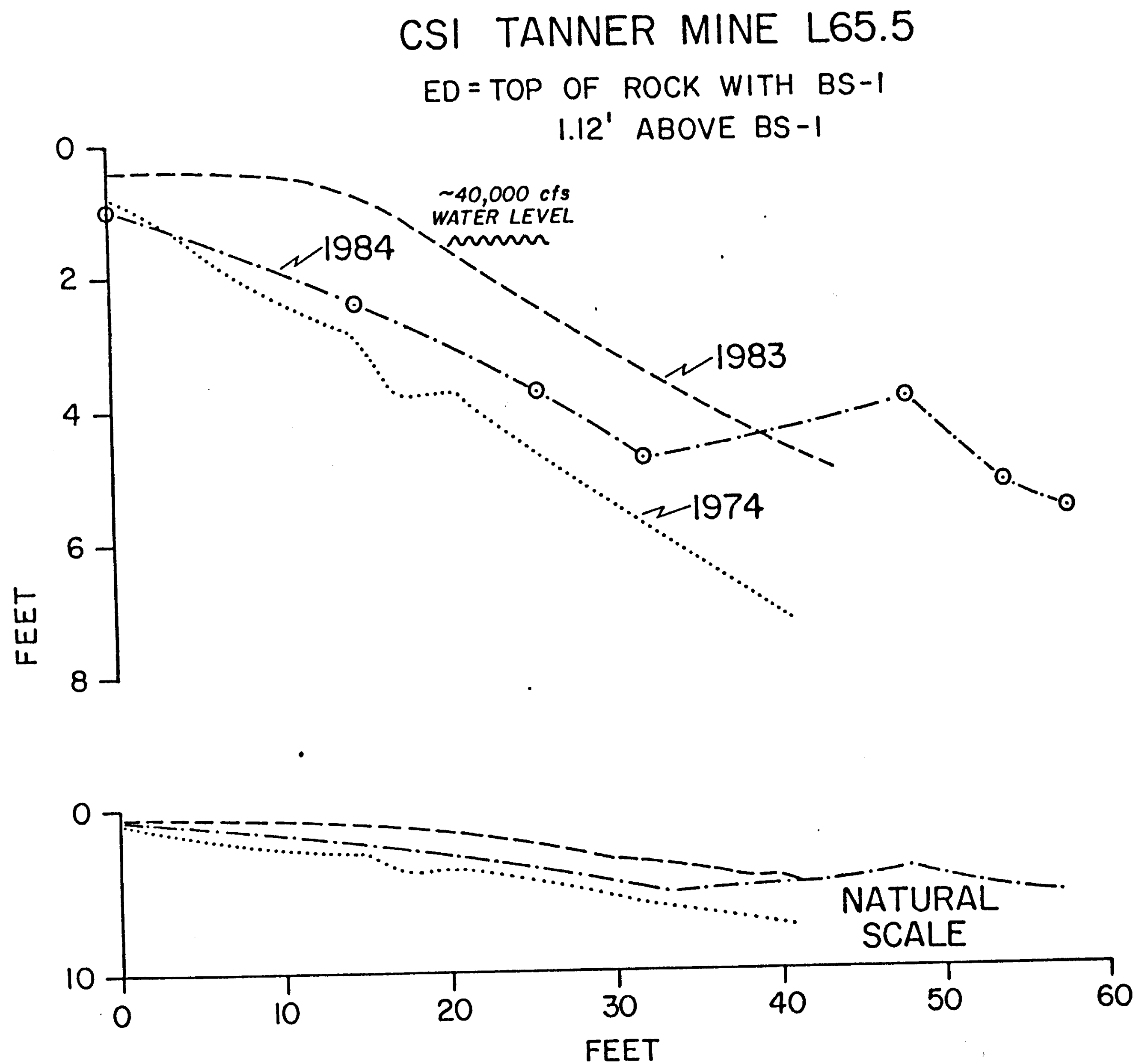

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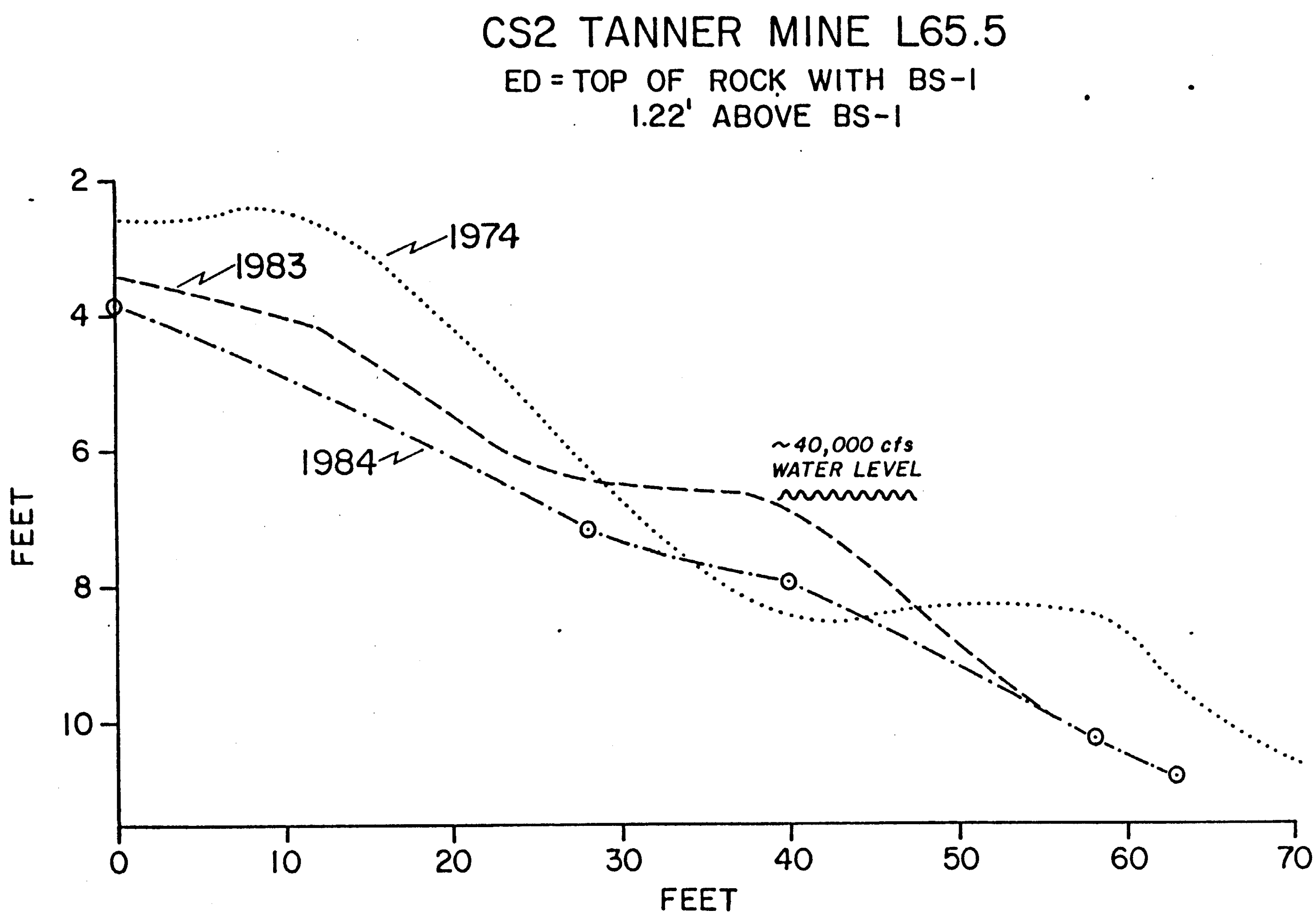

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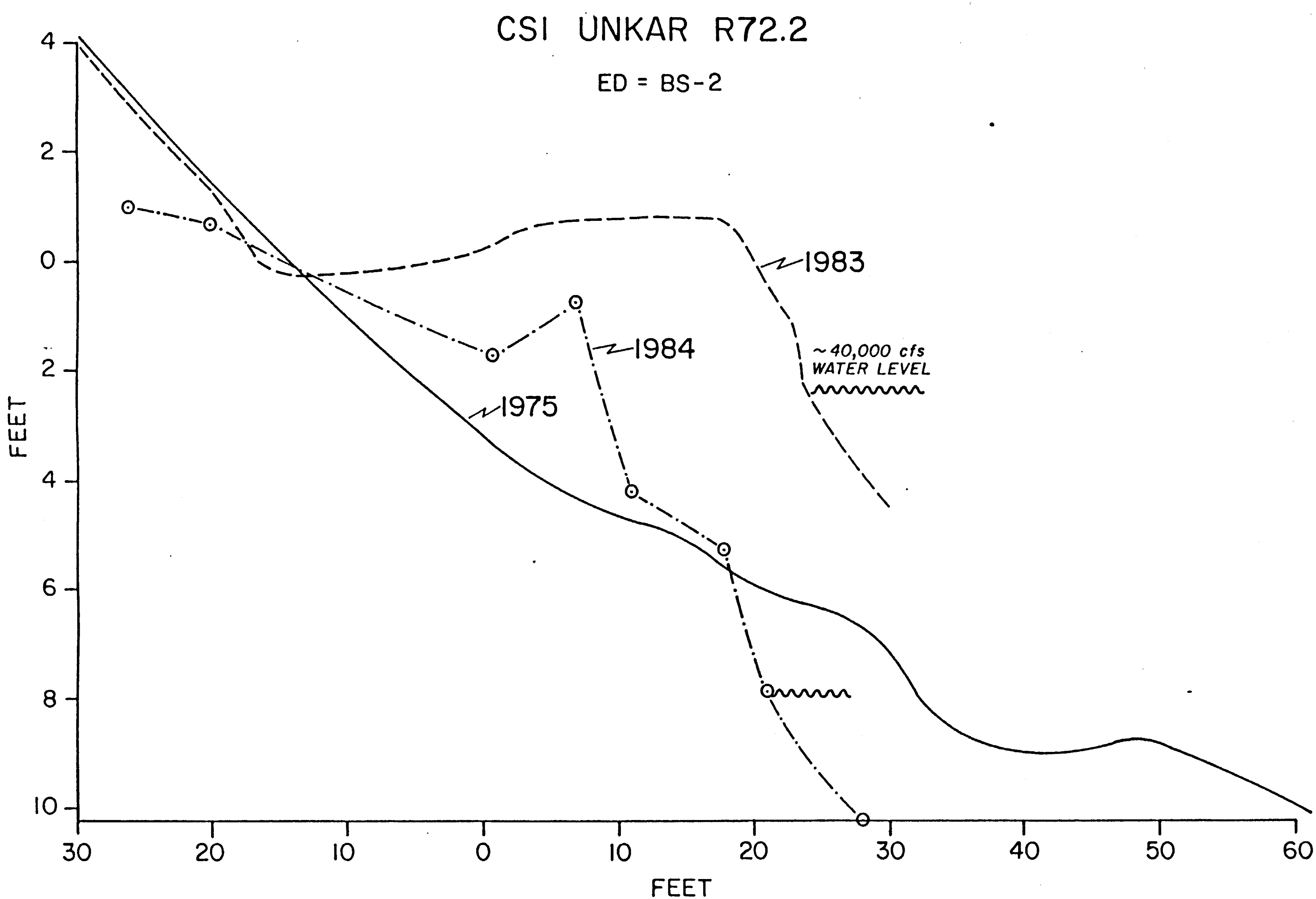


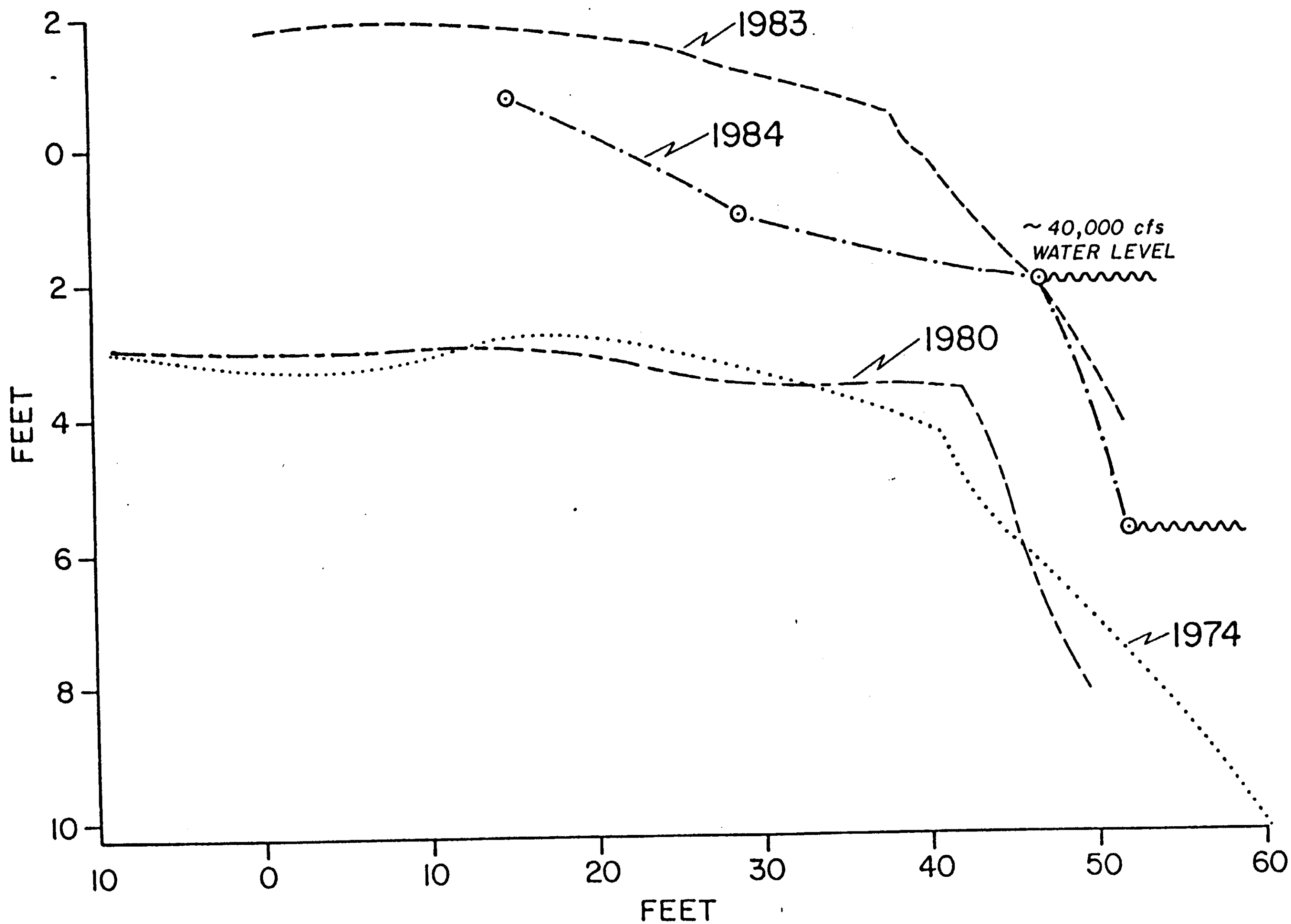
Figure III-18.

Figure III-20. Base station 1 at Nevills Rapid, L75.

Figure III-21. Base station 2 at Nevills Rapid, L75.

CS2 GRAPEVINE L81.1

ED = BS-2



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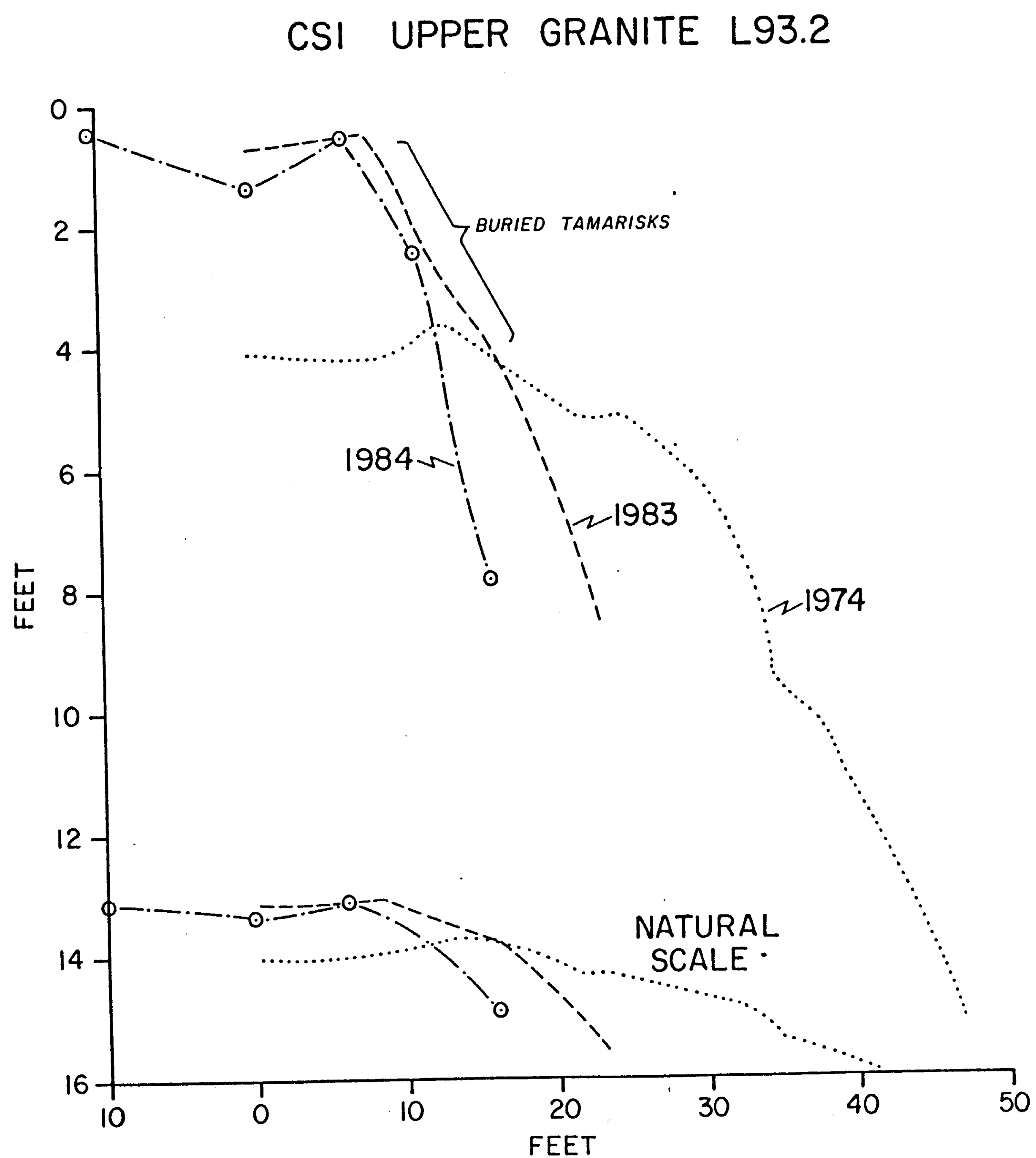

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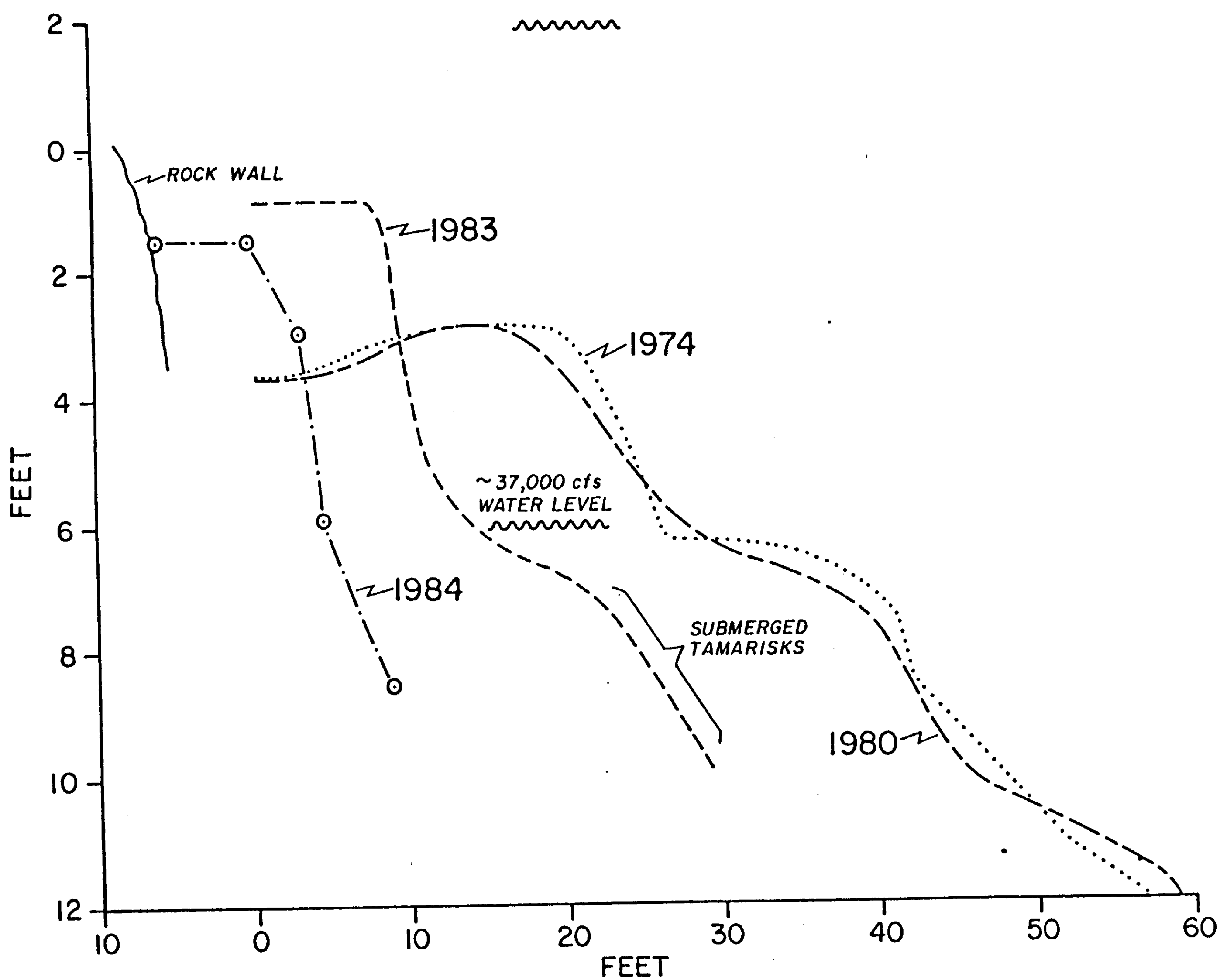
CS2 UPPER GRANITE L93.2



