FEASIBILITY REPORT

ON

KARNAFULI HYDRO-POWER PROJECT

EAST PAKISTAN

OVERSEAS TECHNICAL COOPERATION AGENCY

JAPAN MARCH 1970

LETTER OF SUBMITTAL

His Excellency Mr. Kiichi Miyazawa
Minister of International Trade and Industry
Tokyo, Japan

Excellency,

I have the honor to present herewith a Feasibility Report on the Extension Project of the Karnafuli Power Station, which was undertaken by the Government of Japan as an economic co-operation to East Pakistan, and implemented by this agency assigned as an executive agency.

This agency has entrusted the Nippon Koei Co., Ltd., consulting engineers, Tokyo, with the field investigation and project study to culminate in a feasibility report. The Nippon Koei despatched survey team twice to East Pakistan for such periods as from October 30, 1967 to February 10, 1968 and August 20 to September 19, 1969 completed their study, and submitted a feasibility report as presented herewith by this time.

The report concludes that the extension project of the Karnafuli Power Station, in which present installed capacity is increased from 130,000 KW to 230,000 KW, is technically and economically feasible and that such extension may be best timed when the first 50,000 KW addition is made in around 1976–77 and the second 50,000 KW addition in around 1982.

As East Pakistan is not so well endowed with the hydro power sources, such potential as endorsed this time should be regarded really valuable, and we sincerely hope that this report will be found useful for the effective development of such valuable resources.

Yours very truly,

Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency

Date: February 28, 1970

LETTER OF TRANSMITTAL

Mr. Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency
Tokyo, Japan

Dear Sir,

It is our great pleasure to submit to you a Feasibility Report on the Extension Project of the Karnafuli Power Station in compliance with the agreement executed on September 26, 1969 between your esteemed agency and this firm.

We confirmed that the actual reservoir storage capacity is about 23 percent larger than the figure used in the planning of the present power station, and this facts and a study on the future power market have lead to a conclusion that an extension of the present capacity as from 130,000 KW to 230,000 KW (addition of two 50,000 KW units) is technically and economically feasible.

Taking opportunity of submitting this report, we also with to report to you that in the course of our field investigation, we have received generous support and co-operation from various departments of the Government of East Pakistan, the Japanese consulate and consulting engineering firms concerned, and to all of them we are greatly indebted.

With our heartfelt gratitude for your constant support and encouragement, we remain,

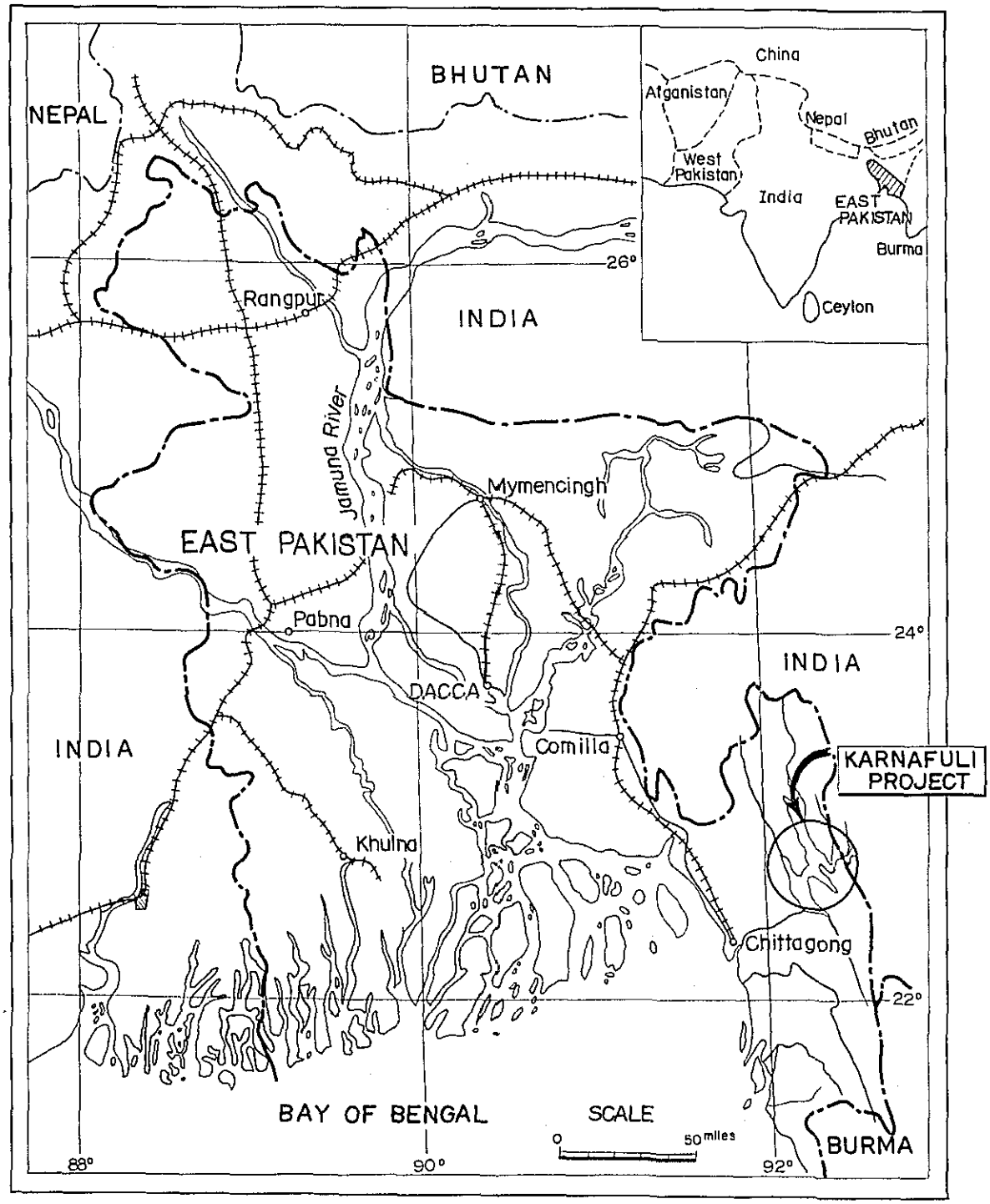
Your most obediently,

Y. Kubota

Yutaka Kubota
President

Nippon Koei Co., Ltd.

LOCATION MAP



PREFACE

For various facts discovered after the completion of the Karnafuli Project, the accuracy of the reservoir storage capacity used in the planning of the project was questioned, and the East Pakistan Water and Power Development Authority (EPWAPDA), the Government of East Pakistan, the owner of the project, desired to check of the reservoir storage capacity and in relation thereto to study a feasibility of the extension of the existing Karnafuli Power Station and requested the co-operation therefore from the Government of Japan.

The Government of Japan accepted the request, assigned the Overseas Technical Co-operation Agency (OTCA) for the executive agency for the project, and the OTCA entrusted the Nippon Koei Co.,Ltd., consulting engineers, Tokyo, with the performance of the actual work. The OCTA has also despatched an expert on the aerial photo mapping in order to assist in the new mapping work in 1969.

The first survey by the Japanese team, consisted of topographical and geological survey and collection of data, was carried out during the period from October 30, 1967 to February 10, 1968, and the second survey, consisted of the discussion with EPWAPDA and collection of new contour maps and other up-to-date data, was carried out from August 20 to September 19, 1969.

The member of the survey teams and the expert for aerial photo mapping are listed as follows.

First Survey Team

Leader:	FUCHIMOTO, Masahiro	(Civil engineer)
Members:	ENOMURA, Akira	(Electrical engineer)
	SUMI, Kazuhiko	(Geologist)
	ARAIDA, Eiichiro	(Civil engineer)

Second Survery Team

Leader:	ENOMURA, Akira	(Electrical engineer)
Member:	ARAIDA, Eiichiro	(Civil engineer)
	NOGAMI, Makoto	(Economist, coordinator)

Expert in Arial Photographing

HAYASHI, Yoshiro

The field work required for the present project was shared by EPWAPDA and the Japanese survey teams as follows.

Investigation performed by the Pakistan Government

(a) Aerial photographing and ground control survey of the Karnafuli reservoir area, and the mapping by Survey of Pakistan.

(b) Topographic survey of the proposed power station site by EPWAPDA.

(c) Geological investigation by boring at the proposed power station site by EPWAPDA.

Investigation performed by the Japanese Team

(a) Reconnaissance of the project area.

(b) Reconnaissance of transmission line route.

(c) Power market survey.

(d) Survey of construction materials and study of transportation problems.

(e) Collection of data on hydrology, meteorology, cost estimate, etc.

During the period of the field investigation in East Pakistan for the feasibility study of the extension project of the Karnafuli Power Station, the members of the survey teams worked closely with the administrative and technical personnel of the East Pakistan Water and Power Development Authority (EPWAPDA), Survey of Pakistan, Directorate of Agriculture, Regional Meteorological Directorate, International Engineering Co. (U.S.A.), Fichtner Consulting Engineers (West Germany), Acres International Ltd. (Canada), Consulate-General of Japan, and Japan Consulting Institute in Dacca. Without their generous aid and co-operation the accomplishments described in this report would not have been possible, and the members of the survey teams with to acknowledge such aid and co-operation and thank collectively and individually all the people of the organizations mentioned above.

Despite our indebtedness to these individuals and organizations who generaously shared information and judgement with us, any errors of facts or interpretation in the report are fully the responsibility of ours.

SUMMARY

1. Due to the facts discovered after the completion of the dam such as the increase in the population to be moved from the submerged area, the smaller drawdown of the reservoir water than the anticipated, the accuracy of the old contour maps was questioned.

2. New aerial photographs were taken, ground control survey was made and new maps were prepared in a scale of 8 inches to 1 mile and with contours 130, 120, 109 and 95 ft. above the sea level.

3. A new reservoir storage curve was prepared based on the abovementioned new contour maps, and it was found that the storage of the present reservoir is about 23 percent larger than the previously estimated. The storage 4.25 million acre-feet at EL. 118 is to be corrected to 5.235 million acre-feet.

4. By a study of reservoir operation based on the new storage curve and a study of power market it is concluded that the installation of additional 100,000 kW (50,000 kW x 2) generating equipment is justified and that it is also economically feasible. After the extension, the total installation becomes 230,000 kW which products 907.6 millionkWh annually. The benefit-cost ratio is calculated as 1.07.

5. It is recommended to implement the first extension of 50,000 kW in around 1976-77 and the second in around 1982.

6. The construction cost including the import taxes are estimated as follows:

No.4 unit and a 132 kV transmission line to Sikalbaha

Foreign currency	US$ equivalent 13,790,000
Local currency	US$ equivalent 10,238,000
Total	US$ equivalent 24,028,000

No.5 unit

Foriegn currency	US$ equivalent 4,060,000
Local curency	US$ equivalent 1,912,000
Total	US$ equivalent 5,972,000

Grand total US$ equivalent 30,000,000

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ABBREVIATION

ft.	foot
m	meter
cu. ft.	cubic foot
cu. yd.	cubic yard
EL.	Elevation in foot
m^3/sec	cubic meter per second
cusec	cubic foot per second
kW	kilowatt
MW	megawatt
kWh	kilowatt-hour
GWh	gegawatt-hour
kV	kilovolt
Rs	Rupees
US$	United States dollar
HP	horse-power
BHP	British horse-power
^oF	degree Fahrenheit
^oC	degree Centigrade

CHAPTER I KARNAFULI PROJECT

1.1 History of the Project

The study on the development of the Karnafuli River was started in 1906, and after that, various investigations and study were made in 1922–24, 1946, 1949–50 and 1951. The reports based on these investigations are listed below.

