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14. ABSTRACT

The purpose of this report is to summarize briefly the history of the Surface Water Research project since its inception in 1952, the work accomplished, and the problems encountered. In general, each topic is discussed under two periods of time: 1952-1963, when projects were confined to the Helmand River Valley and was entitled "Helmand Surface Water Investigations (306-12-021, 306-M-12-AD and 306-AC-12-AD5)," and 1963-1969 when activities were expanded to cover most of Afghanistan and title was changed to "Surface Water Research (306-11-190-002)".

Prepared by the United States Geological Survey in cooperation with the Water and Soil Survey Department, Ministry of Agriculture and Irrigation, Royal Government of Afghanistan under the auspices of the United States Agency for International Development.

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HYDROLOGIC AND SEDIMENTATION SURVEY

KAJAKAI RESERVOIR

1968

HYDROGRAPHIC AND SEDIMENTATION SURVEY

OF KAJAKAI RESERVOIR

By

Don Perkins and James K. Culbertson

Water Resources Division
United States Geological Survey

For

United States Agency for International Development
in cooperation with
Ministry of Agriculture and Irrigation
Royal Government of Afghanistan

Kabul, Afghanistan
December 1968

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HYDROGRAPHIC AND SEDIMENTATION SURVEY
OF KAJAKAI RESERVOIR

by Don Perkins and J. K. Culbertson
U.S. Geological Survey

ABSTRACT

A hydrogrphic and sedimentation survey of Kajakai Reservoir was carried out during the period September through December 1968. Underwater mapping techniques were used to determine the reservoir capacity as of 1968. Sediment range lines were established and monumented to facilitate future sedimentation surveys. Afghanistan engineers and technicians were trained to carry out future reservoir surveys.

Samples were obtained of the lake bed and in the river upstream of the reservoir. Virtually no sediments coarser than about 63 microns were found on the lake bed surface. The median diameter of sanus being transported into the reservoir ranged from 40 microns to 110 microns. The average annual rate of sedimentation was 7,800 acre-feet. Assuming an average density of 50 pounds per cubic foot, the estimated average sediment inflow to the reservoir was about 8,500,000 tons per year.

The decrease in capacity at spillway elevation for the period 1953 to 1968 due to sediment deposition was 7.8 percent or 117,700 acre-feet. Redefinition of several contours above the fill area resulted in an increase in capacity at spillway

elevation of 13,600 acre-feet, thus the net change in capacity was 7.0 percent or 104,800 acre-feet.

Based on current data and an estimated rate of compaction of deposited sediment, the assumption of no appreciable change in hydrologic conditions in the drainage area, the leading edge of the principal delta will reach the irrigation outlet in 40 to 45 years.

It is recommended that a resurvey of sediment range lines be made during the period 1973 to 1975.

INTRODUCTION

Storage of water behind Kajakai Dam began in January 1953. A reconnaissance survey of Kajakai Reservoir was made May 1967 to observe generally the magnitude and extent of sediment deposition that occurred during the first 14 years of storage. Sediment deposition appeared to be significant, and recommendations were made that a more comprehensive sedimentation survey be carried out.

The Agency for International Development (USAID), an agency of the Government of the United States of America, and the Ministry of Agriculture and Irrigation (MAI), an agency of the Royal Government of Afghanistan (RGA), signed an agreement to conduct a hydrographic and sedimentation survey of Kajakai Reservoir. A survey was carried out during the period September through December 1968. The results of the survey are presented in this report.

Purpose of Survey

The objectives of the survey were (1) to define the current stage-capacity relation, (2) to determine the rate of sedimentation since closure in 1953, (3) to establish sediment range lines in order to simplify future

sedimentation surveys, and (4) to train Afghan engineers and technicians in the techniques and procedures used in the survey.

ACKNOWLEDGEMENTS

Accomplishment of the hydrographic and sedimentation survey of Kajakai Reservoir in the relatively short period of time allotted was the result of cooperative efforts of several organizations and many individuals. Planning and execution of the survey was done by U.S.Geological Survey Engineers of the Surface Water Research Project, NAD, USAID, in cooperation with the Water and Soils Survey Department (WSSD) of MAI. USAID and RGA provided funding. The following engineers and technicians worked on the project:

USAID: A. O. Westfall, Project Manager; Don Perkins and J. K. Culbertson, Consultants; V. Piro and D. Childers, Field Engineers.

WSSD: Abdul Jadar Haidari, Mirza Mohammad Mushtaq, Anwar Lodin, Engineers; M. Asif, Najibullah, M. Omer, Rahmanudin, Wali Mohamadi, Nazar M., Abdul Aziz, Technicians.

PEACE CORPS: Patrick Molinari, Forrest Garrison, Joseph Goss, Volunteers.

Individual and personal thanks go to Messrs. Jumma Mohammadi, President, WSSD; Marion Patten, Gordon V. Potter, Drew Mills, and Elonzo B. Grantham,Jr., of USAID; and Governor Safi, President, HAVA, for their efforts and cooperation before and throughout the survey.

LOCATION AND DESCRIPTION OF RESERVOIR

Construction of Kajakai Dam was completed in November 1952, and the gates were closed January 1953. The reservoir is located approximately 90 miles upstream of Lashkar Gah on the Helmand River. The dam is earth-fill construction and rises 85 meters above the river bed to a crest elevation of 1050.0 meters. Water is stored primarily to furnish irrigation water to the lower Helmand River Valley. Future plans for water use include installation of hydroelectric units to provide power for the Helmand-Arghandab Valley region.

Original capacity of the reservoir was 1,495,000 acre-feet at a spillway elevation of 1033.5 meters and a capacity of 2,300,000 acre-feet at elevation 1045 meters. Original zero storage elevation was 965.0 meters. The reservoir extends approximately 49,000 meters (thalweg distance) upstream of Kajakai Dam. Full-capacity widths of the reservoir vary considerably from a minimum of about 200 meters in the "narrows" to about 2,400 meters at several points. Figure 1 is a sketch map showing the water-surface contour at an elevation of approximately 1015 meters. Also shown on figure 1 are approximate locations of permanent sediment range lines set up as a result of the 1968 survey.

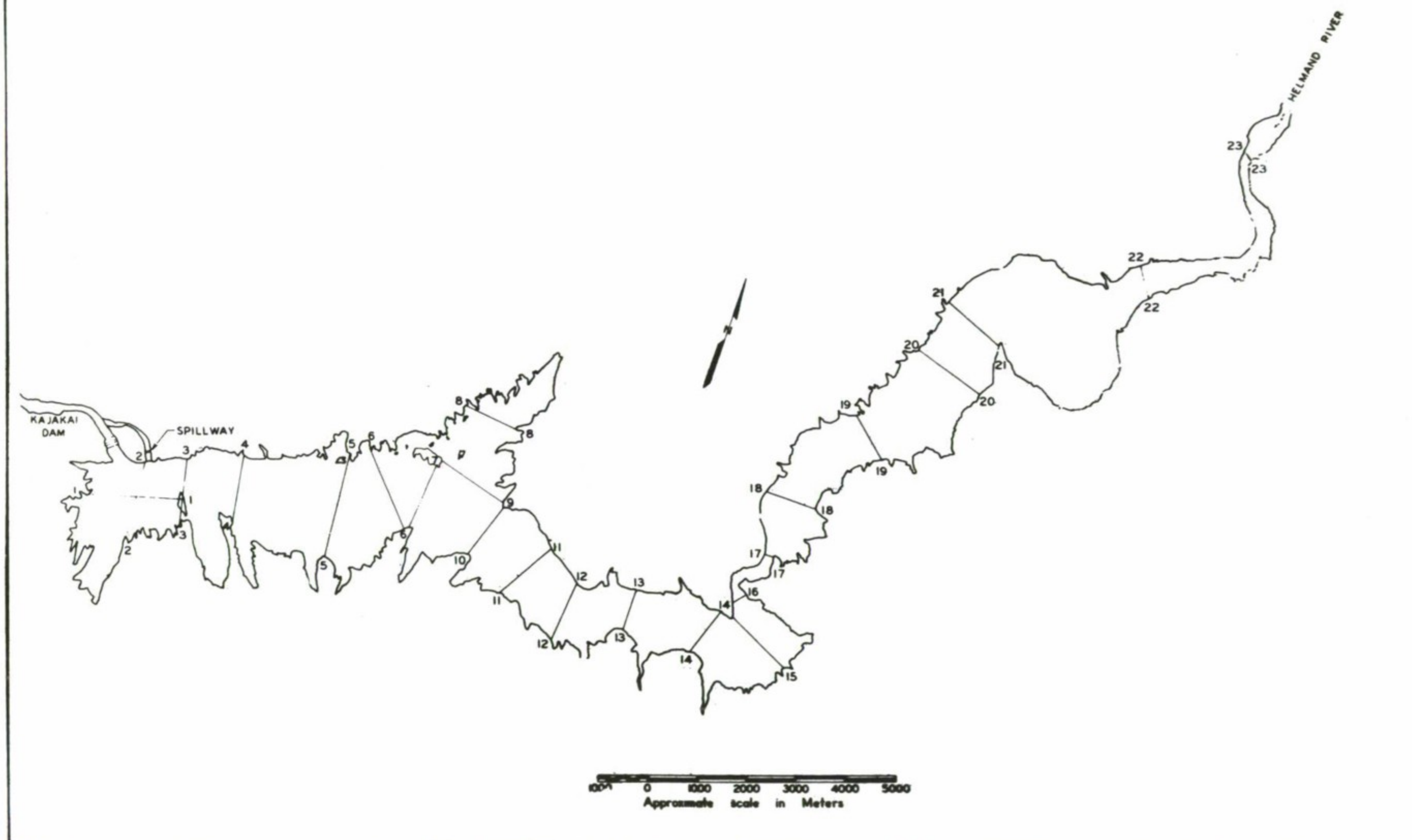

FIGURE 1.--SKETCH MAP OF KAJAKAI RESERVOIR SHOWING LOCATION OF SEDIMENT RANGE LINES

HYDROGRAPHIC SURVEY

A comparative summary of the initial capacities, the 1968 capacities, change in capacities, and percent change in capacities at five-meter increments of elevation are given in table 1. The new 1968 capacity table is shown in table 2.

The hydrographic survey determined locations of current underwater contours as described in the following sections. New contours were drawn on prints of the original topographic maps produced by the Fairchild Surveys. Areas within each contour were planimetered and capacities between contours computed as shown in the example at the bottom of table 1. Locations of some contours above the water surface at the time of the survey were refined based on levels run from the water surface to sediment range line monuments. As a result of the refinement in location of some contours, capacity increased somewhat in several reaches of the reservoir.

Sediment range lines were established to aid in future sedimentation monitoring surveys. Permanent concrete monuments were located at either end of each range line. These monuments were painted white and numbered according

Table 1.--COMPARATIVE SUMMARY, ORIGINAL AND 1968 SURVEYS

Elev. in Meters	Capacity in A.F. x10^3		Change in Capacity A.F. x 10^3 (15 yrs.)	Percent Loss in Capacity
	1953	1968		
1035	1587.0	1479.1	107.9	6.8
1033.5*	1495.0	1390.9	104.8	7.0
1030	1294.0	1185.3	108.7	8.4
1025	1039.0	931.6	107.4	10.3
1020	824.0	723.9	100.1	12.1
1015	644.0	554.3	89.7	13.9
1010	489.0	422.0	67.0	13.7
1005	364.0	321.2	42.8	11.8
1000	266.0	242.5	23.5	8.8
995	186.0	175.0	11.0	5.9
990	123.0	117.7	5.3	4.3
985	73.0	70.8	2.2	3.0
980	35.0	34.2	0.8	2.3
975	13.3	10.5	2.8	21.1
970	2.7	1.2	1.5	55.6
968	--	0		
965	0			

*Spillway elevation.

EXAMPLE OF VOLUME COMPUTATION:

Given:

A = Area of 1005 meter contour = 26,681,000 M^2

B = Area of 1000 meter contour = 21,672,000 M^2

Find:

V = Volume, in acre-feet, between elevations 1000 and 1005 meters

$$= \frac{A+B}{2} \times 5 \div 1233.49 \text{ (cubic meters per acre-foot)}$$

$$= \frac{26{,}681{,}000 + 21{,}672{,}000}{2} \times 5 \div 1233.49$$

$$= \frac{48{,}353{,}000}{2} \times 5 \div 1233.49 = \underline{98{,}000} \text{ acre-feet}$$

Table 2.--CAPACITY TABLE, KAJAKAI RESERVOIR, 1968 in 1000's ACRE-FEET

Elevation (meters)	0	1	2	3	4	5	6	7	8	9
960									0	0.5
970	1.2	2.1	3.5	5.3	7.6	10.5	14.0	18.1	22.8	28.2
980	34.2	40.7	47.6	54.9	62.6	70.8	79.4	88.4	97.8	107.6
990	117.7	128.2	139.2	150.7	162.7	175.0	187.7	200.9	214.4	228.3
1000	242.5	257.1	272.2	287.9	304.2	321.2	339.1	358.0	378.0	399.3
1010	422.0	446.0	471.3	497.9	525.8	554.3	584.3	615.9	649.7	685.7
1020	723.9	763.4	803.9	845.4	887.9	931.6	977.2	1024.9	1075.2	1128.3
1030	1185.3	1243.9	1302.7	1361.5	1420.3	1479.1				

to the range lines. Each monument was located by triangulation. Azimuths from monument to monument were determined and are given in table 3 for rapid location of range lines in future surveys.

In order to facilitate future resurveys of Kajakai Reservoir, the reservoir has been divided into separate reaches defined by range lines. The reaches are delineated by adjacent range lines, or between a range line and the end of a definite arm of the lake. For instance, that portion of the reservoir between the dam and range line 2-2 constitutes a single reach, and that portion between range lines 2-2 and 3-3 constitutes a second reach. Capacity was determined for each reach. The sum of the capacities in all reaches equals the total reservoir capacity. Table 4 gives the areas for each contour and the incremental capacity in acre-feet between contours for each reach. The incremental capacities are added to give the total capacity within the reach. Also given in this table are coefficients to be applied to resurvey data in order to compute changes in capacity. Coefficients vary for each contour interval and between reaches.

The coefficients are empirical and have the dimension, acre-feet/square meters. The coefficient simply relates the average area between contours (contour interval) of the range line cross sections to capacity in acre-feet in that reach for the same contour interval. Cross-section areas of sediment range lines are given in table 5. For example, the capacity in acre-feet between elevation 1005 and 1010 in the reach 3-3 to 4-4 may be computed by multiplying the average area in square meters between elevations 1005 and 1010 of cross sections 3-3 and 4-4 by the coefficient 1.25. Using the data from table 5, and the coefficient from table 3 for the reach 3-3 to 4-4, the capacity in acre-feet is

$$\text{Capacity} = \frac{3930 + 5950}{2} \times 1.25 = 6{,}180 \text{ acre-feet}$$

Therefore, in future surveys the only base data necessary to collect, in order to compute a reasonably correct change in storage, will be cross-section areas of each sediment range line.

Horizontal Control

A topographic map compiled by Fairchild Aerial Surveys, Inc., U.S.A., using a sterophotogrametric methods was used as the base map. The scale of this map was 1:50,000, with a contour interval of five meters. The original Fairchild triangulation stations were plotted on the map.

Prior to the 1968 hydrographic survey, the U.S. Bureau of Reclamation of HAVR recovered and placed flags on the Fairchild triangulation stations that were above the lake level. The bearing of the lines between triangulation stations were available for the 1968 survey. The azimuth of lines as computed from the bearings are given in table 1 in the appendix.

A new triangulation net was established at the approximate high-water elevation and tied to the Fairchild triangulation net. The new triangulation net was necessary in order to establish a horizontal reference system with which to correlate the 1968 survey with the Fairchild base map.

The new triangulation station network and the lines, or courses, to be sounded were plotted on an overlay of the base map. The azimuths of the lines to be sounded were determined from the overlay and recorded for use in the field.

The horizontal location of the boat was determined by a transitman located on shore directing the boat operator, by two-way radio, on the predetermined azimuth. A standard navigational sextant (figure 2) was used to fix the position of the boat on the line being sounded (figure 3).

The fathometer chart was marked by the sextant operator pressing the remote control switch mounted on the sextant (figure 4).

The notekeeper recorded the angle observed by the sextant operator and a fix number on the field notes (figure 5). The fix numbers were also recorded on the fathometer chart (figure 4). The distance from shore was estimated and recorded for the first and last sextant angle observed.

An alternate method using two transits to locate the position of the boat was used (figure 6). The sextant

Figure 2.--View of standard navigational sextant.

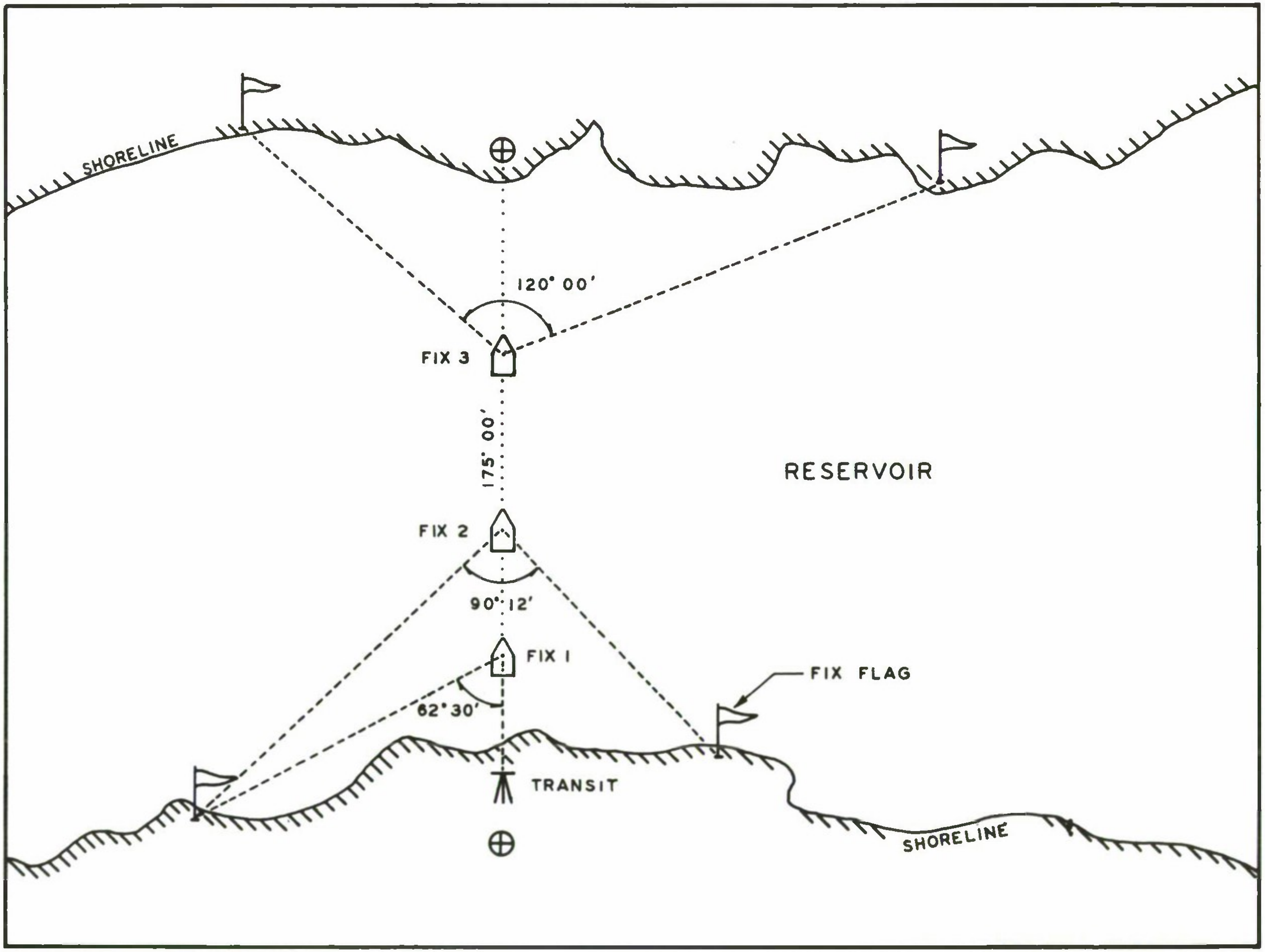

FIGURE 3.--SKETCH MAP ILLUSTRATING POSITION FIX BY SEXTANT.