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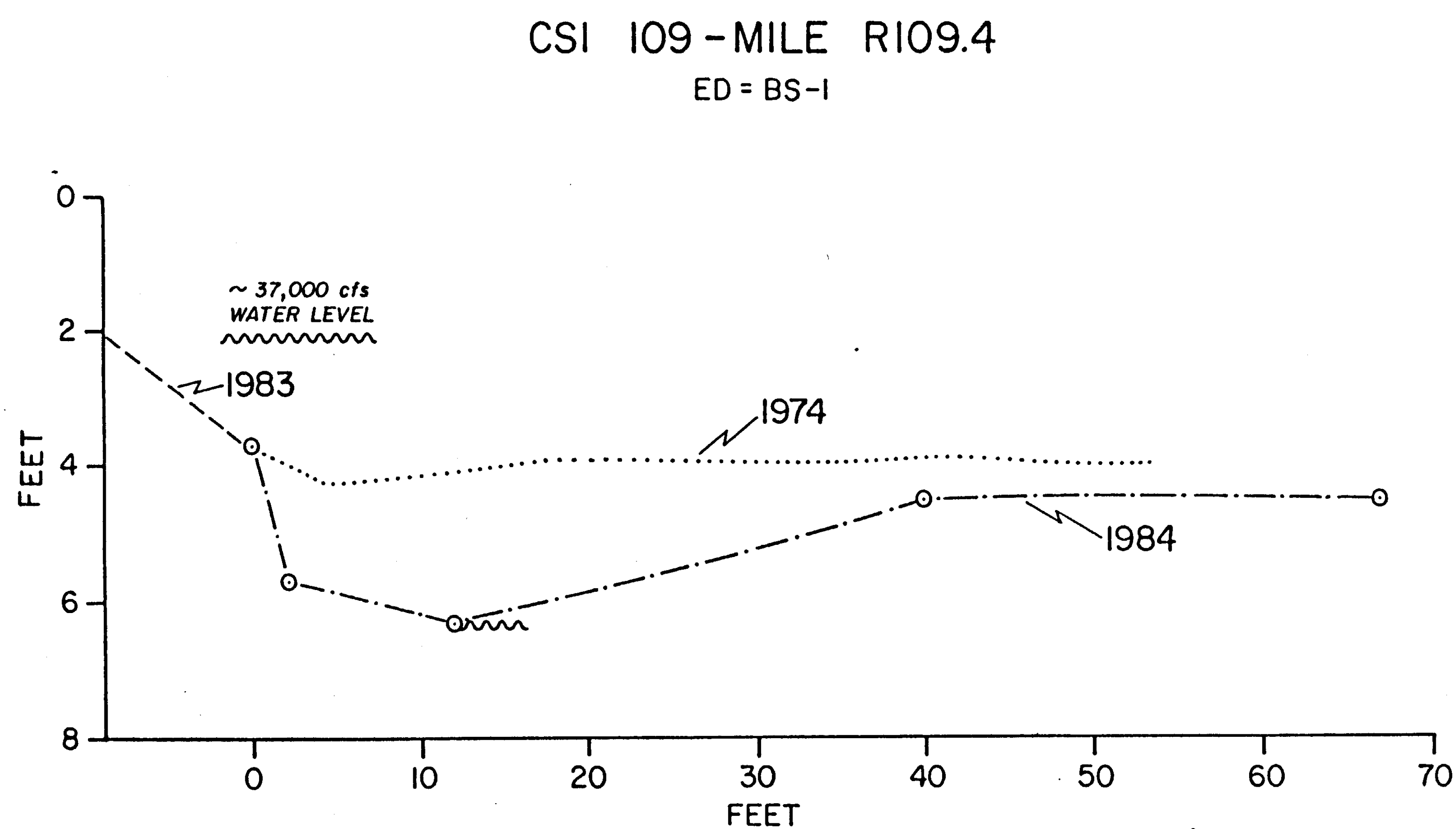

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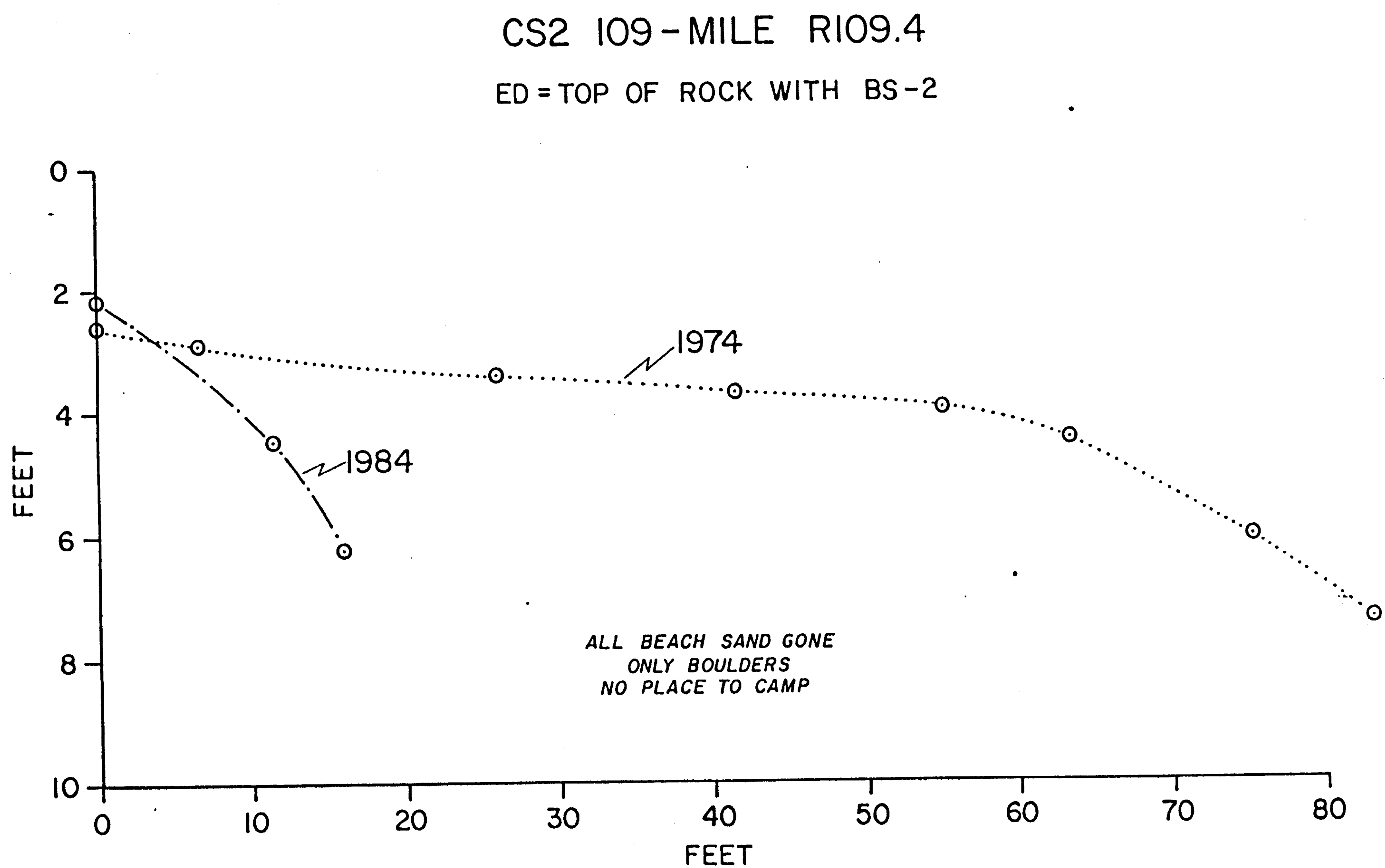

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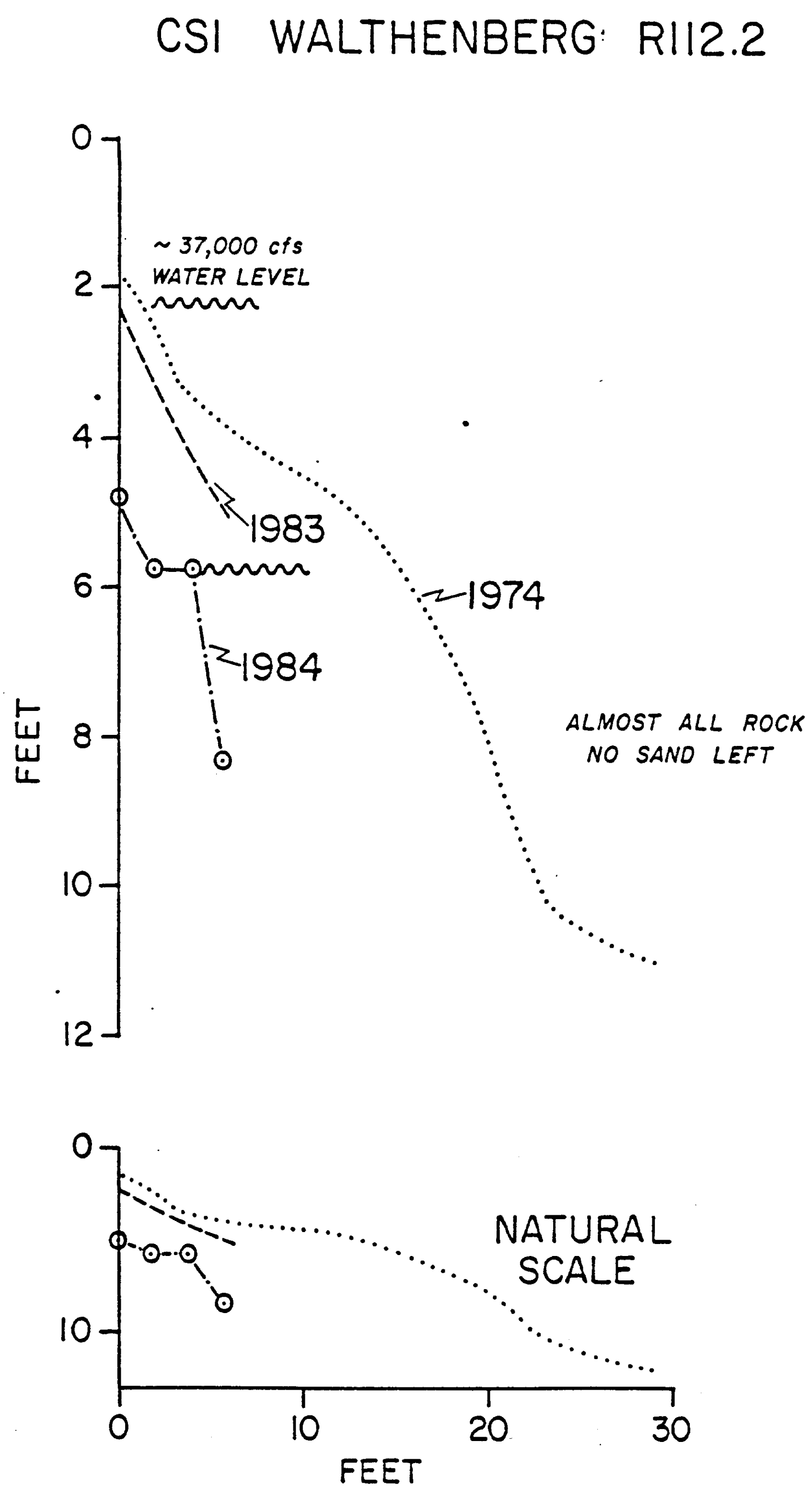
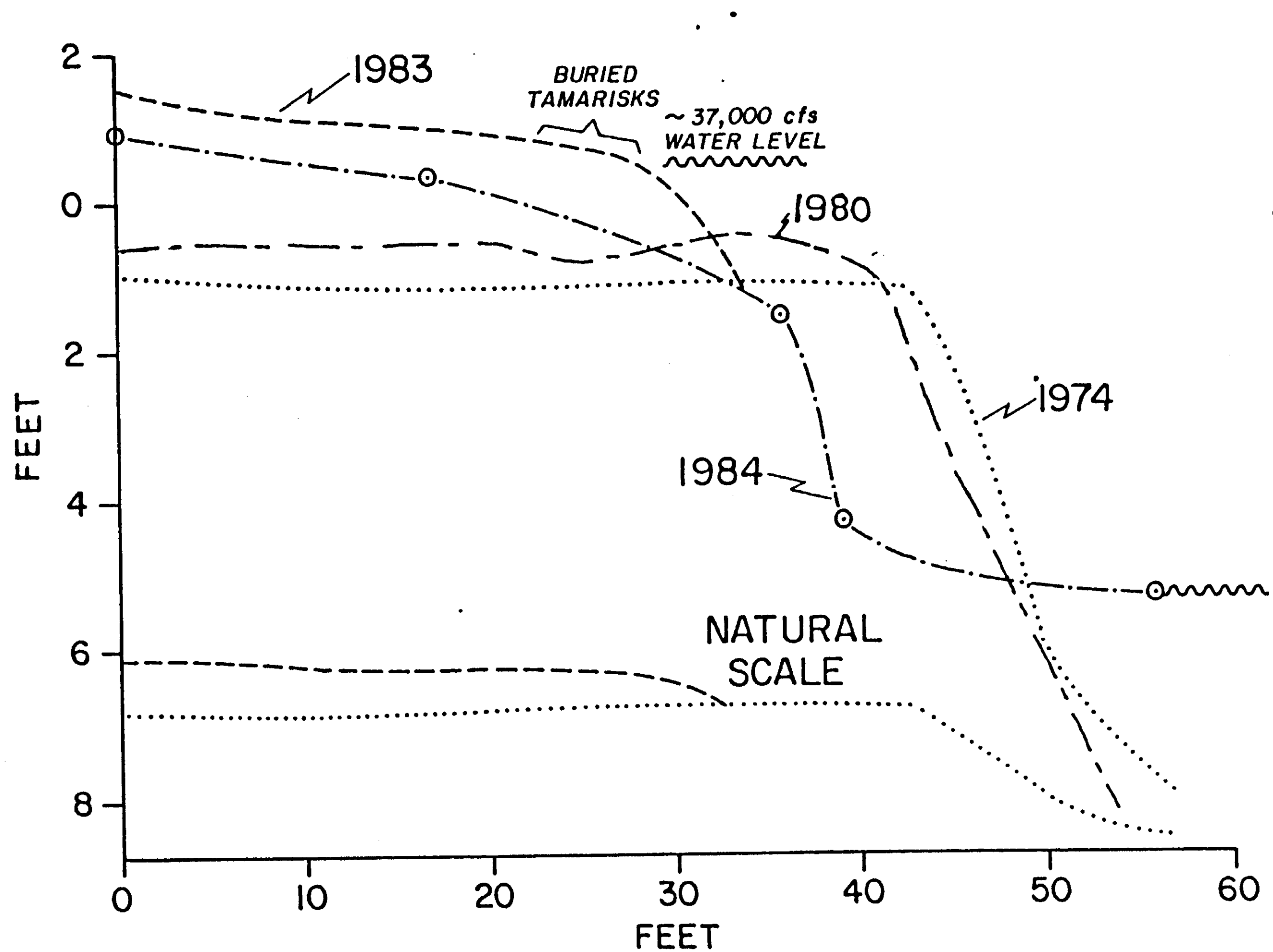


Figure III-27.

CSI BLACKTAIL CN. R120.1



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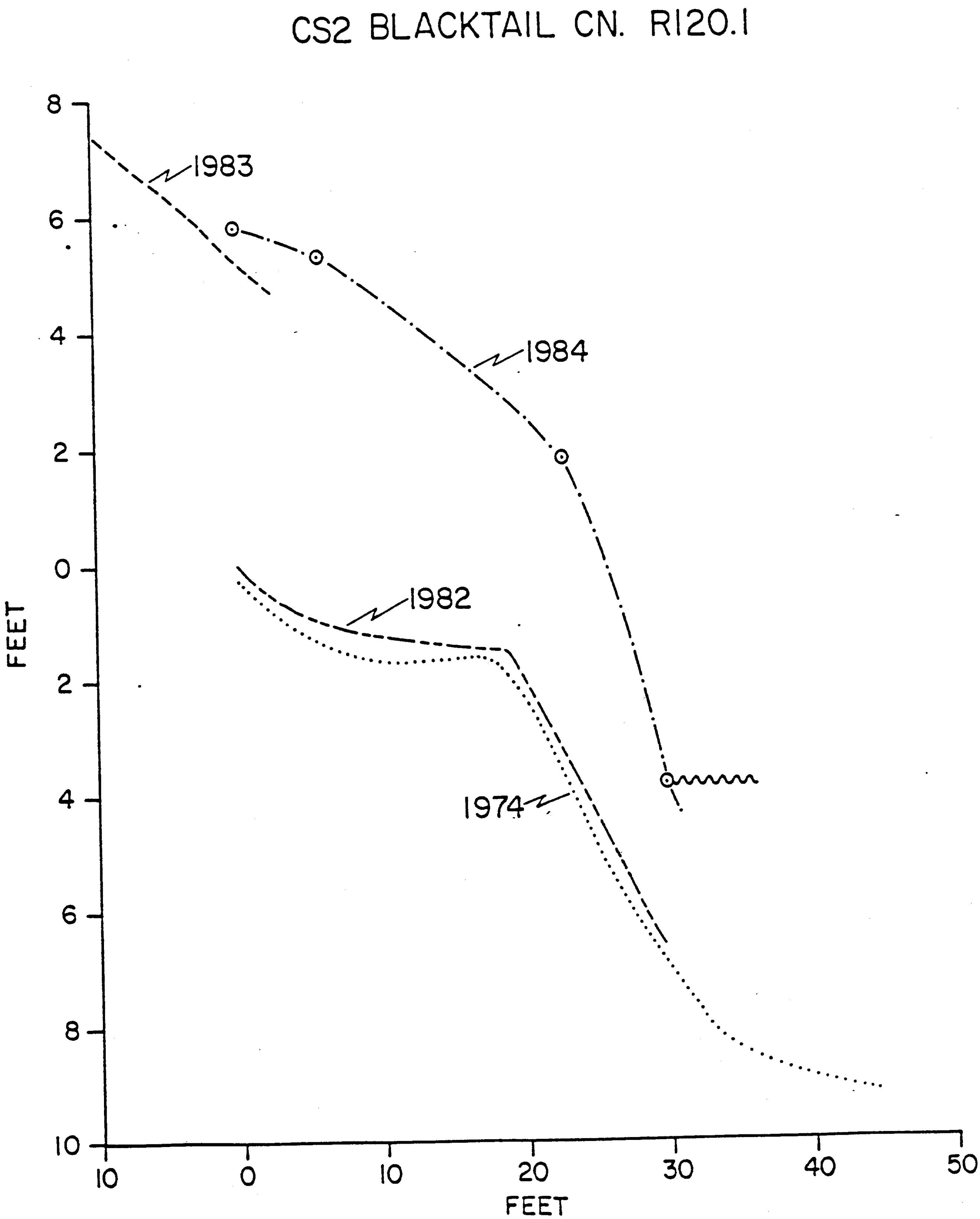

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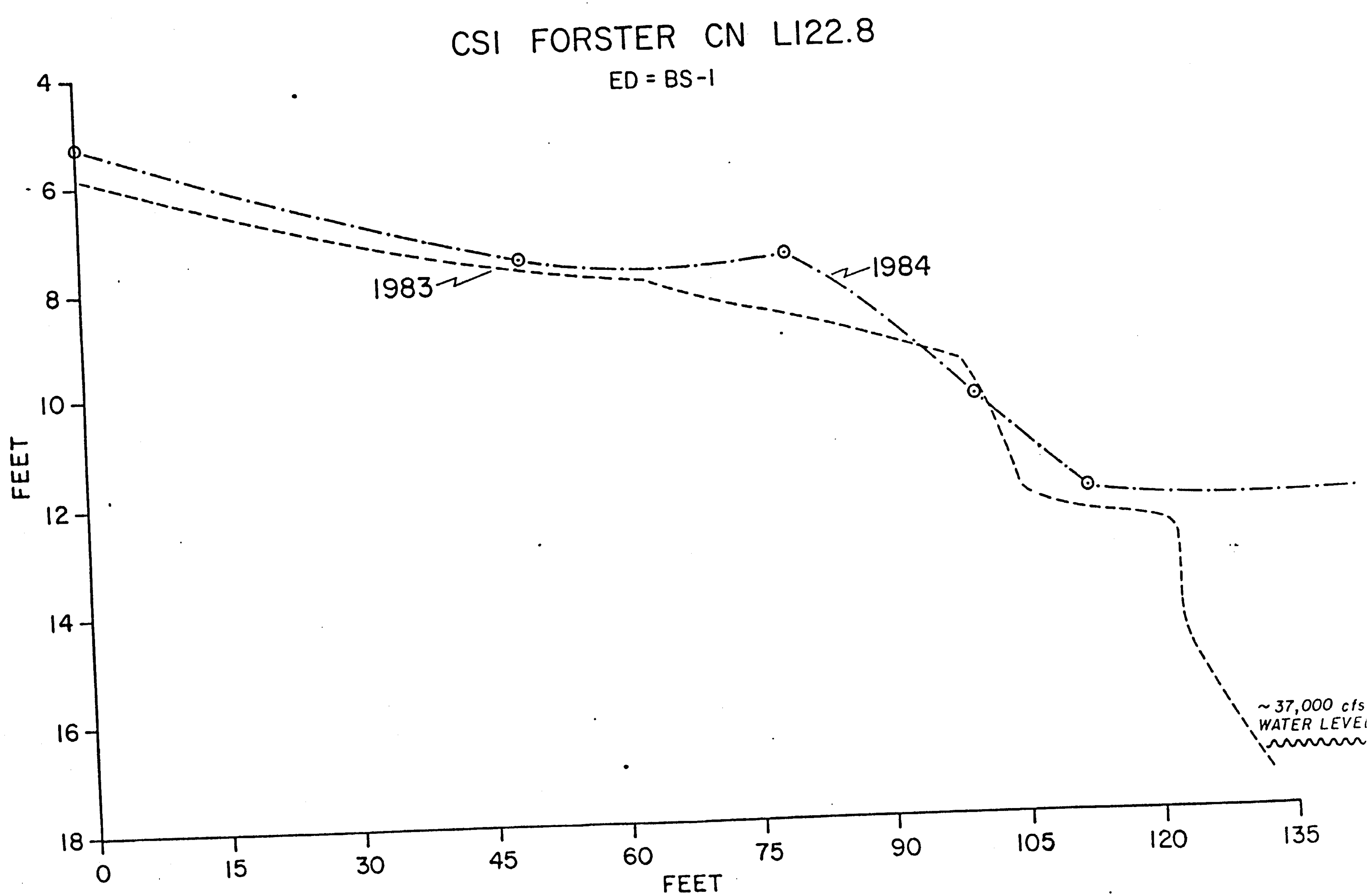
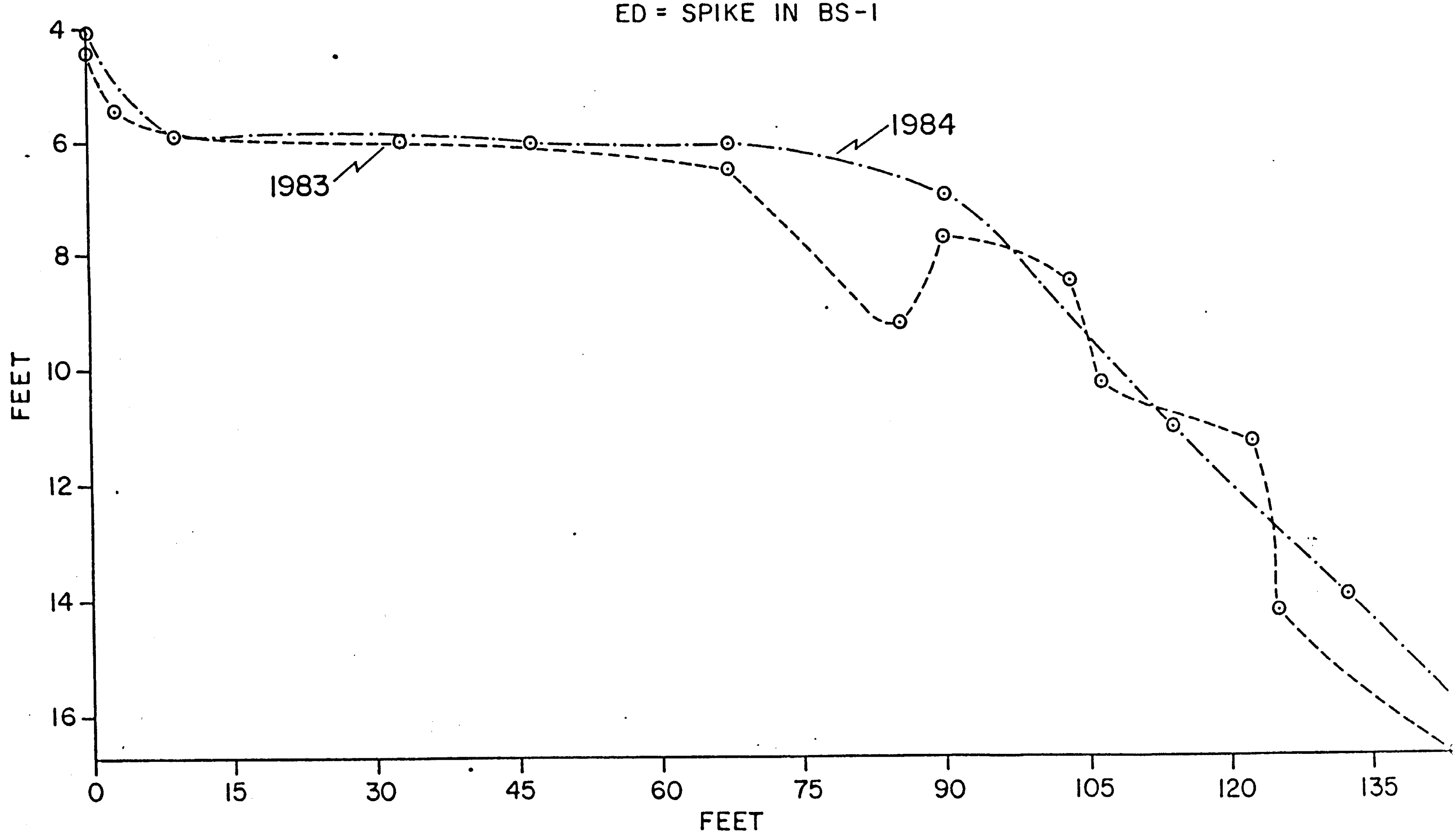