- Preliminary Report on the Karnafuli Flood Control, River Improvement and Power Scheme, Nov. 1946
- Interim Report on the Karnafuli Hydro-Electric Project, June 1950
- Report on Power Development Plan, Dec. 1950
- Karnafuli Multipurpose Project, Dec. 1951
- *Karnafuli Multipurpose Project, Plans, June 1953*
- Karnafuli Hydro-Electric Project, Report in Three Parts, Part I, June 1952

Based on the above reports, the Irrigation Directorate, East Pakistan Government, selected the damsite and carried out the field investigation in 1951–52. In March 1952, the preparatory work of the project was started, and the Economic Committee of the Pakistan Government authorized the budget of 182,800 thousand Rupees (39 million U.S. dollars) in August 1952 for the construction of the Karnafuli Project. The plan at this time was of earthfill type dam, spillway with capacity of 500,000 cusecs and installed capacity 120,000 kilowatts, 4 units of 30,000 kilowatts each. In September 1952, the construction of cofferdams and a diversion tunnel was commenced. However, in 1953 when the cofferdams were near completion, they were washed away by the abnormal large flood. After the flood damage, the construction was immediately reopened, and the cofferdams and diversion tunnel were completed in 1954.

In parallel to the above movement, a feasibility study on the Karnafuli Project was carried out by the *International Engineering Co., Inc. (IECO), Los Angeles as an economic aid by the United States. The IECO* submitted a Reconnaissance Report in August 1954 and a Master Report in March 1955. In these reports, *IECO concluded that the project was quite feasible.*

The construction work which was interrupted during the period of the negotiation about the contract between the Government of Pakistan and IECO, was resumed in April, 1957 by the Utah International Inc. under the supervision of IECO.

During the construction of the project, East Pakistan Water and Power Development Authority (EPWAPDA) was established in 1959 combining the Irrigation Directorate and the Power Directorate, and the Karnafuli Project was managed by EPWAPDA. Until the end of 1961, the main structure and equipment such as dam, spillway, intake, powerhouse and cargo transfer were completed, and the Karnafuli Project commenced its operaton in 1962.

1.2. Outline of the Project

The Karnafuli Project is the only hydro-power station in East Pakistan. The Karnafuli station is located *at about 45 miles eastward from Chittagong city, which is the second largest city in East Pakistan with a* population of about 370,000.

The power station was planned for an installed capacity of 120,000 kW (40,000 kW x 3 units), and already two units have been installed. The third unit is expected to be put on operation in 1972 under the USAID fund. The capacity of the last unit was increased to 50,000 kW from 40,000 kW making the total installed capacity 130,000 kW.

The Karnafuli dam, as one of its many purposes, should provide navigation for the transport of timber, bamboo, etc. For this purpose IECO proposed in its first report (1954) to construct a lock gate. But this proposal was not taken up for the reason that the time was premature for its construction and cargo transfer facilities were provided instead. The facilities now became too small in capacity to deal with the annually increasing cargo and the construction of a lock gate is envisaged again. The cargo handled amounts to 250,000 tons per annum.

Electric power generated at the existing station is transmitted to Chittagong and Dacca over a transmission line 170 miles long.

The principal features of the Karnafuli Project are as follows, referring to IECO's design.

Catchment area	4,250 square miles
Reservoir	
H.W.L. (June to Sept.)	118 feet P.D.[1]
" (Oct. to May)	113 feet P.D.
L.W.L.	80 feet P.D.
Storage capacity at Max. W.L. 119 ft.	4.35×10^6 acre-feet
Surface area at Max. W.L. 119 ft.	146×10^3 acres
Dam	
Type	Earch dam, compressing of homogeneous rolled earth fill
Length	2,200 feet
Crest El.	127 feet P.D.
Maximum height	150 feet
Spillway	
Capacity	562,000 cusecs
Length	745 feet
Crest El.	80.25 feet P.D.
Power house	
Installed capacity	130,000 kW (initially 80,000 kW)
Maximum discharge	28,000 cusecs

1) Project datum

CHAPTER II RESERVOIR STORAGE CAPACITY

The reservoir storage curve which was used for the planning of the existing power station was drawn based on the 6 inches to 1 mile map with 20 ft. contours completed in 1954.

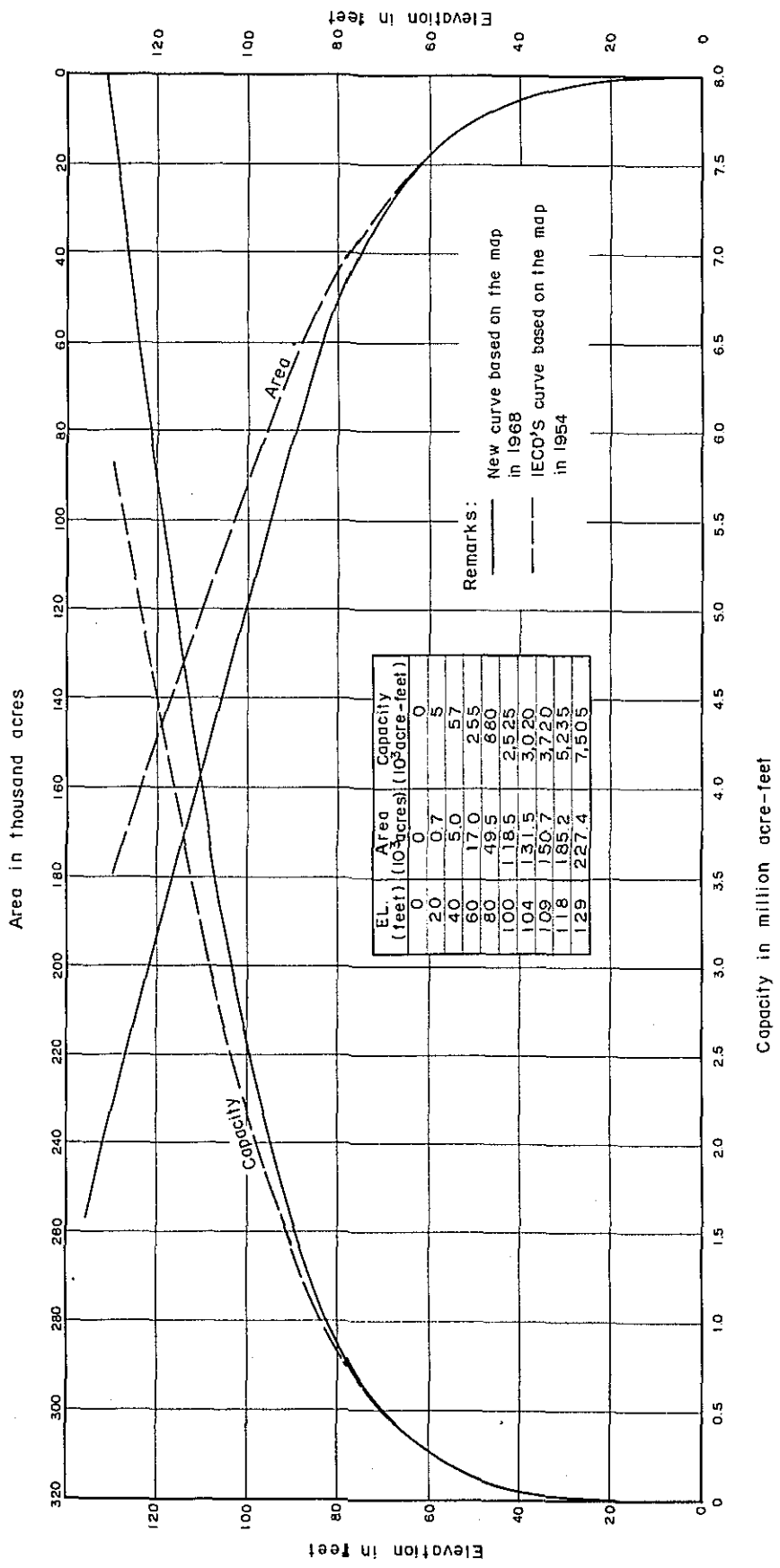
However, when the reservoir was completed new facts were found that the extent of submergence was larger than the expected resulting in the increase of population to be moved from 80,000 to 100,000, and that the drawdown of the reservoir water level due to power station operation was smaller than the anticipation. Therefore, there arose the question about the accuracy of the map used for the storage calculation.

In 1964, new photographs were taken again, ground control survey was carried out and mapping was started. The maps were only partly completed when the First Survey Team was despatched to East Pakistan. To promote the mapping an expert on the aerial photo mapping was despatched by the Japanese Government for three months to East Pakistan. The Second Survey Team received the remaining sheets of new contour maps in August, 1968. The new contour maps were made to a scale of 8 inches to 1 mile (or 1 to 7,920) and with contours of 130, 120, 109 and 95 feet above sea level.

Using the new contour maps, a new storage curve of the reservoir was drawn as shown in Fig. 2.1., and it was found that the reservoir area newly measured is about 30 percent larger than the old one.

It is considered that there should have been errors in reading the tree height, and in the present planning the new storage curve in therefore used.

Fig. 2.1 AREA AND CAPACITY CURVES OF KARNAFULI RESERVOIR



CHAPTER III METRORDLOGY AND HYDROLOGY

3.1. Meteorology

3.1.1. Rainfall

The rainfall records of the Karnafuli basin are available for the period from 1936 to 1969. Although there are certain interruptions in them, they give more or less reliable information on the rainfalls in the project area. The records of observations at foruteen stations in the basin are summarized in Table 3.1, and location of observations is shown in Fig. 3.1.

As seen in Table 3.1, although some rainfall may be expected during every month of the year, the heavy rainfall occurs in the summer monsoon; in particular in June, July and August.

A number of different types of storms pass over the watershed of the Karnafuli river. First there are thunderstorms associated with sufface northwestern squalls in which wind speed may equal a gale force. H However, the amount of rainfall from these storms is not large since they occur in the non-monsoon season.

During the monsoon, June to October, rainstorms move in the northern direction following the general seasonal movement of the atmosphere. These rainstorms vary greatly in magnitude and intensity, yet they do not appear to be so extensive to cover the watershed hundred per cent at a time.