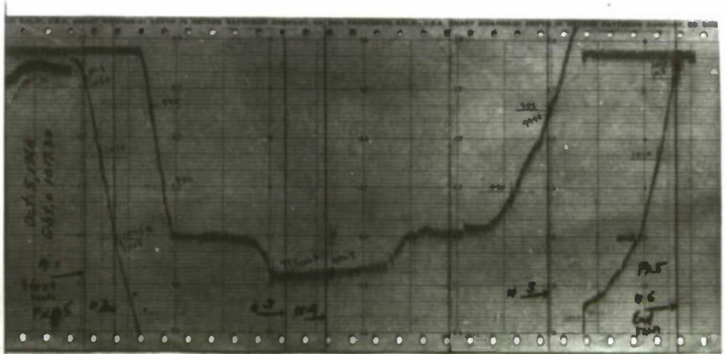

Figure 4.--View of fathometer chart for sediment range line 12-12 cross section.

Lake: Kajakai | Date: Sept. 20, 1968

Location: π at 5R | Gage: 1018.40 | Sheet 12 of 22 sheets

Line Azim	Fix	Sextant Angle	Target	Dist to/fr shore	Elev at fix	Contour locations at proportioned distance between sextant fixes
5R to 5L $175^{\circ}00'$	1	$44^{\circ}59'$	6L-5L	2 m.	1016.2	
	2	$60^{\circ}56'$	10L-5L		998.9	1015/.07 1010/21 1005/.34 1000/94
	3	$63^{\circ}00'$	10L-5L		975.8	995/.29 990/.33 985/.44 980/.53
	4	$75^{\circ}00'$	5R-9		974.3	975/.38
	5	$67^{\circ}00'$	5R-9		975.4	975/.52
	6	$58^{\circ}53'$	5R-6R	3 m.	1016.7	980/.07 985/.10 990/51 995/.70 1000/.78 1005/.86 1010/.92 1015/.99

Figure 5.--Example of field notes and office compilation sheet for determination of position fix by sextant.

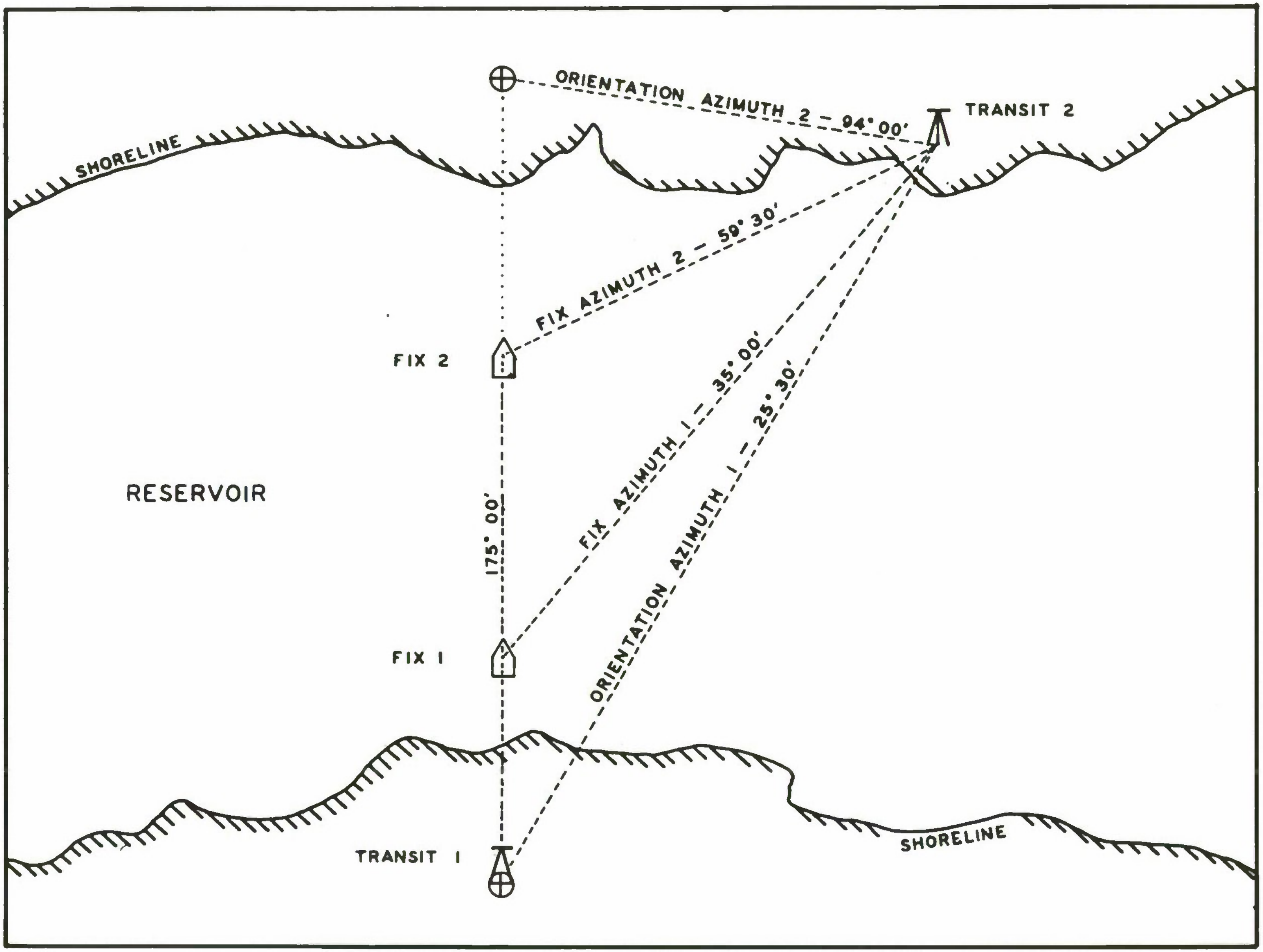

FIGURE 6.--SKETCH MAP ILLUSTRATING POSITION FIX BY 2-TRANSIT METHOD.

operator assumed the duties of the second transitman. The transit was located on shore to observe intersecting angles over the entire length of the line being sounded. It was necessary to establish temporary triangulation stations for this purpose when the intersecting angles could not be observed over the entire length of the line being sounded from the previously established triangulation stations.

Two-way radios were used by the first transitman to direct the boat operator along the selected course. The second transitman and notekeeper in the boat were in radio communication; however, a different frequency was used to prevent confusing the commands given by the two transitmen, boat operator and fathometer operator-notekeeper.

Coordinating the time of the first and last fix marked on the fathometer chart and the observation of the intersecting angle by the second transitman was accomplished by the fathometer operator giving the command by radio. The intermediate fix marks on the chart were made by the fathometer operator on command from the second transitman. The intersecting angles observed by the second transitman were transmitted by radio to the notekeeper-fathometer operator to record on the field notes (figure 7).

Figures 8 through 11 are photographs of other phases of field work.

Lake: Kajakai   Date: Sept. 20, 1968

Location: ⊼ #2 at 4L   Gage: 1018.40   Sheet 12 of 22 sheets

Line Azim	Fix	Azimuth to Fix	Dist to/fr shore	Elev at fix	Contour locations at proportioned distance between sextant fixes
5R to 5L $175^\circ00'$	1	$40^\circ28'$	2 m.	1016.2	
	2	$42^\circ00'$		998.9	1015/07 1010/21 1005/34 1000/94
	3	$44^\circ00'$		975.8	995/29 990/33 985/44 980/53
	4	$57^\circ00'$		974.3	975/38
	5	$70^\circ00'$		975.4	975/52
	6	$84^\circ32'$	3 m.	1016.7	980/07 985/10 990/51 995/70 1000/78 1005/86 1010/92 1015/99

Figure 7.--Example of field notes and office compilation sheet for determination of position fix by 2-transit method.

Figure 8.--View of transitman directing boat on a given azimuth.

Figure 9.- View of boat with fathometer crew beginning sounding run.

Figure 10.--View of triangulation transitman at F2X.

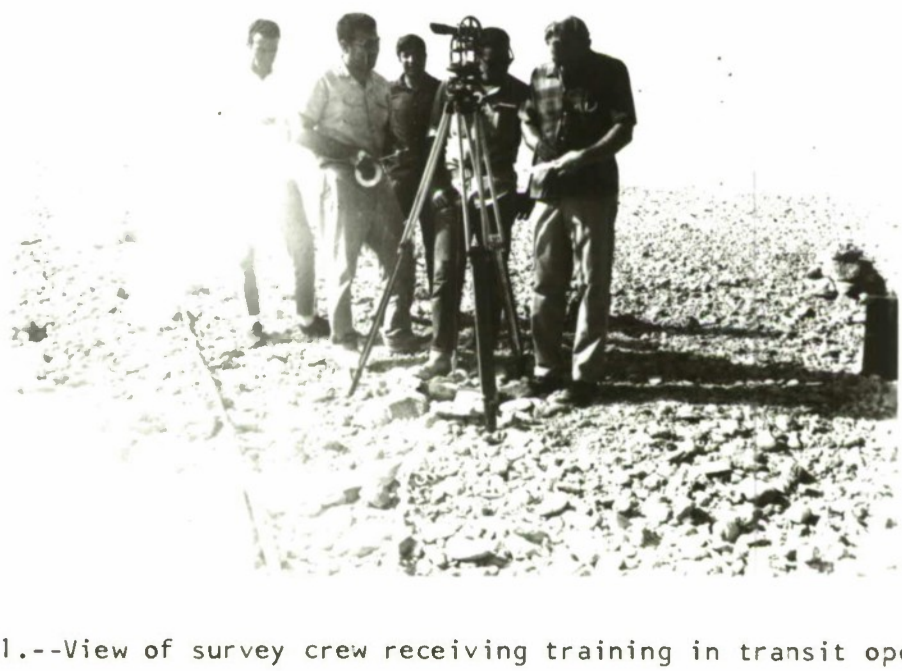

Figure 11.--View of survey crew receiving training in transit operation.

Vertical Control

A continuous water-level recorder installed at the outlet tower provided a continuous record of the lake level. The water surface was determined by levels from selected Fairchild triangulation stations and compared with the level recorded at the outlet tower to determine the slope throughout the reservoir. The slope of the reservoir water surface was determined to be negligible between sediment range line 21-21 and the tower. Corrections were applied to compensate for water-surface slope upstream from this range line.

Table 3.--AZIMUTH OF MONUMENTS AND SEDIMENT RANGE LINES

Monument* Occupied	Monument* Observed	Azimuth of Monument Observed	Remarks
F2x	Orientation	0° 00'	F2x at lookout point near tower. Orientation point near north end dam.
	1L1	208° 33'	
	2L	158° 49'	
	3L	121° 04'	
	4L	102° 19'	
	1L2	100° 47'	On island - under water above elevation 1020.0.
	6L	84° 07'	
	9R	77° 17'	
	11R	81° 42'	
	13L	89° 46'	Same as F11x
1L1	F2x	28° 33'	Backsight
	Line 1-1	75° 58'	
	2L	136° 21'	
	3R	54° 24'	
	3L	96° 14'	
	4R	85° 05'	
	5L	86° 17'	
	5R	61° 17'	
	7R	65° 35'	
2L	F2x	338° 49'	Backsight
	1L	316° 22'	
	Line 2-2	353° 58'	

Table 3.--Continued

Monument* Occupied	Monument* Observed	Azimuth of Monument Observed	Remarks
3L	F2x	301° 02'	
	1L	276° 14'	
	1L	348° 30'	
	Line 3-3	348° 32'	
	2R	316° 52'	
4L	F2x	282° 19'	Backsight
	Line 4-4	351° 02'	
	3R	314° 02'	
	2R	290° 47'	
	1L	265° 05'	
	5L	88° 11'	
	5R	36° 35'	
	6R	27° 40'	
	1L	284° 54'	
5R	4L	216° 35'	Backsight
	Line 5-5	174° 57'	
	6L	127° 30'	
	8L	63° 40'	
6L	5R	307° 30'	Backsight
	8L	27° 09'	
	Line 6-6	316° 02'	
	Line 6-7	5° 25'	
	9	56° 24'	
	11R	76° 37'	

Table 3.--Continued

Monument* Occupied	Monument* Observed	Azimuth of Monument Observed	Remarks
8L	6L	207° 09'	Backsight
	Line 8-8	272° 22'	
	7	227° 08'	
9	6L	236° 24'	Backsight
	Line 9-7	285° 15'	
	Line 9-10	197° 30'	
	11R	111° 35'	
	12R	114° 26'	
	5R	271° 40'	
11L	10	307° 20'	Backsight
	Line 11-11	210° 00'	
	7	318° 27'	
	9	347° 38'	
	12R	61° 52'	
12R	10	263° 16'	Backsight
	6L	266° 30'	
	Line 12-12	185° 02'	
	7	290° 33'	
	9	294° 26'	
	13L	126° 22'	Same as F11x
13L	12R	306° 22'	Backsight
	Line 13-13	0° 00'	
	11R	302° 55'	
	5R	285° 46'	
	7	294° 41'	

Table 3.--Continued

Monument* Occupied	Monument* Observed	Azimuth of Monument Observed	Remarks
	9	299° 00'	
	6R	290° 20'	
	14R	53° 30'	
14L	13R	233° 30'	Backsight F10x to F11x
	Line 14-14	198° 07'	Across lower end of narrows
	Line 14-15	115° 44'	
	Line 14-16	40° 04'	
	11L	252° 57'	
17R	Orientation	90° 05'	17R monument is at upper end of narrows. Orientation is 176.
	Line 17-17	90° 05'	
	21L	29° 01'	
	18R	31° 04'	
	19R	12° 25'	
	20R	13° 25'	
	20L	38° 58'	
18R	17R	211° 04'	Backsight
	Line 18-18	270° 05'	
	19R	0° 20'	
	20R	7° 18'	
	21L	28° 24'	
	21R	13° 16'	

Table 3.--Continued

Monument* Occupied	Monument* Observed	Azimuth of Monument Observed	Remarks
19R	17L	188° 42'	Backsight
	Line 19-19	132° 00'	
	20R	15° 15'	
	20L	69° 31'	
	19R	180° 20'	
	17R	192° 25'	
	18L	207° 58'	
20R	17L	191° 02'	Backsight
	Line 20-20	108° 05'	
	19R	195° 15'	
	21L	74° 14'	
	19L	166° 15'	
	18R	187° 18'	
21L	17L	207° 16'	Backsight
	20R	254° 14'	
	19L	199° 35'	
	19R	225° 49'	
	17R	209° 01'	
	18L	218° 23'	
	Line 21-21	293° 04'	
	22R	39° 27'	
22R	21L	219° 27'	Backsight
	Line 22-22	146° 05'	3320 meters upstream of 21
23L	Line 23-23	306° 42'	

Table 3.--Continued

*Monument numbers indicated by R denote right bank and L denote left bank location. Right and left bank determined by facing downstream.

Table 4.--SUMMARY OF 1968 RESERVOIR REACH DATA

Elev. in Meters	Reach Dam to 2-2			Reach 2-2 to 3-3		
	Area $M^2 x10^3$	Capacity A.F. $x10^3$	Coef.	Area $M^2 x10^3$	Capacity A.F. $x10^3$	Coef.
968	0			0		
		.25	1.07		.24	1.39
970	154			150		
		1.05	0.689		.98	0.694
975	367			336		
		1.70	0.676		1.51	0.615
980	471			410		
		2.16	0.698		1.77	0.584
985	596			464		
		2.75	0.732		2.04	0.592
990	762			541		
		3.55	0.782		2.39	0.600
995	991			638		
		4.60	0.914		2.98	0.693
1000	1280			833		
		5.78	1.05		3.62	0.783
1005	1573			951		
		7.04	1.19		4.13	0.840
1010	1900			1088		
		8.46	1.20		4.68	0.821
1015	2276			1220		
		9.96	1.32		5.33	0.872
1020	2638			1413		
		11.50	1.38		6.11	0.825
1025	3034			1604		
		13.30	1.32		6.72	0.752
1030	3529			1715		
		10.77	1.50		5.06	0.79
1033.5	--			--		
		4.62	--		2.17	--
1035	4064			1850		
Total		87.49			49.73	

Table 4.--Continued

Elev. in Meters	Reach 3-3 to 4-4			Reach 4-4 to 5-5		
	Area M^2x10^3	Capacity A.F.x10^3	Coef.	Area M^2x10^3	Capacity A.F.x10^3	Coef.
968	0			0		
		.57	1.06		.09	0.189
970	352			56		
		2.23	1.14		4.43	2.75
975	748			2128		
		3.18	0.896		9.77	1.75
980	823			2695		
		3.60	0.926		11.37	1.86
985	952			2913		
		4.07	1.02		12.18	1.94
990	1054			3094		
		4.54	1.07		12.99	1.99
995	1188			3313		
		5.07	1.15		13.82	2.01
1000	1314			3505		
		5.58	1.20		14.58	2.02
1005	1439			3687		
		6.18	1.25		15.33	2.01
1010	1610			3877		
		6.91	1.24		16.18	1.96
1015	1798			4107		
		7.73	1.31		17.27	2.02
1020	2018			4413		
		8.79	1.28		18.44	2.07
1025	2320			4687		
		9.92	1.26		19.56	2.05
1030	2576			4965		
		7.63	1.34		14.47	2.12
1033.5	--			--		
		3.27	--		6.20	--
1035	2802			5234		
Total		79.27			186.68	

Table 4.--Continued

Elev. in Meters	Reach 5-5 to 6-7			Reach 6-7 to 9-10		
	Area $M^2 x10^3$	Capacity A.F. $x10^3$	Coef.	Area $M^2 x10^3$	Capacity A.F. $x10^3$	Coef.
968						
970	0					
		.65	2.07			
975	320			0		
		4.58	1.13		1.96	1.78
980	1939			968		
		8.30	1.50		4.79	1.41
985	2170			1394		
		9.40	1.48		6.16	1.23
990	2468			1646		
		10.52	1.56		7.00	1.31
995	2721			1808		
		11.42	1.60		7.60	1.34
1000	2912			1940		
		12.17	1.64		8.13	1.41
1005	3093			2072		
		12.89	1.67		8.63	1.47
1010	3265			2188		
		13.63	1.70		9.12	1.50
1015	3460			2310		
		14.35	1.68		9.59	1.48
1020	3621			2420		
		15.32	1.71		10.06	1.50
1025	3938			2542		
		16.48	1.76		10.56	1.54
1030	4194			2669		
		12.18	1.86		7.74	1.61
1033.5	--			--		
		5.22	--		3.32	--
1035	4390			2784		
Total		147.11			94.66	