Figure III-30.

CS2 FORSTER CN L122.8

ED = SPIKE IN BS-I



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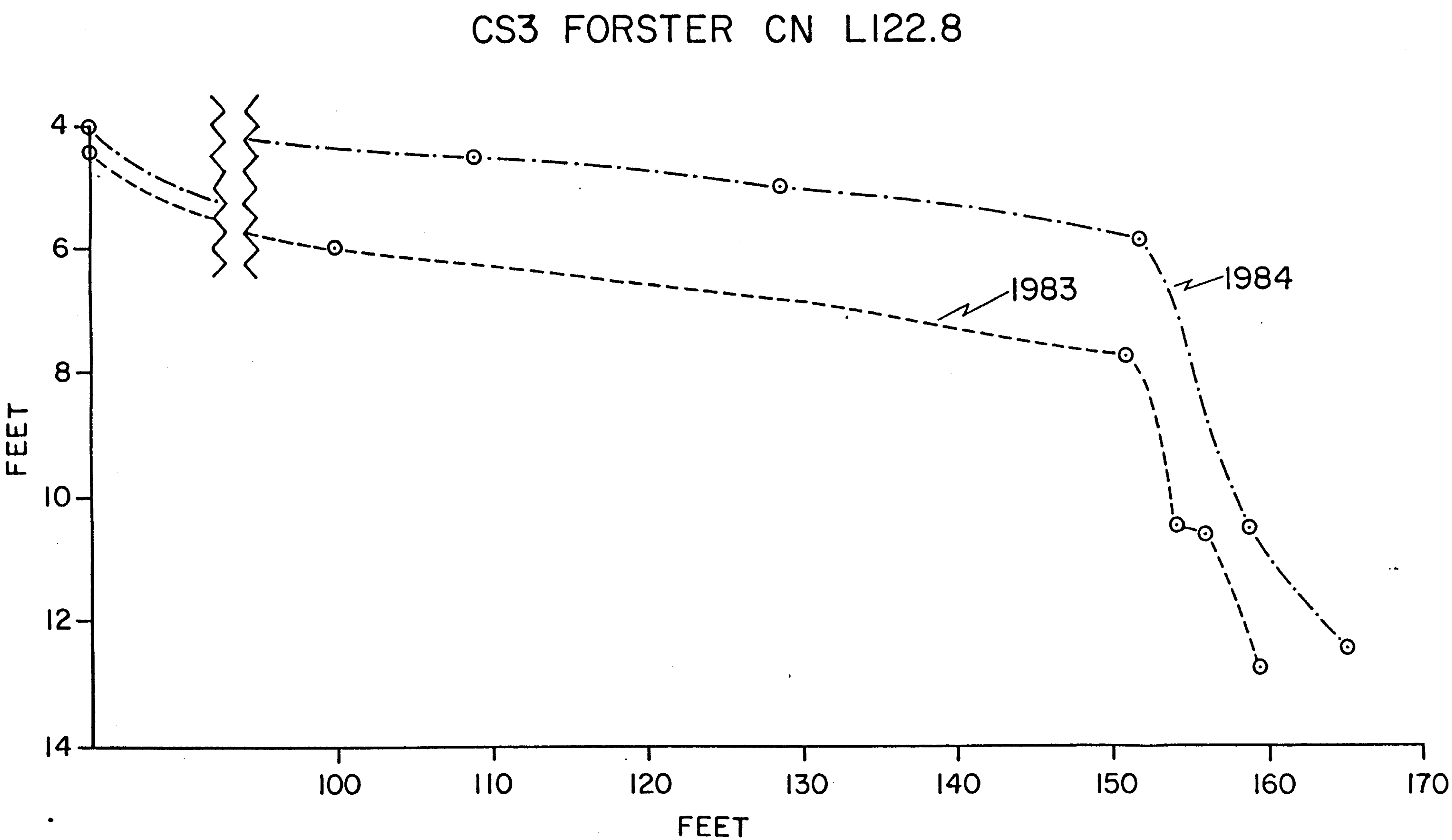

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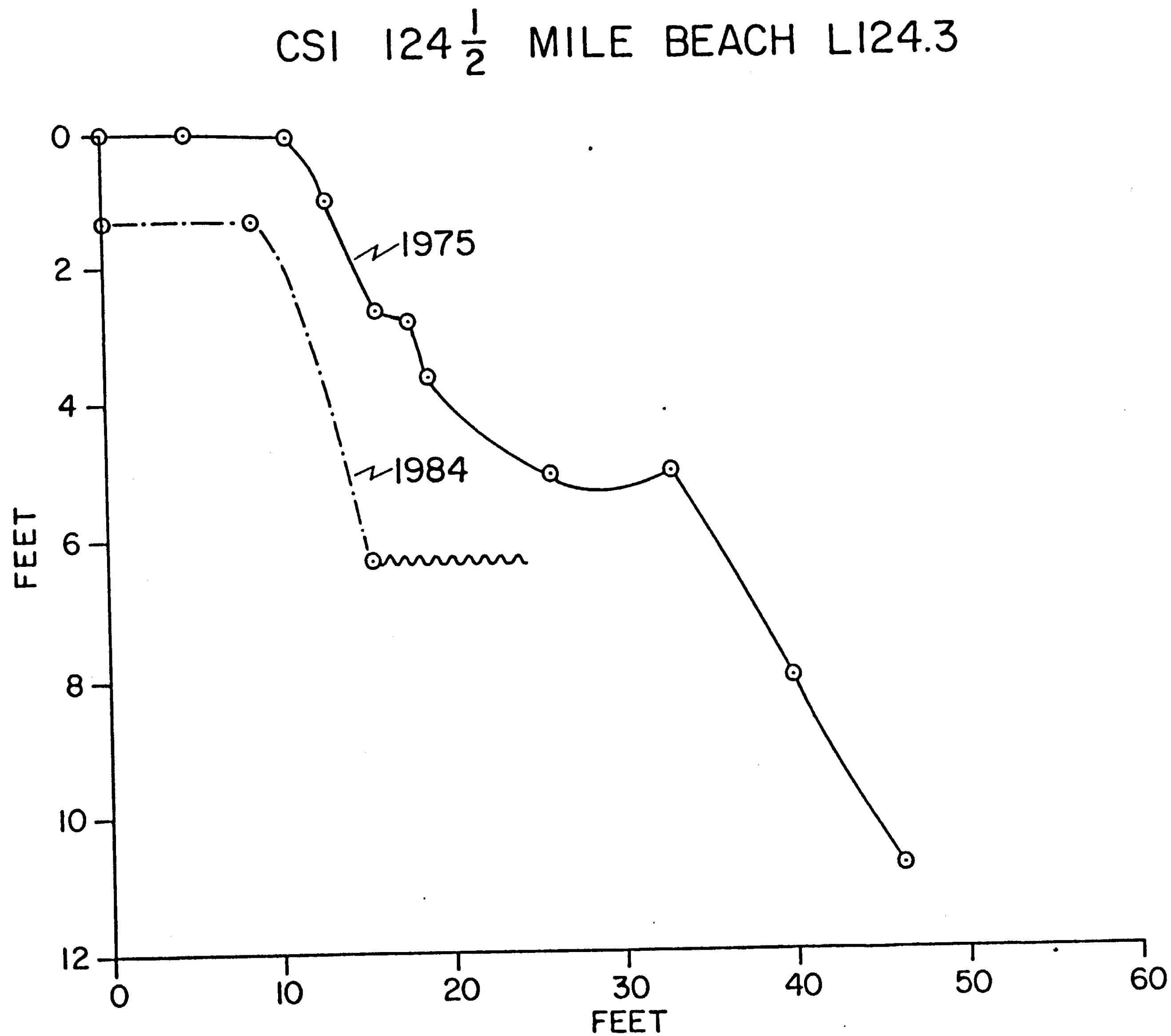

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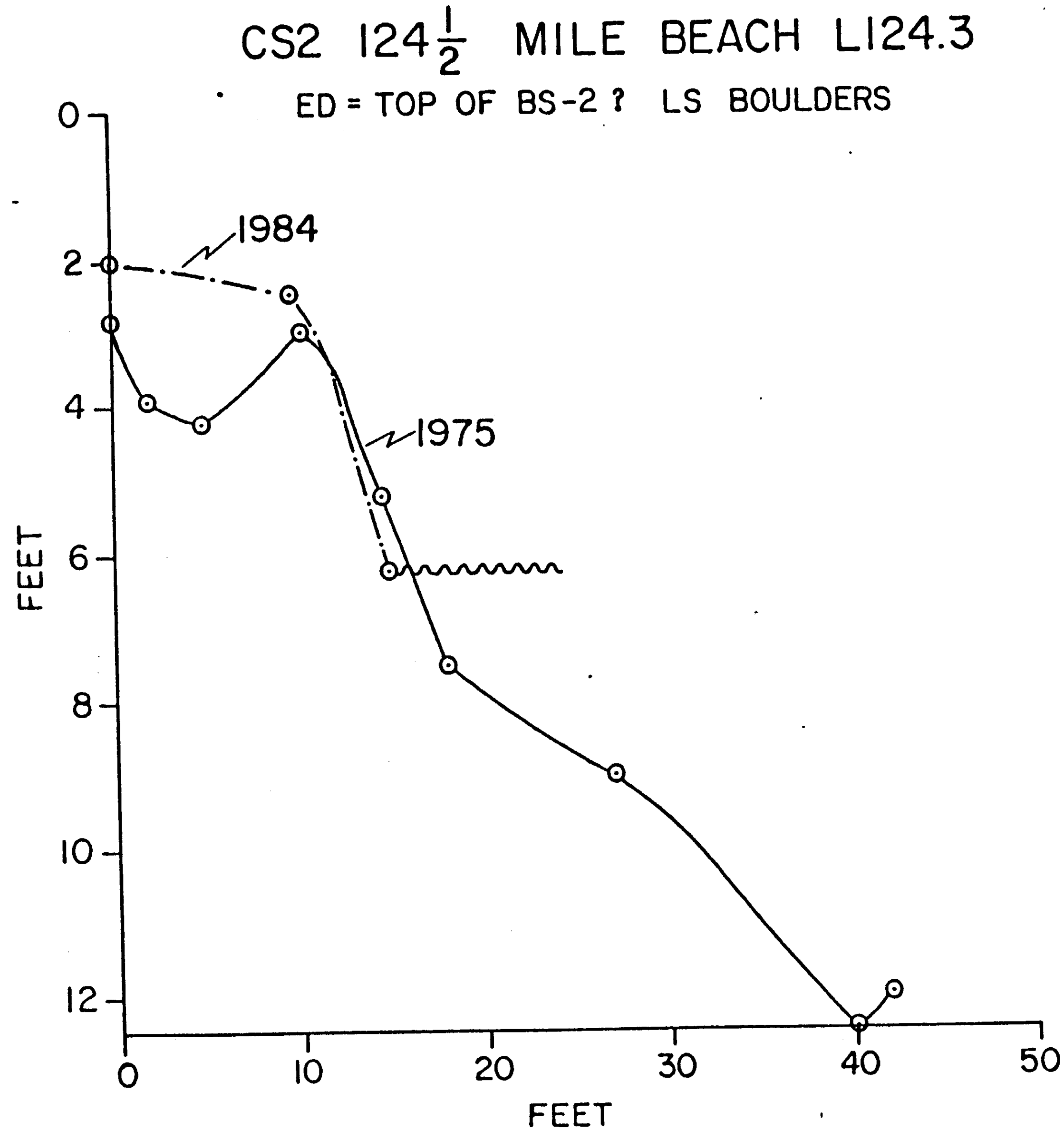

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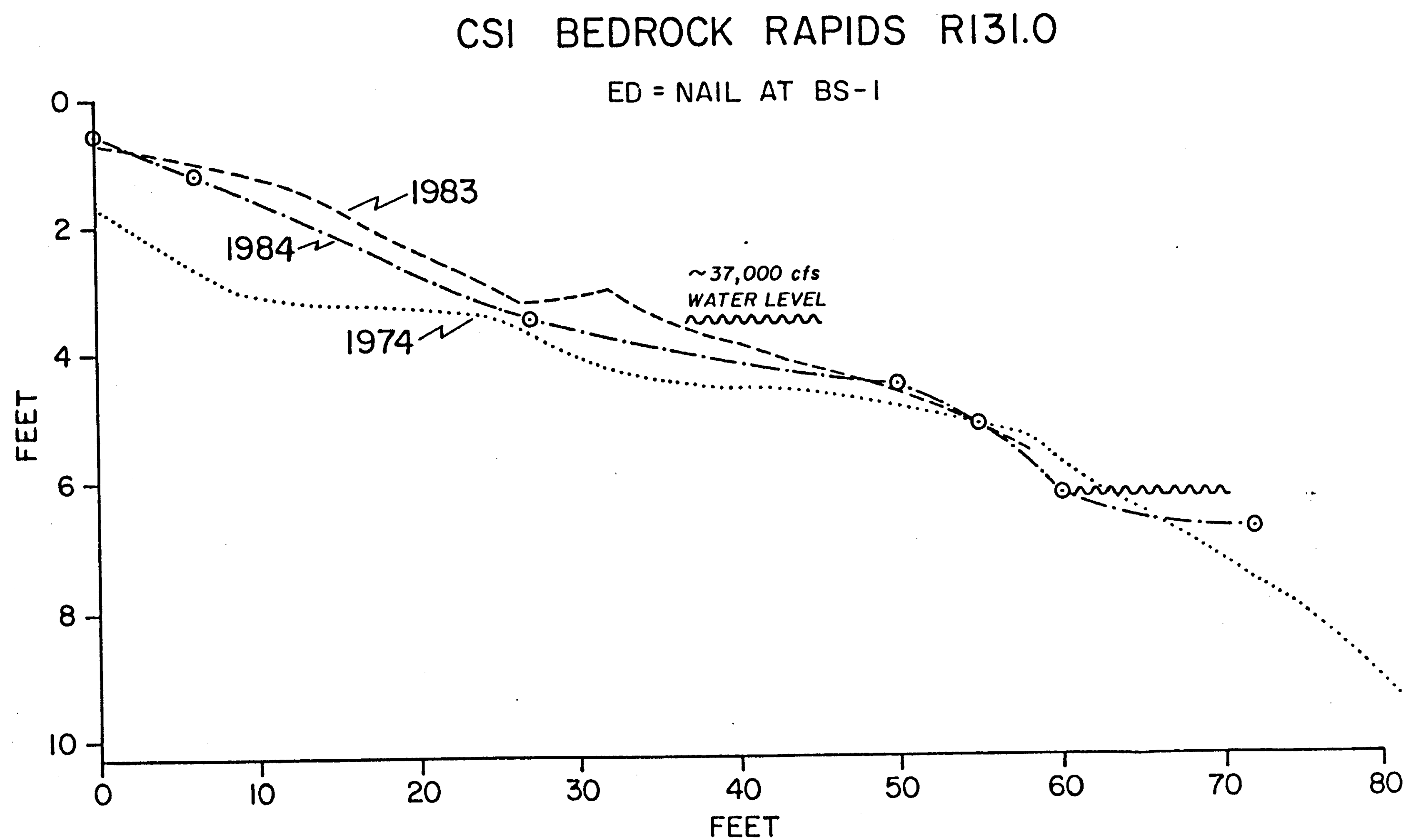

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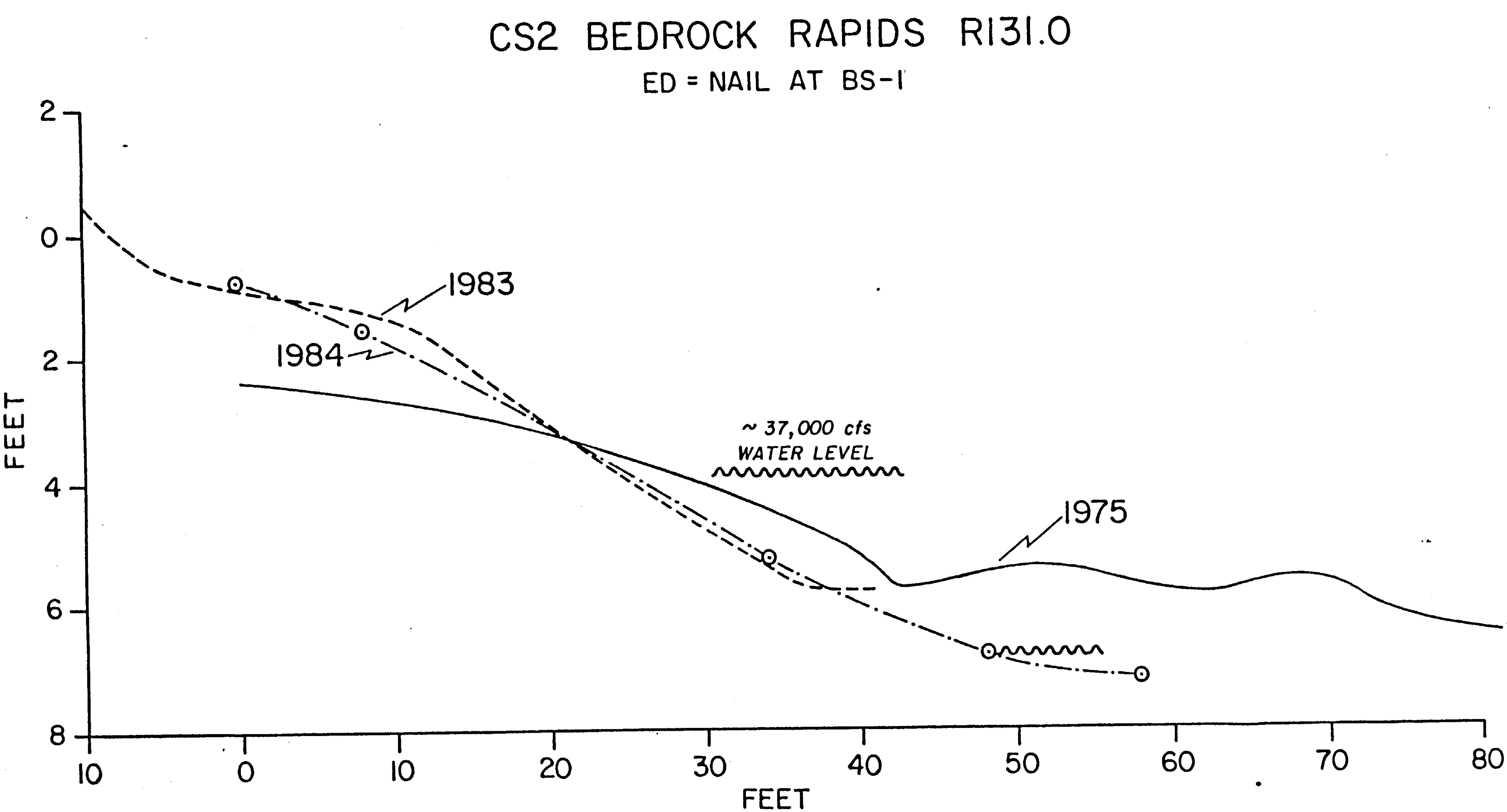