Fig. 3.1 LOCATION OF RAINFALL GAUGING STATION

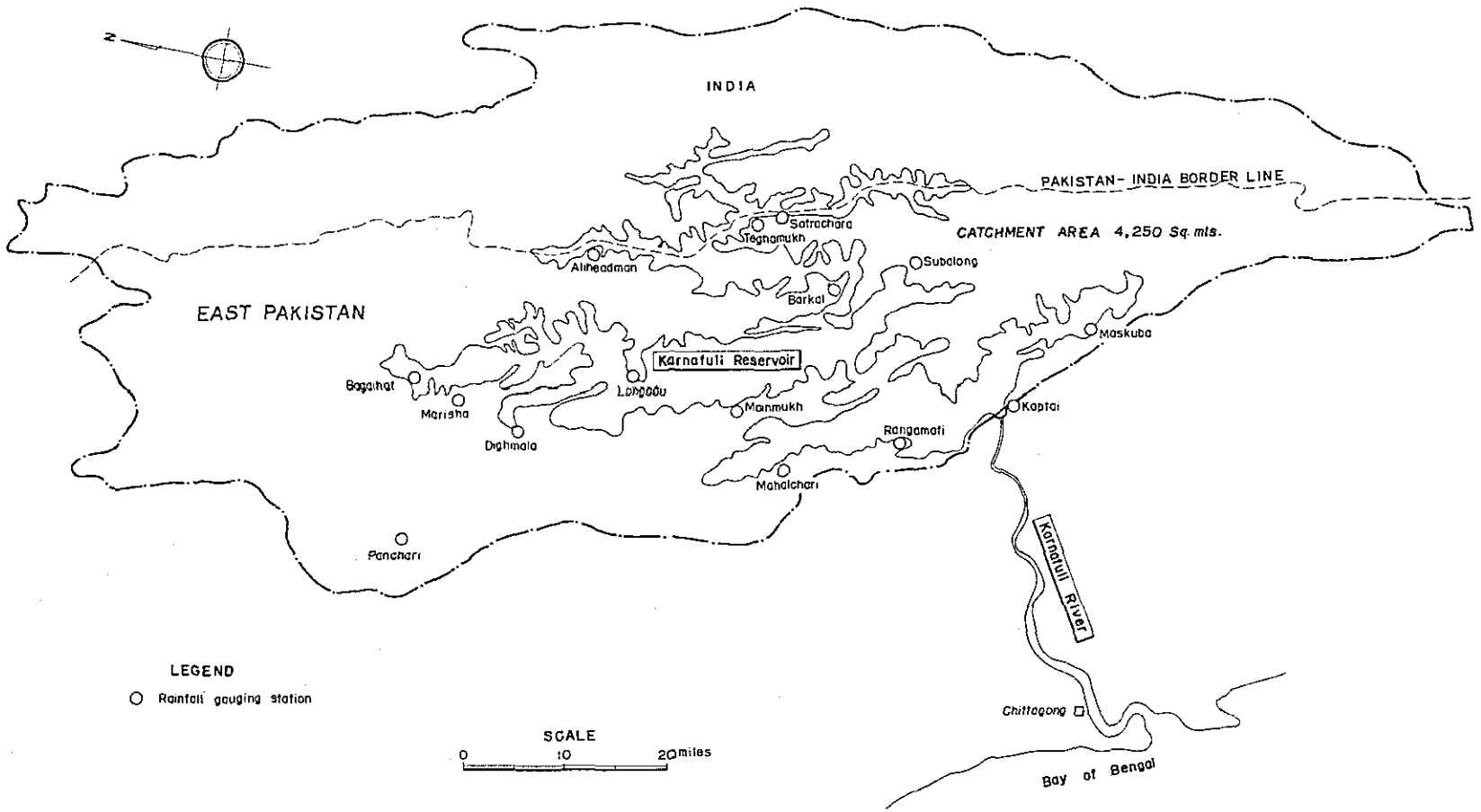


Table 3.1. Average Monthly Rainfall in the Karnafuli Basin

(Unit: inch)

Month	Kaptai (1936 −1969)	Rangamati (1963 −1969)	Mahalchari (1936 −1969)	Barkal (1936 −1969)	Dighinala (1936 −1969)	Mainmukh (1936 −1963)	Panchari (1936 −1969)	Maskba (1961 −1969)
Jan.	0.34	0.45	0.40	0.25	0.39	0.60	0.43	0.44
Feb.	0.94	0.83	0.89	0.86	0.77	1.01	0.97	0.19
Mar.	2.41	1.94	2.15	1.73	2.58	2.73	2.15	1.06
Apr.	4.86	3.78	4.97	4.31	5.06	5.74	6.00	5.54
May	12.15	4.25	10.92	10.43	24.84	13.29	12.81	8.01
June	23.10	18.03	20.31	16.56	17.46	22.37	20.62	23.34
July	20.70	20.50	20.72	18.03	15.63	19.42	18.91	20.72
Aug.	19.57	16.38	16.76	16.32	15.28	20.81	16.76	17.29
Sept.	15.42	12.30	13.39	12.03	12.21	14.75	12.23	12.92
Oct.	7.90	6.61	7.10	5.89	6.36	7.73	6.92	8.49
Nov.	1.18	1.21	1.51	1.06	0.43	1.35	1.09	0.72
Dec.	1.05	0.78	0.44	0.98	0.39	0.70	0.44	1.37
Total	108.68	91.73	115.24	88.23	84.86	108.86	100.27	94.35

Month	Marisha (1964 −1969)	Longadu (1964 −1969)	Teghamukh (1964 −1969)	Bagaihat (1961 −1964)	Alibeadman (1961 −1964)	Satrachara (1961 −1963)	Subalong (1961 −1963)	Average
Jan.	0.22	0.29	0.14	0	0	0.02	0.43	0.47
Feb.	0.25	0.43	0.58	0.91	0.44	0	0	0.81
Mar.	3.02	3.70	2.01	2.27	1.10	0.93	0.47	2.08
Apr.	3.63	1.98	3.35	4.42	3.37	9.06	6.16	4.62
May	7.98	6.47	6.49	6.31	8.59	7.92	9.95	10.88
June	19.23	17.62	19.93	28.31	23.33	23.27	26.24	19.82
July	21.77	22.60	21.49	20.46	25.44	18.49	16.57	19.55
Aug.	13.36	16.38	16.10	13.65	15.95	9.08	15.33	17.23
Sept.	10.77	9.10	12.38	12.86	9.90	7.40	10.39	12.93
Oct.	8.53	9.25	8.36	9.62	9.80	4.89	6.95	7.08
Nov.	0.77	0.62	1.12	0.06	0.15	0.01	0.19	1.13
Dec.	1.02	0.97	1.07	0	0	0	0.04	0.64
Total	101.26	86.99	96.02	107.78	–	70.80	103.64	97.18

3.1.2. Temperature, humidity and evaporation

The mean annual temperature in the project area is about 77 degrees F. The monthly variation of maximum, mean or minimum temperatures in this region is comparatively small. The maximum mean temperature of about 85 degree F. occurs in May, June and July and the minimum of about 60 degrees F. in January. The mean, maximum and minimum temperatures at Kaptai are shown in the following table.

Table 3.2. Mean, Maximum and Minimum Temperatures at Kaptai

(Unit: °F)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
Mean	67	72	78	82	84	83	82	82	83	82	79	75	79
Max.	90	94	94	101	102	100	95	98	97	96	93	88	96
Min.	52	49	52	57	56	69	65	72	73	69	59	57	53

The mean annual relative humidity at Kaptai is about 80 percent. The monthly mean ranges from 75 percent in January to about 87 percent in August and September. The mean, maximum and minimum humidities at Kaptai are as follows.

Table 3.3. Mean, Maximum and Minimum Humidities at Kaptai

(Unit: %)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
Mean	75	78	77	72	79	86	87	87	82	79	76	80	80
Max.	100	98	94	100	95	100	100	100	100	97	96	94	98
Min.	49	46	43	50	59	66	53	57	73	50	45	46	53

The pan evaporation rates were measured from 1963 upto date at Kaptai and shown in Appendix. The evaporation from the reservoir is estimated by assuming 70 percent of the pan evaporation. According to the estimation, the annual evaporation from free water surface is about 42 inches. The actual monthly evaporation from the reservoir is taken as the balance between the monthly averate evaporation from the reservoir from 1963 to 1969 and monthly rainfall, as shown in Appendix. The average values of the monthly evaporation from free water surface and actual evaporation from the reservoir area as follows.

Table 3.4. Monthly Evaporation

(Unit: inch)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
From free water surface	2.55	3.23	4.49	4.76	4.97	2.83	3.21	3.25	3.24	3.30	3.01	3.05	41.89
From the reservoir	2.35	2.81	3.60	2.65	0.27	-5.88	-0.76	-0.94	-2.45	0.22	2.52	3.06	-0.87

3.1.3. Wind velocity

The wind velocity varies with location. Station near the coast such as Chittagong has registered a mean annual velocity of 5.87 miles per hour. Comilla, about 60 miles inland, recorded a comparable velocity of 3.41 miles per hour. In 1960, the wind velocity of 130 miles per hour was recorded at Chittagong.

The yearly maximum wind velocities at Chittagong and Dacca are shown in the following table.

Table 3.5. Yearly Maximum Wind Velocity

(Unit: mile/hour)

	1955	1956	1957	1958	1959	1960	1961	1962	1963
Dacca	46	24	59	53	60	32	90	62	77
Chittagong	29	29	29	50	29	130	59	61	125

	1964	1965	1966	1967	1968	1969	Maximum
Decca	67	100	94	35	75	90	100
Chittagon	79	60	90	61	66	46	130

3.2. Hydrology

According to the IECO's Report, gage height of the Karnafuli River before the completion of the dam have been kept at thirteen stations, located at various sites along the river from its mouth to the Indian border. While the records of all thirteen stations were utilized in the hydrological studies, the Rangamati station supplied the record of most important. It is located about 12 miles upstream of the damsite and measures runoff from about 3,830 square miles against 4,250 square miles at the damsite.

The discharge at damsite before the completion of the dam has been adjusted by the ratio of drainage areas of the gage site and the damsite which resulted in an increase of eleven percent to each discharge.

Runoff records at Kaptai are included in the data furnished by EPWAPDA, in the IECO's report and in the Report by Bengal Government, but these data are found not identical for unknown cause. However the difference of mean annual runoff in the period shows only 2 or 3 percent. The data furnished by EPWAPDA were used in the present study.

The run-off estimation after the completion of the dam is to be made by the revised capacity curve of the reservoir, the data for the reservoir water level, spillway discharge, diversion discharge and powerhouse didcharge. The run-off so estimated are shown in Table 3.6 together with the recores before the completion of the dam..

According to Table 3.6, the annual mean runoff at the damsite for the period of 34 years from 1936 to 1969 is 17,940 cusecs, though the annual mean run-Off varies from year to year.

In general, the stream flow increases gradually from April, and finally reaches its peak in August or September. After reaching the peak, it drops sharply. About 90 percent of the annual runoff is concentrated is seven months, from April to October.

Large floods occur during the monsoon season each year. According to the IECO's Report, based on the data obtained at the Rangamati gauge, estimates were made of the peak discharge of the largest floods recorded at the gage and the damsite before the consrruction of the dam. The peak flood before the consturction of the dam was estimated from the reservoir water level, capacity curve and outflow from spillway, diversion tunnel and powerhouse in the same manner as the estimation of the monthly inflow to the reservoir. The list of peak flood at damsite is as follows.

Recorded Peak Discharge at Damsite
(1935 – 1954)

1946	259,000 cusecs	1935	172,000 cusecs
1947	239,000 "	1936	171,000 "
1939	187,000 "	1951	170,000 "
1941	175,000 "	1954	170,000 "
1937	172,000 "		

Estimated Peak Inflow of the Reservoir
(1960 – 1969)

1960	108,300 cusecs	1965	154,000 cusecs
1961	197,800 "	1966	147,900 "
1962	115,900 "	1967	195,600 "
1963	274,300 "	1968	395,000 "
1964	73,100 "	1969	369,000 "