Table 4.--Continued

Elev. in Meters	Reach 8-8 to End			Reach 8-8 to 9-7		
	Area $M^2 x10^3$	Capacity A.F. $x10^3$	Coef.	Area $M^2 x10^3$	Capacity A.F. $x10^3$	Coef.
968						
970						
975						
980						
985				0		
					.12	.018
990				60		
					.71	.499
995	0			293		
					1.86	1.05
1000	2			628		
		.20	.188		3.16	1.19
1005	98			933		
		.79	.276		4.45	1.10
1010	294			1262		
		2.30	.548		6.18	1.14
1015	840			1787		
		4.41	.833		7.98	1.24
1020	1338			2149		
		6.80	1.08		9.56	1.35
1025	2016			2567		
		10.84	1.36		10.98	1.38
1030	3331			2850		
		9.90	1.60		8.35	1.44
1033.5	--			--		
		4.24	--		3.58	--
1035	3649			3036		
Total		39.48			56.93	

Table 4.--Continued

Elev. in Meters	Reach 9-10 to 11-11			Reach 11-11 to 12-12		
	Area M^2x10^3	Capacity $A.F.x10^3$	Coef.	Area M^2x10^3	Capacity $A.F.x10^3$	Coef.
968						
970						
975	0					
		.96	3.51			
980	477			0		
		2.83	.976		1.53	1.01
985	918			756		
		4.17	.793		3.92	.915
990	1140			1179		
		4.96	.895		5.02	1.01
995	1305			1299		
		5.52	.956		5.44	.978
1000	1416			1384		
		5.96	1.01		5.72	.957
1005	1523			1440		
		6.36	1.05		5.95	.951
1010	1614			1495		
		6.73	1.08		6.14	.948
1015	1708			1537		
		7.13	1.11		6.32	.925
1020	1810			1581		
		7.56	1.15		6.53	.923
1025	1918			1639		
		7.98	1.19		6.75	.922
1030	2019			1690		
		5.88	1.21		4.86	.928
1033.5	--			--		
		2.52	--		2.08	--
1035	2125			1738		
Total		68.56			60.26	

Table 4.--Continued

Elev. in Meters	Reach 12-12 to 13-13			Reach 13-13 to 14-14		
	Area $M^2 x10^3$	Capacity A. F. $x10^3$	Coef.	Area $M^2 x10^3$	Capacity A. F. $x10^3$	Coef.
968						
970						
975						
980	0					
		.28	1.71			
985	137			0		
		1.75	.917		.34	.869
990	726			170		
		3.22	1.02		2.19	1.76
995	864			973		
		3.75	.944		4.17	1.41
1000	985			1148		
		4.27	.961		5.07	1.60
1005	1120			1352		
		4.78	1.01		5.98	1.70
1010	1237			1596		
		5.20	1.03		6.83	1.63
1015	1326			1773		
		5.66	1.05		7.43	1.64
1020	1468			1894		
		6.18	1.09		7.86	1.63
1025	1580			1983		
		6.72	1.13		8.27	1.64
1030	1733			2098		
		5.16	1.24		6.13	1.75
1033.5	--			--		
		2.21	--		2.63	--
1035	1903			2223		
Total		49.18			56.90	

Table 4.--Continued

Elev. in Meters	Reach 14-14 to 14-15			Reach 14-15 to 14-16		
	Area $M^2 x 10^3$	Capacity A.F. $x 10^3$	Coef.	Area $M^2 x 10^3$	Capacity A.F. $x 10^3$	Coef.
968						
970						
975						
980						
985						
990	0					
		.23	1.23			
995	111					
		1.22	.792			
1000	490			0		
		3.54	1.76		.78	1.95
1005	1256			383		
		5.60	1.91		2.62	.952
1010	1507			908		
		6.49	1.19		3.88	.982
1015	1692			1004		
		7.09	1.18		4.23	.975
1020	1805			1084		
		7.52	1.20		4.58	1.01
1025	1908			1174		
		7.93	1.22		4.96	1.06
1030	2005			1272		
		5.83	1.27		3.74	1.11
1033.5	--			--		
		2.50	--		1.60	--
1035	2106			1362		
Total		47.95			26.38	

Table 4.--Continued

Elev. in Meters	Reach 14-16 to 17-17			Reach 17-17 to 18-18		
	Area $M^2 x10^3$	Capacity A. F. $x10^3$	Coef.	Area $M^2 x10^3$	Capacity A. F. $x10^3$	Coef.
968						
970						
975						
980						
985						
990						
995						
1000	0			0		
		.08	--		.04	--
1005	40			22		
		.59	.601		1.69	1.14
1010	251			810		
		1.06	.856		3.84	1.54
1015	274			1082		
		1.16	.881		4.87	1.71
1020	298			1320		
		1.26	.891		5.79	1.92
1025	323			1538		
		1.35	.915		6.69	2.09
1030	344			1763		
		1.01	.931		5.41	1.49
1033.5	--			--		
		.43			2.32	
1035	371			2050		
Total		6.95			30.65	

Table 4.--Continued

Elev. in Meters	Reach 18-18 to 19-19			Reach 19-19 to 20-20		
	Area $M^2 x 10^3$	Capacity A.F. $x 10^3$	Coef.	Area $M^2 x 10^3$	Capacity A.F. $x 10^3$	Coef.
968						
970						
975						
980						
985						
990						
995						
1000						
1005	0			0		
		3.68	1.58		4.04	3.32
1010	1817			1997		
		7.85	1.70		10.25	2.20
1015	2055			3059		
		8.91	1.76		13.38	2.09
1020	2342			3542		
		10.07	1.51		15.38	2.09
1025	2628			4055		
		11.39	1.85		17.55	2.09
1030	2994			4603		
		9.20	1.53		13.88	2.12
1033.5	--			--		
		3.94	--		5.95	--
1035	3490			5176		
Total		55.04			80.43	

Table 4.--Continued

Elev. in Meters	Reach 20-20 to 21-21			Reach 21-21 to 22-22		
	Area M^2x10^3	Capacity A. F. $x10^3$	Coef.	Area M^2x10^3	Capacity A. F. $x10^3$	Coef.
968						
970						
975						
980						
985						
990						
995						
1000						
1005	0					
		.07	--			
1010	34			0		
		3.29	1.16		3.32	4.43
1015	1588			1638		
		6.69	.956		16.45	4.74
1020	1713			6480		
		7.19	.954		28.19	6.33
1025	1834			7427		
		7.65	.928		31.11	5.90
1030	1940			7921		
		5.73	.936		23.12	6.18
1033.5	--			--		
		2.46	--		9.91	--
1035	2101			8377		
Total		33.08			112.10	

Table 4.--Continued

Elev. in Meters	Reach 22-22 to 23-23			Reach 23-23 to End		
	Area $M^2 x10^3$	Capacity A. F. $x10^3$	Coef.	Area $M^2 x10^3$	Capacity A. F. $x10^3$	Coef.
968						
970						
975						
980						
985						
990						
995						
1000						
1005						
1010						
1015	0			0		
		1.61	8.27		.05	--
1020	796			25		
		4.48	3.31		10.53	24.0
1025	1416			5169		
		6.44	2.53		30.50	22.8
1030	1720			9881		
		5.44	2.69		34.19	27.4
1033.5	--			--		
		2.33	--		14.66	--
1035	2112			14221		
Total		20.30			89.93	

Table 5.--CROSS-SECTION AREA OF SEDIMENT RANGE LINES, M^2

Elevation	Sediment Range Lines				
	2-2	3-3	4-4	5-5	6-7
968	0	0	0		
	233	116	961	0	
970					
	1,530	1,310	2,600	627	0
975					
	2,510	2,400	4,700	6,460	1,640
980					
	3,100	2,960	4,800	7,400	3,690
985					
	3,760	3,120	4,830	7,710	5,020
990					
	4,540	3,430	5,030	8,060	5,440
995					
	5,040	3,560	5,290	8,470	5,820
1000					
	5,490	3,750	5,540	8,870	5,930
1005					
	5,920	3,930	5,950	9,340	6,100
1010					
	7,080	4,310	6,830	9,660	6,400
1015					
	7,540	4,710	7,080	10,030	7,060
1020					
	8,360	6,460	7,260	10,600	7,350
1025					
	10,050	7,830	7,910	11,130	7,590
1030					
	7,200	5,610	5,800	7,870	5,230
1033.5					
1968 Total	72,350	53,500	74,580	106,230	67,270

Table 5.--Continued

Elevation	Sediment Range Lines				
	8-8	9-7	9-10	11-11	12-12
968					
970					
			0		
975					
		0	550	0	0
980					
		30	3,090	2,720	329
985					
		1,390	4,970	5,560	3,020
990					
	0	2,860	5,290	5,780	4,200
995					
	62	3,480	5,480	6,060	5,070
1000					
	1,080	4,230	5,600	6,180	5,790
1005					
	2,880	5,220	5,670	6,400	6,120
1010					
	4,190	6,670	5,760	6,680	6,290
1015					
	5,300	7,560	5,890	6,900	6,760
1020					
	6,300	7,830	6,040	7,120	7,020
1025					
	7,960	7,920	6,080	7,310	7,340
1030					
	6,190	5,360	4,420	5,250	5,230
1033.5					
1968 Total	33,960	52,550	58,840	65,960	57,170

Table 5.--Continued

Elevation	Sediment Range Lines				
	13-13	14-14	14-15	14-16	17-17
968					
970					
975					
980					
	0				
985					
	795	0			
990					
	2,130	358			
995					
	2,870	3,070	0		
1000					
	3,090	3,230	797	0	0
1005					
	3,330	3,690	4,250	1,250	720
1010					
	3,800	4,570	6,290	1,600	880
1015					
	3,990	5,060	6,990	1,690	940
1020					
	4,330	5,330	7,240	1,820	1,000
1025					
	4,570	5,510	7,460	1,900	1,060
1030					
	3,100	3,890	5,320	1,390	780
1033.5					
1968 Total	32,000	34,708	38,350	9,650	5,380

Table 5.--Continued

Elevation	Sediment Range Lines				
	18-18	19-19	20-20	21-21	22-22
968					
970					
975					
980					
985					
990					
995					
1000					
	0	0			
1005					
	2,230	2,430	0	0	
1010					
	4,090	5,120	4,190	1,500	0
1015					
	4,750	5,380	7,440	6,550	390
1020					
	5,030	6,280	8,440	6,630	2,270
1025					
	5,250	7,060	9,690	6,800	3,740
1030					
	6,500	5,500	7,560	4,690	2,790
1033.5					
1968 Total	27,850	31,770	37,320	26,170	9,190

Table 5.--Continued

Elevation	Sediment Range Lines 23-23
968	
970	
975	
980	
985	
990	
995	
1000	
1005	
1010	
1015	0
1020	438
1025	1,340
1030	1,250
1033.5	
1968 Total	3,030

OFFICE PROCEDURE

The Fairchild maps were photographically transferred to a mat surface stable-base film. An overlay drafted on stable-base film was prepared for each map sheet.

The new triangulation net, location of the flags and sounding lines were plotted on the overlay. The fix locations on the sounding lines, as indicated in the field notes as sextant angles between targets (figure 5) were plotted on the overlay by using a two-arm protractor. This method of horizontal positioning is based on the assumption that the boat is in line at the time the sextant angles are observed.

Errors in the observed angles or in the plotting of the angles were usually apparent when the proportionate distance between plotted fix locations were compared with the fix locations indicated on the fathometer chart. Minor variations in the proportionate distances were acceptable and were considered due to minor variations in boat speed.

Compilation of the data recorded on the fathometer chart was accomplished in three steps.

Step 1. The chart (see figure 3) was visually inspected to determine if the zero setting as indicated on the chart remained in the correct position, if the fathometer operator switched to the correct depth range without a loss of record, and maintained the gain control at the proper level. The field notes were correlated with the fathometer chart and notations made on the chart indicating the reservoir level at the time the soundings were obtained, and the date the soundings were made.

Step 2. The depths indicated on the chart were converted to elevations by using a graphical sliding scale placed on the chart in a position to relate the gage height at the time the soundings were made to the zero depth as indicated on the chart. The depth indicated by the chart record was converted to elevation by the sliding scale.

The elevation at each fix mark and the position of each contour elevation to be transferred to the map were noted on the fathometer chart.

Step 3. The elevations at each fix and the contour locations at proportionate distances between fixes were recorded on the field note sheet.

A variable scale, or a 10-point divider, was used to determine the contour locations at proportionate distances between fixes. The data recorded opposite fix 2 (figures 5 and 7), 1015/.07, 1010/.21, 1005/.34, 1000/.94, indicated that the 1015 meter contour was located 0.07 of the distance between fix 1 and fix 2, and the 1010, 1005, and 1000 meter contours were at the proportional distances between fix 1 and fix 2 of 0.21, 0.34, and 0.94 respectively.

The proportionate distance between fixes, determined from the recorder chart for each contour location, was transferred to the overlay. Where more definition of the underwater contours was required, additional lines to be sounded were plotted on the overlay and the azimuth determined.

SEDIMENTATION

One of the objectives of the survey was to establish permanent sediment range lines which could be resurveyed at any later date to determine future rates of sediment deposition. Location of range lines was based on probable representativeness of the cross sections to the reach upstream and downstream. Cross-section areas of these range lines are related to capacity in adjacent reaches. Cross sections of all sediment range lines are shown in figures 1 through 21 in the appendix.

Figure 12 shows the relation between the original streambed, or thalweg, profile and the 1968 profile as determined by this survey. Locations of sediment range lines are indicated. Range lines were established uplake only to the point where the current and original stream-bed elevations coincided. This point was determined to be at about elevation 1025 meters, and approximately 45,000 meters thalweg distance from the dam.

Depths of deposited material reached a maximum at about range line 14-16 (figure 16-appendix) where the average depth of sediment in the cross section was 18.5 meters. The leading edge of the deposition was at cross section 11-11

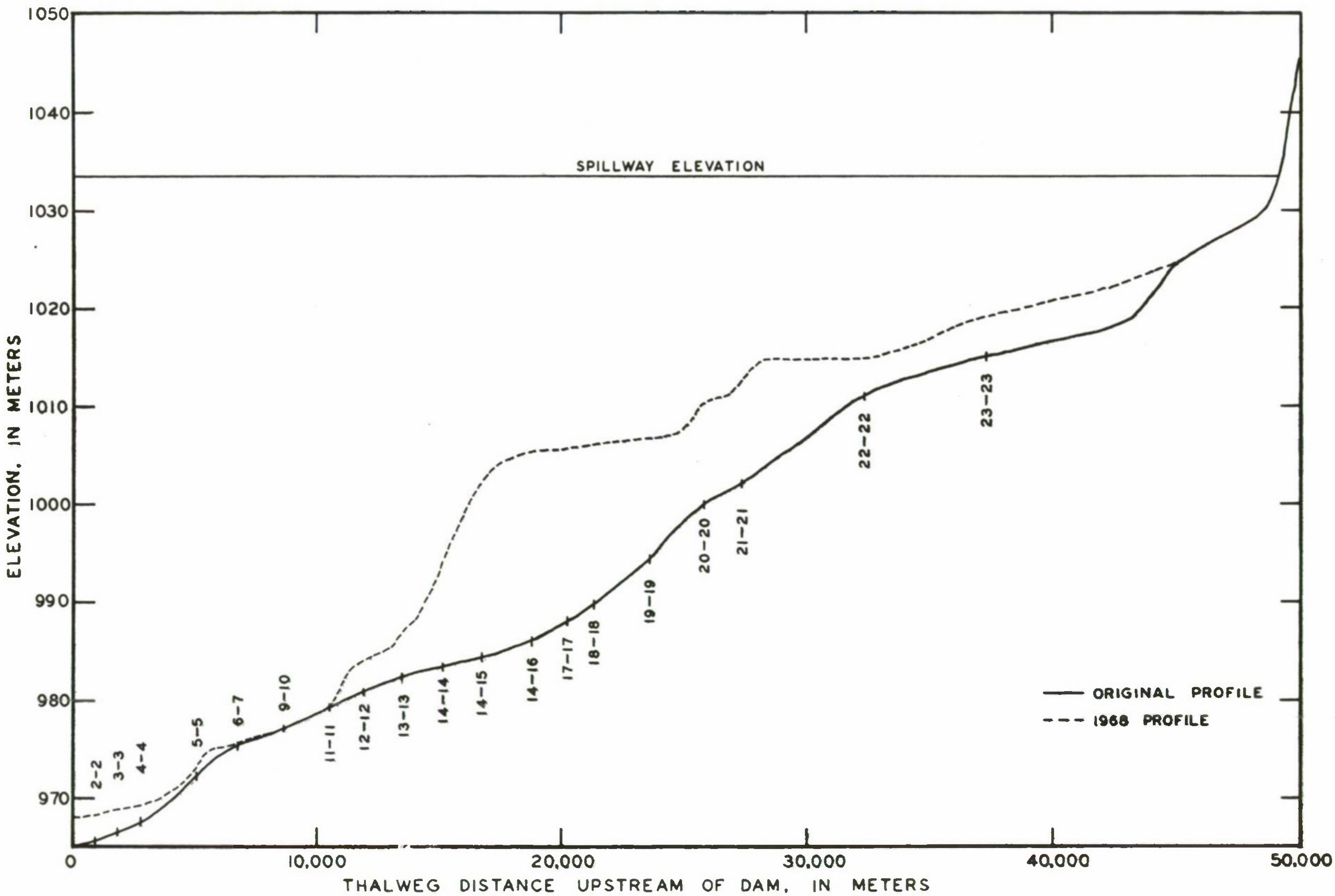

FIGURE 12. --PROFILE OF SEDIMENT DISTRIBUTION ALONG HELMAND RIVER CHANNEL THROUGH KAJAKAI RESERVOIR.

(figure 11-appendix). The most active area of deposition was in the delta area formed where the river enters the reservoir. Position of this active delta is governed by reservoir elevation and river discharge. The rate of movement of the delta becomes more rapid when the reservoir elevation is low and river discharge is high. During that period of the year when river discharge becomes significantly greater than releases, the reservoir elevation rises rapidly, and the delta movement into the lake slows as more deposition occurs at the higher elevations upstream. As the elevation of the reservoir drops, a portion of the sediment deposited in the upstream reaches is carried further into the reservoir. The two small deltas at elevations 1010 and 1015 meters (figure 12) are the relatively recent effects of the later phenomena.

Movement of the leading edge of the deposit, in that reach between range lines 12-12 and 14-15, will not advance appreciably until the secondary deltas between range lines 19-19 and 21-21 are moved to range line 14-15. This may occur rapidly if the water level in the reservoir is drawn down to an elevation of 1005 meters or less for two or more years in succession. However, if the minimum reservoir elevation is not drawn down below about 1015 meters for a number of years, delta encroachment to the narrows will be slower because the sediments would be deposited as berms in the upstream river channel between range line 21-21 and some point upstream of where the current profiles coincide.

Samples of the deposited bed material were obtained with a Foerst bed-material sampler. The sampler was raised and lowered by means of a U.S. B-54 sounding reel powered by a 12-volt power unit. Reel, power unit, and sampler were attached to a simple pipe crane which was mounted on the boat (figure 13). Samples were collected throughout the reservoir, from the river at the confluence and in the river channel upstream of the reservoir. Core samples of the sediment deposits in the reservoir were not obtained because of funds and time limitations.

Samples of the lake-bed material were not analyzed for particle-size distribution other than to determine percent passing a 63 micron sieve. These samples were virtually all identical in composition, 99.4% limestone clays and silts, and 0.6% coarser than 63 micron. Estimated density of these fine-material surface deposits was 30-50 pounds per cubic foot. Apparently, much of this material originates from the banks of the reservoir, being sorted and washed out of the natural soils by wave action.