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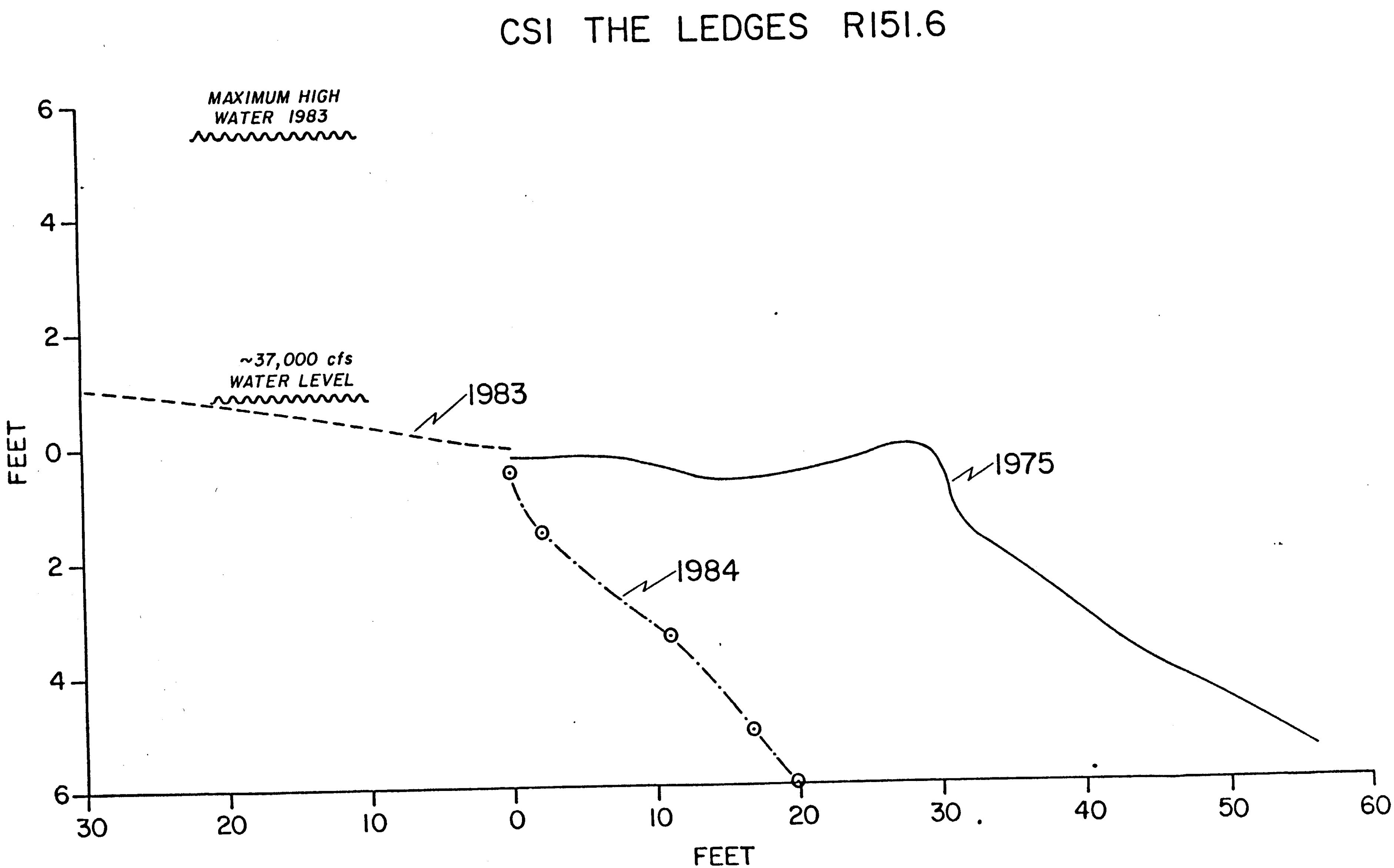

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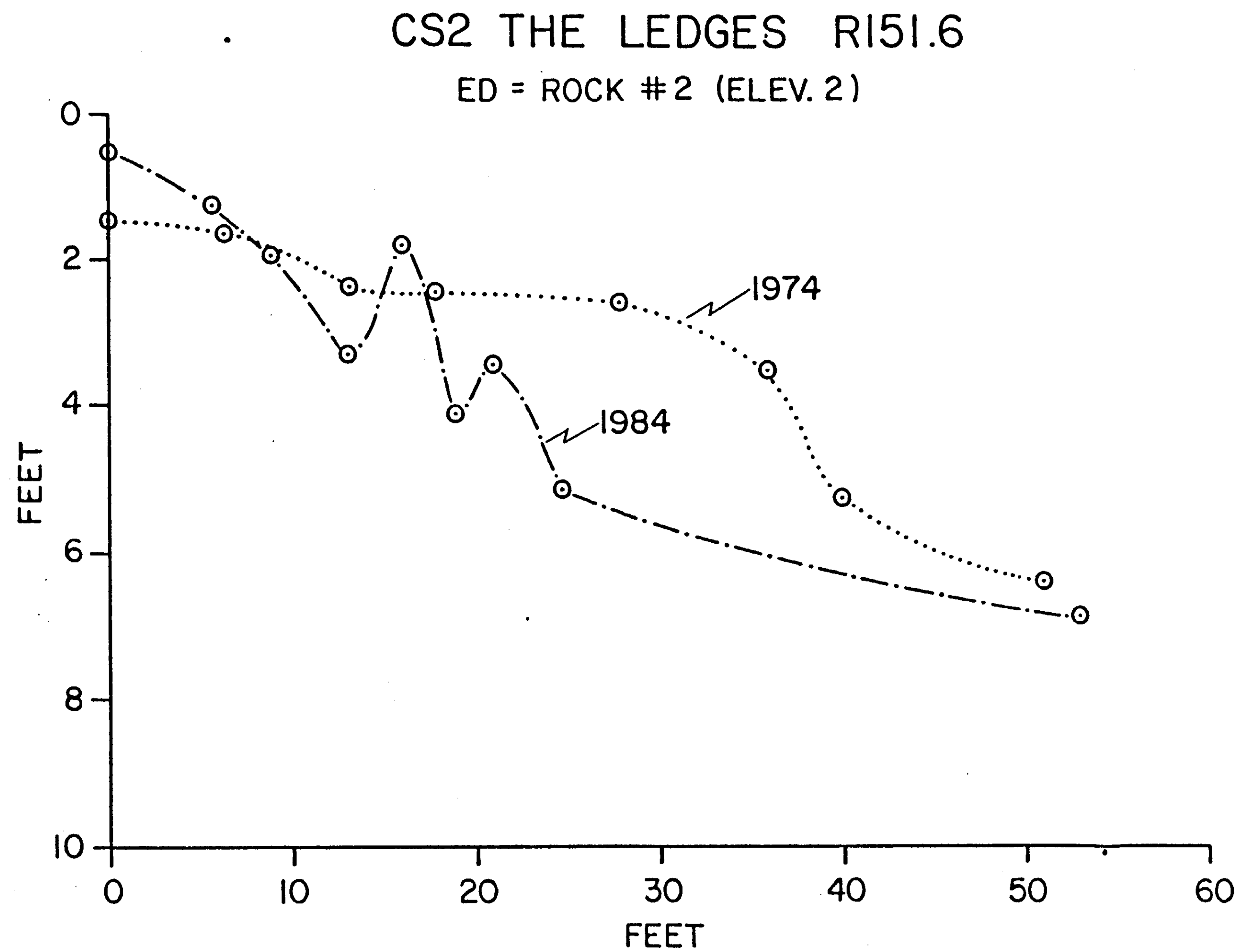

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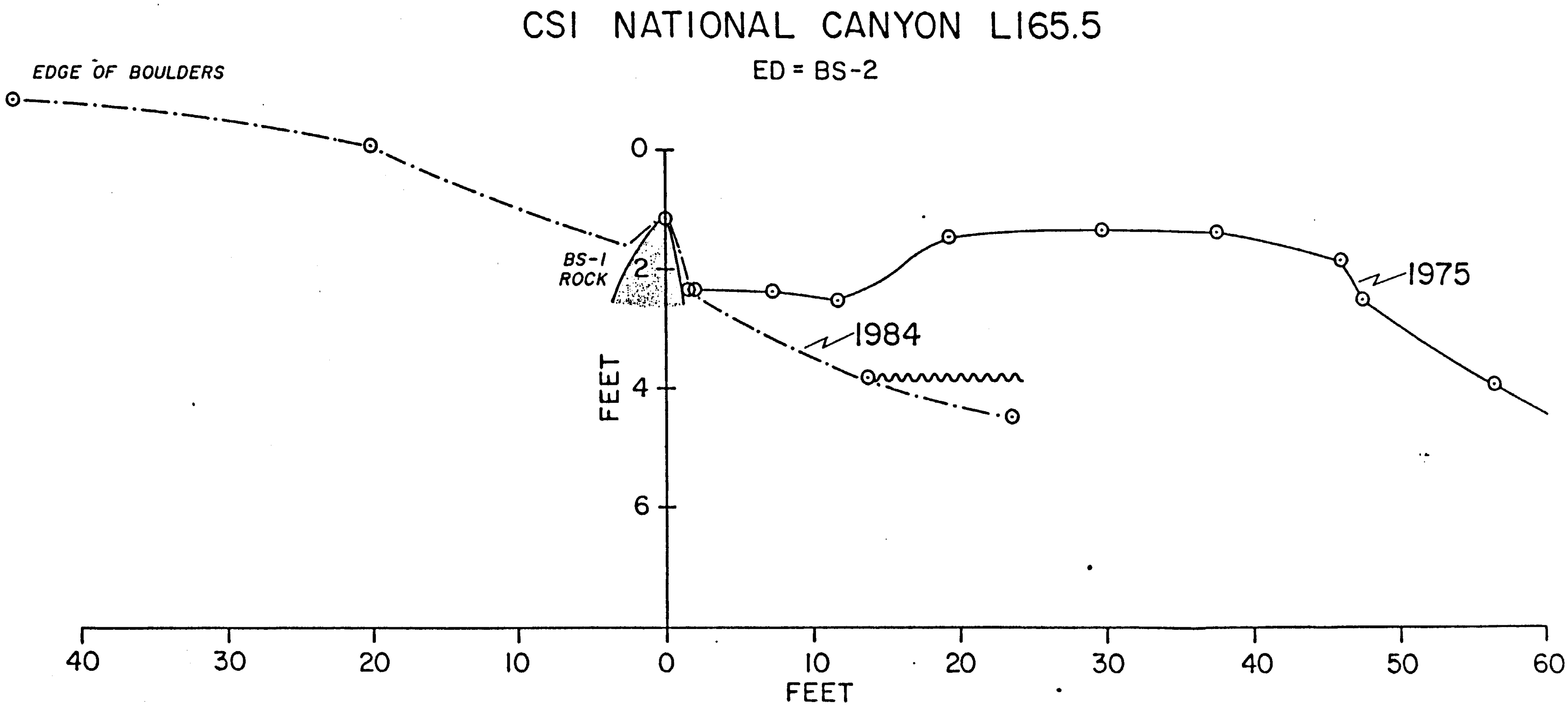
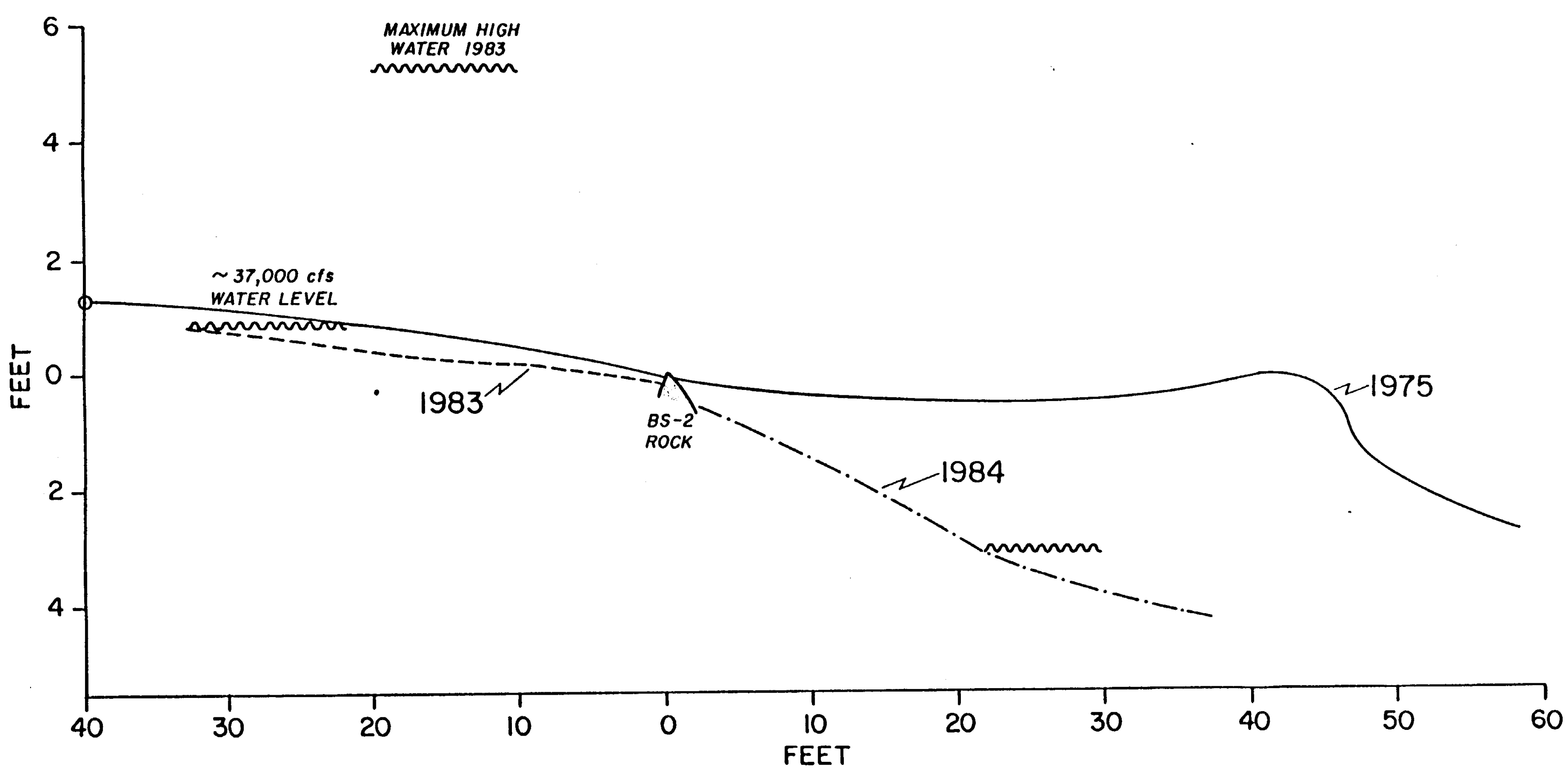


Figure III-39.

CS2 NATIONAL CANYON L165.5



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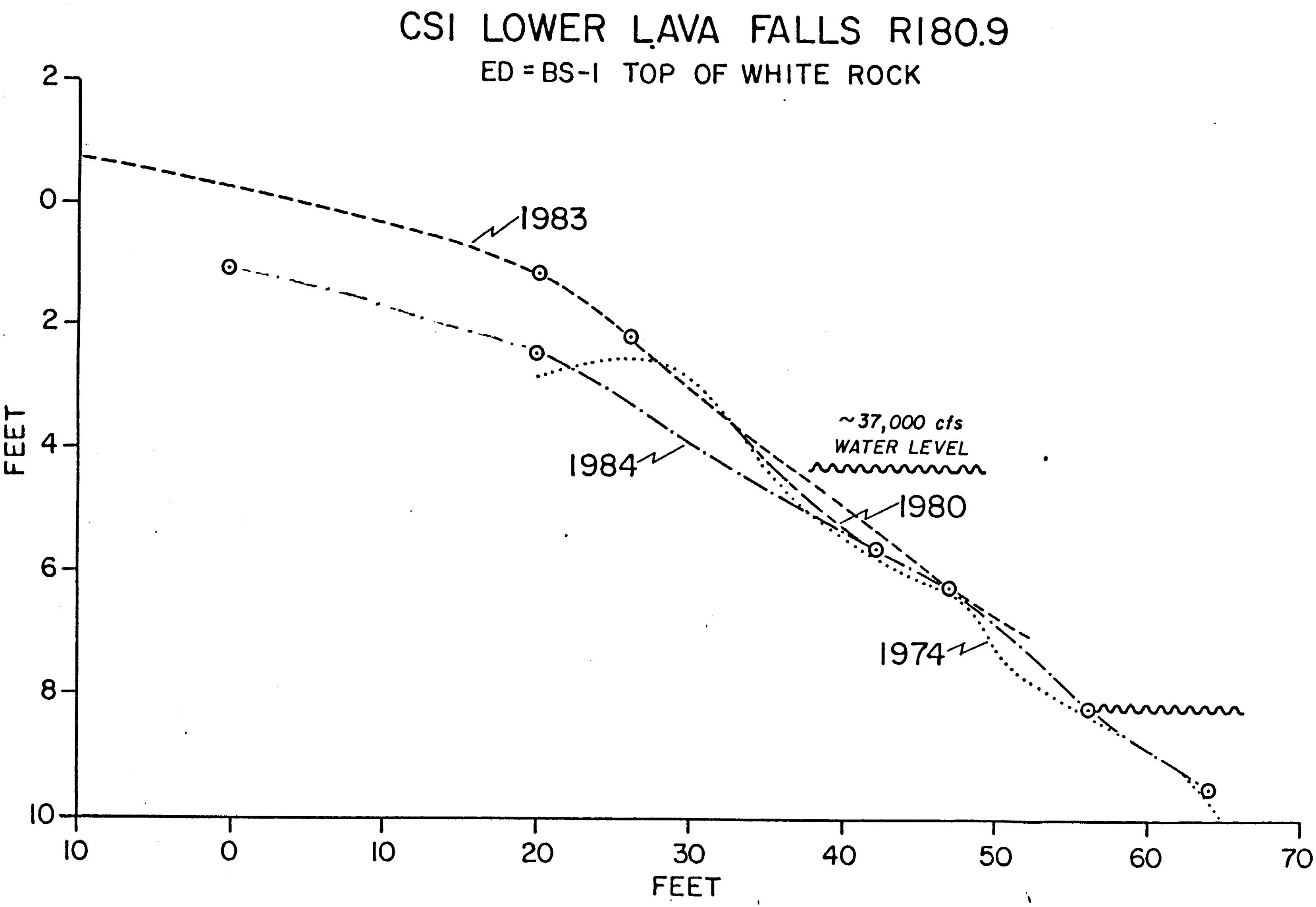

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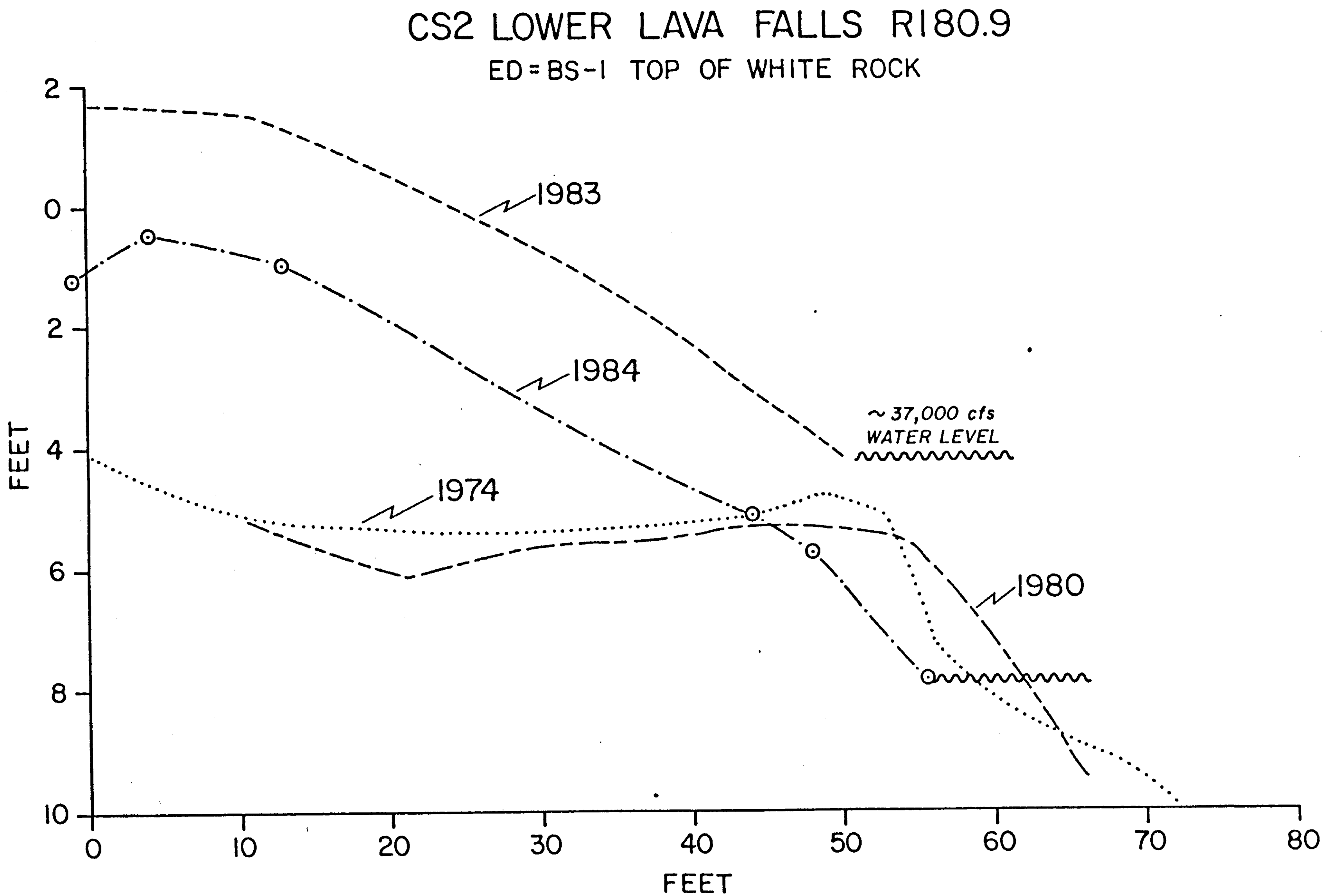