Table 3.6. Monthly Mean Runoff at Kaptai

(Unit: cusec)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual mean
1936	768	614	145	4,600	19,500	30,000	34,500	59,000	29,850	14,225	3,070	1,920	16,533
1937	768	650	384	768	3,840	20,630	23,400	76,000	35,700	17,850	3,070	8,900	15,997
1938	1,300	958	1,150	958	12,250	37,200	30,250	51,900	68,600	21,610	11,700	4,100	20,165
1939	2,300	1,536	1,150	3,070	4,980	11,700	30,100	71,000	38,900	26,200	3,450	2,300	16,391
1940	958	768	1,070	958	6,500	27,600	15,700	41,000	56,000	11,500	3,070	1,300	14,039
1941	958	2,300	364	4,700	36,800	67,900	91,500	42,900	39,800	20,900	4,790	2,300	26,275
1942	1,340	768	8,820	768	10,350	29,700	59,300	52,900	43,700	22,400	5,360	2,880	19,857
1943	1,340	1,150	1,070	2,380	1,540	10,150	28,900	35,200	42,900	8,620	2,300	1,340	11,408
1944	958	768	575	1,150	2,690	31,600	39,100	26,100	36,800	12,250	2,880	2,490	13,113
1945	2,300	2,110	768	768	5,160	25,300	20,100	53,200	47,750	14,350	4,790	4,980	15,131
1946	958	768	1,536	2,880	12,250	12,650	83,300	33,300	36,200	22,000	4,790	4,700	17,936
1947	1,300	958	768	1,150	4,980	67,100	70,500	114,000	67,000	37,800	8,320	3,250	31,261
1948	1,536	1,536	1,340	3,405	22,400	22,200	18,300	48,000	43,700	14,750	3,250	1,750	15,181
1949	958	575	768	4,790	14,400	20,900	50,100	33,900	35,800	30,200	5,000	1,920	16,616
1950	1,150	1,072	1,150	1,140	1,725	8,030	9,050	53,300	28,000	19,350	10,500	1,920	11,382
1951	1,150	768	768	1,920	10,350	35,700	56,700	48,500	36,700	59,000	9,000	5,750	22,184
1952	3,840	2,680	2,300	4,790	8,430	39,300	57,600	32,000	36,800	39,400	10,730	3,450	20,035
1953	1,536	1,150	958	1,150	14,400	41,000	28,330	57,100	65,500	23,750	6,500	3,450	20,402
1954	2,490	1,340	1,150	1,725	2,490	24,100	33,300	74,800	37,900	32,900	7,480	4,025	18,642
1955	4,025	2,680	4,600	8,420	12,250	31,200	52,400	48,500	22,000	10,380	16,680	3,070	18,017
1956	1,536	1,150	1,340	958	7,480	109,500	48,250	57,600	39,500	18,000	12,250	2,490	25,005
1957	2,490	1,340	958	768	2,490	9,580	24,100	13,600	21,820	15,900	2,680	1,725	8,121
1958	1,150	958	768	690	4,975	6,900	12,450	14,170	28,800	21,610	5,940	1,536	8,329
1959	1,536	2,300	3,450	1,536	4,600	55,500	36,600	36,800	28,000	27,200	21,820	10,380	19,144
1960	1,920	1,536	1,536	1,340	1,920	21,080	55,800	21,420	23,750	20,500	7,730	3,840	13,531
1961	2,220	1,920	3,070	2,375	2,300	57,200	71,300	55,400	36,200	19,570	4,500	2,370	21,535
1962	1,800	1,390	2,090	4,050	5,090	70,200	22,200	39,500	37,400	14,890	7,250	1,490	17,279
1963	3,070	1,100	2,400	7,320	10,410	90,000	94,000	29,000	18,590	36,600	10,970	2,200	25,472
1964	2,970	2,030	2,270	5,480	14,820	15,630	32,400	28,100	33,900	29,700	5,660	4,350	14,768
1965	3,100	4,490	2,060	3,630	11,610	31,200	58,300	50,700	23,800	32,400	6,550	5,770	19,468
1966	7,000	1,110	2,620	3,800	7,410	31,700	47,100	42,600	40,000	24,000	4,950	3,240	17,961
1967	1,050	480	4,380	4,330	7,410	13,140	46,500	29,900	26,900	30,300	3,130	2,980	14,208
1968	3,960	4,860	4,530	5,330	9,810	49,000	115,500	46,700	37,400	11,690	4,830	5,350	24,913
1969	3,700	5,120	2,650	8,450	3,070	67,000	56,900						
Mean	2,042	1,616	1,975	2,995	8,444	35,929	45,701	46,003	37,744	23,082	6,760	3,438	17,944

CHAPTER IV POWER MARKET STUDY

4.1 *Power Facilities in East Pakistan*

4.1.1. General

The existing power supply system and its extension programme as planned in the 3rd Five Year Plan in East Pakistan are shown in Fig. 4.1, "EAST PAKISTAN POWER PROJECT".

At present, the power supply system in East Pakistan consists of two main grids, the eastern with a 132 kV transmission line connecting as Sylhet-Dacca-Chittagong and the western grid connecting Khulna and Bheramara, and isolated power generating facilities.

The installed capacity for power generation belonging to EPWAPDA is 252,849 kW in the eastern grid, 59,743 kW in the western grid, and 47,704 kW in isolated stations, the total being 360,296 kW. The total *installed capacity of private owned power stations is 120,000 kW.*

The connection of the eastern and western grids by a 230 kV transmission line, and the incorporation of isolated power generating facilities into an expanded grids are considered in the 3rd Five Year Plan.

The standard voltage and frequency system of EPWAPDA is as follows.

Transmission line	230 kV, 132 kV, 66 kV, 33 kV
Distribution line	11 kV, 6.6 kV
Low tension line	400/230 V, 3-phase 4-wire system
Frequency	50 Hz.

4.1.2. Existing generating facilities

The existing generating facilities in East Pakistan are as follows.

EPWAPDA – as of June 1969

I. Eastern Grid

1. Karnafuli Hydro	80,000 kW	hydro
2. Shahjibazar Gas Turbine	87,000 "	gas-fired
3. Chittagong Diesel	10,708 "	
4. Chittagong Gas Turbine	13,000 "	stop for emergency
5. Siddhirganj Steam	30,000 "	changed to gas-fired
6. Siddhirganj Diesel	13,348 "	
7. Dhanmandi Steam	6,000 "	coal-fired
8. Railmounted Movable Gas Turbine	6,500 "	HSD-Fired, Chittagong
9. Other diesels	6,293 "	
Total	252,849 kW	

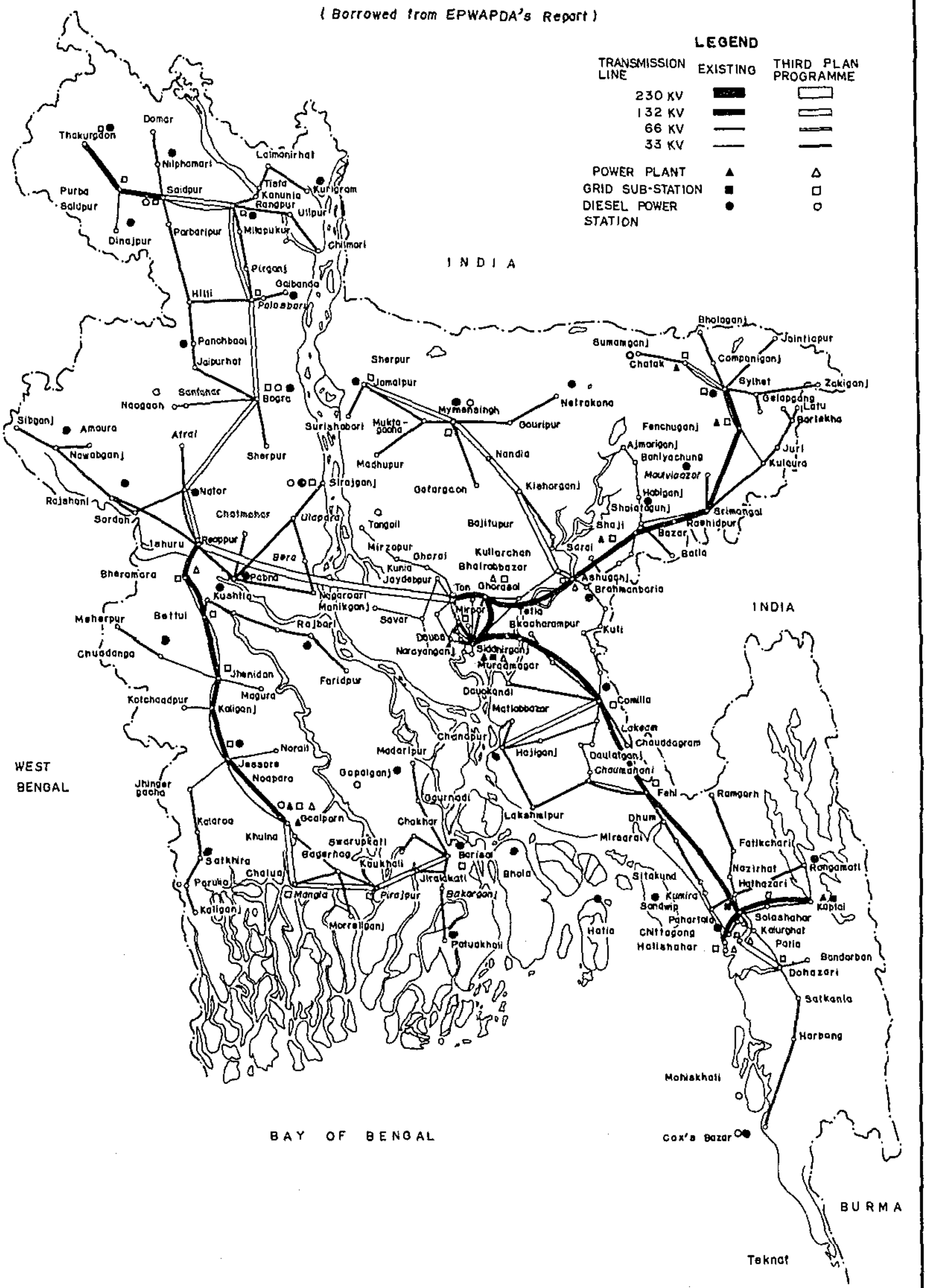
II. Western Grid

1. Goalpara Steam	16,640 kW	oil/coal-fired
2. Goalpara Diesel	7,840 "	
3. Goalpara Gas Turbine	24,000 "	naphtha-fired
4. Bheramara Steam	8,320 "	oil-fired
5. Other diesels	2,943 "	
Total	59,743 kW	

Fig.4.1 EAST PAKISTAN POWER PROJECT

3RD FIVE-YEAR PLAN, 1965-70

(Borrowed from EPWAPDA's Report)



III. *Isolated stations*

9 - stations, east of Brahmaputra	7,175 kW diesel
23 - stations, west of "	40,529 " "
Total	47,704 kW
Grand Total of EPWAPDA	360,296 kW

PRIVATE FACILITIES

EPIDC Fertilizer Factory, Fenchuganj	36,000 kW
EPIDC Cement Factory, Chattak	7,000 "
EPIDC Sugar & other Mills	19,000 "
Khulna Newsprint Mill, Khulna	17,000 "
Karnafuli Paper Mill, Chandraghona	14,000 "
PE Rly (consolidated)	7,000 "
Other private industries	12,000 "
Tea gardens (consolidated)	8,000 "
Total	120,000 kW

The installations of EPWAPDA are classified in different categories for the reference as follows.

Hydro	80,000 kW	
F.O./Gas fired S. P. S.	30,000 "	
Coal fired S. P. S.	6,000 "	60,960 kW
Coal oil fired S. P. S.	24,960 "	
Gas fired G. T. P. S.	87,000 "	
Oil fired G. T. P. S.	43,500 "	130,500 kW
Diesel	88,836 "	

4.1.3. Facilities under construction and planning

The power stations under construction or planning by EPWAPDA are listed as below.

Name of P. S.	Unit	Combustion	Expected Completion Date
Ashuganj	No. 1, 60 MW	Gas-fired, steam	Mar. 1970
	No. 2, 60 MW	"	Apr. 1970
Siddhirganj	1 x 50 MW	"	Dec. 1969
Ghorasal	2 x 55 MW	"	Dec. 1970
Khulna	1 x 60 MW	Oil-fired, steam	June 1970
Chittagong	1 x 60 MW	Gas/oil-fired, steam	Dec. 1971
Kaptai	1 x 50 MW	hydro	Dec. 1972
Total	450 MW		

4.1.4 Retiring schedule

The retiring schedule of antiquated generating units is expected as follows:

Name of P. S.	Installed Capacity	Date of Retirement Expected
Dhanmandi	4.5 MW	June 1969
Chittagong Diesel	8.0 MW	Feb. 1970
Siddhirganj	10.0 MW	Feb. 1970

Goalpara Diesel	7.0 MW	Feb. 1970
Mis. small diesel units	7.0 MW	Feb. 1970
Mis. small diesel units in Eastern Region	9.0 MW	Sep. 1972
Mis. small diesel units in Western Region	28.0 MW	June 1976
Total	73.5 MW	

4.1.5. Scheduled power installation up to 1976

Considering the power facilities present, under construction planning and retiring the available power output in each year up to 1976 are given as follows.