Samples taken from the area of the river confluence and the river channel upstream were analyzed for particle-size distribution by wet-sieve method. Results of these analyses are shown in table 6.

Figure 13.--View of Foerst bed-material sampler in use.

Table 6.--PARTICLE-SIZE ANALYSES OF BED-MATERIAL SAMPLES OF HELMAND RIVER

Location of Sample	Percent Finer than indicated size (microns)			
	63	125	250	500
Confluence w/river at elev. 1015 meters	75.3	98.6	99.8	100
Confluence w/river at elev. 1015 meters	77.5	98.8	99.9	100
Dry sample-deposited about 1600 meters upstream of range line 23-23	11.6	93.9	99.9	100
River channel at elev. 1026 meters	4.2	63.1	99.2	100

Note: Range line 23-23 is not shown on figure 1. It is located approximately 5,000 meters upstream of range line 22-22.

Upstream of sediment range line 23-23, the bed of the river channel consists largely of rock and gravel with only minor deposits of sands and silts. Virtually all material finer than about 500 microns is carried in suspension into the upper reaches of the reservoir. During periods when the reservoir elevation is at or above spillway elevation, river discharge is also high and most of the sands carried in suspension are deposited in the old river flood plain (figure 14). To date, these deposits appear to be relatively insignificant in terms of reducing the useful capacity. Measurement of the volumes of sediment

Figure 14.--View of sediment deposited along river floodplain near range line 22-22.

deposited in the reservoir area upstream of sediment range line 23-23 was not accomplished by the 1968 survey. Figure 21 in the appendix is an illustration of typical cross sections in the upper reservoir reaches where berms of fine sand and clay are found in the flood plain areas.

Future Sedimentation

As shown in table 1, the results of the 1968 survey indicated a loss in capacity of 7.0 percent at the spillway elevation 1033.5 meters. However, due to discrepancies found in several original contours, this indicated loss in capacity cannot be used strictly as a loss due to sediment deposition. Refinement of original contours resulted in an increase in capacity in those reaches between range line 5-5 and 13-13 of about 13,600 acre-feet. Applying this correction to the original capacity of 1,495,000 acre-feet at spillway elevation results in a loss due to sediment deposition of 7.8%, or a sediment deposition of 117,700 acre-feet during the first fifteen years of storage. This was an average annual loss in capacity to spillway elevation of about 7,800 acre-feet per year. Assuming an average sediment density of 50 pounds per cubic foot, the average annual sediment inflow was about 8,500,000 tons per year.

A flow-duration curve (figure 15) based on data given in table 7 shows that the average annual inflow to Kajakai Reservoir for the period 1953-1965 was 5,200,000 acre-feet

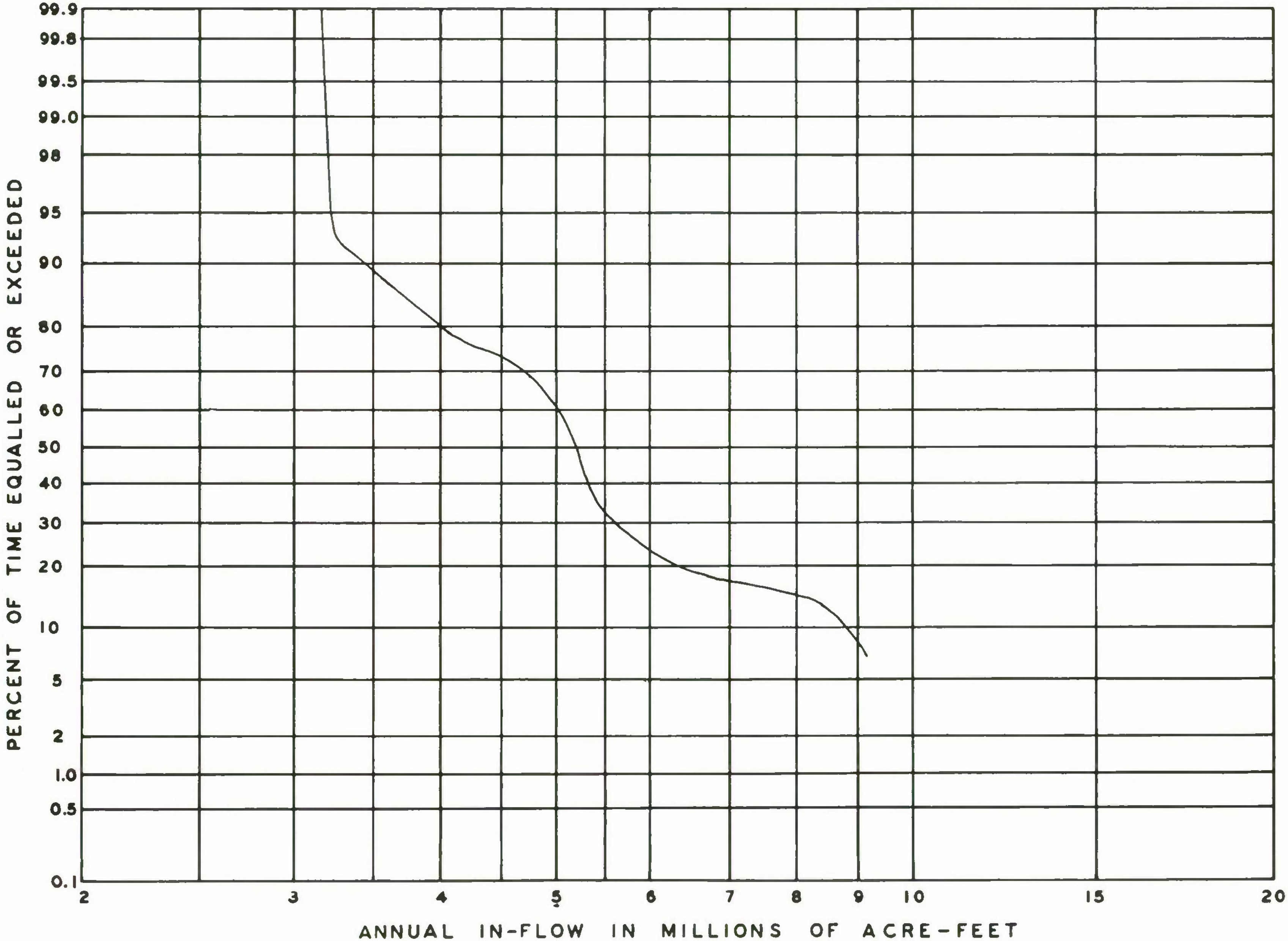

FIGURE 15.--FLOW-DURATION CURVE OF ANNUAL INFLOW TO KAJAKAI RESERVOIR, 1953-1965 WATER YEARS.

Table 7.--SUMMARY OF ANNUAL INFLOW TO KAJAKAI RESERVOIR

Water Year	Helmand River Near Dehraout Acre-feet	Tirin River at Dehraout Acre-feet	Total Acre-feet
1953	3,896,000	260,000	4,156,000
1954	4,932,000	591,000	5,523,000
1955	3,575,000	221,000	3,796,000
1956	5,295,000	657,000	5,952,000
1957	8,589,000	470,000	9,059,000
1958	4,949,000	302,000	5,251,000
1959	4,548,000	455,000	5,003,000
1960	4,411,000	324,000	4,735,000
1961	4,591,000	544,000	5,135,000
1962	2,999,000	176,000	3,175,000
1963	3,119,000	182,000	3,301,000
1964	4,784,000	371,000	5,155,000
1965	7,171,000	704,000	7,875,000
1966	3,110,000		

Assuming that inflow characteristics do not change appreciably over the next 15-year period, it is probable that the sediment inflow will average about 8,500,000 tons per year during that period. Future rate of change in capacity, however, may vary considerably if reservoir operation is changed due to an increase in rate of release for irrigation or power production, or if the timing of releases is changed. Sediment deposits will gradually become compacted over the years as more sediment is deposited over earlier deposits. Rate of compaction of sediment can be estimated only if data are available on size of the deposited material. These data are not available and cannot be obtained without core samples of the entire depth of deposit.

Samples that were obtained indicate that the greater percentage of the deposited material consists of extremely fine material at densities of 30-50 pounds per cubic foot. These deposits will compact under water over the years. Also, if the water level in the reservoir were to be lowered to an elevation of 1005 meters or lower each year for a number of years, the fine sediments at elevations about 1005 meters would compact more rapidly due to alternate wetting and drying.

To estimate future volumes of sediment deposition based on an average annual fill rate of 7,800 acre-feet determined after 15 years might be conservative. An experiment to determine reduction in volume due to drying was performed during the survey on material sampled from the lake bed. When the samples were thoroughly dried, the average percent reduction in volume was 53 percent. This value was used as a basis for estimating reduction in volume of deposits due to alternate wetting and drying.

Based on data which have been presented in this report, an estimated rate of compaction, and the assumption that hydrologic conditions in the reservoir drainage area do not change appreciably, the principal delta front will reach the irrigation outlet (approximate elevation 968 meters) in 40 to 45 years. At the end of this 40 to 45-year period, it is estimated that the reservoir capacity at spillway elevation will be reduced to about 1,200,000 acre-feet. It is recommended that a resurvey of sediment range lines be made at some time during the period 1973 to 1975, especially if changes in reservoir operation are made during the next few years.