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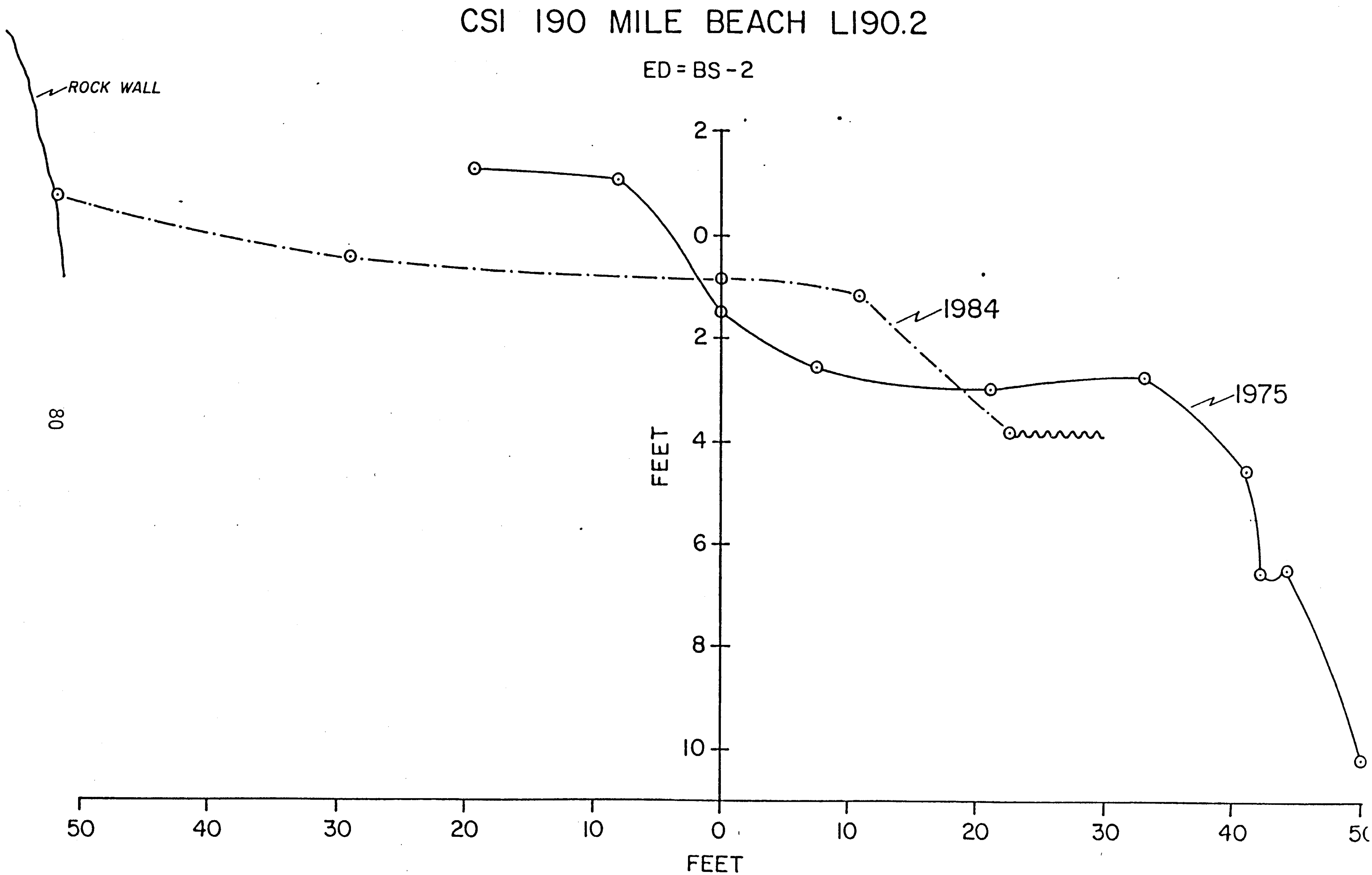

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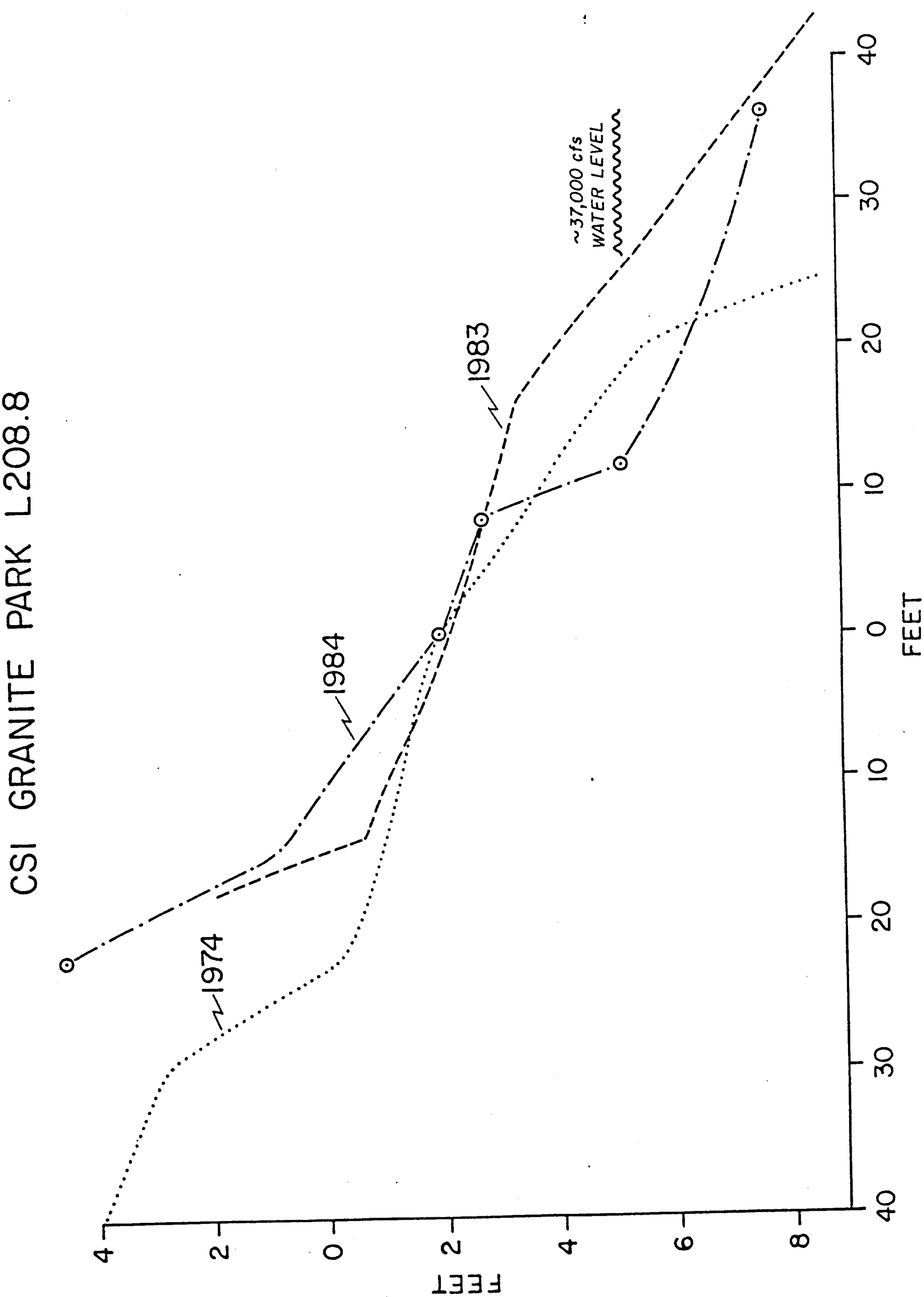

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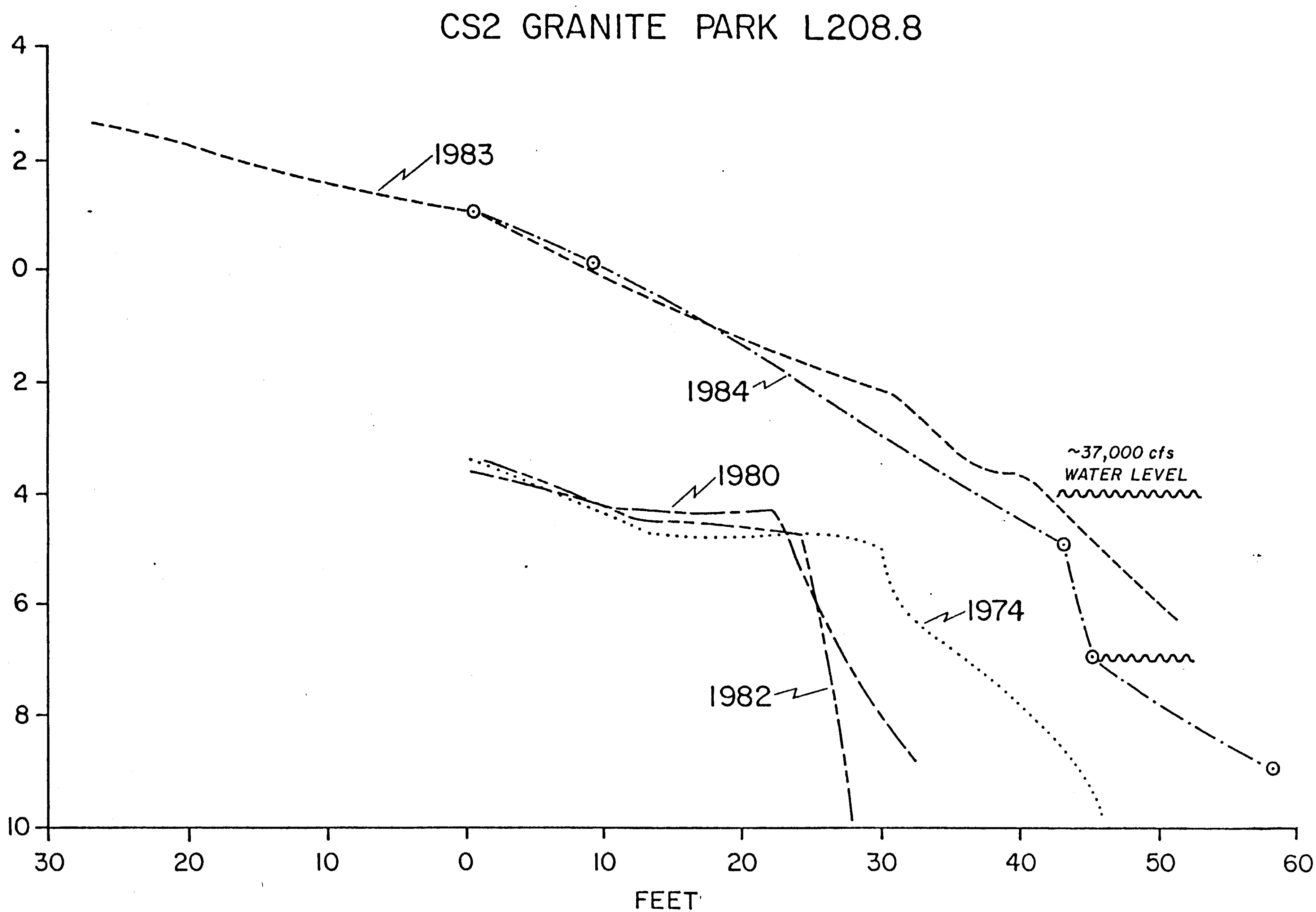


Figure III-45.

CHAPTER IV

BEACH SAND GRAIN SIZE ON THE COLORADO RIVER IN THE GRAND CANYON

Frank B. Lojko

INTRODUCTION

Beach sand samples were taken from 24 beaches in the Grand Canyon during an 11-day period from the first of August to the eleventh of August, 1984. The 51 samples were collected from previously sampled sites and from new sites. They were analyzed to determine sand mean size. It is possible to predict from the sand grain size the minimum water current velocity required to initiate transport of the beach sand.

Comparison of sand grain size from different locations on the same beach, and from the same locations in different years, yields information about the deposition and erosion of the beaches through time. The 1984 data were derived from beaches that had been inundated in the 1983 flood, and when compared to data collected in 1982 before the flood, give an indication of how the high water flows have effected the beaches.

This report presents field measurements, the results of the grain size analysis, a comparison of the data with results from the 1982 and 1983 sand grain studies, and conclusions.

METHODS

Four types of sites were sampled:

1. Surface samples collected at previously sampled transect and non- transect sites for the purposes of comparison.

2. Surface samples collected at measured transect sites not previously sampled.

3. Random surface samples collected at high dunes on beaches.

4. Profile samples collected from eroded and exposed sand banks.

Transect samples were collected at randomly selected points along a tape stretched across the site. Some of the transects were run parallel to the river bank; others were skewed away from the bank. Surface samples were collected at or near the surface of the beach. One or more of the following field techniques were employed to insure continued accuracy in future sand studies: compass bearings, photographs, surveying, mapping, and transect measurements of sand sample sites.

Sand samples ranging from 38 to 82 grams, and averaging 52.69 grams, were collected in small uniform plastic vials. The 51 samples were sieved through a standard set of 3-inch-diameter sieves graduated in 1/2 ø sizes. Each sample was shaken by hand for ten minutes using a clammping device that held two sieve sets together. Each size fraction was weighed using a Ohaus triple beam balance. The mean phi size and Wentworth Scale rating (very fine, fine, medium, coarse) were determined for each sample site. The results were tabulated and are summarized in Table IV-I.

The samples collected were saved for future reference and study.

RESULTS

The sand was found to be generally fine- to medium-grained. Of the 51 samples, two were very fine-grained, 36 were fine-grained, 12 were medium-grained, and one was coarse-grained (Table IV-1).

The mean grain size was 2.19 Ø, with mean grain size of the samples generally between 1.5 Ø (.375 mm) and 3.0 Ø (.125 mm).

A river current velocity of 22 to 25 cm/sec would be sufficient to initiate erosion of any beach sands sampled.

The mean grain size was larger in samples taken closer to the water's edge than in samples collected at areas further from the river.

The sand grains were mostly moderately- to well-sorted.

A preliminary examination of the grain composition indicates mainly quartz.

Thirty-five of the 51 sites sampled in this study coincided with sites previously sampled in either 1982 or 1983, or in both of those years. The number of sand sample sites which were compared to previously sampled sites are as follows: four identical sand sample sites for 1982, 1983 and 1984; ten identical sand sample sites for 1982 and 1984 (including the four noted above); and 29 identical sand sample sites for 1983 and 1984 (also including the four noted above).

In the first group of four sites, the respective mean phi sizes were 2.28 Ø in 1982, 1.99 Ø in 1983, and 1.99 Ø in 1984.

In the second group of ten sites, the respective mean phi sizes were 2.56 Ø in 1982 and 2.32 Ø in 1984. In the third group of 29 sites, the respective mean phi sizes were 2.14 Ø in 1983 and 2.19 Ø in 1984. The data from these sites suggest that, from 1982 to 1983, and from 1982 to 1984, there was a increase in mean sand grain size on the beaches tested. There was little difference in mean grain size between 1983 and 1984 (Fig. IV-1 and Table IV-2).

At these 35 sites, for which there are comparative data from identical sites, the sand tended to be fine-grained in 1982, and fine- to medium-grained in both 1983 and 1984 (Table IV-2).

The data for all three years indicate that a sample collected closer to the river along a transect was larger in mm size than a sample collected at the upper end of the transect.

The sand grains were mostly moderately- to well-sorted each year.

CONCLUSIONS

The trend of increased mean sand grain size between 1982 and the years 1983 and 1984 supports evidence of a resorting of beach sands by the high water flow in 1983.

ACKNOWLEDGEMENTS

I wish to extend my appreciation to Dr. Stanley S. Beus and Dr. Steven W. Carothers for their guidance and support with this study. A very special thanks and appreciation to the following dedicated individuals for their field assistance with sand sieving, sand weighing, and data recording for this project: Bud Cowan, Mary White, Sylvia Jernigan, Sher Renken, Mary Lou Holmes, Wanda Wynne, and Elaine Mooneyham.

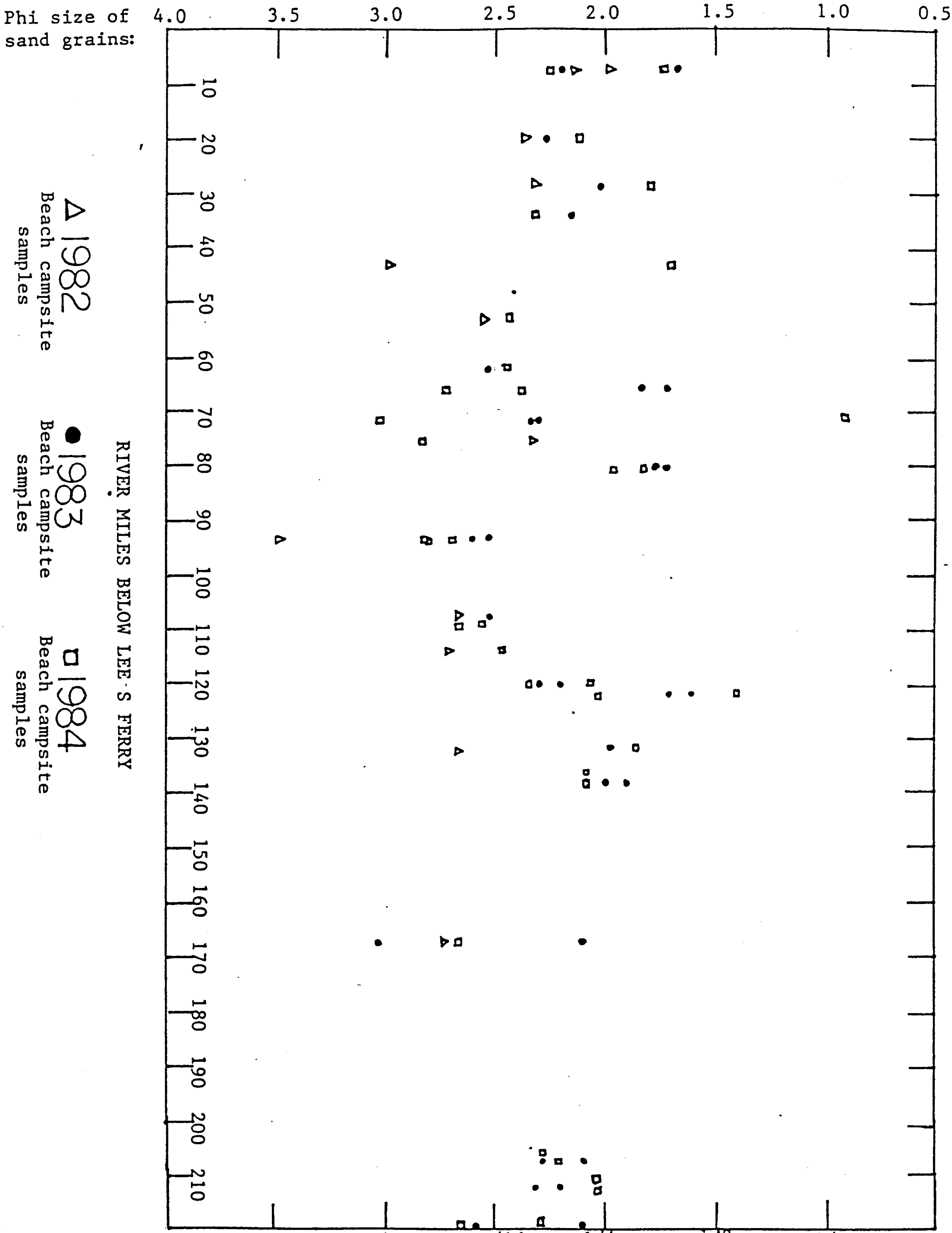


Figure IV-1. Mean sand grain size of beach campsite samples for 1982,1983 and 1984.

Table IV-1. Sand sampling sites, 1984.

River Mile	Beach & Sampling Site		Mean Phi Size	Grain Size (in mm)	Wentworth Scale
8	Badger Creek	T-3m	1.75	.300	medium
		T-27m	2.25	.210	fine
20	20 Mile	T-34m	2.10	.234	fine
29	Shinumo Wash	T-19m	1.78	.294	medium
34.7	Nautiloid	T-12m	2.28	.207	fine
43.5	Anasazi Bridge	T-14m	1.69	.312	medium
53	Lower	T-30	2.46	.183	fine
53+	Nankoweap	A	1.18	.442	medium
		A-1	1.93	.263	medium
		B	2.22	.214	fine
		C	2.15	.226	fine
61.8	Lower LCR	8m from BS- 2	2.45	.184	fine
65.5	Lava Canyon	T-6m	2.73	.151	fine
	(Chuar)	T-39m	2.37	.195	fine
72.2	Unkar	T-9m	0.88	.543	coarse
		T-35m	3.04	.121	very fine
		A	2.19	.219	fine
		B	2.24	.212	fine
		C	3.03	.122	very fine
75.5	Nevills Rapid	T-6m	2.82	.142	fine
		50m from BS- 2	2.35	.198	fine
81.1	Grapevine	T-9m	1.81	.285	medium
		T-36m	1.91	.265	medium
93.2	Granite Rapid	T-4m	2.78	.146	fine
		T-8m	2.68	.156	fine
		T-12m	2.77	.147	fine
108.5	Lower Bass	T-4m	2.66	.158	fine
	Camp	T-19m	2.57	.166	fine
114	114 Mile	T-4m	2.46	.183	fine
120.1	Blacktail	BS-1	2.08	.237	fine
	Canyon	BS-2	2.36	.196	fine
122	122 Mile	T-38m	1.82	.286	medium
122.8	Forster	T-6m			
		Sec.A	2.02	.246	fine
		Sec.0	1.40	.370	medium
		1	2.26	.210	fine
		2	2.06	.240	fine
		3	2.17	.222	fine
132	Dubendorff	T-27m	1.86	.275	medium
		T-29m	1.86	.275	medium
137	Pancho's	T-5m	2.06	.240	fine
	Kitchen	T-35m	2.06	.240	fine

Table IV-1 continued.

River Mile	Beach & Sampling Site		Mean Phi Size	Grain Size (in mm)	Wentworth Scale
166	National	T-38m			
	Canyon	Sec.B	2.66	.158	fine
		Old trench site	2.10	.234	fine
196	196 Mile (new beach)				
		Lower/rt. side	1.96	.265	medium
		T-35m	2.05	.242	fine
208.5	Granite Park	T-6m	2.23	.213	fine
		Dune	2.28	.207	fine
212	Pumpkin Bowl	T-3m	2.06	.240	fine
		T-38m	2.06	.240	fine
220	220 Mile	T-20m	2.63	.160	fine
		T-40m	2.28	.207	fine

Data summary of sand sampling sites, 1984:

*Fifty-one sand samples were collected and measured.
*Thirty-nine of the 51 were transect (T) samples.
*Twelve of the 51 were from specialized study areas.
*Sand samples were taken from 24 beach sites along a 220 mile course of the Colorado River.
*Wentworth Scale classification of 51 samples collected: 2% (1) coarse, 24% (12) medium, 71% (36) fine, 4% (2) very fine.
*Wentworth Scale classification of 39 transect sammples collected: 3% (1) coarse, 25% (10) medium, 69% (27) fine, 3% (1) very fine.

Table IV-2. Sand analysis - mean phi size. Comparison of sand samples taken at the same sites during the studies of 1982, 1983 and 1984.