1969	405.8 MW
1970	663.8 MW
1971	723.8 MW
1972	763.8 MW
1973	823.8 MW
1974	"
1975	"
1976	795.8 MW

4.2 Natural Resources for Power Generation

4.2.1 Hydro power potential

Topographycally, east pakistan is not endowed well with the hydro power potential. The Matamuhuri Project, 30 MW, Old Brahmaputra Project, 40 MW, Sangu Project, 87 MW, Brahmaputra Barrage Project, 1,000 MW are the projects considered so far in East Pakistan, and they provide a total figure of 1,157 MW. However, except for the Sangu Project, for which a feasibility study was made by a Canadian consultant, they are only of preliminary idea. Brief description of these projects will be given below.

Matamuhuri Project

This is a project for an irrigation and power development conceived on the Matamuhuri River in the southern part of the Chittagong Hill Tracts. The power output is estimated at approximately 30 MW.

Old Brahmaputra Project

This project was conceived in the section between Mywensign and Toke along both banks of the old Brahmaputra River. The project is devided into three phases requiring a total capital investment of 1,328 millions Rupees. Hydro power generation is included in phase I and planned to provide 40 MW output.

Sangu Project

The project is located along the Sangu River, south of Chittagong. The Tarasa Chara Dam would, according to a preliminary feasibility study, accommodate 3 units of turbine generators, 82.5 MW in total and produce 233 million KWH of a mean annual firm energy.

Brahmaputra Barrage Project

The Master Plan proposes Brahmaputra Barrage Project as an alternative to the irrigation pumping projects. A barrage across the Brahmaputra Jamuna River constructed for the irrigation of 4,400,000 acres of farm land (in case of largest development scale) could also be utilized for electric power generation. A rail-road on this barrage may substitute a ferry connection between Bahadurabad Ghat and Phulchari Ghat. A minimum of about

400 MW of continuous power output is expected throughout the year. The final installation would be 1,000 MW.

4.2.2 Coal

At present the coal required in East Pakistan is imported from the People's Republic of China and Australia. The recent discovery of a coal reserve at Bagra with an estimated quantity of 500,000 tons gave a bright hope to the energy situation in this country. The coal bed in this reserve, however, lies a depth of some 3,000 – 4,000 feet below the ground and therefore any economical mining thereof would be possible only if it is done on large scale. It is therefore estimated that the development of this coal reserve could be expected after 1980 and the rate would be around 60 Rs. per ton.

4.2.3. Petroleum

Investigation of the oil reserve has been conducted, but the results have been negative so far.

4.2.4. Natural Gas Resources

In East Pakistan, during the last two decades, six major natural gas fields have been discovered and some of them have already started the delivery.

1. *Chattak;* *0.03 million million cubic feet deposit.*
   This field supplies fuel to the Chattak Cement Factory.
2. Haripur; 0.43 million million cubic feet deposit.
   This field provides fuel and raw materials for the EPIDC fertilizers factory at Fenchuganj.
3. Rashidpur; 1.06 million million cubic feet deposits.
4. Kaila Tila; 0.6 million million cubic feet deposits.
5. Titas; 2.25 million million cubic feet deposits.
   Tital Gas Transmission and Distribution Company was formed with manifested aim of transmitting Titas gas from the field to Dacca for the industrial, commercial and domestic use.
   The operation has been commenced in April, 1968. Siddhirganj's 30 MW steam turbines are run by Titas gas. Gas fuel for the Ghorasal and Ashuganj power stations which are under construction will be supplied by the same pipe line.
6. Habiganj; 1.28 million million cubic feet deposits Shahjibazar gas turbines of EPWAPDA are firing the gas directly supplied from the well head at Habiganj field.

A new gas deposit has been discovered recently at Jaldi, not far from Chittagong.

The gas is now supplied to EPWAPDA at rates as 0.9 Rs or 0.189 US$ per 1000 cubic feet at Shahibazar and 1.2 Rs or 0.252 US$ at Siddhirganj.

4.3 Power Rates

The power rate system in East Pakistan is as follows:

For lights and fans	36 paisa per unit or 7.35 cent per unit.
For domestic power	16 paisa per unit or 3.46 cent per unit.
For L. T. bulk supply (transformer & switchgear at WAPDA cost) upto 150 kW.	a fixed monthly charge of Rs. 14 per kW of maximum demand plus 12.5 paisa per unit subject to fuel variation.

For H. T. supply (transformer & switchgear at the cost of consumer)	a fixed monthly charge of Rs. 13 per kW of maximum demand plus 11.37 paisa per unit subject to variation for every Rs 20 per ton in the price of fuel

4.4. Production Cost

The cost of generation was 13.90 paisa per kWh for fiscal year of 1968–1969 as broken down below.

Fuel cost	3.90 paisa/kWh
Establishment charges	2.81
Repairs & Maintenances	1.26
Sundries	0.53
Interest & Depreciation	5.40
production cost	13.90 paisa/kWh [1]
or	2.92 cents/kWh

The fuel cost per kWh shown above was obtained by dividing fuel cost by the total energy generated including hydro. Actually the fuel cost for the thermal units was 12.83 paisa per kWh on an average for the first half of 1968–69 fiscal year. The cost for the second half has been improved to 6.81 paisa per kWh by introducing natural gas fired units and switching from high cost imported coal to low cost naphtha. The average cost of fuel per kWh in June 1969 as low as 5.41 paisa. The energy from the Karnafuli hydro power station counted, the same becomes only 2.79, an improvement of 1.11 paisa compared with 3.90 paisa for 1968–1969.

The statistics for June, 1969 shows that gas-fired energy amounts to 51% of the total energy generated by thermal units but only cost 12% of the total fuel expenses.

As the Titas Gas Transmission and Distribution Company has commenced its supply of natural gas in Dacca area from April 1968, the Siddhirganj steam plant, 30 MW, has changed the fuel from oil to natural gas. With the gas supplied at a rate of 1.2 Rupees per 1,000 normal cubic feet, the fuel cost at this station is calculated as 1.07 paisa per kWh or 0.435 center per kWh.

The gas turbines at Shahjibazar are running on the natural gas delivered from the nearby well head. The fuel cost is only 1.09 paisa per kWh or 0.229 cents per kWh as the gas is supplied at a rate of 0.5 Rupees per 1,000 normal cu.ft. As the gas rate was changed to 0.9 Rupees from 1st of July 1969, the fuel cost will become 1.96 paisa per kWh or 0.412 cents per kWh, thereafter.

The completion of such gas fired units as Ashuganj, Ghorasal and Siddhirganj, extension, will reduce the fuel cost to a great extent.

The fuel cost at coat fired power stations is high. At Dhanmandi where uses imported coal of 180 Rupees per ton, it is 57.97 paisa or 12.2 cents per kWh, and it Goalpara where uses imported coal of 204 Rupees per ton it is 8.98 paisa per kWh.

Diesel oil is as high as 400 Rupees per ton.

1) : The above includes transmission and distribution cost. The cost of generation for 1968–69 remained the same as 1967–68.

4.5 Power Consumption

Records of installed capacity, peak demand, generated energy and sold energy from 1959 June, 1969 are shown on Table 4.1 The power demand reached 181.22 MW of all EPWAPDA and 138.20 MW of the eastern grid in June, 1969. Hydro-power energy generated at the Karnafuli Station was 607 million kWh in 1968, equivalent to 66 percent of total generated energy of 921 million kWh. Billed energy was 707.121 million kWh in 1968, the difference between generated energy and billed energy being 23.25 per cent of the generated energy As the station use energy is approximately 2 percent, the transmission and distribution loss is estimated as rough roughly 20 percent.

The number of consumers in July 1969 was 195,502; 2.85 consumers per 1,000 persons of the estimated population of about 68.5 million. The rate is very low. Energy consumption per consumer per annum was 3,823 kWh in 1968, which seems to be on an average level. Peak demand per consumer was 0.927 kW in June 1969. Per capita consumption for 1968 was 10.8 kWh against the estimated population of 65.54 million.

Figs. 4.2 shows daily load curves of the recent peak days.

4.6 Load Forecast in East Pakistan

There is a close but complex relationship between energy need and economic growth. The determination of this relationship is possible if the relevant statistical data on past and present use of energy and economical situation are available.

As the necessary statistical materials for forecasting the future demands are not yet sufficient, the method of direct extrapolation on the basis of past trends of generated energy was used tentatively. Table 4.2. shows the projected future power and energy requirements by year to the year 1985. This table is basis of Figs. 4.3 and 4.4, and must be considered only a tentative estimate.

To calculate firm peak power output needed each year, a 60 per cent annual load factor was used in view of a tendency in variation of annual load factor in past ten years.

East Pakistan is at present endeavoring to develop new industries by which an unprecentented increase rate of energy need might be brought. In fact, a fairly remarkable increase rate is seen in EPWAPDA's projection. Yearly maximum demand estimated by EPWAPDA for east and west zones is given in the following Table 4.3. and is also shown on Fig. 4.5.

Table 4.1. Electric Power Stations Relating to EPWAPDA Power Stations and Undertakings from 1959 to June 1969

(Obtained from EPWAPDA)

No.	Year	Generating Capacity in MW			Peak Demand for Electricity in MW			Electricity Generated in GWh		
		Eastern Zone	Western Zone	Total	Eastern Zone	Western Zone	Total	Eastern Zone	Western Zone	Total
1.	1959	60.630	14.514	75.144	30.340	8.280	38.620	137.914	29.886	167.800
2.	1960	63.838	24.434	88.272	33.940	8.460	42.400	181.407	37.493	218.900
3.	1961	58.288	36.986	95.274	46.010	10.620	56.630	218.144	40.356	258.500
4.	1962	138.694	37.061	175.755	57.750	12.687	70.437	273.950	54.150	328.100
5.	1963	142.451	41.348	183.799	65.560	16.170	81.730	340.728	74.912	415.640
6.	1964	145.451	47.597	193.408	79.000	17.350	96.350	371.462	86.174	457.636
7.	1965	147.472	56.840	204.312	89.900	21.110	110.010	461.160	105.560	566.720
8.	1966	150.368	61.664	212.032	103.750	29.250	133.000	529.770	130.160	659.930
9.	1967	165.747	75.003	240.750	127.210	35.700	162.910	648.000	155.680	803.680
10.	1968	224.013	97.918	321.931	136.520	39.599	176.119	724.054	197.269	921.323
11.	Up to June 1969	260.024	100.272	360.296	138.390	42.831	181.221	360.288	107.365	467.653

No.	Year	Electricity Sold in GWh			Electricity Consumed in GWh		
		Western Zone	Western Zone	Total	Industrial	Domestic & others	Total
1.	1959	117.588	20.612	138.200	114.700	23.500	138.200
2.	1960	151.110	27.390	178.500	147.000	31.500	178.500
3.	1961	175.780	36.820	212.600	169.800	42.800	212.600
4.	1962	209.690	42.410	252.100	201.700	50.400	252.100
5.	1963	273.320	73.470	346.770	289.300	57.400	346.700
6.	1964	322.440	63.840	386.280	320.600	65.680	386.280
7.	1965	369.450	95.750	465.200	366.600	98.600	465.200
8.	1966	427.760	105.900	533.660	424.860	108.800	533.600
9.	1967	517.250	125.920	643.170	514.500	128.670	643.170
10.	1968	547.076	160.045	707.121	479.781	227.340	707.121
11.	1969	264.064	82.583	346.652	–	–	346.652