APPENDIX

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Tables

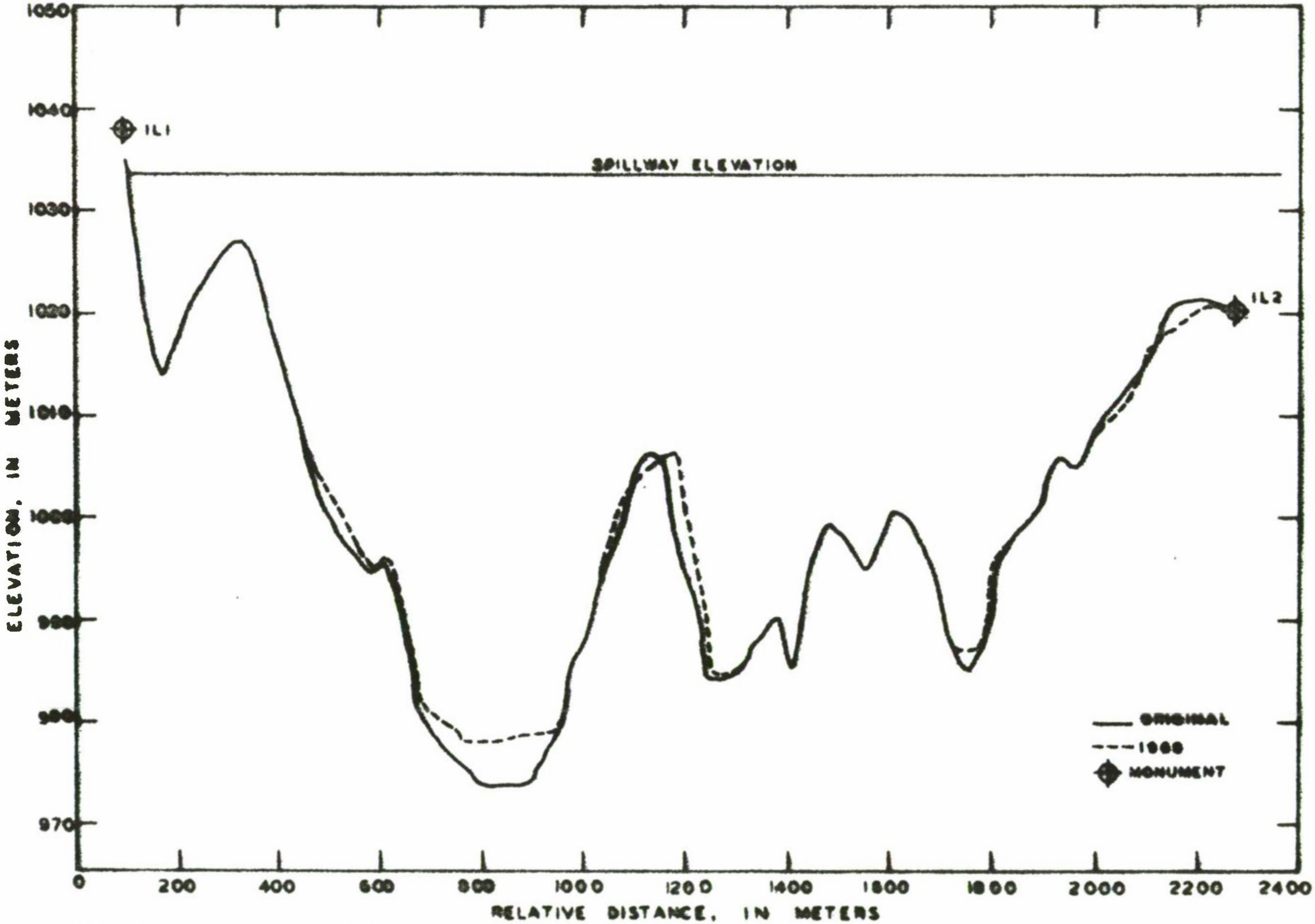

FIGURE 1.--CROSS-SECTION OF SEDIMENT RANGE LINE NO. I-1, KAJAKAI RESERVOIR, AFGHANISTAN

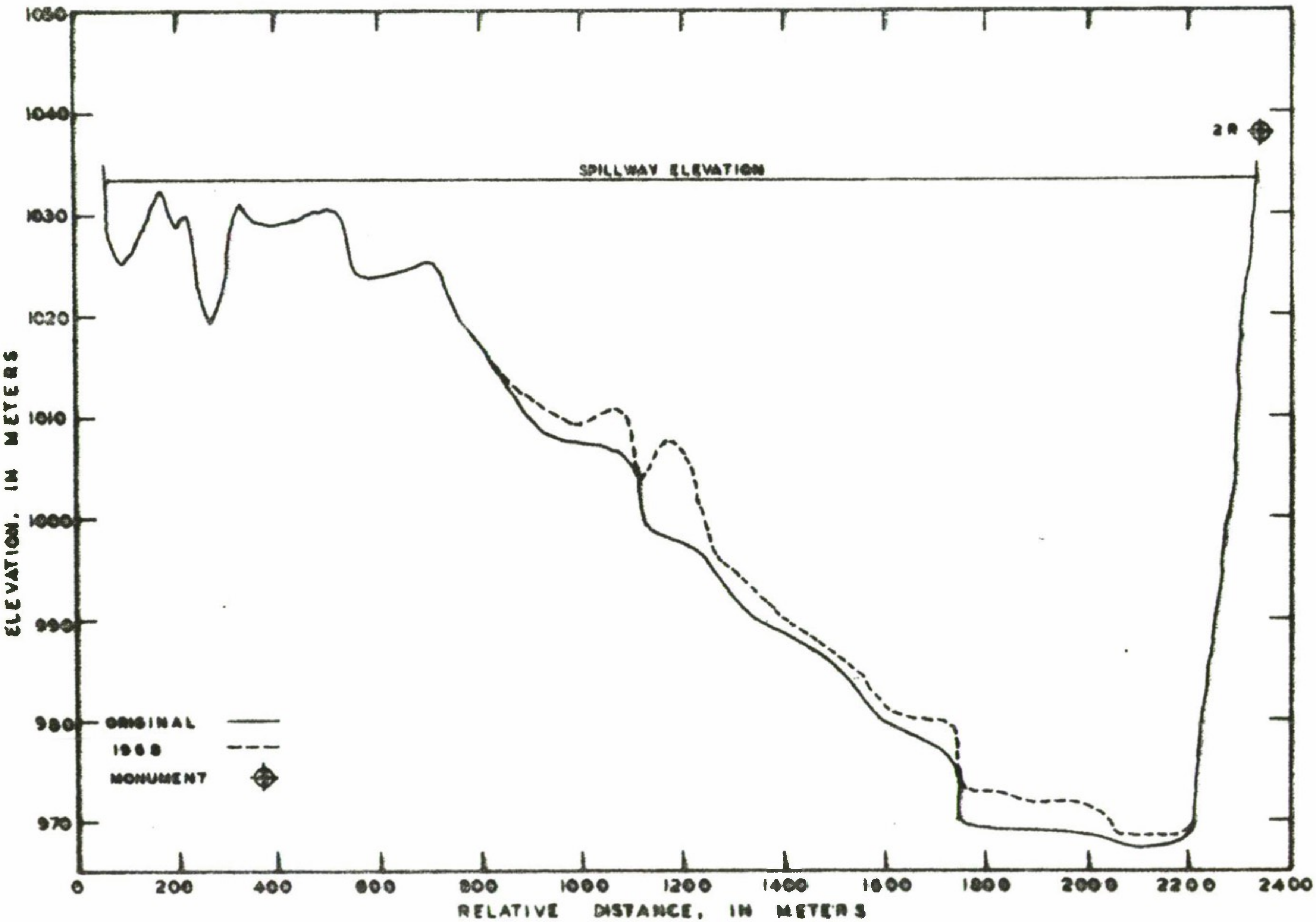

FIGURE 2.-- CROSS — SECTION OF SEDIMENT RANGE LINE NO. 2-2, KAJAKAI RESERVOIR, AFGHANISTAN

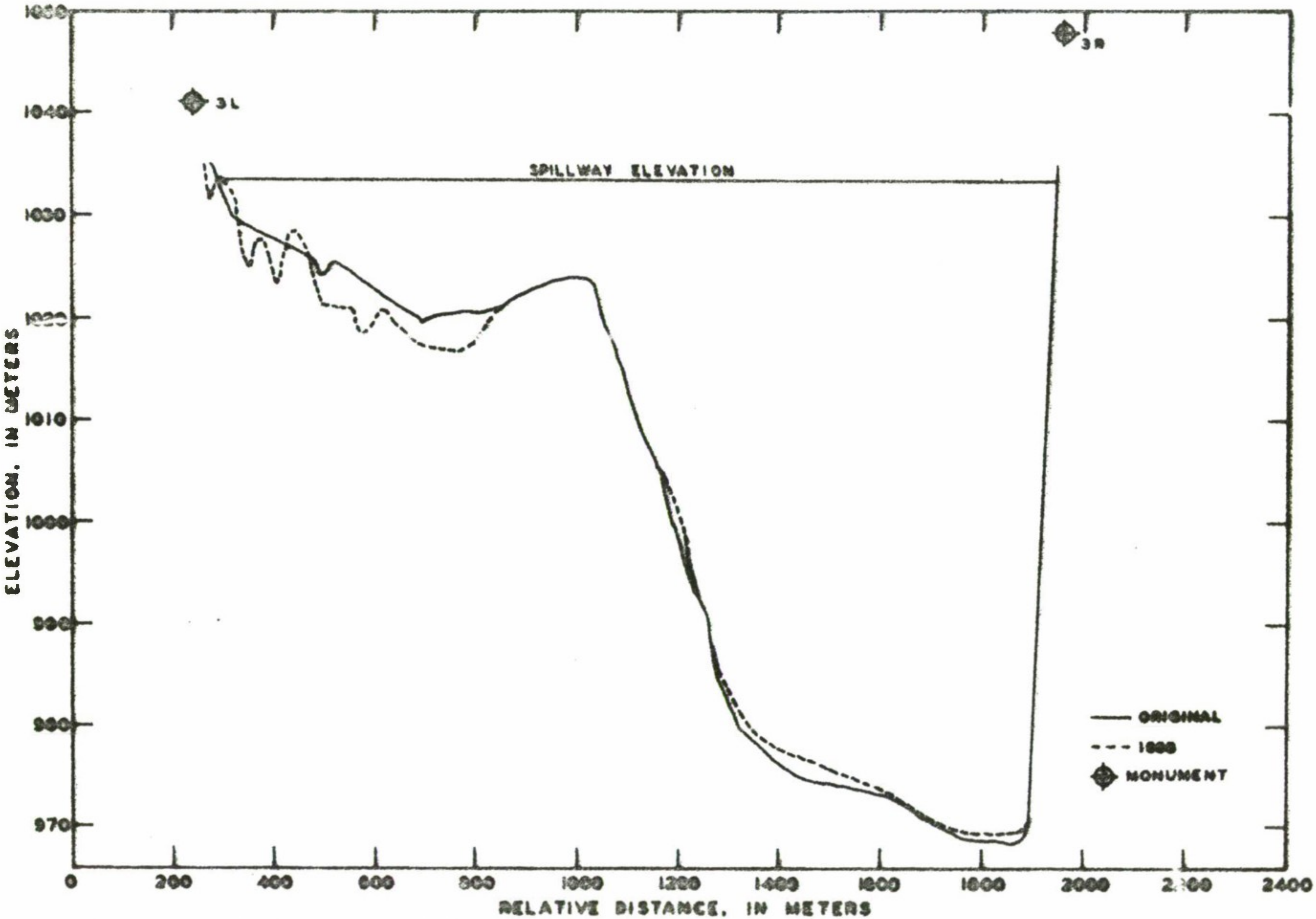

FIGURE 3.--CROSS-SECTION OF SEDIMENT RANGE LINE NO. 3-3, KAJAKAI RESERVOIR, AFGHANISTAN

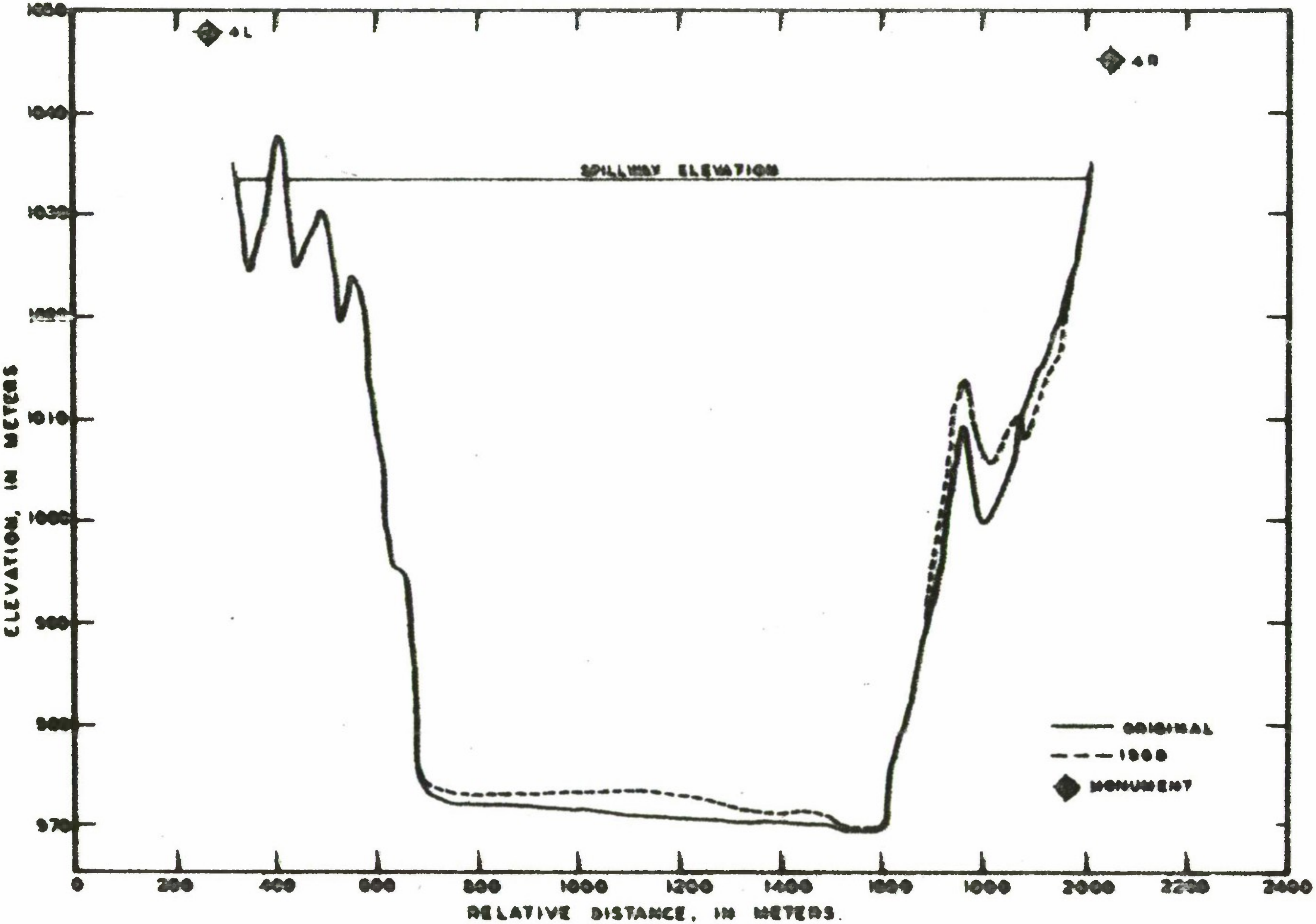

FIGURE 4.--CROSS-SECTION OF SEDIMENT RANGE LINE NO. 4-4. KAJAKAI RESERVOIR, AFGHANISTAN

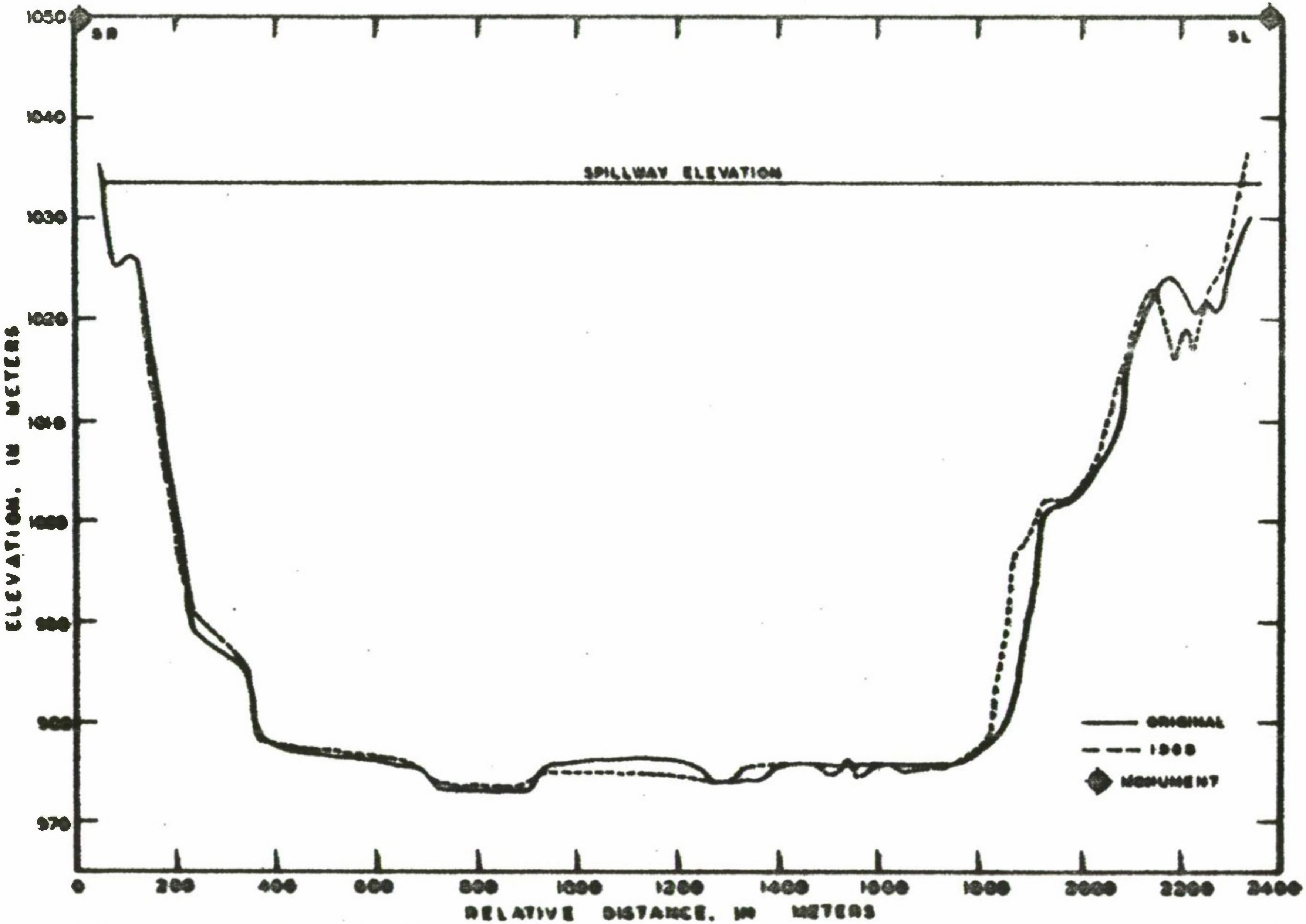

FIGURE 5.--CROSS-SECTION OF SEDIMENT RANGE LINE NO. 5-5, KAJAKAI RESERVOIR, AFGHANISTAN

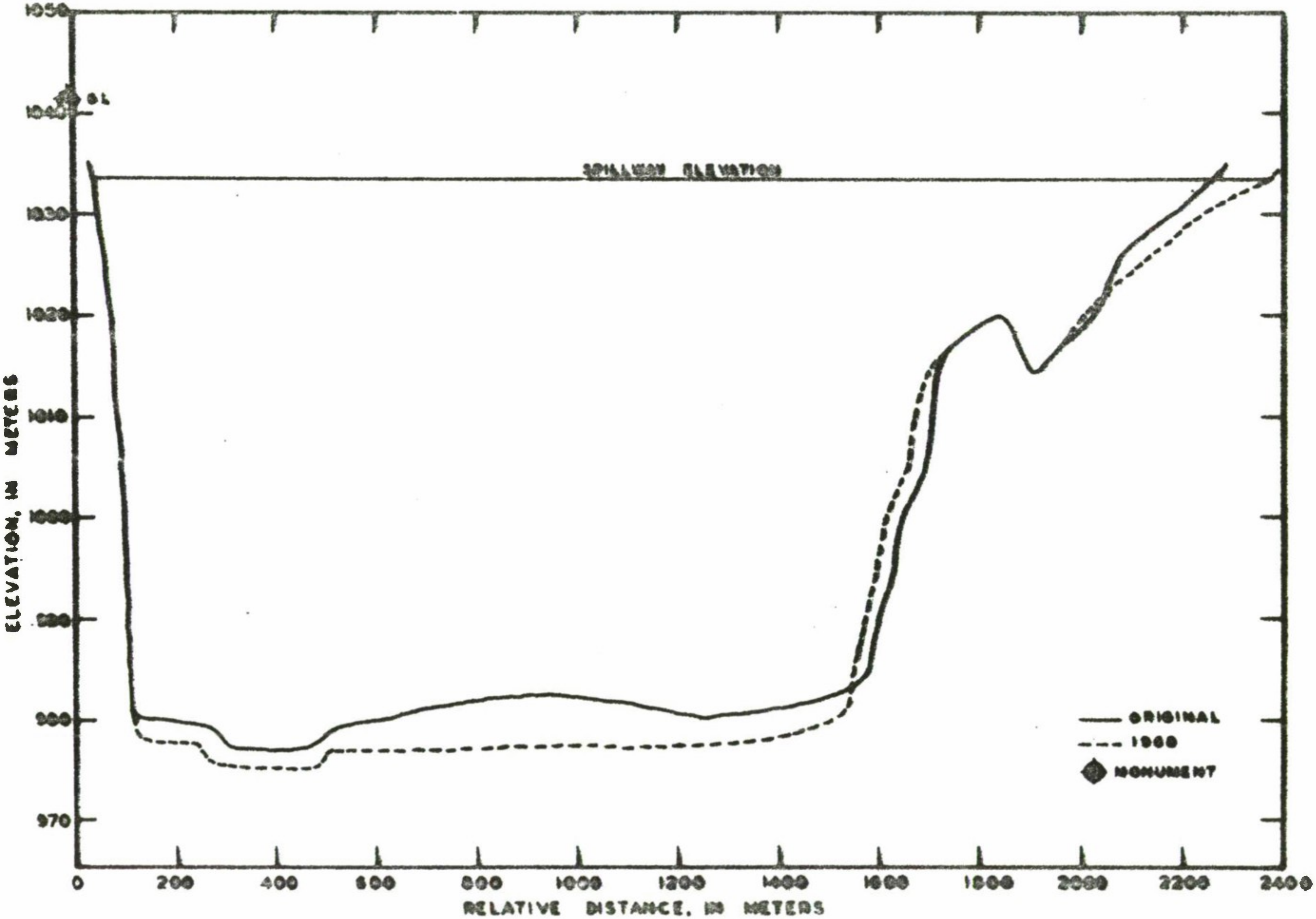

FIGURE 6 -- CROSS - SECTION OF SEDIMENT RANGE LINE NO. 6-6, KAJAKAI RESERVOIR, AFGHANISTAN

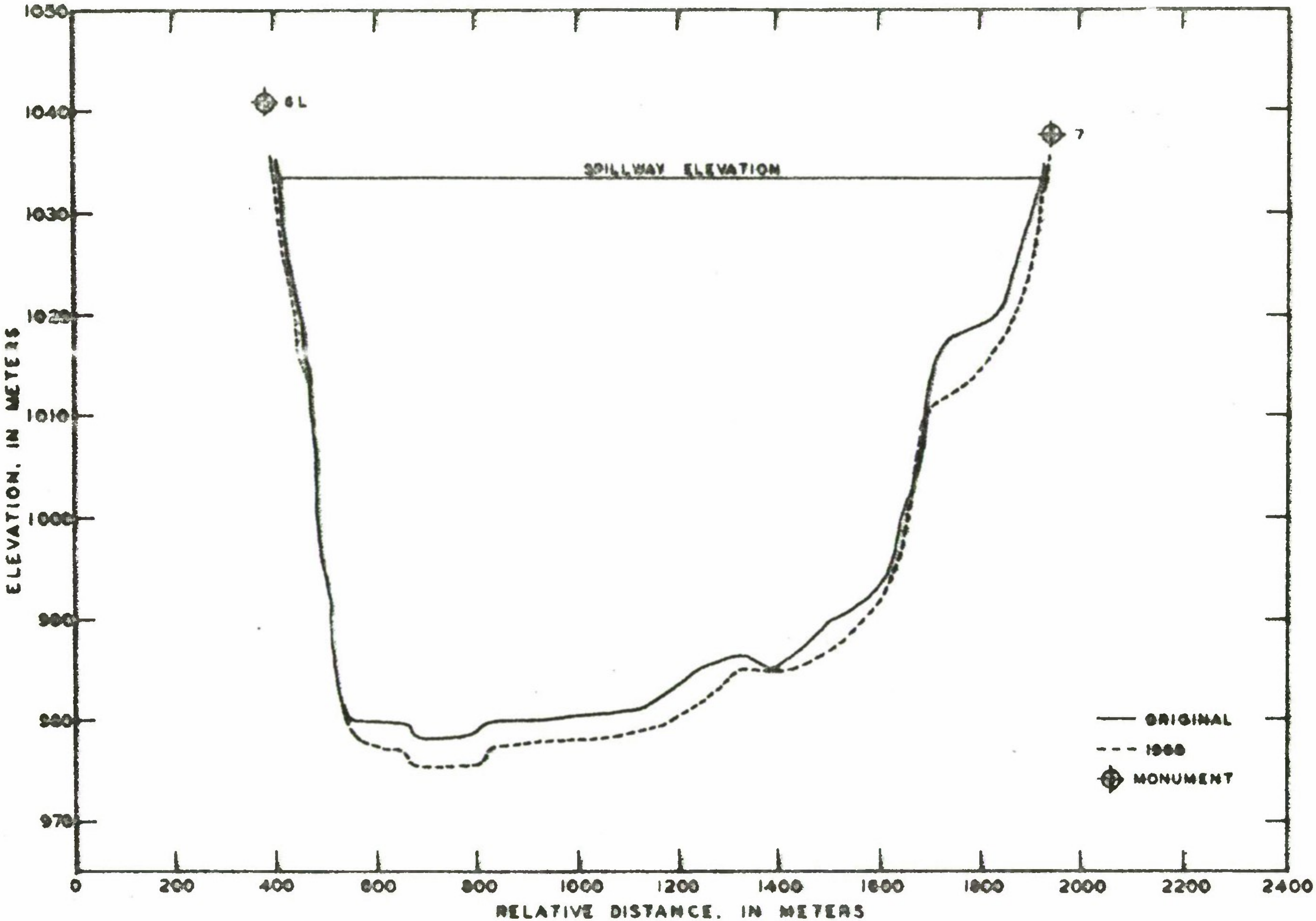

FIGURE 7.--CROSS-SECTION OF SEDIMENT RANGE LINE NO. 6-7, KAJAKAI RESERVOIR, AFGHA ISTAN

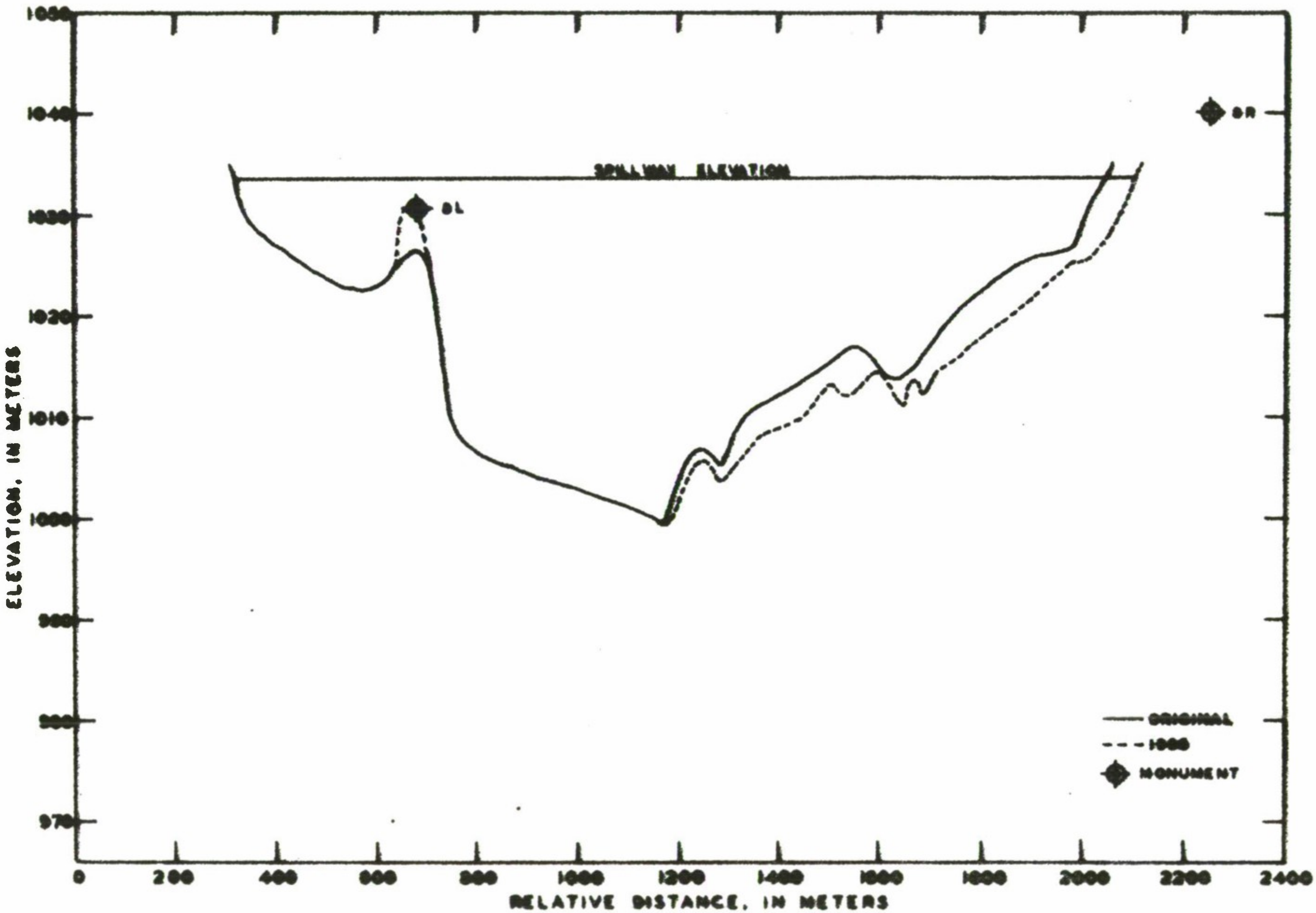

FIGURE 8.--CROSS-SECTION OF SEDIMENT RANGE LINE NO. 8-8. KAJAKAI RESERVOIR, AFGHANISTAN

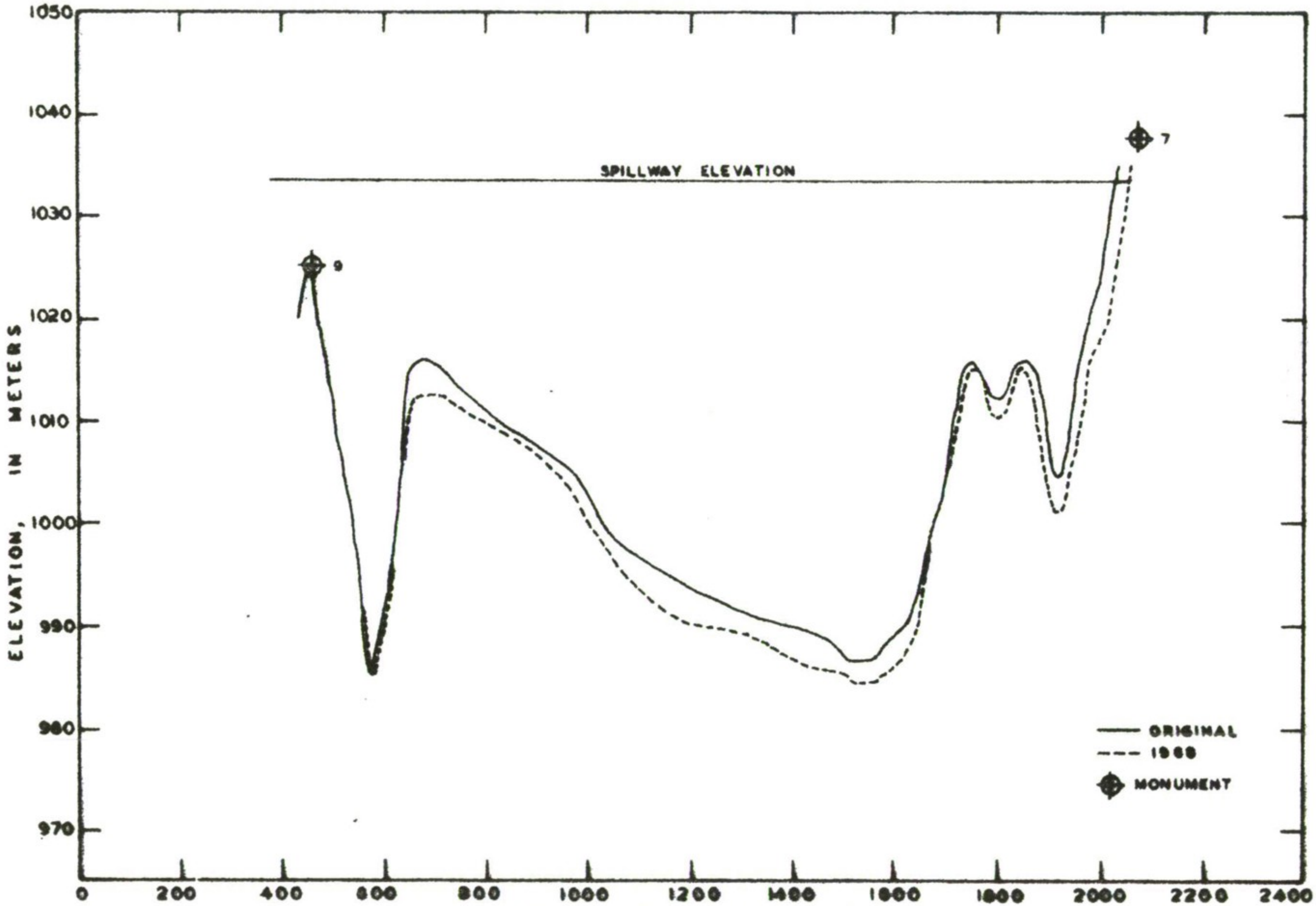

FIGURE 9.--CROSS-SECTION OF SEDIMENT RANGE LINE NO. 9-7, KAJAKAI RESERVOIR, AFGHANISTAN

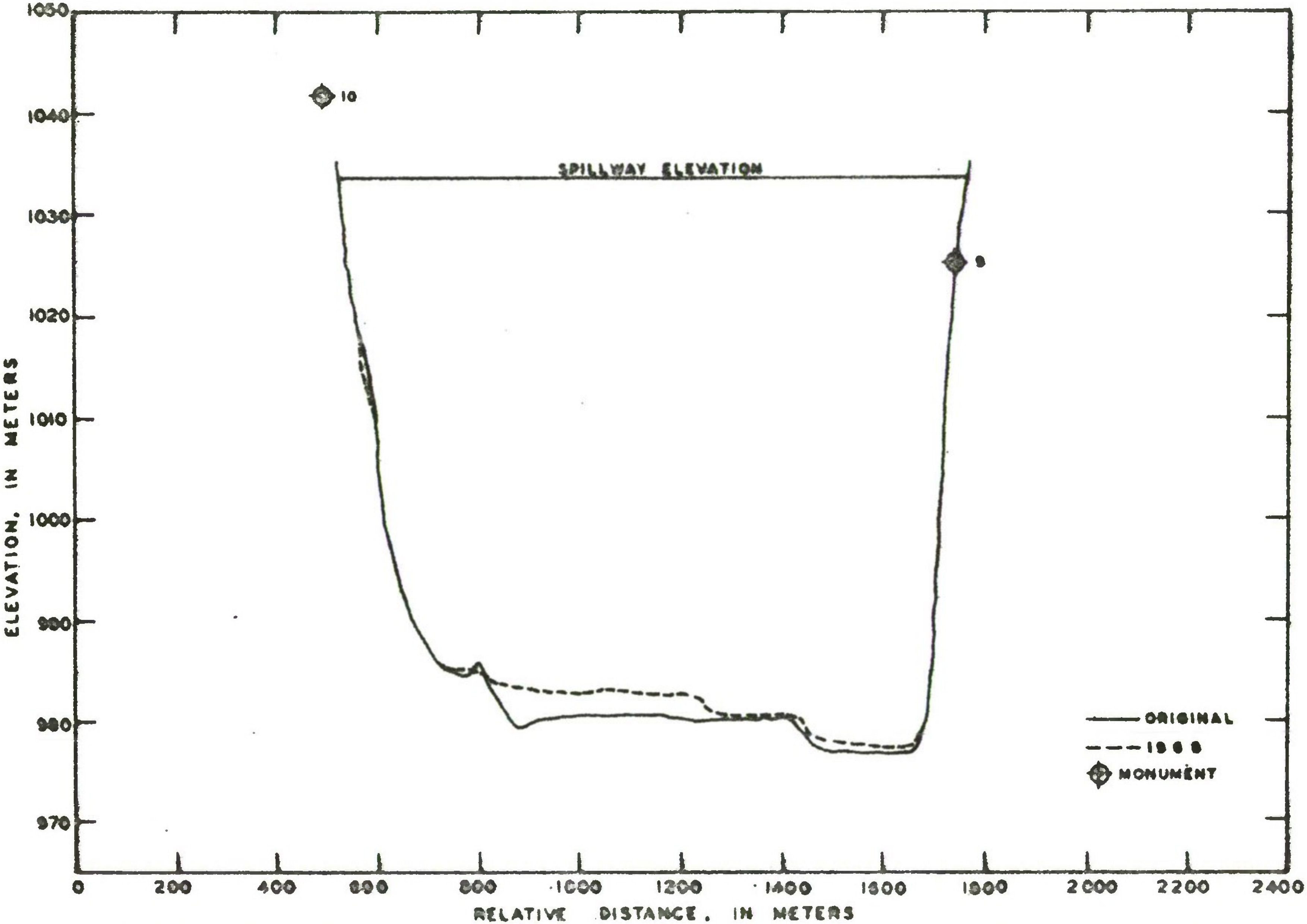

FIGURE 10.--CROSS-SECTION OF SEDIMENT RANGE LINE NO. 9-10, KAJAKAI RESERVOIR, AFGHANISTAN

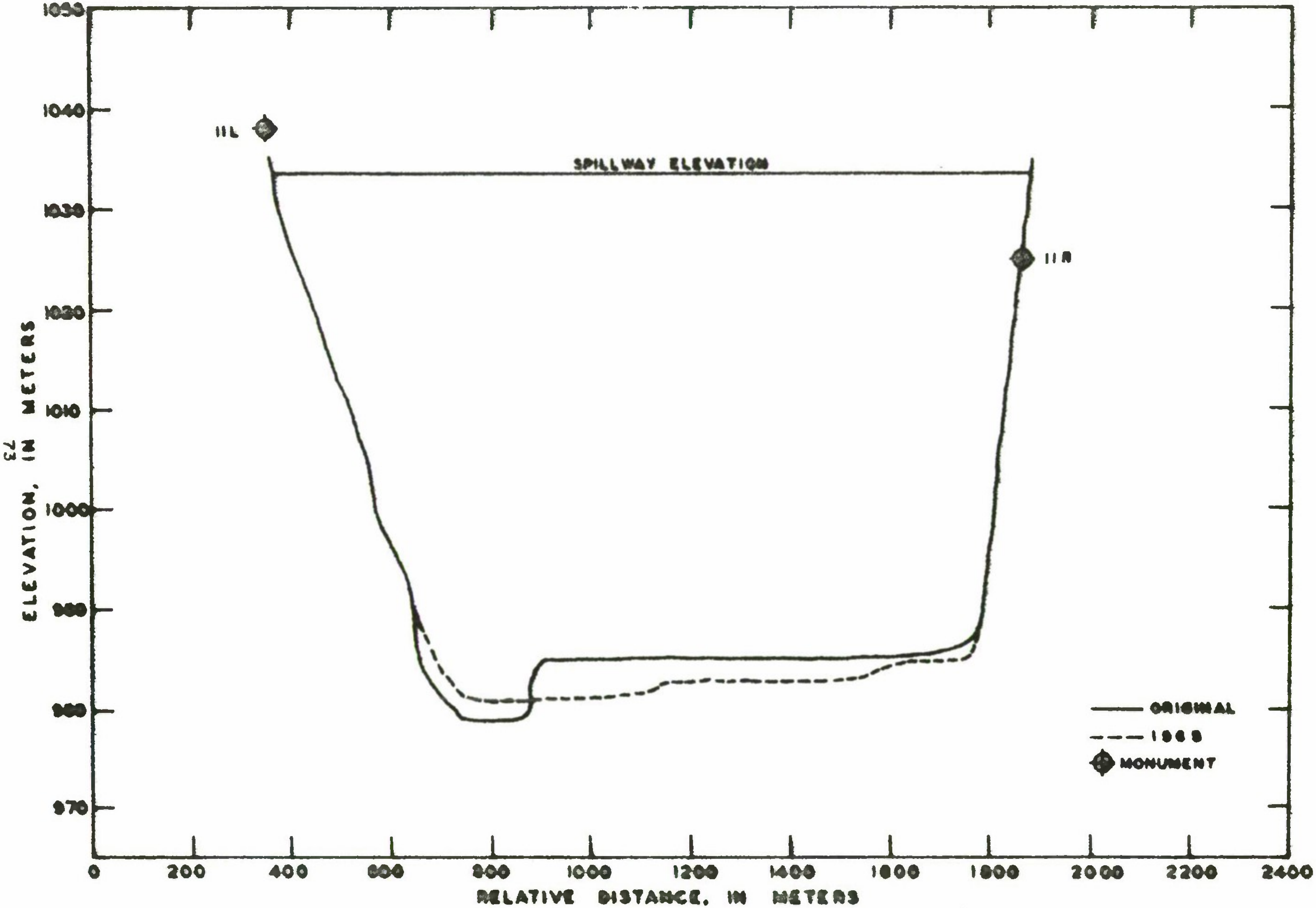

FIGURE 11 .--CROSS - SECTION OF SEDIMENT RANGE LINE NO. 11-11, KAJAKAI RESERVOIR, AFGHANISTAN