River Mile	Beach	Sample Site	Mean Phi Size 1982	1983	1984
8	Badger Creek	T-3m	2.10	2.20	1.75
		T-27m	2.00	1.66	2.25
20	20 Mile	T-34m	2.38	2.23	2.10
29	Shinumo Wash	T19m	2.30*	2.03	1.78
34.7	Nautiloid	T-12m		2.13	2.28
43.5	Anasazi Bridge	T-14			1.69
		T-31m	3.00		
53	Lower Nankoweap	T-30	2.55		2.46
61.8	Lower LCR	BS-2		2.53	2.45
65.5	Lava Canyon (Chuar)	T-6m		1.85	2.73
		T-39m		1.73	2.37
72.2	Unkar	T-9m		2.31	0.88
		T-35m		2.28	3.04
		Willow	3.10		
		Tamarisk	3.21		
75.5	Nevills Rapid	T-6m	2.30		2.82
81.1	Grapevine	T-9m		1.76	1.81
		T-36m		1.66	1.91
93.2	Granite Rapid	T-4m		2.61	2.78
		T-8m		2.53	2.68
		T-12m	3.50		2.77
108.5	Lower Bass Camp	T-4m	2.66		2.66
		T-4m (new)		2.90	
		T-19		2.53	2.57
114	114 Mile	T-4m	2.70		2.46
120.1	Blacktail Canyon	BS-1		2.20	2.08
		BS-2		2.33	2.36
122.8	Forster	T-6m Sec.A		1.73	2.02
		T-6m Sec.0		1.60	1.40
132	Dubendorff	T-27m	2.66	1.90	1.86
137	Pancho´s Kitchen	T-5m		2.00	2.06
		T-35m		1.88	2.06
166	National Canyon	T-38 Sec.B		3.03	2.66
		Old trench site	2.73		2.10
208.5	Granite Park	T-6m		2.28	2.23
		Dune		2.10	2.28
212	Pumpkin Bowl	T-3m		2.30	2.06
		T-38m		2.20	2.06
220	220 Mile	T-20m		2.60	2.63
		T-40m		2.11	2.28

* The 1983 report does not record 1982 data from T-19m, Shinumo Wash. That report lists only four sites as having been sampled in both 1982 and 1983: T-3m and T-27m, Badger Creek; T-34m, 20 Mile; and T-27m, Dubendorff. This figure has been disregarded.

CHAPTER V

REPORT ON VEGETATION ALONG THE COLORADO RIVER OLD HIGH WATER LINE GRAND CANYON NATIONAL PARK 1984

L. Susan Anderson and George A. Ruffner
Assisted by M. C. White, S. J. Jernigan and E. V. Mooneyham

INTRODUCTION

The effects of Glen Canyon Dam on aspects of the biology, geology, and hydrology of Grand Canyon have been detailed by several investigators (Carothers and Aitchison 1976; Carothers et al. 1976; Turner and Karpiscak 1980; Howard and Dolan 1981). Significant changes have occurred during the past 20 years. Most attention has been directed toward the strip of "new" riparian vegetation which developed between the old high water line (OHWL, i.e. pre-dam) and new high water line (NHWL, i.e. post-dam).

There have been only cursory investigations of the vegetation comprising the OHWL riparian zone. Shrub liveoak (*Quercus turbinella*) occurs between Glen Canyon Dam and Lees Ferry. Redbud (*Cercis occidentalis*) and Apache plume (*Fallugia paradoxa*) occur from the dam to the vicinity of river mile (RM) 60, near the confluence of the Colorado and Little Colorado Rivers. Hackberry (*Celtis reticulata*) occurs sporadically from Glen Canyon Dam to Lake Mead. These species dominate the OHWL riparian zone between the dam and RM 40. Catclaw acacia (*Acacia* *greggii*) and western honey mesquite (*Prosopis glandulosa torreyana*) first appear in the OWHL riparian zone at RM 40. Catclaw acacia occurs continuously along the river to Lake Mead. Western honey mesquite has two centers of distribution in Grand Canyon -- from RM 40 to RM 77 and from RM 165 to Lake Mead. Where acacia and mesquite co-occur they dominate the OHWL riparian zone almost to the exclusion of other species. In addition, they can be very deep-rooted and are more likely to respond to variations in water level anticipated from fluctuating flows than the more shallowly-rooted shrub species. Acacia dominates in the reach from RM 77 to RM 165. This study will concentrate on catclaw acacia and western honey mesquite.

Details of life history characteristics of OHWL plants are unknown in the Grand Canyon. Following the construction of Glen Canyon Dam it was assumed that the new flow regime would not provide sufficient water to maintain the OHWL zone. Seedlings and saplings of OHWL species began appearing in the NHWL riparian zone. Under the scenario of dam operations between 1963 and 1983, it was expected that the OHWL riparian zone would become more like that of the adjacent talus slope and the NHWL would more closely resemble the OHWL riparian zone. However, spills from the dam (1981 and 1983), the filling of Lake Powell, exceptionally high releases (1983), and the promise of more frequent high releases in the future suggest that this successional scenario is unlikely. It seems likely that the OHWL riparian zone will periodically recieve water after 20 years of "drought".

The study reported here was conducted in August, 1984, as part of the Northern Arizona University field investigations in the Grand Canyon. Mary C. White, Sylvia J. Jernigan, and Elaine V. Mooneyham acted as assistants to L. Susan Anderson and George A. Ruffner.

OBJECTIVES

The overall objective of this project was to evaluate the effects of Glen Canyon Dam and fluctuating water levels on the growth and vigor of the OHWL vegetation. Specific objectives were to:

1. Measure growth rates (shoot length and radial growth) of mesquite and acacia of different size classes under varying high flows (1983 and 1984) to determine whether infrequent high flows, such as that in 1984, have a significant effect on growth and vigor of the OHWL vegetation.

2. Measure germination success and seedling survival for acacia and mesquite to determine whether infrequent high flows lead to increased germination or survivorship.

3. Measure growth rates and seedling sucess in both the OHWL zone and adjacent tributaries. Acacia and mesquite occurring along perennial and semi-perennial tributaries of the Colorado are not subject to the same degree of water strees as those individuals occurring in the OHWL zone and can be used as a control for the effects of very high flows and fluctuating flows from Glen Canyon Dam.

METHODS

Sites were selected on the basis of two criteria: 1) where adequate populations of acacia and mesquite are distributed in the OHWL and adjacent tributaries in the four reaches of the river below Lees Ferry, and 2) where low level aerial photo coverage of OHWL sites is available.

Selected sites:

Lees Ferry - Little Colorado: Nankoweap Canyon

Little Colorado - Phantom Ranch: Unkar Canyon

Phantom Ranch - National Canyon: National Canyon

National Canyon - Diamond Creek: Granite Park

Aerial photos were used to define the immediate study area at each site and to distribute sampling localities equally within a site.

At each study area, both an experimental plot at the OHWL and a control plot in the adjacent tributary were selected.

First year (1984) and second year (1983) shoot growth of mesquite or acacia were measured. Growth of first and second year shoots can be easily distinguished. First year shoots have one leaf/node and are often still green at the tip. Second year shoots have more than one leaf/node, but lack the fascicled nodes of older shoots. Physical features of the OWHL, individual tree characteristics, and shoot length of current year´s and previous year´s growth were measured for trees of four different size classes in both the OHWL and adjacent tributaries at each site. Dendrometers were placed on each tree sampled to measure radial growth.

Seedling and sapling density and growth were sampled at Nankoweap, Unkar and National canyons. Number of seedlings germinated in the present year and previous years were tallied and marked to follow survivorship in subsequent years.

RESULTS

There was a highly significant difference in mean shoot growth of mesquites between years in the OHWL experimental plots at Unkar and Granite Park (Tables V-1 and 2). Shoot growth was greater in OHWL mesquites in 1983, the year of 90,000+ cfs flow, than in 1984 when flows were lower. This indicates that OHWL mesquites at these sites may respond with increased growth as a result of periodic high flows.

The pattern of shoot growth in control plots, established outside of the area influenced by high river flows, was consistently different from the pattern of growth in experimental plots. The control plot at Unkar showed no difference in shoot growth between years (Table V-1). In the Granite Park control, mesquite shoot growth was greater in 1984 than in 1983 (Table V-2).

Mesquite growth at Nankoweap Canyon showed no difference in shoot length between years in either the OHWL experimental plot or the tributary control plot (Table V-3).

Acacia forms the OHWL at National Canyon. Unlike mesquite, it is not restricted to riparian areas in Grand Canyon. Mean shoot growth of acacia was greater in 1984 than in 1983 for both experimental and control plots (Table V-4).

The major objective of the germination studies was to analyze replacement and survivorship of OHWL trees. Seedlings and saplings permanently tagged this year will provide information on growth and survivorship in subsequent years. At Nankoweap Canyon there were no mesquite seedlings in either control or experimental sites. In addition, the seed crop at this site was low. In contrast, seedlings were abundant under

OHWL mesquite trees at Unkar. The seedling census at Unkar has not been completed, however, some seedlings and saplings were permanently marked for future censusing (Table V-5). Seedlings and saplings were not sampled at Granite Park.

There were five times as many acacia seedlings and saplings on the control plot at National Canyon as on the experimental plot (Table V-6). In general, seedlings and saplings were more abundant in the open than under the canopy on both sites. Sapling growth was greater in 1983 on the OHWL experimental plot than on the control plot (Mann-Whitney $U=23.5$, $p<.05$). In addition, total sapling growth was greater on the experimental plot than on the control plot (Mann-Whitney $U=47.5$, $p<.05$). There was no significant difference in either seedling height or current year's sapling growth between the control and experimental plots.

Table V-1. Mesquite shoot growth in 1984 and 1983 at Unkar Canyon. Mean shoot growth between years is compared with a t-test, n=40. All measurements are in centimeters.

Site	Dendrometer Number	DRC	Ht.	Canopy max/min	Mean Shoot Growth 1984	1983
River	80484-11	34.1	314	625/573	29.98	29.50
	80484-12	12.1	226	320/320	17.38	28.40***
	80484-13	10.7	244	488/488	39.38	35.20
	80484-14	14.7	171	387/341	17.00	29.90***
	80484-15	18.5	360	655/518	17.32	26.28**
	80484-16	61.0	533	631/442	26.58	20.52**
	Grand Mean				24.65	28.36***
Tributary	80484-1	17.1	259	387/259	31.55	26.50
	80484-2	8.9	198	320/244	19.68	16.82
	80484-3	34.3	274	299/204	21.95	22.42
	80484-4	34.7	411	731/1189	30.35	29.32
	80484-5	11.2	381	427/320	24.02	22.65
	80484-6	4.5	335	457/427	30.98	35.02
	Grand Mean				26.47	25.51

** t>2.70 p<.01 *** t>3.55 p<.001

Table V-2. Mesquite shoot growth for 1984 and 1983 at Granite Park. Mean shoot growth between years is compared with a t-test, n=40. All measurements are in centimeters.

Site	Dendrometer Number	DRC	Ht.	Canopy max/min	Mean Shoot Growth 1984	1983
River	81184-1	18.8	265	518/488	20.05	25.22
	81184-2	16.5	229	335/274	10.95	28.35***
	81184-3	13.6	302	430/311	18.90	29.38***
	81184-4	19.6	347	549/442	25.60	28.30
	81184-5	14.2	271	296/265	13.85	28.38***
	81184-6	23.6	347	762/552	24.58	38.10**
	Grand Mean				18.99	29.63***
Tributary	81184-1	16.0	427	628/616	28.27	19.25***
	81184-2	25.9	268	634/442	28.15	18.35***
	81184-3	29.2	238	1052/533	17.00	16.82
	81184-4	6.1	177	335/280	19.92	22.45
	81184-5	25.7	390	671/579	44.42	29.35**
	81184-6	34.0	585	905/774	24.48	14.32***
	Grand Mean				27.05	20.10***

** $t>2.70$ $p<.01$ *** $t>3.55$ $p<.001$

Table V-3. Mesquite shoot growth for 1984 and 1983 at Nanokoweap Canyon. Mean shoot growth between years is compared with a t-test, n=40. All measurements are in centimeters.

Site	Dendrometer Number	DRC	Ht.	Canopy max/min	Mean Shoot Growth 1984	1983
River	80384-1	13.9	207	661/427	19.50	27.90**
	80384-2	10.9	204	271/207	21.38	26.70*
	80384-3	6.8	113	238/232	19.98	16.87
	80384-4	31.3	411	549/427	24.85	24.85
	80384-5	2.8	76	177/162	16.60	20.08
	80384-6	26.7	472	994/896	23.48	17.28*
	80384-8	1.3	122	290/198	19.55	21.08
	80384-9	37.4	305	640/518	25.35	20.38*
	80384-10	3.2	168	238/149	21.55	25.10
	80384-11	31.2	405	1152/887	24.30	23.28
	80381-0	--	122	2300/900	24.42	30.72*
	Grand Mean				21.63	23.12
Tributary	80284-1	13.7	192	375/378	22.70	19.98
	80284-2	13.6	177	424/326	16.75	17.08
	80284-3	--	216	402/360	23.68	24.45
	80284-3a	54.1	366	579/488	28.38	26.62
	80284-6	29.3	427	731/594	20.90	21.35
	80284-0	32.4	215	1097/427	25.00	28.10
	Grand Mean				22.90	22.93

* $t>2.02$ $p<.05$ ** $t>2.70$ $p<.01$

DRC = Diameter at the root crown (basal diameter)

Table V-4. Acacia shoot growth in 1984 and 1983 at National Canyon. Mean shoot growth between years is compared with a t-test, n=40. All measurements are in centimeters.

Site	Dendrometer Number	DRC	Ht.	Canopy max/min	Mean Shoot Growth 1984	1983
River	80984-1	6.3	335	268/256	15.80	24.65
	80984-2	2.0	165	88/82	4.37	6.09*
	80984-3	--	305	509/366	10.15	10.88
	80984-4	6.5	265	222/204	25.75	35.35
	80984-5	14.4	344	427/296	19.58	18.95
	80984-6	8.7	274	293/277	22.32	24.32
	80984-7	13.0	460	655/564	11.80	24.10***
	80984-8	4.0	329	290/238	12.40	11.00
	80984-9	6.7	311	247/238	13.22	16.52
	80984-10	7.8	460	329/299	10.10	15.94***
	80984-11	10.1	369	378/375	10.82	18.15**
	80984-12	7.5	366	372/347	9.8	12.47
	80984-13	11.2	323	408/329	10.42	15.25*
	80984-14	9.8	390	354/241	13.85	20.08*
	Grand Mean				13.60	18.12***
Tributary	80984-1	15.7	390	549/436	19.98	23.40
	80984-2	36.1	664	786/692	11.62	22.97***
	80984-3	6.1	347	335/250	14.42	18.22
	80984-4	14.5	341	457/415	10.50	11.60
	80984-5	3.5	143	198/128	6.85	14.70***
	80984-6	28.1	475	884/686	14.95	16.90
	80984-7	5.6	244	375/320	15.80	19.40
	80984-8	2.1	258	143/137	17.60	31.85**
	80984-9	16.1	442	747/744	14.05	18.48*
	80984-10	7.3	378	375/302	11.20	15.02*
	80984-11	7.7	357	442/317	11.70	14.15
	80984-12	8.7	454	335/424	13.38	16.28
	80984-13	18.8	427	457/418	17.70	17.25
	80984-14	20.1	341	625/442	23.88	21.52
	Grand Mean				14.54	18.70***

* $t>2.02$ $p<.05$ ** $t>2.70$ $p<.01$ *** $t>3.55$ $p<.001$

Table V-5. Mesquite shoot growth for two years in Grand Canyon National park. All measurements are in cm with 15 samples per tree.

Site	Riparian DRC	Riparian $\bar{X}$ Shoot Growth 84	Riparian $\bar{X}$ Shoot Growth 83	Riparian t	Non-riparian DRC	Non-riparian $\bar{X}$ Shoot Growth 84	Non-riparian $\bar{X}$ Shoot Growth 83	Non-riparian t
Parashant	10	24.9	32.2	-2.1	13	29.8	14.1	7.1
	<2,<2	27.1	63.8	-5.1	6	21.4	18.7	1.1
	5,5,5	29.7	27.6	0.6	14,14	21.8	25.9	-1.5
	15	30.8	32.1	-0.3	16	16.8	26.5	-3.3
Granite	22	27.5	40.2	-3.4	30	21.5	20.6	0.4
Park	10,15,15 16,17	20.9	28.4	-2.7	13	17.7	20.9	-1.4
	5	37.9	68.7	-4.3	7.5	13.1	20.4	-1.8
	2,2,3	33.3	72.5	-4.6	19	42.6	28.0	4.4
Overall Mean		29.0	45.7			23.1	21.9	

$p<.05$, $t=1.7$ $p<.001$, $t=3.4$ $df=28$

Table 6. Acacia shoot growth for two years at Grand Canyon National Park. All measurements in cm, 15 samples per tree.

Site	Riparian DRC	Riparian $\bar{X}$ Shoot Growth 84	Riparian $\bar{X}$ Shoot Growth 83	Riparian t	Non-riparian DRC	Non-riparian $\bar{X}$ Shoot Growth 84	Non-riparian $\bar{X}$ Shoot Growth 83	Non-riparian t
National	10	15.3	33.8	-2.6	10	27.8	24.3	0.8
	18	11.0	12.7	-1.0	20	13.6	8.1	3.5
	7	24.2	31.9	-1.0	3	14.7	12.5	0.9
	3.5	8.3	7.4	0.5	16	12.3	13.1	-0.4
Parashant	8	24.6	33.5	-1.5				
	4	23.0	24.4	-0.3				
Granite Park	15,7	16.3	37.4	-5.5				
	2	14.1	13.2	0.4				
Overall Mean		17.1	24.3			17.1	14.5	

$p<.05$, $t=1.7$ $p<.001$, $t=3.4$ df=28

Shoot growth of acacia and mesquite was higher in 1983 than in the present year in the OHWL. In adjacent tributaries there was no significant difference in 1983 and 1984 growth of mesquite and acacia shoots.

Figure V-1.
GRAND CANYON OHWL VEGETATION ANALYSIS - GROWTH

Species: Mesquite [] Acacia [] Dendrometer #________

Location (site):

Observers:________________ Date:________________

Physical features: River [] Tributary []

Exposure ____________ Slope ___________

Distance from river ________ Wash _________

Height above river ________ Wash _________

Substrate: Talus [] Silty alluvium [] Cobbles []

Tree Characteristics:

Height (m) _________

Canopy Diameter (m) max__________ min___________

Stem Basal Diameter (cm) _____ _____ _____ _____ _____

Single Stem Equiv. (cm) _________

Mistletoe (proportion of canopy vol.) _________
(1=0-5%, 2=5-15%, 3=15-30%, 4=30-50%, 5=>50%)

Dead Canopy (%) ________ Number of pods _________

Shoot Growth (cm): Still growing [] Growth finished []

Current Year		Previous Year	
North	South	North	South
1	11	1	11
2	12	2	12
3	13	3	13
4	14	4	14
5	15	5	15
East	West	East	West
6	16	6	16
7	17	7	17
8	18	8	18
9	19	9	19
10	20	10	20

Notes:

Figure V-2.

GRAND CANYON OHWL VEGETATION ANALYSIS - GERMINATION/SURVIVAL

Site: Riv. [ ] Trib. [ ]

Observers:____________________ Date:______________

Transect Location:

____

Transect #__________ Open = (o) Canopy = (c)

Acacia			Mesquite		
Current Year	Previous Year	Tag #	Current Year	Previous Year	Tag #

Transect #__________

Notes:

CHAPTER VI

FURTHER INVESTIGATIONS ON POGONOMYRMEX ANTS ON COLORADO BEACHES IN GRAND CANYON

Wanda Wynne

INTRODUCTION

This study, a continuation of the 1982 and 1983 studies undertaken as part of the Northern Arizona University Colorado River Investigations, sought to determine if densities of harvester ants on selected Grand Canyon beaches could be correlated to human use. The 1982 study provided baseline data for conditions before the 1983 flood. The 1983 study was conducted while water levels were still high, approximately 44,000 cfs to 37,000 cfs. The campsites were partially submerged, and sampling sites were not identical to those sampled the previous year. In this study, conducted in August, 1984, river flows had returned to pre-flood levels, 28,000 cfs to 25,000 cfs, and the research group could return to many of the originally sampled sites as well as to many new ones. The data collected in this study reflects post-flooding conditions with beaches cleansed of human debris.

As in 1983, the investigation was conducted in two parts. In the first, harvester ant nest densities were determined for selected campsites along the river. In the second part, harvester ants were observed to determine if there was a correlation between the kinds of food particles chosen by foraging ants and the degree of human use of an area.

METHODS

1. Twenty beach campsites with varying levels of known human use were selected. Seven of these had been tested in 1982 before the flood. Nineteen of them had been visited in 1983, but the test sites were not identical due to high water levels.

2. A 40 meter transect line was run across the principal use area of each beach. The same transect was used for the human impact study (see chapter VII). The number of harvester ant hills within 50 feet of the line were then counted and recorded for each of the 20 study beaches. The numbers were transformed into nests per 100 m^2.

3. In the second part of the study, the frequency with which various food items were taken by foraging ants was noted by direct observation. Each study beach was divided into three test areas: a) on or within 10 feet of a heavily used campsite, b) 10 to 50 feet from the campsite, and c) more than fifty feet from the campsite. As many nests as possible were observed in each test area, and as many foraging ants as possible were observed from each nest. The numbers ranged from 14 to 59 ants per nest.

4. Foraged items were then counted, identified, and assigned to one of five categories: seeds, plant parts, insect parts, human food debris, and sand grains (grease covered from human waste). In some cases it was difficult to identify the materials carried

by the ants.

RESULTS

Nineteen of the twenty campsites were free of harvester ant nests. Ants were observed coming down to forage from colonies which were at or above the old high water level, but at only one site, Trail Canyon at mile 219, was there a new colony on a camping beach. Several food scraps had been left on the beach at that site, and the harvester ants appeared to be establishing a new colony near the source of food.

At Unkar beach harvester ants were observed moving down toward the camping beach carrying their larvae. The old colony appeared to have been partly destroyed by a recent flash flood.

The almost total absence of ants from the beaches is a radical departure from observations and studies of previous years. For purposes of comparison, the numbers obtained were transformed into ant hills/m^2.

For each of the campsites sampled the density of harvester ant nests was much lower in 1984 after the flood than it was before. As in the previous two studies, ant densities for each campsite are shown with the known human use level (low, medium, high, continuous) to determine if a correlation exists (see Table VI-1). Because almost no ants were found on any of the beaches, no correlation to human use can be shown, other than the fact that the one ant nest observed was centered on human waste.

The results obtained in the second part of the study are reported in Table VI-2. Because of the small number of nests within 50 feet of any campsite (a total of one), no significant comparison can be made of the frequencies of human food particles collected by foraging ants relative to their distance from a campsite.

CONCLUSIONS

The marked absence of harvester ants from the study campsites is attributed to the high river levels in 1983, which completely inundated the beaches, washing them free of ants and relatively free of human debris. It will be interesting to see if, in the years to come, the harvester ants return to the beaches and in what numbers. If the water level remains consistently below 30,000 cfs, it is predicted that the harvester ants will return to colonize the campsites.

LITERATURE CITED

Byars, Betty. 1983. "Further investigations on Pogonomyrmex ants on Colorado River beaches in Grand Canyon." In Colorado River investigations II, edited by S. S. Beus and S. W. Carothers. Northern Arizona University manuscript report submitted to Grand Canyon National Park. p.133-142.

Table VI-1. Harvester ant densities (nests/100 m^2) and patterns of human use on selected Colorado River beaches in the Grand Canyon.