Fig. 4.2 LOAD CURVES OF MAJOR POWER STATIONS OF E.P. WAPDA OF APRIL 7, 1969
MONDAY ON WHICH MAXIMUM DEMAND OCCURRED

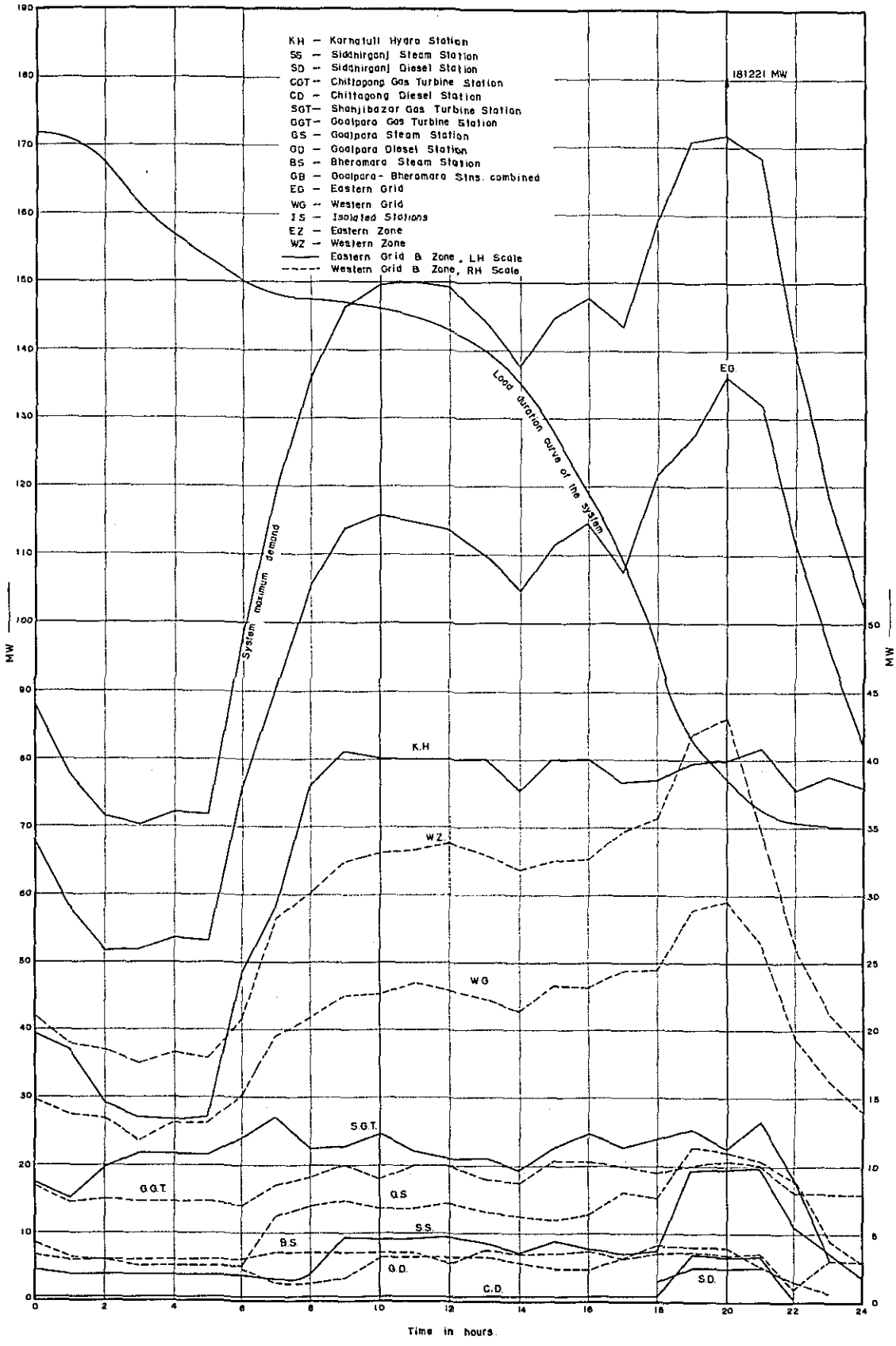


Table 4.2. Forecast of Annual Energy and Peak Demand in East Pakistan

(by extrapolation method)

Year	Eastern zone		Western zone		Total		Remarks
	Annual energy (GWh)	Frim peak (MW)	Annual energy (GWh)	Frim peak (MW)	Annual energy (GWh)	Frim peak (MW)	
1959	137.91	30.34	29.89	8.28	167.80	33.62	
1960	181.41	33.94	37.50	8.46	218.90	42.40	
1961	218.14	46.01	40.36	10.62	258.50	46.63	
1962	273.95	57.73	54.15	12.69	328.10	70.44	
1963	340.73	65.56	74.91	16.17	415.64	81.73	
1964	371.46	79.00	86.17	17.35	457.64	96.35	Actual
1965	461.16	89.90	105.56	21.11	566.72	110.01	
1966	529.77	103.75	130.16	29.25	659.95	133.00	
1967	648.00	127.21	155.68	35.78	803.68	162.91	
1968	724.05	136.52	197.27	39.60	921.32	176.12	
1969	830.77	158.06	227.38	43.26	1059.15	201.32	
1970	942.33	179.29	265.94	50.60	1208.27	229.88	
1971	1061.68	201.99	307.96	58.59	1369.63	260.58	
1972	1188.82	226.18	353.42	67.24	1542.23	293.42	
1973	1323.75	251.85	402.33	76.55	1726.08	328.40	
1974	1466.47	274.01	454.69	86.51	1921.16	365.52	
1975	1616.99	307.65	510.50	97.13	2127.49	404.77	
1976	1775.30	337.77	569.73	108.40	2345.06	446.17	
1977	1941.40	369.37	632.46	120.33	2573.87	489.70	Estimated
1978	2115.30	402.45	698.62	132.92	2813.92	535.37	
1979	2296.99	437.02	768.22	146.16	3065.21	583.17	
1980	2486.47	473.07	841.28	160.06	3327.74	633.13	
1981	2683.74	510.61	917.78	174.62	3601.52	685.22	
1982	2888.81	549.62	997.73	189.83	3886.54	734.45	
1983	3101.66	590.12	1081.14	205.70	4182.80	795.81	
1984	3322.31	632.10	1167.99	222.22	4490.30	854.32	
1985	3550.76	675.56	1258.29	239.40	4809.04	914.96	