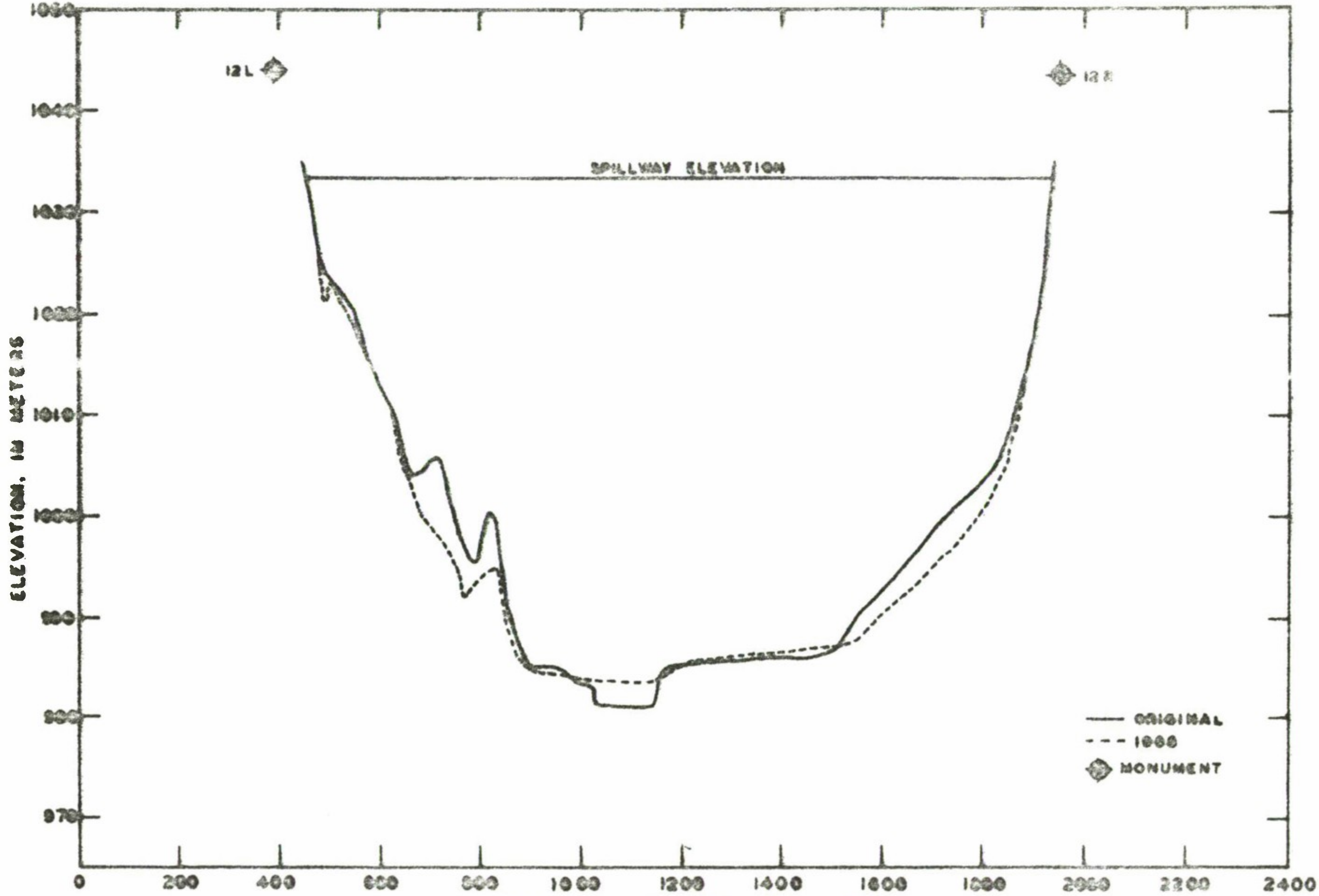

FIGURE 12.--CROSS-SECTION OF SEDIMENT RANGE LINE NO. 12-12, KAJAKAI RESERVOIR, AFGHANISTAN

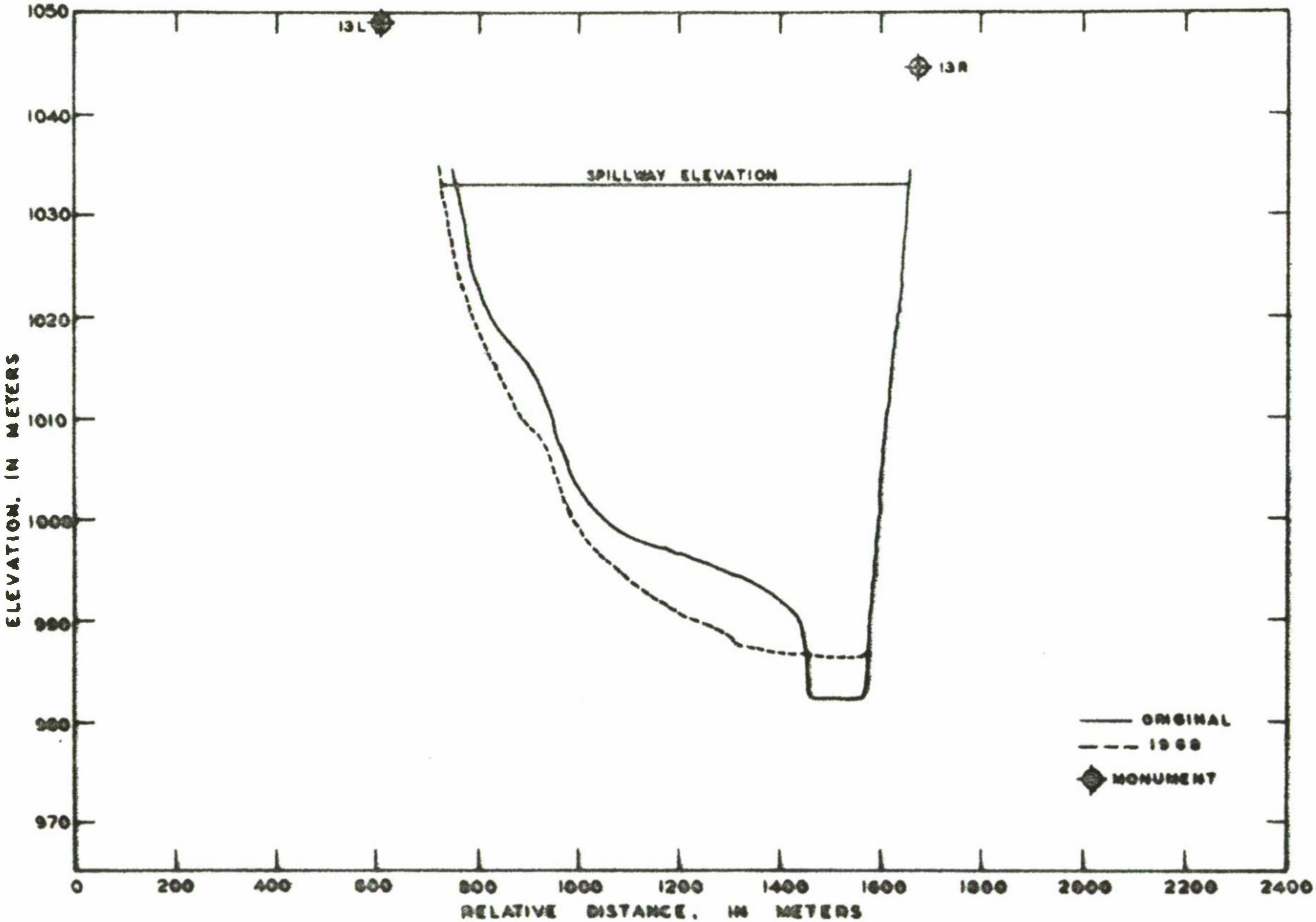

FIGURE 13.-- CROSS - SECTION OF SEDIMENT RANGE LINE NO. 13-13, KAJAKAI RESERVOIR, AFGHANISTAN

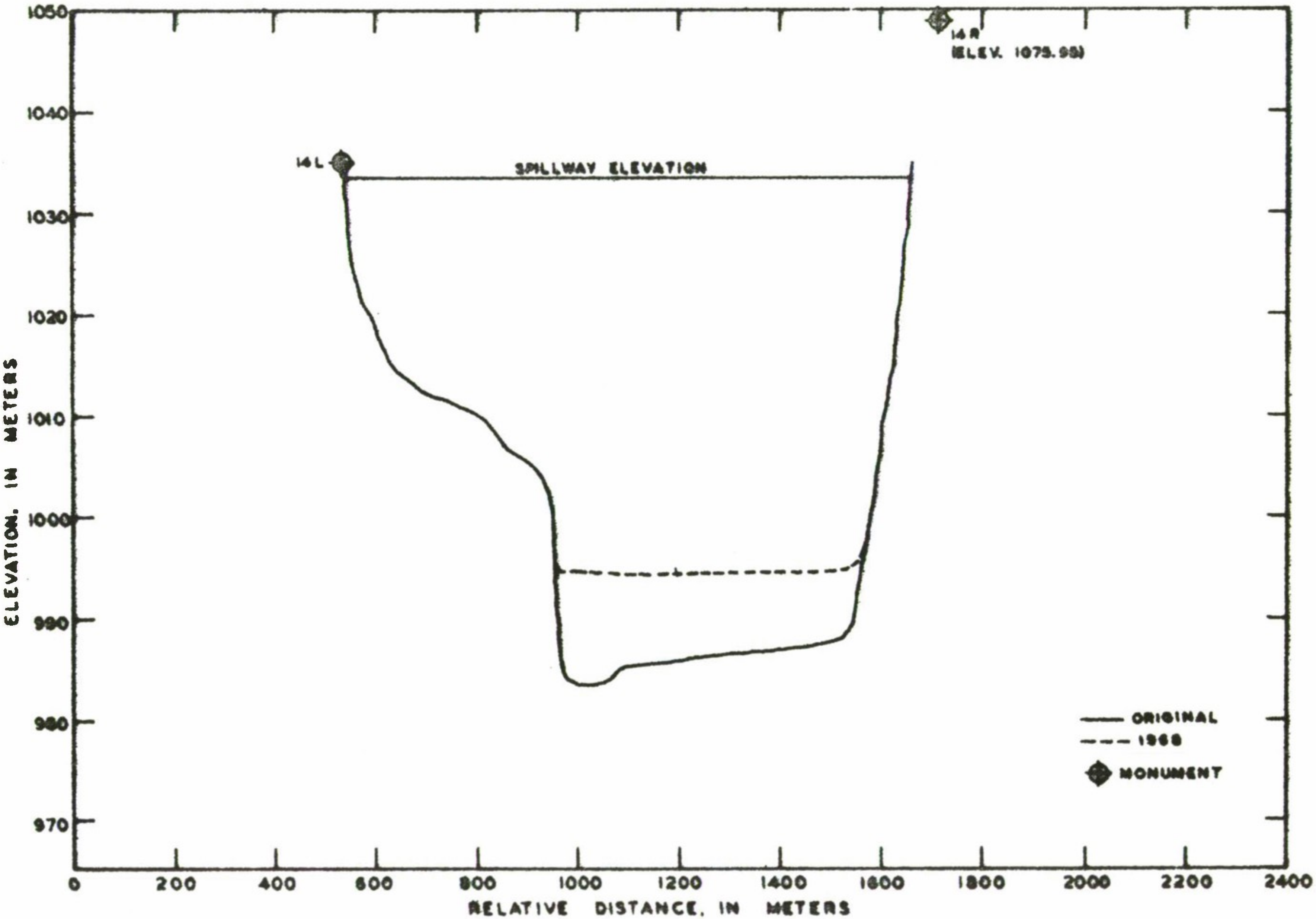

FIGURE 14.-- CROSS - SECTION OF SEDIMENT RANGE LINE NO. 14-14, KAJAKAI RESERVOIR, AFGHANISTAN

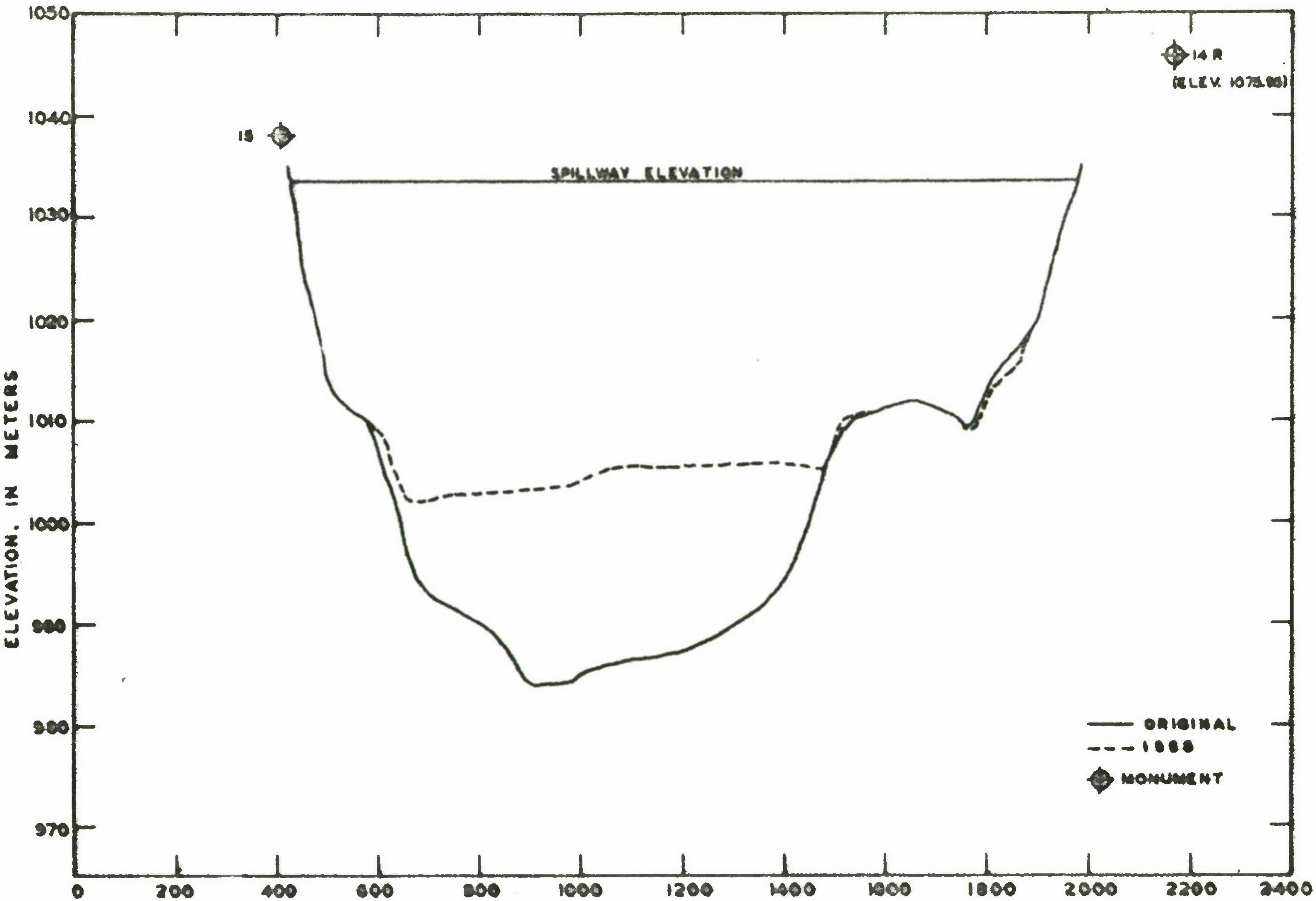

FIGURE 15.-- CROSS - SECTION OF SEDIMENT RANGE LINE NO. 14-15, KAJAKAI RESERVOIR, AFGHANISTAN

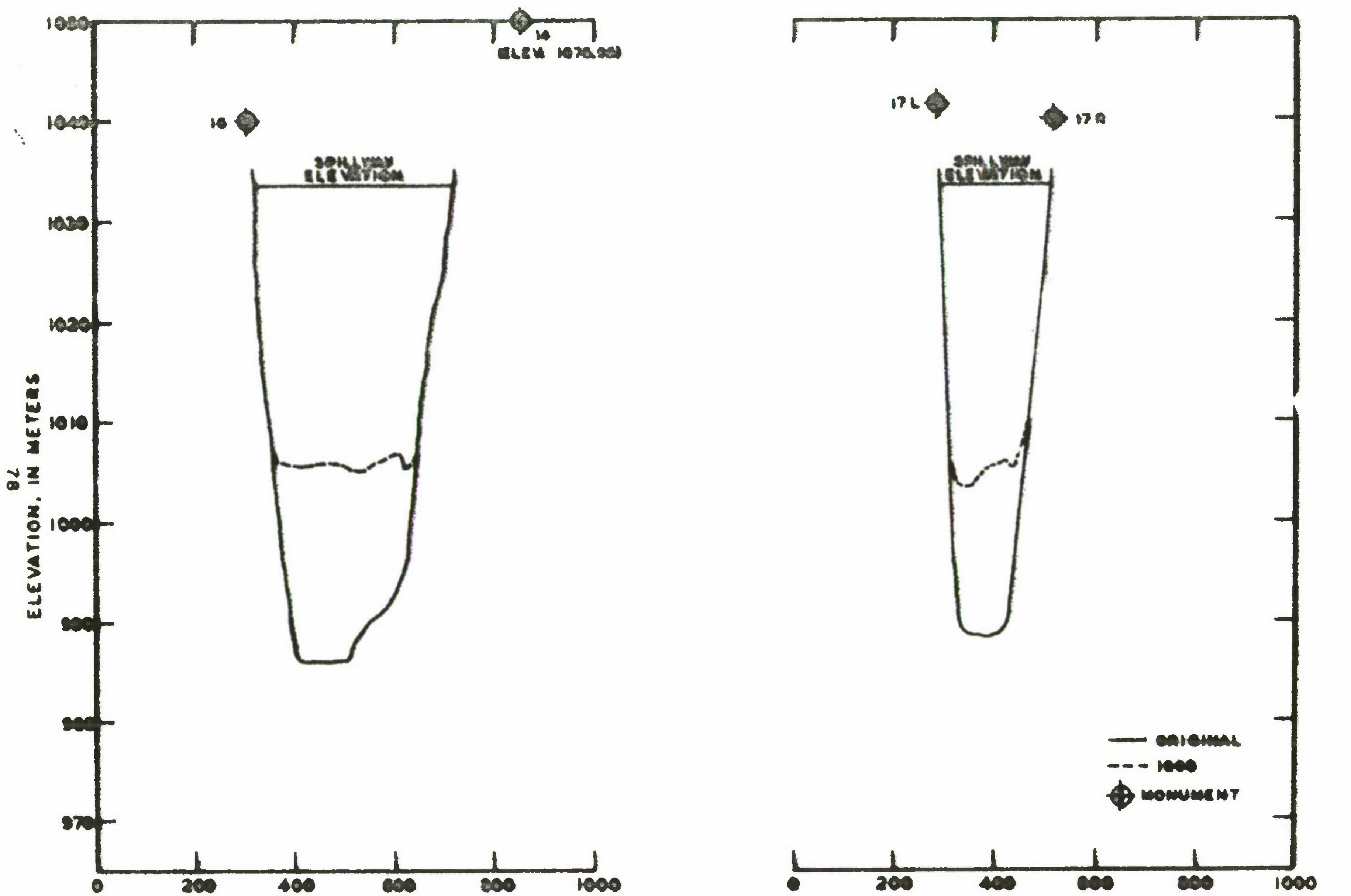

FIGURE 16--CROSS-SECTION OF SEDIMENT RANGE LINE NO. 14-16 & 17-17, KAJAKAI RESERVOIR, AFGHANISTAN

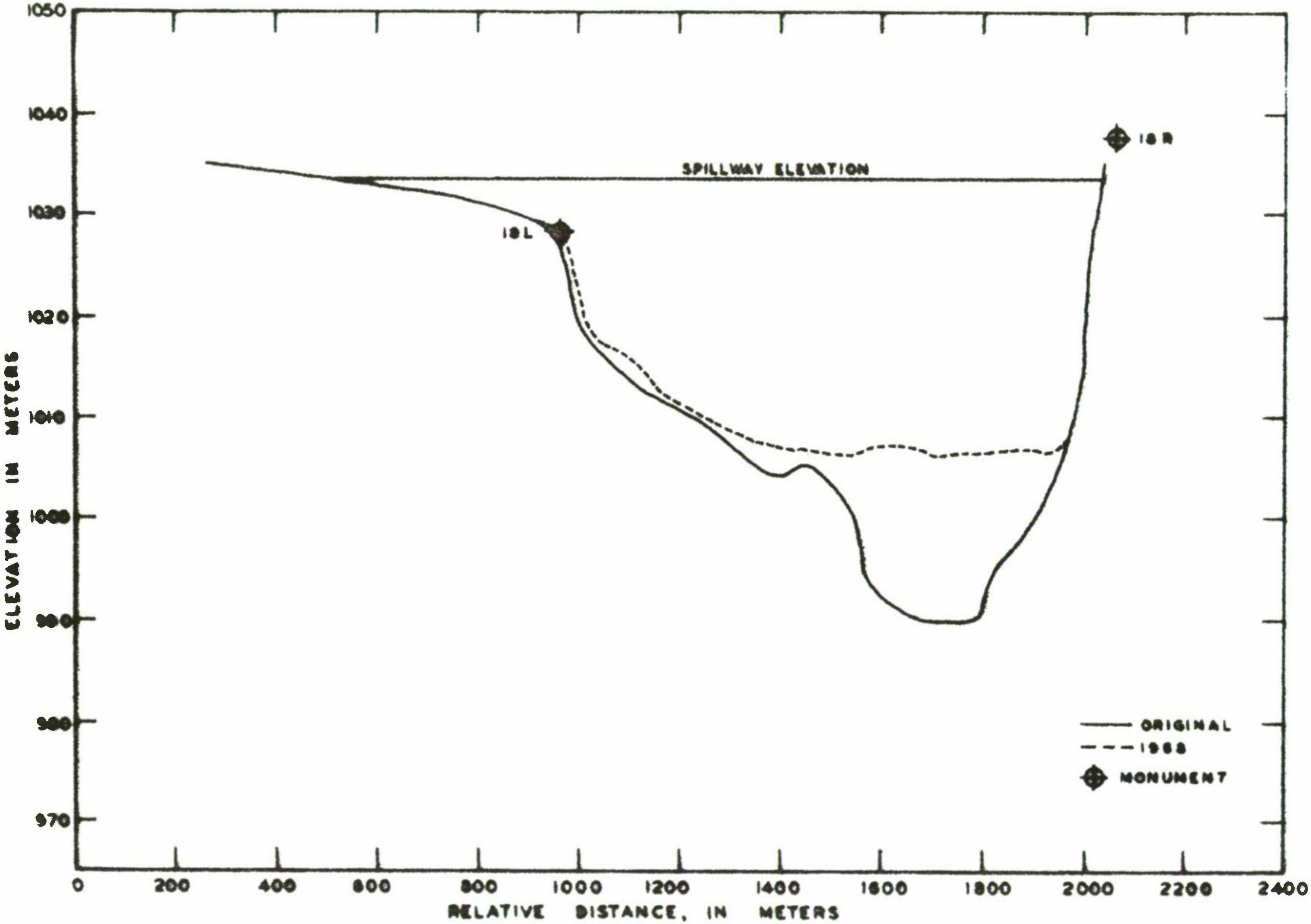

FIGURE 17.--CROSS-SECTION OF SEDIMENT RANGE LINE NO. 18-18, KAJAKAI RESERVOIR, AFGHANISTAN

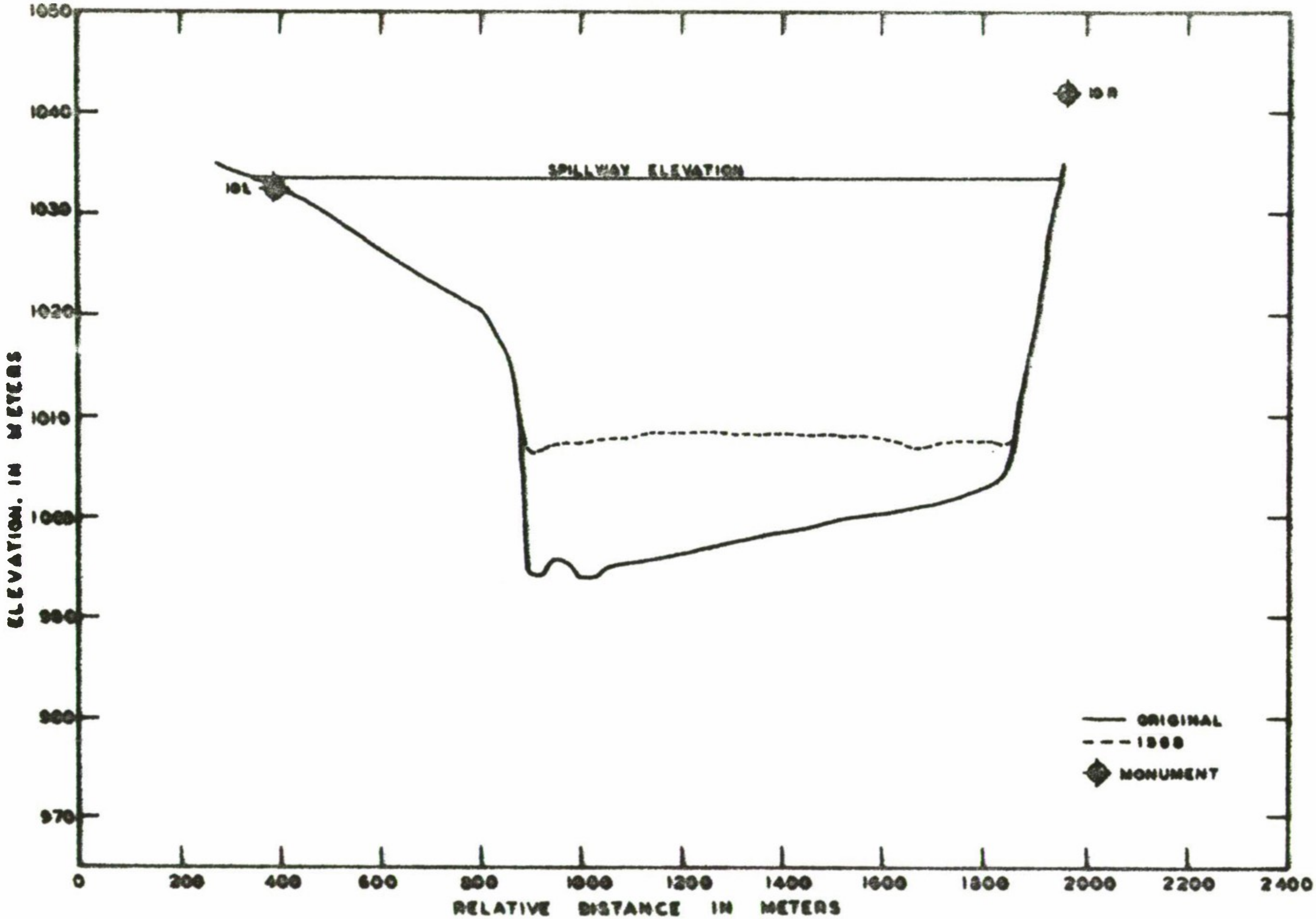

FIGURE 18.--CROSS-SECTION OF SEDIMENT RANGE LINE NO. 10-10, KAJAKAI RESERVOIR, AFGHANISTAN

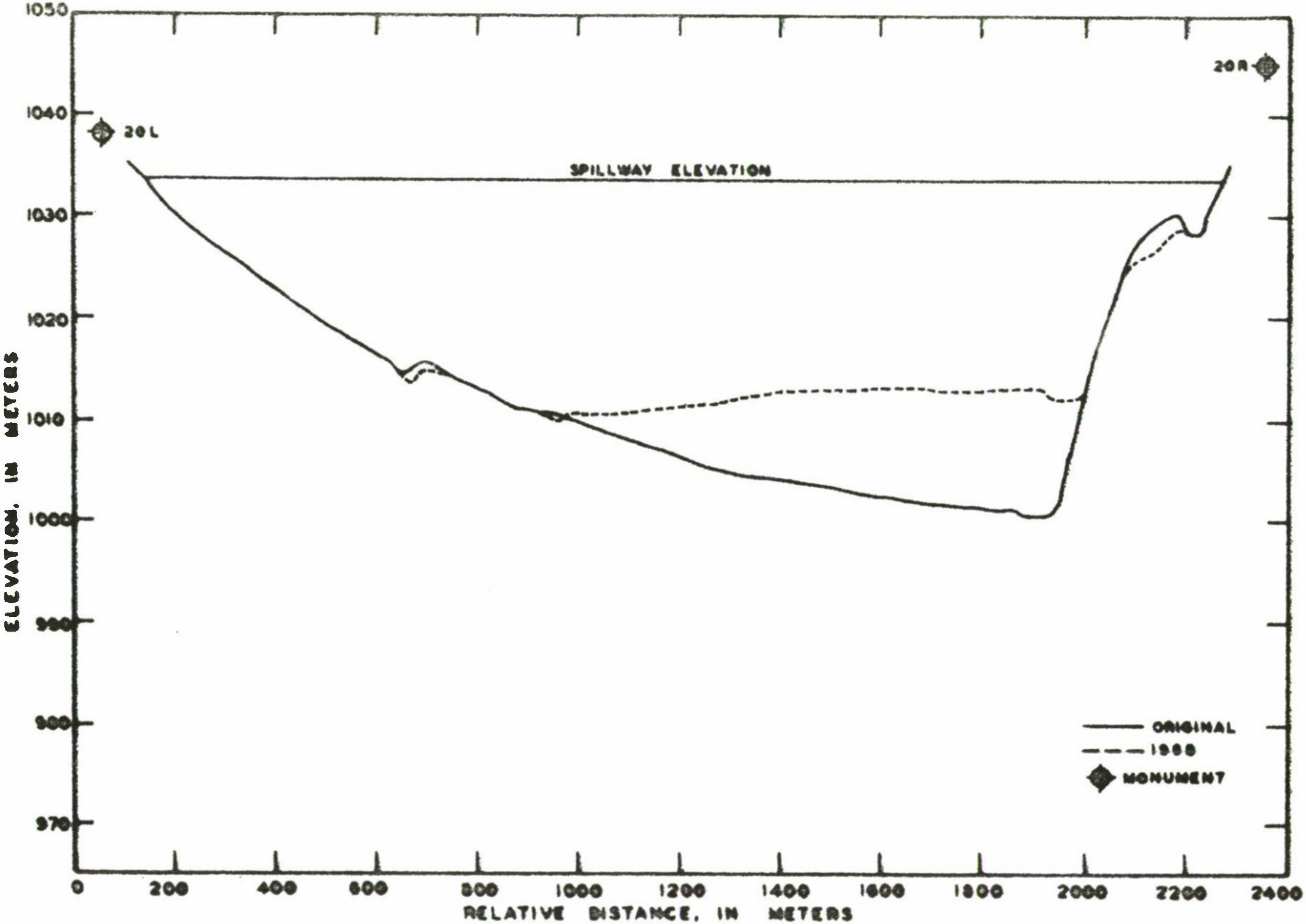

FIGURE 19.--CROSS-SECTION OF SEDIMENT RANGE LINE NO. 20-20, KAJAKAI RESERVOIR, AFGHANISTAN

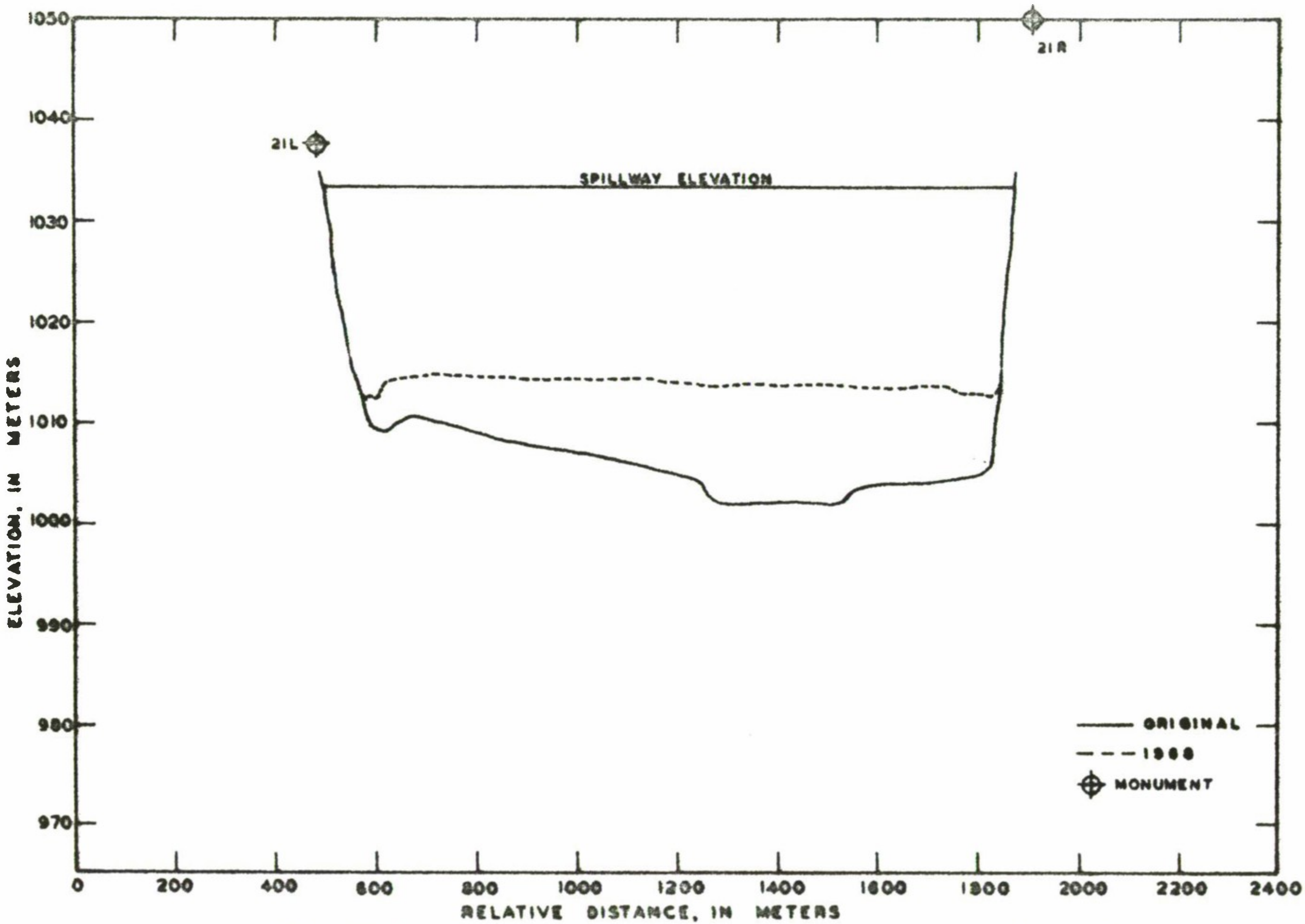

FIGURE 20.--CROSS-SECTION OF SEDIMENT RANGE LINE NO. 21-21, KAJAKAI RESERVOIR, AFGHANISTAN

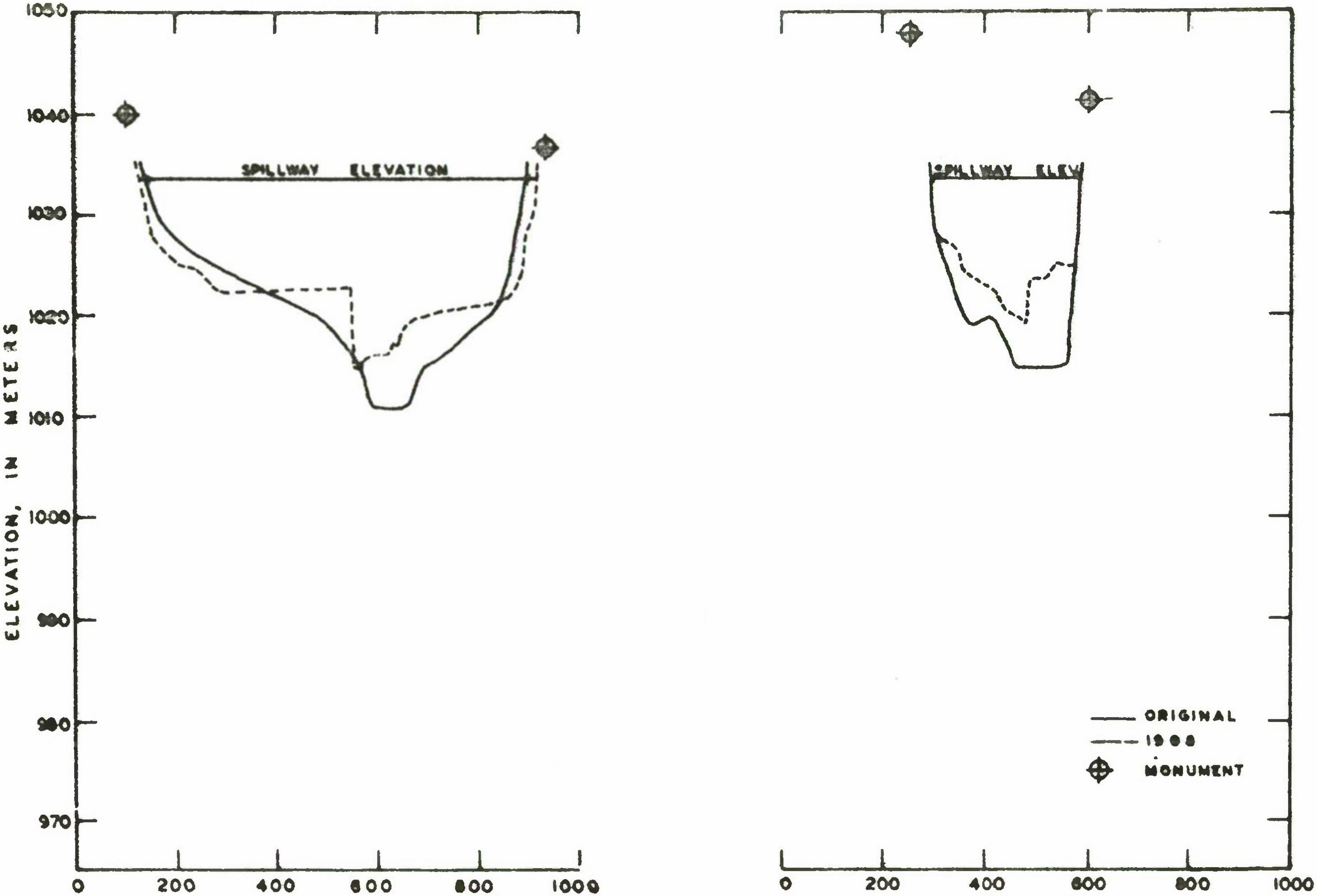

FIGURE 21.-- CROSS-SECTION OF SEDIMENT RANGE LINES NO. 22-22 & 23-23, KAJAKAI RESERVOIR, AFGHANISTAN

Table 1.--AZIMUTHS TO TRIANGULATION STATIONS
(BASED ON THE FAIRCHILD SURVEY)