River Mile	Beach	Nests/100 m^2 1982	1983	1984	Human Use
8	Badger Creek		3.00	0.00	high
34.7	Nautiloid		3.00	0.00	high
43.5	Anasazi Bridge	0.00	3.00	0.00	high
53	Lower Nankoweap	1.10	3.00	0.00	high
58.2	Awatubi		2.00	0.00	high
60.5	Upper LCR		4.00	0.00	continous
65.5	Lava Canyon (Chuar)		3.00	0.00	medium
72.2	Unkar		3.00	0.00	high
75.5	Nevills Rapid		2.00	0.00	high
81.1	Grapevine		2.00	0.00	high
108.5	Lower Bass Camp	0.00	3.00	0.00	high
120.1	Blacktail Canyon	0.49	2.00	0.00	medium
122.8	Forster		3.00	0.00	low
124.4	124.5 Mile		5.00	0.00	low
131	Bedrock		1.00	0.00	low
179	Upper Lava Falls	0.00	1.00	0.00	medium
180.9	Lower Lava Falls		2.00	0.00	medium
208.5	Granite Park	0.67	2.00	0.00	medium
219	Trail Canyon	0.67	-	.17	?
220	220 Mile		4.00	0.00	high

Table VI-2. The relative frequency of food items collected by foraging harvester ants in relation to distance from heavily used campsites on Colorado River beaches in Grand Canyon.

Food Categories	Test Area 1 1983 (n=7)	Test Area 1 1984 (n=1)	Test Area 2 1983 (n=15)	Test Area 2 1984 (n=0)	Test Area 3 1983 (n=5)	Test Area 3 1984 (n=9)
Seeds	58(33%)		203(54%)	0	82(66%)	8 (3%)
Plant parts	14 (8%)		88(24%)	0	34(27%)	136(55%)
Insect parts	10 (6%)		60(16%)	0	7 (6%)	60(24%)
Human food	32(18%)	17(82%)	6 (2%)	0	0 (0%)	2(.8%)
Greasy sand	62(35%)	4(18%)	17 (5%)	0	2 (2%)	40(16%)
Total	176(100%)	21(100%)	374(100%)	0	125(100%)	246(100%)
Total % Human food plus sand	53%	100%	25%	0	2%	16.8%

Test Areas:

1. On or within 10 ft. of a heavily used campsite.
2. 10-50 feet of a heavily used campsite.
3. More than 50 feet from a heavily used beach.

CHAPTER VII

HUMAN IMPACT ON THE BEACHES OF THE COLORADO RIVER

Steven W. Carothers and Darlyne Penner

INTRODUCTION

Within the past 20 years two major and distinctly interrelated natural resource management problems have arisen along the river corridor of the Colorado River in Grand Canyon National Park. Specifically, the problems relate to: 1) the extensive environmental changes that have taken place in the hydrological characteristics of the river as a result of Glen Canyon Dam, and 2) the dramatic increase in recreational use of the systems by river runners.

Although located 15 miles upstream of the national park boundary, Glen Canyon Dam changed the very nature of the Colorado River in Grand Canyon almost as soon as construction began in the mid 1950s. Post-dam changes in water flow, temperature, and sediment discharge have all combined, often synergistically, to alter the Grand Canyon river ecosystem. On one side of Glen Canyon Dam, the wildly variable and raging Colorado River has been buried beneath the deep waters of Lake Powell; on the other side, the river we still call the Colorado is now released through turbines and gates as a predictable, computer-regulated, icy cold, sediment-free, and partially tamed river. To further complicate the matter, the "new" dam-controlled Colorado River in Grand Canyon has recently proven to be one of the most popular white-water recreation areas in the world, with a strict National Park Service permit system regulating and allocating both private and commercial use of the 225 miles of Colorado River from Lees Ferry to Diamond Creek (NPS 1981). The high waters and ensuing floods of 1983 unexpectedly disrupted the stabilizing patterns of water flow established during the past 20 years.

Given the above considerations, the present challenges to developing an adequate system for resources management along the river corridor of Grand Canyon National Park include: a) determining the eventual ecological "steady state" of the dam-altered river in terms of sediment erosion and deposition, vegetation and animal community composition, and overall ecosystem stability; b) determining and evaluating the impacts of river recreationists on the changing aquatic and terrestrial systems; and c) mitigating such recreational impacts to the extent that natural park values are not compromised.

As mandated by "The Planning Process of the National Park Service" in 1975, a Colorado River Management Plan (NPS 1981) was drafted to guide short- and long-term management of the riverine and riparian areas of Grand Canyon National Park. Subsequently, a monitoring program was inititated to analyze and quantify human impacts and to determine how changes in management policies influence present resource trends. This monitoring program was designed to gather baseline data and show the impact(adverse and otherwise) of visitor numbers and use patterns on the riparian environment.

Heavy recreational use in other parks has caused changes in plant species composition and vegetation density and diversity (Burden and Randerson 1972; Whitson 1974; Dolan et al. 1974; Bates 1935; Dotzenko et al. 1967; LaPage 1967; Liddle 1975; Greig-Smith 1975; Young and Gilmore 1976). Preliminary data from Grand Canyon (Carothers and Aitchison 1976) indicated that similar changes or impacts were taking place on the principal 100 plus campsites (Borden 1976) of the river corridor. All of these campsites are on alluvial terraces (sand and silt/sand composition) that were deposited during pre-dam flood discharges. In the 20 years prior to 1983, vegetation previously scoured from the beaches on an annual basis proliferated, while human related debris incorporated into beach sands during normal camping activities accumulated. With no natural purging of recreation related debris (organic as well as inorganic) there existed the potential for popular beaches to fill "cat box style" with any number of forms of human waste products. Additional problems of a similar vein have recently been observed in backcountry campsites where recreational use is clearly in excess of the natural purging capacity of the system.

The 1983 floods cleaned the beaches, resorted the sand, and gave the system a fresh start. Along with this cleansing, new beaches formed and others disappeared. The 1983 study established important baseline data for future investigations.

Early in 1976, approximately 25 Colorado River campsites in Grand Canyon were selected for the purpose of monitoring levels of recreational impact (see Carothers 1977). In 1980-81, nine additional beaches in the 15 miles of Glen Canyon below Glen Canyon Dam were evaluated for levels of human impact (Carothers et al. 1981). Since 1976, the original Grand Canyon sites have been monitored and re-evaluated several times (Carothers and Johnson 1980). In 1982, human impact data for 35 beach sites in Glen and Grand Canyons were presented and compared with the results of previous sampling efforts.

In 1983, human impact data for 22 Grand Canyon beach sites, including 17 of the beaches evaluated in 1982 and 5 new beaches, were compared to the 1982 data. Eleven of the original beaches were no longer comparable in 1983 and were dropped from the study. This report presents human impact data for 29 Grand Canyon beach sites. Two previously studied beaches were not included, however, seven new beaches were added.

OBJECTIVES

The objectives of this study in 1984 were to establish baseline data on the beaches that were cleansed and resorted in 1983 and to compare data from 1982-1984 to determine the human impact on the beaches of the Colorado River.

METHODS

1. A 40 meter transect line was established through the principal use area of the beach. The first choice was to use the exact same line as in the previous years. If the beach was altered so much by the floodwaters as to change patterns of use, a new transect line was established. At several sites, the

transect was taken in two sections. This is documented.

2. Black and white photographs of the transect, including the metric tape and river mile marker, were taken from each direction. It was found that the mile number for the inclusion in the photograph of the transect could be written on the back of the data sheet with a wide-tipped permanent marker. Pencil was used for recording data. The sheet with the mile number was clipped to a clipboard and either held by a person or positioned in the sand for the photographs.

3. Ten $1m^2$ plots were selected along each transect line.

4. Each m^2 sample was inspected for human litter and charcoal, and sand samples from the surface were taken.

5. In addition, a sample from the beach at the sand and water interface and a sample from the terrace were taken.

6. Each sand sample was sifted through a 150 micron stainless steel mesh apparatus until the amount of sifted material completely covered the bottom.

7. A piece of No. 7 course grade filter paper was placed in the lid, hatched side up, and the sifted material shaken against the filter paper 75 times.

8. The filter paper was removed and stored in a labelled petri dish.

9. When all of the samples from a transect were shaken, the

discoloration on the filter paper was evaluated with a Colorguard II Reflectometer and recorded on a data sheet (Figure VII-1).

10. The Colorguard II Reflectometer is an instrument operating with an optical system, photocell amplifier, digital readout and portable power system, and is used to make reflective measurements. Hence, with a digital readout display, reflected light can be measured from any source. The reflectometer was used to obtain reflective values from the filter paper discs which were discolored with filtrate from the sand samples. The reflectometer was standardized prior to each series of readings against a white standard and a grey standard to calibrate the instrument.

11. Means and standard deviation of the reflectometer readings from the ten samples along with each transect were calculated. These were statistically analyzed and compared with the 1983 data and subjected to a small sample t test for level of significance to determine if a significant difference in the 1983-1984 data existed.

EXCEPTIONS TO THE PROCEDURE

1. Mile 20 was taken on a 32 meter transect instead of the usual 40 meters.
2. Mile 29 was taken on a 36 meter transect.
3. Mile 43.5 Azimuth reading is 309 degrees from the tamarisk tree.
4. Mile 59 ran a new transect through the use area and reading 10 was taken at 36-37 meters.
5. Mile 72 was taken on a 33 meter transect and was a new beach. The beach is the first one upstream.
6. Mile 75 had a high beach downstream, and the beach did not

have much sand. Reading 7 was completely black on the surface.

7. Mile 93 was taken on a 21 meter transect.

8. Mile 108 was taken on a 29 meter transect.

9. Mile 114 was taken at the regular readings until reading 10 and it was taken at 36-37 meters.

10. Mile 122 was taken at the regular reading until readings 8 and 9. They were taken at 30-31 and 33-34 respectively.

11. Mile 131 was taken on a 31 meter transect.

12. Mile 132 was taken on a 34 meter transect.

13. Mile 209 was taken in two sections. The lower beach was the kitchen area. Numbers 1-5 were taken in a 20 meter transect. The upper beach was used for numbers 6-10. It was also a 20 meter transect.

14. Mile 219 was taken on a 31 meter transect.

RESULTS

The 1984 findings of sand discoloration as measured by reflectometer reading are presented in Table VII-1. Charcoal and human debris accumulations are presented in Table VII-2. These data are given with equivalent figures from 1982 and 1983. Graphs are also provided to more easily show the relationship of human impact over the last three years (Figs. VII-1 through VII-4).

In the comparison of 1982-1983 data, it was concluded that new baseline data had been established. The results from the cleansed and resorted sand of 1983 are now compared to the 1984 data to determine if degradation caused by human impact has taken place. A pattern exists from 1982, when the beaches showed marked discoloration and debris accumulation, to 1983 after the floods had cleaned the beaches, and now to the 1984 data, which show in general a slight decrease in cleanliness from the previous year (see Table VII-2).

The presence of charcoal was slightly higher than in 1983, but does not begin to compare to the presence exhibited in 1982 (Fig. VII-2). Human litter was also slightly more noticeable than in 1983, but in only one case did it match that found in 1982 (Fig. VII-3). Sand discoloration as measured by the reflectometer shows that there is still great improvement over readings from 1982. In most cases the beaches did not read to be as clean as in 1983, but there were a few that did (Fig. VII-4 and VII-5). The 11 beaches that showed a significant difference in sand discoloration between 1983 and 1984, according to a sample t test for level of significance, are listed in Table VII-3. The beaches that showed no significant difference are listed as well. It must be considered that the presence of silt, clay or natural organic material may also be a natural source of sand discoloration.

CONCLUSIONS

The results of the 1984 study show that there is human impact-causing degradation of the beaches of the Grand Canyon. Time and further research will indicate how rapidly we return to the conditions of 1982. It seems that periodic flooding may contribute to the cleanliness of the beaches.

Table VII-1. Results of human impact (sand discoloration) analysis of beach campsites in Grand Canyon, 1982-1984 (means only).

Campsite Number	Campsite Name	River Mile	Sand Discoloration (Standard Deviation) 1982	1983 (S.D.)	1984 (S.D.)
1	Badger Creek	8.0	64.6	71.65 (1.65)	69.69 (2.52)
2	20 Mile	19.3	58.8	66.74 (3.53)	68.78 (3.14)
3	Shinumo Wash	29.0	62.9	70.01 (3.00)	69.10 (3.16)
4	Anasazi Bridge	43.5	64.8	73.28 (1.24)	70.55 (1.83)
5	Lower Nankoweap	53.0	59.5	73.21 (2.33)	64.91 (3.16)
6	Awatubi	58.2		72.40 (1.34)	64.48 (5.73)
7	Lava Canyon (Chuar 3)	65.5	57.5	70.66 (0.83)	65.91 (4.05)
8	Unkar	72.2	64.3	68.93 (2.67)	67.70 (2.28)
9	Nevills Rapid	75.5	66.9	72.00 (1.91)	66.80 (4.87)
10	Hance Rapid	76.5			66.87 (5.14)
11	Grapevine	81.1		71.91 (1.43)	67.62 (2.18)
12	Granite Rapid (Granite 4)	93.2	58.0	68.20 (2.49)	68.48 (3.28)
13	Lower Bass Camp	108.5	59.0	66.53 (2.39)	63.38 (5.69)
14	114 Mile	114.0			69.22 (2.06)
15	122 Mile	122.0			71.16 (2.15)
16	Forster	122.8		70.04 (3.05)	68.65 (5.16)
17	Bedrock	131.0			70.54 (3.40)
18	Dubendorff	132.0	64.4	69.12 (3.36)	70.22 (2.51)
19	Deer Creek	136.0	62.0	67.82 (2.03)	
20	Pancho's Kitchen	137.0	62.3	65.91 (3.11)	65.90 (3.79)
21	National Canyon (Upper)	166.0	59.2	71.22 (0.96)	68.95 (3.00)
22	National Canyon (Lower) (USGS Site)	166.0		69.39 (2.73)	63.59 (3.00)
23	Upper Lava Falls	179.0	60.8	69.39 (2.60)	
24	186 Mile	186.0			72.06 (1.50)
25	Parashant	198.5			63.94 (4.77)
26	Granite Park	208.5	60.4	69.70 (3.78)	68.93 (2.17)
27	Pumpkin Bowl	212.0		73.66 (0.94)	70.83 (1.75)
28	Trail Canyon	219.0			72.18 (1.45)
29	220 Mile	220.0	62.3	67.50 (2.61)	67.71 ( )

Table VII-2. Results of human impact (charcoal and human litter accumulations) analysis of beach campsites in Grand Canyon 1982-1984 (means only).

Campsite Number	Campsite Name	River Mile	Charcoal cm/m^2 1982	1983	1984	Human Litter m^2 1982	1983	1984
1	Badger Creek	8.0	10.7	0.8	2.5	0.4	0.1	0.2
2	20 Mile	19.3	1.0	0.1	0.0	0.5	0.0	0.0
3	Shinumo Wash	29.0	1.0	0.0	0.0	0.5	0.0	0.1
4	Anasazi Bridge	43.5	0.2	0.0	0.0	0.1	0.0	0.0
5	Lower Nankoweap	53.0	9.0	0.0	0.2	0.0	0.0	0.4
6	Awatubi	58.2		0.0	0.0		0.0	0.0
7	Lava Canyon (Chuar 3)	65.5	1.1	0.1	1.6	0.4	0.0	0.3
8	Unkar	72.2	1.9	0.0	0.2	0.1	0.0	0.1
9	Nevills Rapid	75.5	0.7	0.0	0.3	0.2	0.0	0.0
10	Hance Rapid	76.5			0.2			0.0
11	Grapevine	81.1		0.0	0.0		0.0	0.0
12	Granite Rapid (Granite 4)	93.2	3.0	0.0	0.0	0.2	0.1	0.0
13	Lower Bass Camp	108.5	3.6	0.0	1.5	1.2	0.1	2.2
14	114 Mile	114.0			0.2			0.1
15	122 Mile	122.0			0.0			0.3
16	Forster	122.8		0.0	0.0		0.0	0.0
17	Bedrock	131.0			0.0			0.1
18	Dubendorff	132.0	1.2	0.0	0.0	0.3	0.0	0.0
19	Deer Creek	136.0	4.7	0.2		2.5	0.1	
20	Pancho´s Kitchen	137.0	1.6	0.0	0.0	1.3	0.0	0.4
21	National Canyon (Upper)	166.0	0.8	0.0	0.0	5.6	0.0	0.2
22	National Canyon (Lower) (USGS Site)	166.0		0.0	0.0		0.0	0.0
23	Upper Lava Falls	179.0	2.6	0.0		0.2	0.0	
24	186 Mile	186.0			0.2			0.0
25	Parashant	198.5			0.0			0.2
26	Granite Park	208.5	7.7	0.0	0.1	0.3	0.0	0.1
27	Pumpkin Bowl	212.0		0.0	0.0		0.0	0.1
28	Trail Canyon	219.0			0.1			0.0
29	220 Mile	220.0	13.8	0.0	0.4	0.4	0.0	0.2

Table VII-3. t test for level of significance of differences between 1983 and 1984 sand discoloration measurements for Grand Canyon beaches.

Campsite Number	Campsite Name	t Value	t test	Significant Difference?
1	Badger Creek	t= 2.279	2.279>2.201	Yes
2	20 Mile	t=-1.5	-1.500<2.201	?
3	Shinumo Wash	t= 0.728	0.728<2.201	No
4	Anasazi Bridge	t= 4.285	4.285>2.201	Yes
5	Lower Nankoweap	t= 6.220	6.220>2.201	Yes
6	Awatubi	t= 4.660	4.660>2.201	Yes
7	Lava Canyon (Chuar 3)	t= 3.980	3.980>2.201	Yes
8	Unkar	t= 1.869	1.869<2.201	No
9	Nevills Rapid	t= 3.701	3.701>2.201	Yes
10	Hance Rapid	no data		
11	Grapevine	t= 5.704	5.704.2.201	Yes
12	Granite Rapid (Granite 4)	t=-0.235	-0.235<2.201	?
13	Lower Bass Camp	t= 1.768	1.768<2.201	No
14	114 Mile	no data		
15	122 Mile	no data		
16	Forster	t= 0.803	0.803<2.201	No
17	Bedrock	no data		
18	Dubendorff	t=-0.909	-0.909<2.201	?
19	Deer Creek	no data		
20	Pancho's Kitchen	t= 0.007	0.007<2.201	Yes
21	National Canyon (Upper)	t= 2.497	2.497<2.201	Yes
22	National Canyon (Lower)	t= 4.957	4.957>2.201	Yes
23	Upper Lava Falls	no data		
24	186 Mile	no data		
25	Parashant	no data		
26	Granite Park	t= 0.612	0.612<2.201	No
27	Pumpkin Bowl	t= 4.947	4.947>2.201	Yes
28	Trail Canyon	no data		
29	220 Mile	t=-0.166	-0.166<2.201	?

Figure VII-1. CHARCOAL ($1\ cm/m^2$) FOUND ON BEACH CAMPSITES (1982-1984)

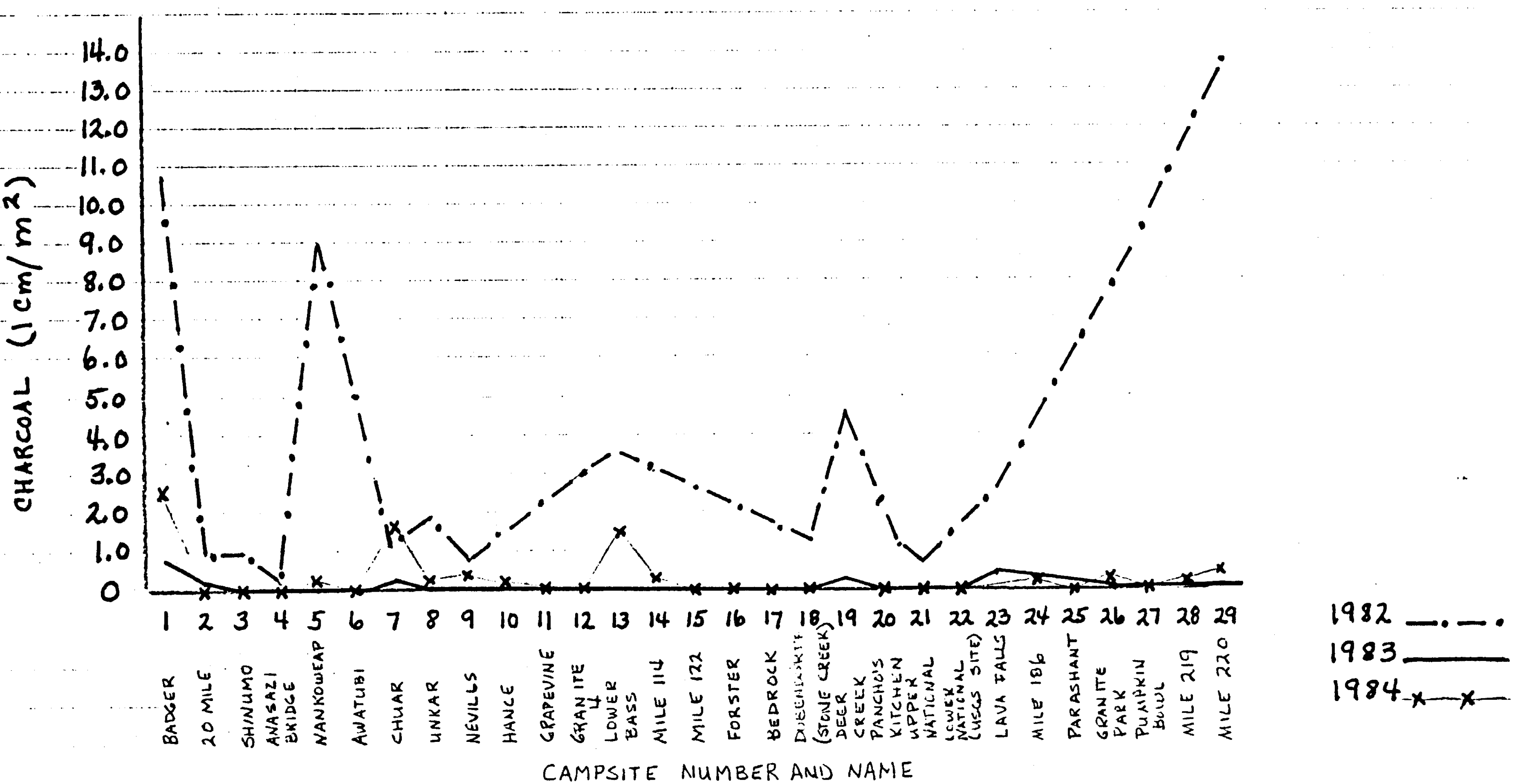


Figure VII-2. HUMAN LITTER (m^2) FOUND ON BEACH CAMPSITES (1982-1984)