Fig.4.3 PEAK LOAD FORECAST

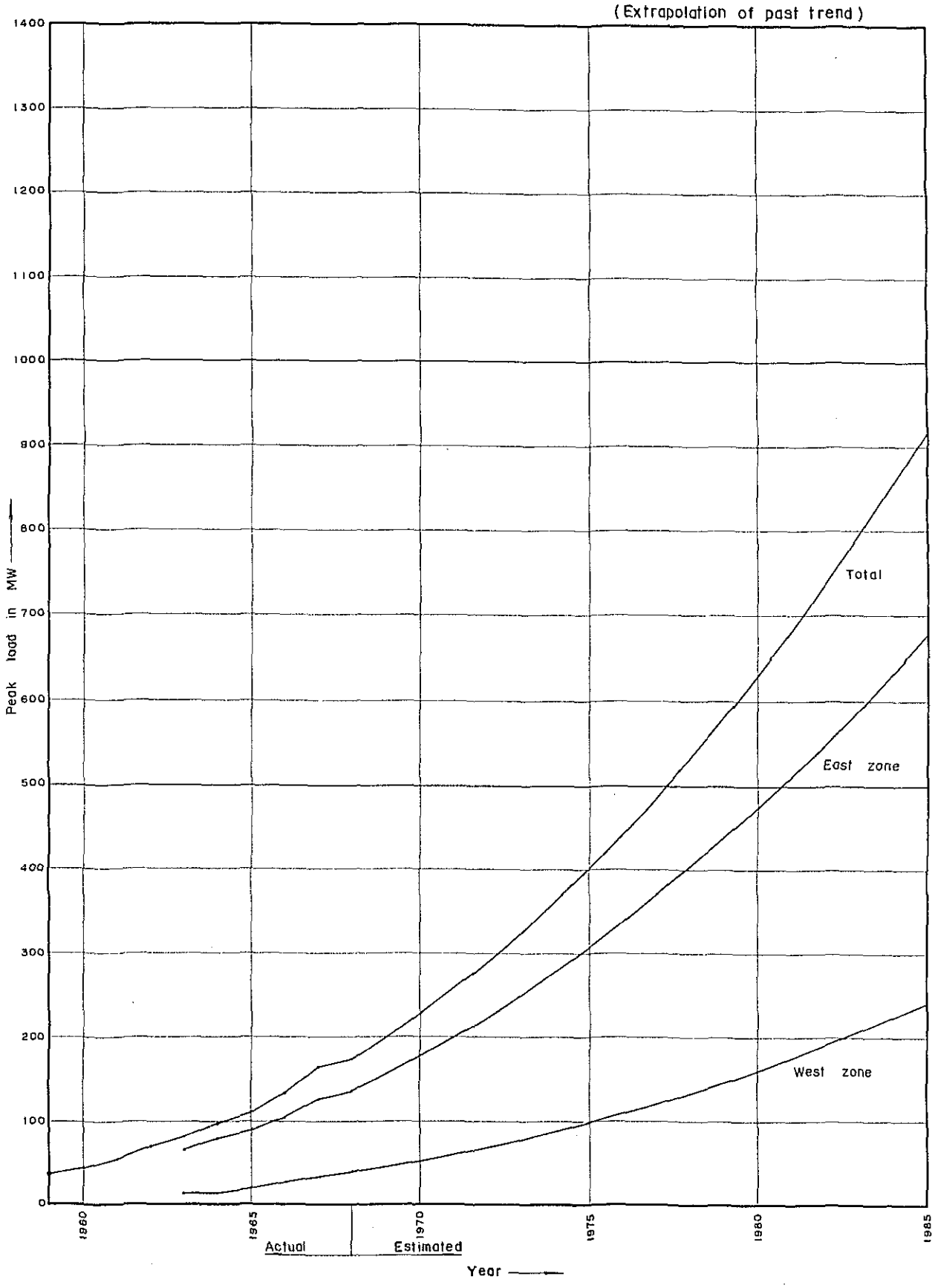


Fig. 4.4 ANNUAL ENERGY FORECAST

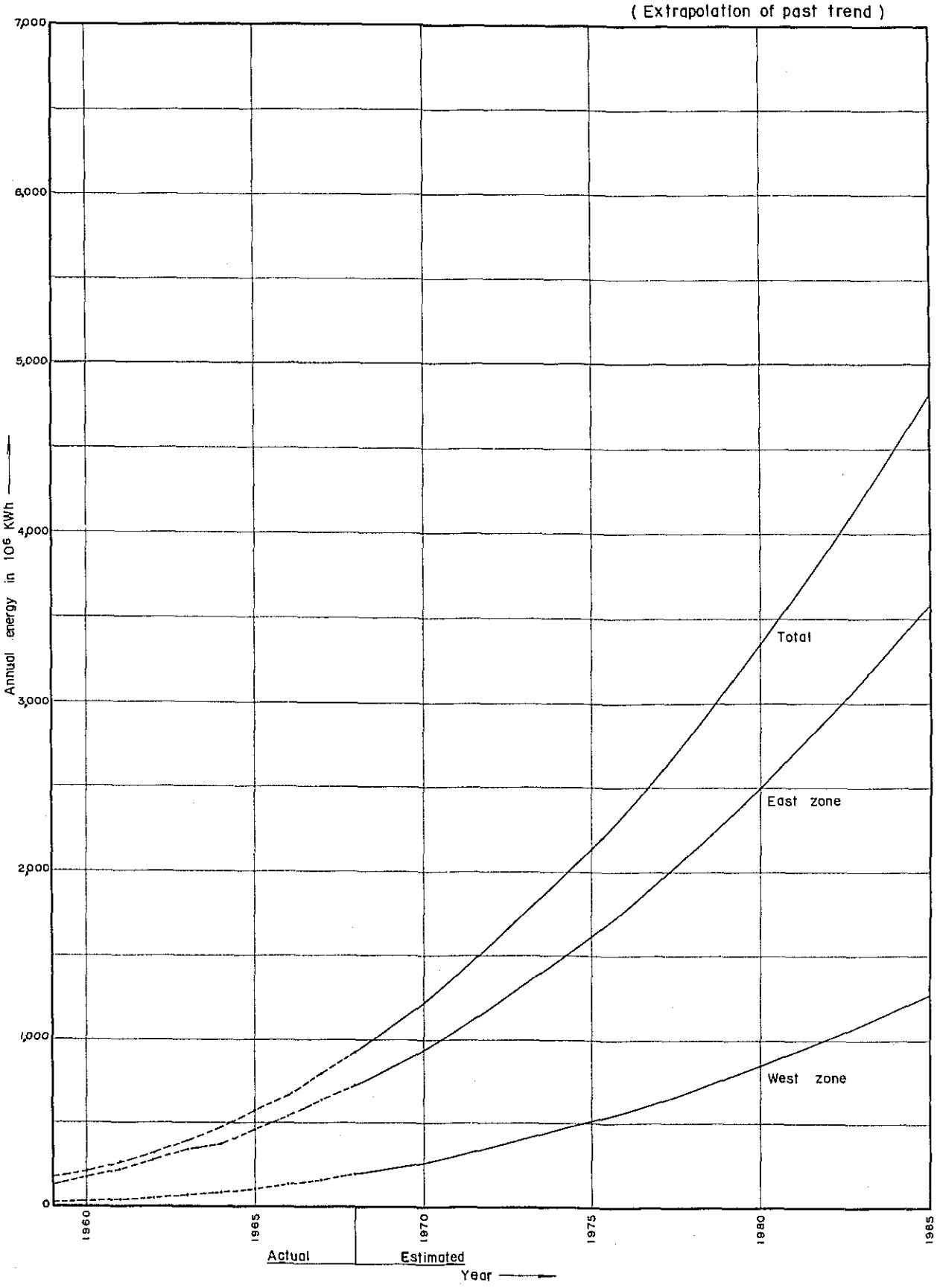


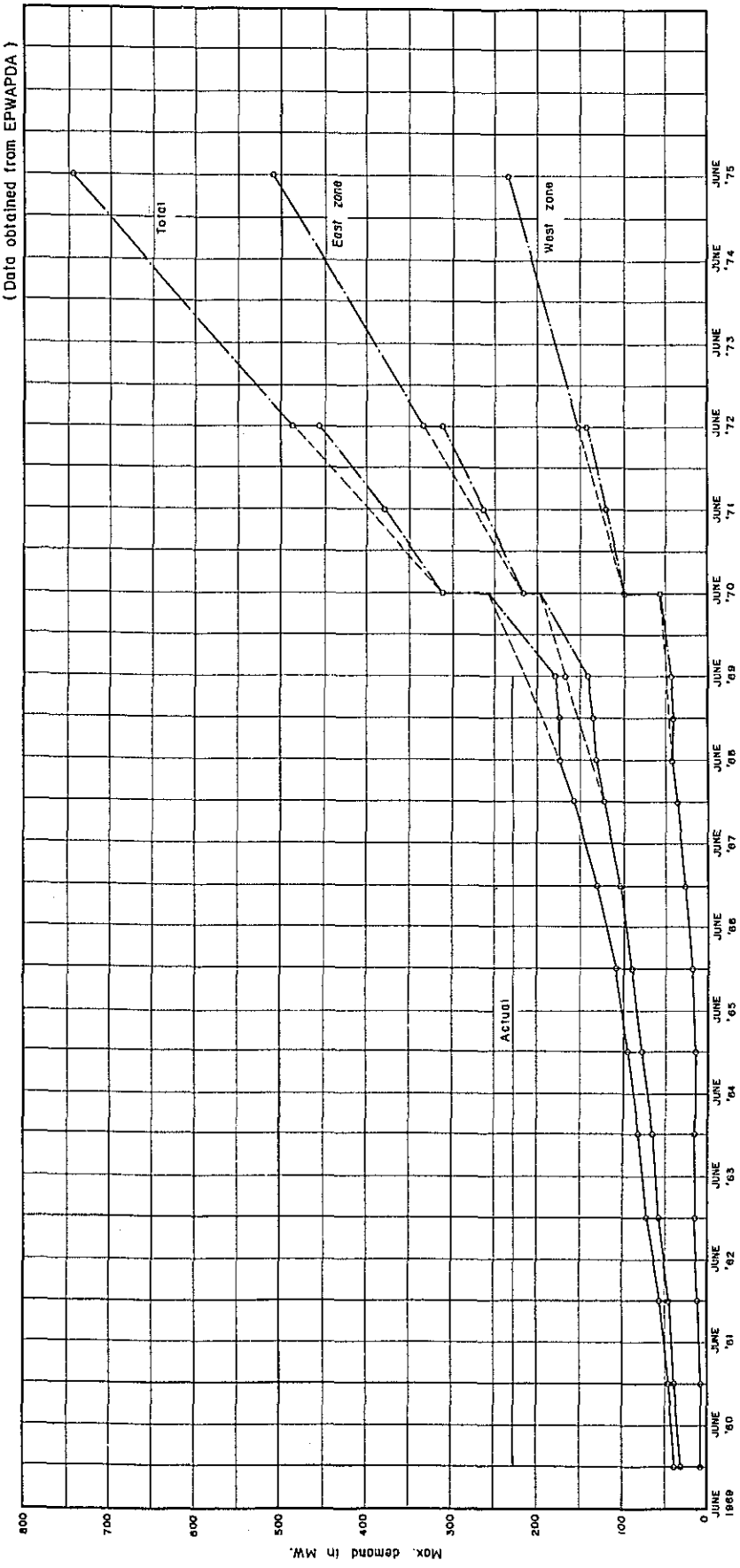
Table 4.3. Year Wise Maximum Demand of East and West Zone

(Data obtained from EPWAPDA)

Year	Eastern zone	Western zone	Total
1958	–	–	33.00 Actual
1959	–	–	38.00 "
1960	–	–	42.20 "
1961	–	–	56.00 "
1962	–	–	69.55 "
1963	65.56 Actual	16.17 Actual	81.73 "
1964	79.00 "	17.35 "	96.35 "
1965	89.90 "	20.11 "	110.01 "
1966	103.75 "	29.25 "	133.00 "
1967	127.21 "	35.70 "	162.81 "
1968	136.52 "	39.80 "	176.12 "
1969	165.401 Estimated	70.416 Estimated	235.817 Estimated
1970	215.517 "	99.329 "	314.846 "
1971	256.000 "	118.100 "	374.100 "
1972	332.000 "	150.000 "	482.000 "
1973	390.000 "	180.000 "	570.000 "
1974	450.000 "	207.000 "	657.000 "
1975	510.000 "	235.000 "	745.000 "

According to the above table, the yearly increases are based upon an arthmetical progression after the year 1972, and its yearly rate reaches to around 20 percent. Although the method and grounds of forecast are not disclosed, the rate appears to be on high side compared with other countries. Statistical data for the year 1968 was lower slightly that EPWAPDA's projection. It is anticipated that an actual future energy and power demand would increase following a mediate rate between two projections mentioned above.

Fig. 4.5 HISTORICAL AND PROJECTED LOAD GROWTH



CHAPTER V POWER DEVELOPMENT SCHEME

5.1. Reservoir Operation

The reservoir operation simulation with respect to the discharge, reservoir surface water level, tail water level, peak power output and plant factor was conducted using the run-off data for the period of 33 years from 1936 to 1968 and the reservoir storage capacity curve as corrected this time.

The cases studied are the following four cases, and the results of respective studies are shown in Fig. 5.2. through Fig. 5.5. and Table A-24 through A-44. For the reference, the reservoir operation rule curve[1] are shown in Fig. 5.6. through Fig. 5.9.

i) Two units operation: No. 1 (40 MW) and No. 2 (40 MW) units
ii) Three units operation: No. 1, No. 2 and No. 3 (50 MW) units
iii) Four units operations: No. 1 to No. 3 and No. 4 (50 MW) units
iv) Five units operation: No. 1 to No. 4 and No. 5 (50 MW) units

The followings are also the conditions considered in the avovementioned studies.

1) The energy generated at the Karnafuli Powerplant are all consumed in the system.

2) The rating curve of the tailwater is taken as shown on Fig. A.2.

3) The evaporation from the reservoir is taken as Table 3.4.

4) The normal high water level of the reservoir is set at EL. 118.0, except for the period from July 1 to September 30 when it is limited to EL. 113.0 for the flood control purpose following the proposition in the IECO's report. The limitation of the lowest water level is set at EL. 80.0.

5) The actual generating capacity of respective units are assumed as follows against the rated capacity (figures in brackets).

No.1 and No.2 units	46,000 kW (40,000 kw)
No.3 unit	64,800 kW[2]
No.4 and No.5 units	57,500 kW (50,000 kW)

6) The power output was computed against overall efficiencies as shown in Fig. 5.1. The efficiency curve for No.1 and No.2 turbine-generators was obtained from the shop test records, but those for the rest are the assumptions from other examples of similar size.

1) The reservoir operation rule curve is a curve showing reservoir water levels of one year period against the assumed use of storage water, in which run-off mass curve is drawn for 50% excess probability in run-off (monthly average) time series (12 months) probability group.

2) The figure from the contract conditions for the Karnafuli third unit project.