Note: Positions originate at F2x (at tower observation point) and are carried through the triangulation net on the assumed azimuth of 130°00' for the line F2x to F4x. Vertical datum in 1051.79 meters below station F2x (elev. = 1051.79 meters).

Station Occupied	Station Observed	Azimuth
F1x	F2x	09° 13' 14"
	F4x	92° 25' 09"
	Cut in Peak	140° 30' 36"
Cut in Peak	F1x	320° 30' 36"
	F2x	344° 13' 11"
	F4x	44° 30' 55"
F2x	F3x	85° 18' 12"
	F4x	130° 00' 00"
	Cut in Peak	164° 13' 11"
	F1x	189° 13' 14"
F4x	Cut in Peak	224° 30' 55"
	F1x	272° 25' 09"
	F2x	310° 00' 00"
	F3x	347° 49' 40"
	F5x	11° 49' 12"
	F6x	46° 49' 39"
F3x	F7x	43° 53' 21"
	F5x	104° 47' 21"
	F4x	167° 49' 40"
	F2x	265° 18' 12"
F5x	F3x	284° 47' 21"
	F7x	21° 02' 11"
	F6x	144° 43' 07"
	F4x	191° 49' 12"
	F3x	284° 47' 21"
F6x	F4x	226° 49' 39"
	F5x	324° 43' 67"
	F7x	01° 21' 28"
	F8x	39° 12' 59"
	F9x	65° 40' 51"

Table 1.--Continued

Station Occupied	Station Observed	Azimuth
F7x	F17x	36° 46' 01"
	F8x	106° 17' 51"
	F9x	137° 42' 26"
	F6x	181° 21' 28"
	F5x	201° 02' 11"
	F3x	223° 53' 21"
F8x	F7x	286° 17' 51"
	F17x	01° 54' 59"
	F18x	33° 39' 29"
	F10x	97° 19' 14"
	F11x	124° 10' 27"
	F9x	180° 13' 05"
	F6x	219° 12' 59"
	F7x	286° 17' 51"
F9x	F6x	245° 40' 51"
	F7x	317° 42' 26"
	F8x	00° 13' 05"
	F11x	84° 04' 37"
F17x	F18x	97° 50' 02"
	F10x	139° 53' 08"
	F8x	181° 54' 59"
	F7x	216° 46' 01"
F11x	F9x	264° 04' 37"
	F8x	304° 10' 27"
	F10x	53° 30' 32"
	F12x	101° 32' 40"
F12x	F11x	281° 32' 40"
	F10x	314° 54' 02"
	F13x	346° 17' 56"
	F14x	25° 21' 28"
F10x	F11x	233° 30' 32"
	F8x	277° 19' 14"
	F17x	319° 53' 08"
	F18x	340° 33' 09"
	F16x	22° 57' 47"
	F13x	76° 40' 42"
	F12x	134° 54' 02"