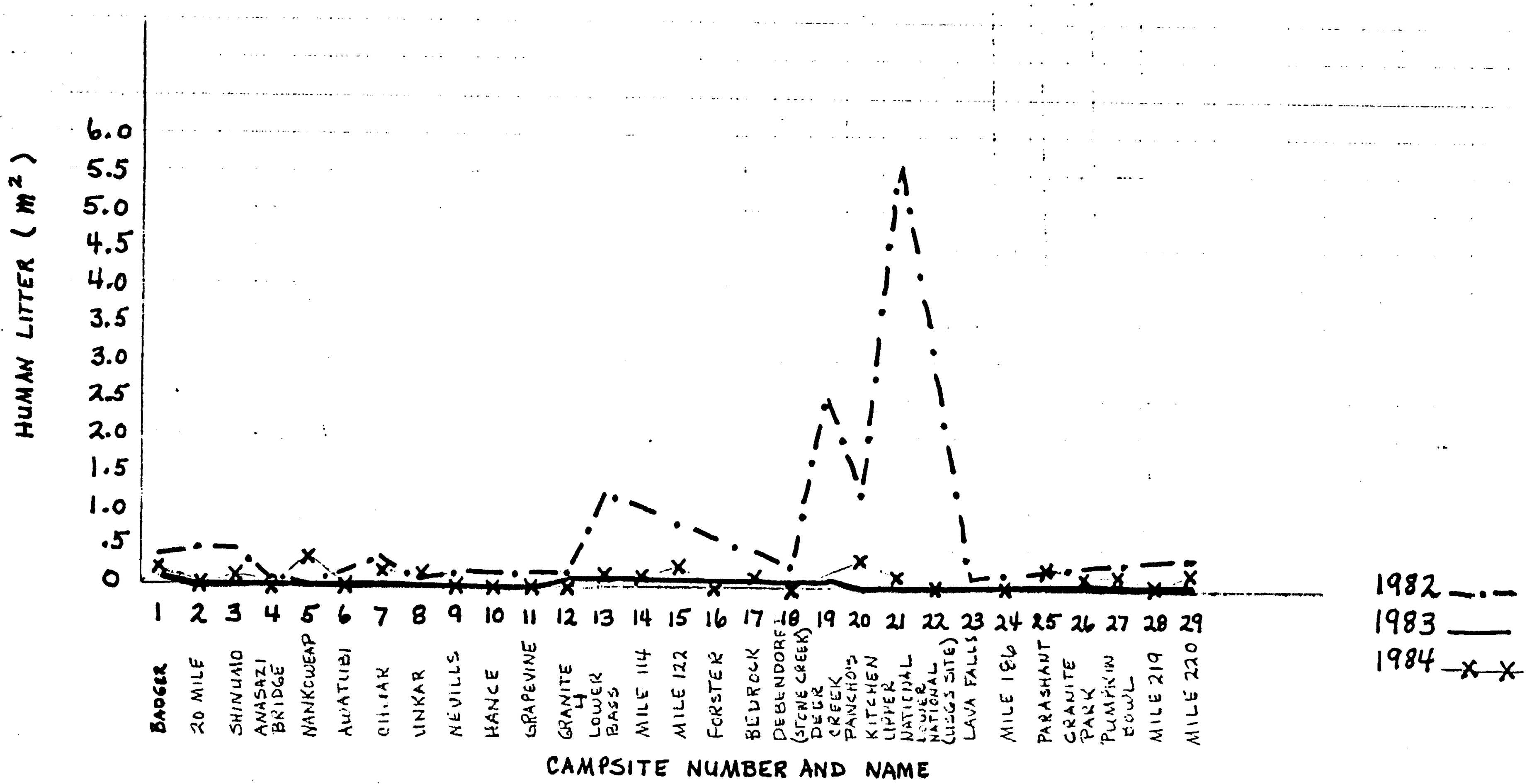


Figure VII-3. TREND IN SAND DISCOLORATION DUE TO HUMAN IMPACT 1982-1984

(HIGH REFLECTOMETER READINGS INDICATE CLEANER SAND)

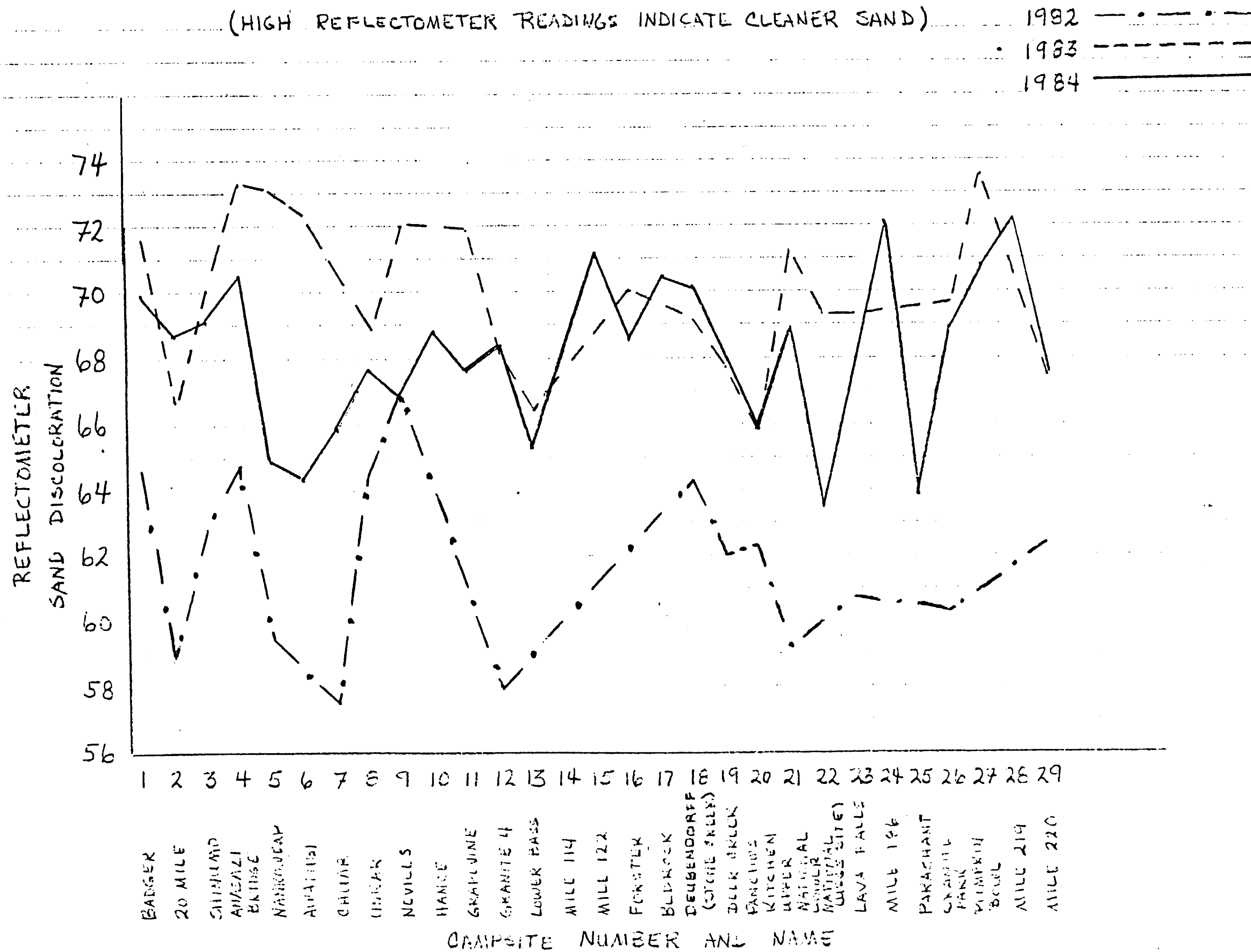
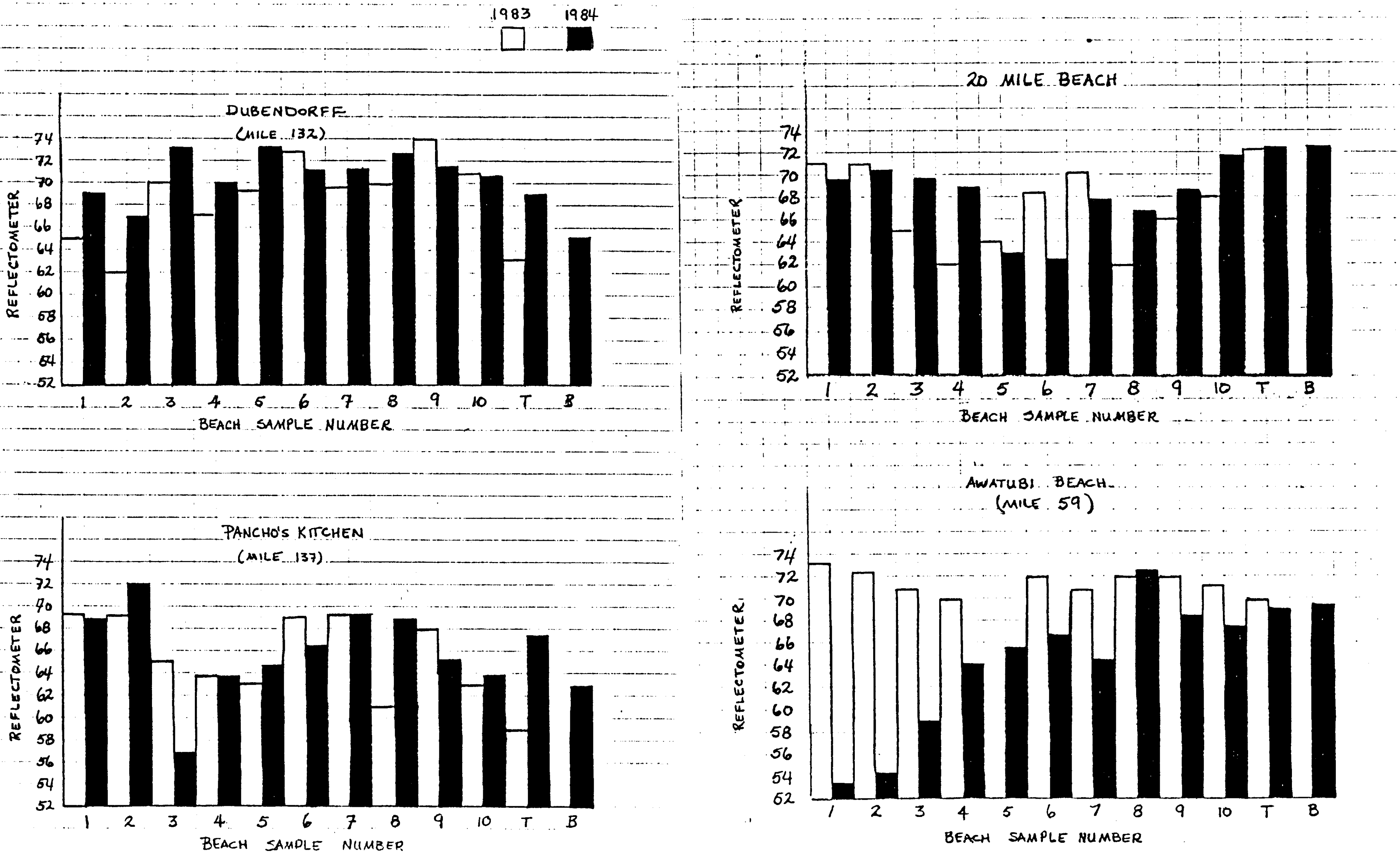


Figure VII-4.
VARIATIONS IN REFLECTOMETER VALUES AT FOUR SITES
1983 - 1984
(HIGH REFLECTOMETER READINGS INDICATE CLEANER SAND)



CHAPTER VIII

. RIVER EXPEDITION REPORT: SOCIOLOGICAL DATA
SUMMER, 1984

Wanda Wynne

INTRODUCTION

This report summarizes field notes compiled during the river expedition, including details on daily river contacts with other river parties, camp contacts, and aircraft encounters. The oar boats did not stop at all the locations due to the pressure of time. The fishing boat stopped at various spots in the river to do electrofishing; these are not recorded here.

This research project involved students and faculty from Northern Arizona University. It also included biologists from the Arizona Game and Fish Department, the U.S. Bureau of Reclamation, and the U.S. Park Service. We were joined for part of the trip by a reporter, Tony Davis, from the Tucson Citizen. Two electrofishing electronics experts also traveled with us to the Little Colorado River where they were taken out by helicopter.

SCHEDULE

A total of 48 stops were made (Table VIII-1), including one for repair, two at attraction points, one for rapids, and three for lunch. Thirty-eight stops for beach research were made. These stops are identified in the Trip Schedule as Beach Research

(BR). Phone calls were made from Phantom Ranch. At our last scheduled stop at Diamond Creek, we learned that rains had washed out the road, so we were forced to travel overnight to the take-out point in Lake Mead at Pierce's Ferry.

CONTACTS

Contacts with groups totaled 58. Ten of these were with private groups, and 48 with commercial groups. The largest number of contacts made on a single day was 14 made on day eight between river miles 122 and 166. The greatest number of contacts were made shore-to-river due to the large amount of time spent by the group doing beach research. Many of the contacts were made with a single commercial group of five oar-powered rafts. We saw them almost every day and camped with them two nights. Group contact data are reported in Table VIII-2.

AIRCRAFT

To be recorded, aircraft had to be both seen and heard. High-altitude commercial airliners and military aircraft were not counted. Since the observer traveled by motor-powered raft, it is possible some planes were missed. Most planes were observed on days six and seven. As in the 1983 study, days six and seven covered river miles 96.5 through 122, with a layover at 122. The total number of sightings by aircraft type are as follows:

Single Engine	Multi Engine	Helicopter	Total
78	35	18	126

Full data for aircraft sightings are recorded in Table VIII-3.

CAMPSITES

We camped alone eight nights, with a commercial group two nights (same group), and with a private party of kayakers one night. We camped across the river from a private group once.

AVERAGES

The average daily group contacts and aircraft sightings are presented in Table VIII-4. Group contacts averaged 5.3 per day, and aircraft encounters averaged 11.5 per day.

Table VIII-1. Trip schedule: 1 August - 11 August, 1984.

Stop Number	Location	River Mile	Arrive Time	Arrive Day	Depart Time	Depart Day	Reason For Stop
0	Lees Ferry	0	---	---	12:00	1	Start
1	Badger Creek	8	14:00	1	14:45	1	BR,L
2	18 Mile Wash	18.2	16:25	1	17:30	1	BR
3	20 Mile	19.3	17:54	1	18:00	1	BR
4	24 Mile	24	19:00	1	9:00	2	C
5	24.5 Mile	24.5	9:00	2	9:30	2	BR
6	26 Mile	26	10:00	2	10:30	2	Repair
7	Shinumo Wash	29	11:40	2	12:15	2	BR
8	Redwall Cavern	33.1	12:44	2	13:00	2	AP
9	Nautiloid	34.7	13:20	2	16:00	2	BR,L
10	Anasazi Bridge	43.5	17:15	2	17:25	2	BR
11	Lower Nankoweap	53	18:45	2	14:23	3	C,BR,L
12	Awatubi	58.2	15:05	3	16:00	3	BR
13	Upper Little Colorado River	60.5	16:35	3	8:50	4	C
14	Lower Little Colorado River	61.8	8:57	4	10:20	4	BR
15	Lava Canyon (Chuar)	65.5	11:00	4	12:30	4	BR
16	69 Mile	69	12:50	4	14:45	4	BR,L
17	Unkar	72.2	15:24	4	17:00	4	BR
18	Nevills Rapid	75.5	18:45	4	9:30	5	C,BR
19	Hance Rapid	76.5	9:45	4	10:22	5	BR,R
20	Grapevine	81.1	11:00	5	12:40	5	BR
21	Phantom Ranch	87.5	13:30	5	15:45	5	L
22	Granite Rapid	93.2	16:30	5	17:30	5	BR,R
23	Boucher Creek	96.5	19:00	5	9:30	6	C
24	Crystal Rapid	98.2	9:45	6	12:00	6	Rapids
25	104 Mile	104	12:45	6	14:30	6	L
26	Lower Bass Camp	108.5	15:23	6	16:20	6	BR
27	109 Mile	109.4	16:30	6	17:30	6	BR
28	Waltenberg	112.2	17:45	6	18:00	6	BR
29	114 Mile	114	18:30	6	19:00	6	BR
30	Blacktail	120.1	19:30	6	20:45	6	BR
31	122 Mile	122	21:30	6	6:23	8	C,BR
32	Forster	122.8	16:30	7	18:30	7	BR
33	124.5 Mile	124.4	6:40	8	9:15	8	BR
34	Bedrock	131	10:00	8	10:50	8	BR
35	Dubendorff	132	11:00	8	11:40	8	BR,AP
36	Pancho´s Kitchen	137	12:40	8	13:15	8	L,BR
37	Ledges	151	15:24	8	16:30	8	AP
38	Havasu Creek	156.9	17:00	8	17:30	8	AP
39	National Canyon	166	18:30	8	9:00	0	C,BR
40	Upper Lava Falls	179	12:30	10	14:10	10	BR,L
41	186 Mile	186	14:40	10	15:00	10	BR
42	190 Mile	190.2	15:30	10	16:26	10	BR

Table VIII-1 continued.

Stop Number	Location	River Mile	Arrive Time -	Day	Depart Time -	Day	Reason For Stop
43	Parashant	198.5	17:23	10	18:16	10	BR
44	Granite Park	208.5	19:45	10	10:00	11	C,BR
45	Pumpkin Bowl	212	10:40	11	10:50	11	BR
46	Trail Canyon	219	12:08	11	12:20	11	BR
47	220 Mile	220	12:35	11	12:45	11	BR
48	Diamond Creek	225	14:00	11	15:30	11	L,TO
49	Pierce´s Ferry	280	9:00	12	---	--	TO

BR = Beach Research
L = Lunch
C = Camp

AP = Attraction Point
R = Rapids
TO = Take-out

Table VIII-2. Group Contacts.

Day	Miles Covered	River Mile	River-River P	River-River C	River-Shore P	River-Shore C	Shore-River P	Shore-River C	Total P	Total C	Total T
1	24	0-24	0	0	0	1	0	3	0	4	4
2	29	24-53	0	1	0	3	0	2	0	6	6
3	7.5.	53-60.5	0	1	1	0	1	0	2	1	3
4	15	60.5-75.5	0	0	1	0	2	2	3	2	5
5	21	75.5-96.5	0	0	0	3	0	0	0	3	3
6	25.5	96.5-12.2	0	0	1	1	0	1	1	2	3
7	0	at 122	0	0	0	0	0	3	0	3	3
8	44	122-166	0	1	1	7	0	5	11	3	14
9	0	at 166	0	0	0	0	1	3	1	3	4
1	42.8	166-208.8	0	3	0	3	0	3	0	9	9
1	16.2	208.8-225	1	0	1	0	0	0	2	0	2
1	55	225-280	1	0	1	0	0	0	2	0	2
	Total		2	6	6	18	4	22	12	46	58

P = Private
C = Commercial
T = Total

Table VIII-3. Aircraft Encounters.

Day	Miles Covered	River Mile	Single Engine	Multi-Engine	Helicopter	Total
1	24	0-24	1	0	0	1
2	29	24-53	4	0	0	4
3	7.5	53-60.5	4	0	0	4
4	15	60.5-75.5	2	0	2	4
5	21	75.5-96.5	10	0	2	12
6	25.5	96.5-122	27	3	8	38
7	0	at 122	18	10	1	29
8	44	122-166	4	4	0	8
9	0	at 166	2	8	0	10
10	42.8	166-208.8	2	8	0	10
11	16.2	208.8-225	2	2	0	4
12	55	225-280	2	0	0	2
		Totals	78	35	13	126

Table VIII-4. Average group and aircraft encounters.

1. Group contacts per day.

River-River			River-Shore			Shore-River			Total		
P	C	T	P	C	T	P	C	T	P	C	T
.2	.5	.7	.5	1.6	2.1	.4	2.0	2.4	1.1	4.2	5.3

2. Aircraft encounters per day.

Single Engine	Multi-engine	Helicopter	Total
7.1	3.5	1.2	11.8

Table VIII-1. Trip schedule: 1 August - 11 August, 1984.

Stop Number	Location	River Mile	Arrive Time	Arrive Day	Depart Time	Depart Day	Reason For Stop
0	Lees Ferry	0	---	---	12:00	1	Start
1	Badger Creek	8	14:00	1	14:45	1	BR,L
2	18 Mile Wash	18.2	16:25	1	17:30	1	BR
3	20 Mile	19.3	17:54	1	18:00	1	BR
4	24 Mile	24	19:00	1	9:00	2	C
5	24.5 Mile	24.5	9:00	2	9:30	2	BR
6	26 Mile	26	10:00	2	10:30	2	Repair
7	Shinumo Wash	29	11:40	2	12:15	2	BR
8	Redwall Cavern	33.1	12:44	2	13:00	2	AP
9	Nautiloid	34.7	13:20	2	16:00	2	BR,L
10	Anasazi Bridge	43.5	17:15	2	17:25	2	BR
11	Lower Nankoweap	53	18:45	2	14:23	3	C,BR,L
12	Awatubi	58.2	15:05	3	16:00	3	BR
13	Upper Little Colorado River	60.5	16:35	3	8:50	4	C
14	Lower Little Colorado River	61.8	8:57	4	10:20	4	BR
15	Lava Canyon (Chuar)	65.5	11:00	4	12:30	4	BR
16	69 Mile	69	12:50	4	14:45	4	BR,L
17	Unkar	72.2	15:24	4	17:00	4	BR
18	Nevills Rapid	75.5	18:45	4	9:30	5	C,BR
19	Hance Rapid	76.5	9:45	4	10:22	5	BR,R
20	Grapevine	81.1	11:00	5	12:40	5	BR
21	Phantom Ranch	87.5	13:30	5	15:45	5	L
22	Granite Rapid	93.2	16:30	5	17:30	5	BR,R
23	Boucher Creek	96.5	19:00	5	9:30	6	C
24	Crystal Rapid	98.2	9:45	6	12:00	6	Rapids
25	104 Mile	104	12:45	6	14:30	6	L
26	Lower Bass Camp	108.5	15:23	6	16:20	6	BR
27	109 Mile	109.4	16:30	6	17:30	6	BR
28	Waltenberg	112.2	17:45	6	18:00	6	BR
29	114 Mile	114	18:30	6	19:00	6	BR
30	Blacktail	120.1	19:30	6	20:45	6	BR
31	122 Mile	122	21:30	6	6:23	8	C,BR
32	Forster	122.8	16:30	7	18:30	7	BR
33	124.5 Mile	124.4	6:40	8	9:15	8	BR
34	Bedrock	131	10:00	8	10:50	8	BR
35	Dubendorff	132	11:00	8	11:40	8	BR,AP
36	Pancho's Kitchen	137	12:40	8	13:15	8	L,BR
37	Ledges	151	15:24	8	16:30	8	AP
38	Havasu Creek	156.9	17:00	8	17:30	8	AP
39	National Canyon	166	18:30	8	9:00	0	C,BR
40	Upper Lava Falls	179	12:30	10	14:10	10	BR,L
41	186 Mile	186	14:40	10	15:00	10	BR
42	190 Mile	190.2	15:30	10	16:26	10	BR