	F11x	233° 30' 32"

Table 1.--Continued

Station Occupied	Station Observed	Azimuth
F18x	F19x	29° 51' 45"
	F16x	124° 09' 50"
	F10x	160° 33' 09"
	F8x	213° 39' 29"
	F17x	277° 50' 02"
F19x	F21x	66° 56' 17"
	F20x	123° 33' 59"
	F16x	171° 12' 53"
	F18x	209° 51' 45"
F16x	F19x	351° 12' 53"
	F20x	36° 39' 02"
	F15x	84° 10' 25"
	F14x	112° 26' 21"
	F13x	173° 20' 41"
	F10x	202° 57' 47"
	F18x	304° 09' 50"
	F19x	351° 12' 53"
F13x	F14x	60° 09' 19"
	F12x	166° 17' 56"
	F10x	256° 40' 42"
	F16x	353° 20' 41"
F14x	F12x	205° 21' 28"
	F13x	240° 09' 19"
	F16x	292° 26' 21"
	F15x	16° 06' 59"
F21x	F24x	63° 52' 50"
	F22x	109° 59' 00"
	F20x	175° 02' 35"
	F19x	246° 56' 17"
F20x	F21x	355° 02' 35"
	F22x	51° 43' 08"
	F15x	168° 13' 12"
	F16x	216° 39' 02"
	F19x	303° 33' 59"
	F21x	355° 02' 35"
F15x	F14x	196° 06' 59"
	F16x	264° 10' 25"
	F20x	348° 13' 12"
	F22x	23° 25' 51"

Table 1.--Continued

Station Occupied	Station Observed	Azimuth		
F22x	F15x	203°	26'	51"
	F20x	231°	43'	08"
	F21x	289°	59'	00"
	F24x	341°	34'	41"
	F23x	23°	10'	03"
F24x	F25x	05°	09'	59"
	F23x	68°	45'	21"
	F22x	161°	34'	41"
	F21x	243°	52'	50"
F25x	F27x	44°	07'	21"
	F23x	121°	15'	21"
	F24x	185°	09'	59"
F23x	F22x	203°	10'	03"
	F24x	248°	45'	21"
	F25x	301°	15'	21"
	F27x	06°	06'	56"
F27x	F23x	186°	06'	56"
	F25x	224°	07'	21"
	F29x	359°	08'	39"
	F28x	22°	07'	33"
F28x	F27x	202°	07'	33"
	F29x	247°	42'	49"
	F31x	357°	43'	12"
	F30x	37°	14'	07"
F29x	F31x	20°	07'	57"
	F28x	67°	42'	49"
	F27x	179°	08'	39"
F31x	F30x	128°	47'	33"
	F28x	177°	43'	12"
	F29x	200°	07'	57"
F30x	F28x	217°	14'	07"
	F31x	308°	47'	33"