Fig. 5.1 OVERALL EFFICIENCY OF TURBINE-GENERATOR

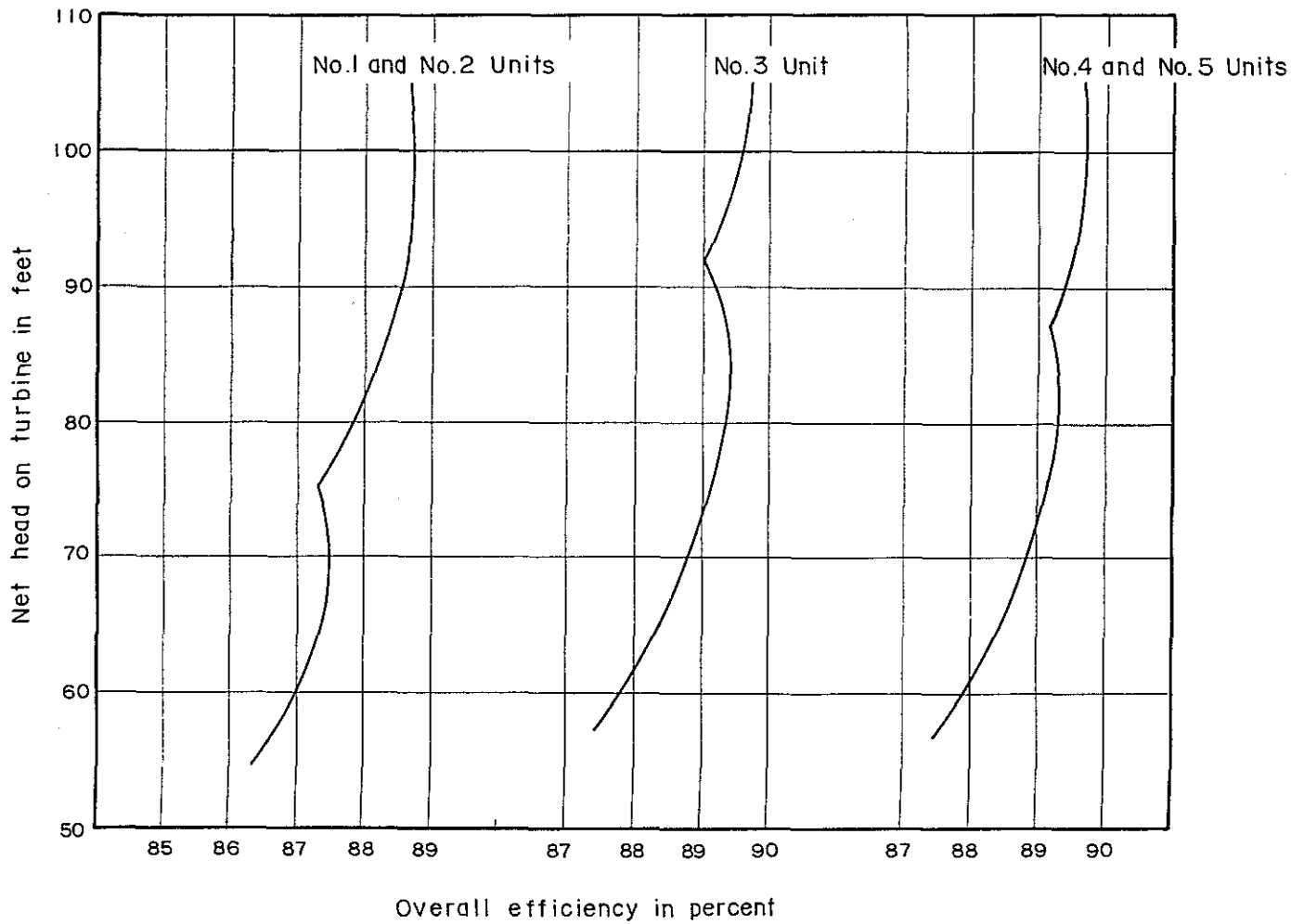


Fig. 5.2 RESERVOIR OPERATION, 2-UNIT OPERATION

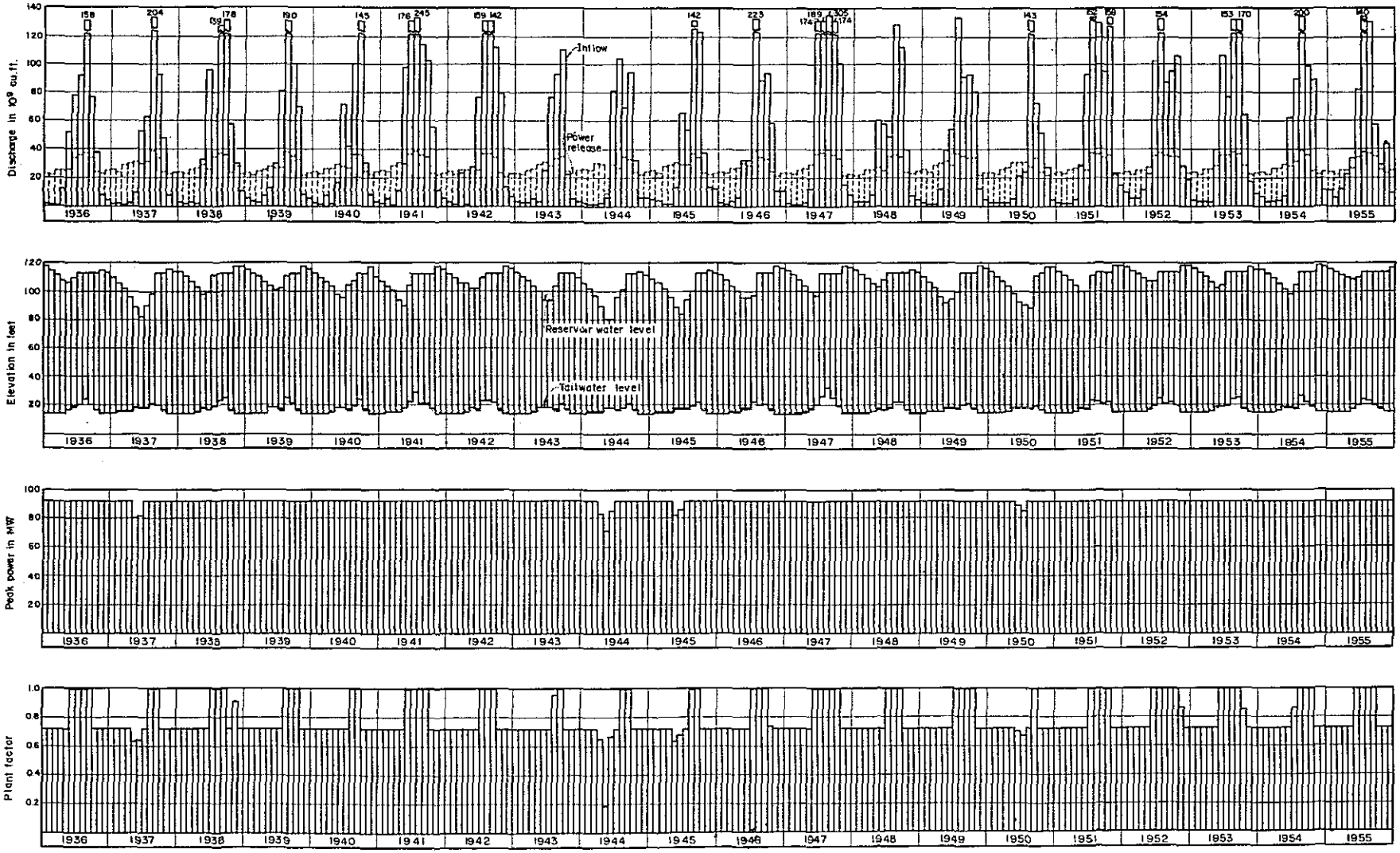
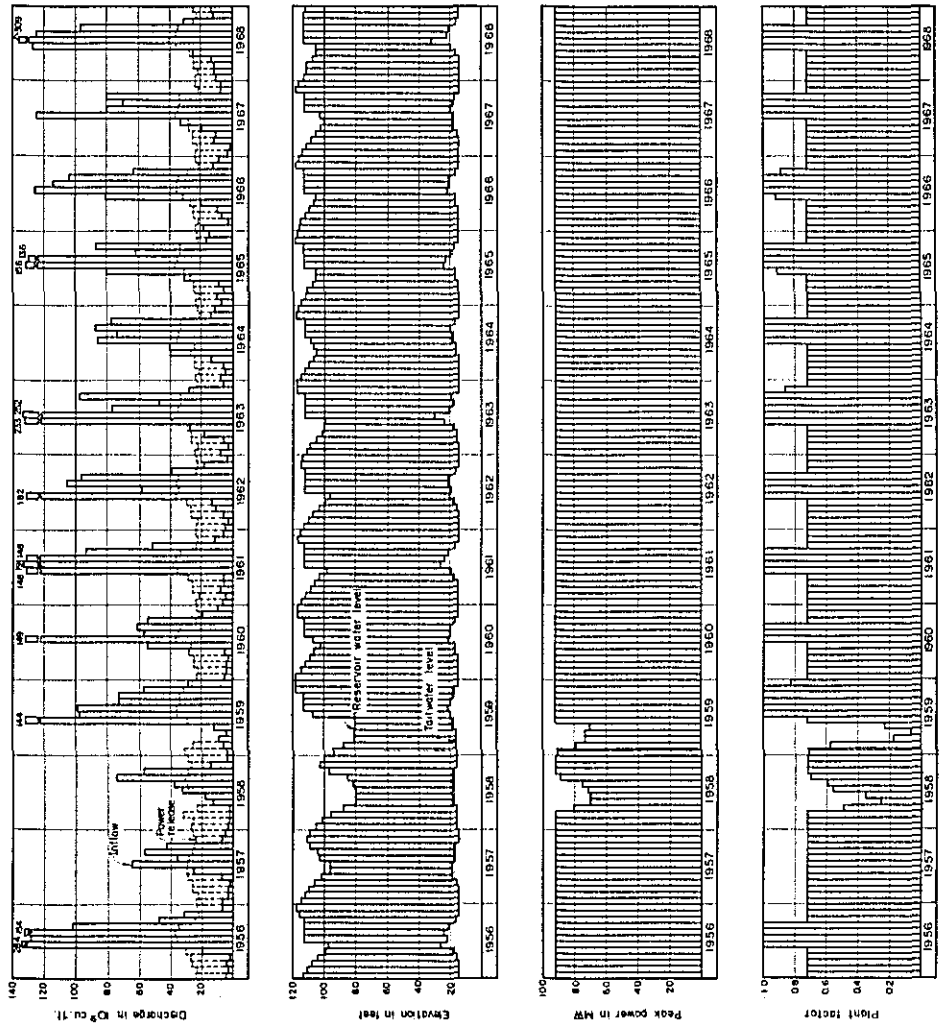


Fig. 5.2 (CONTINUED).



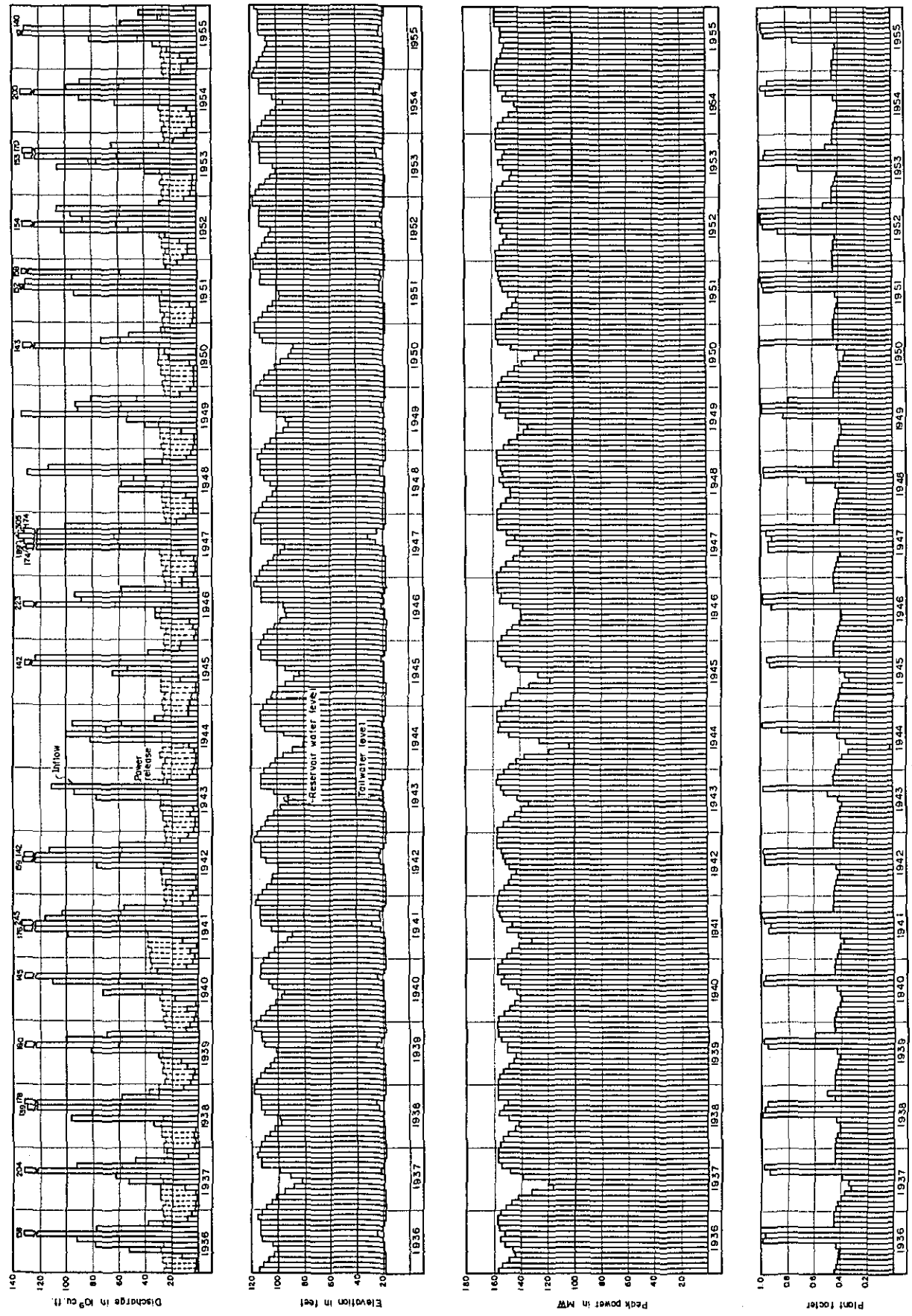
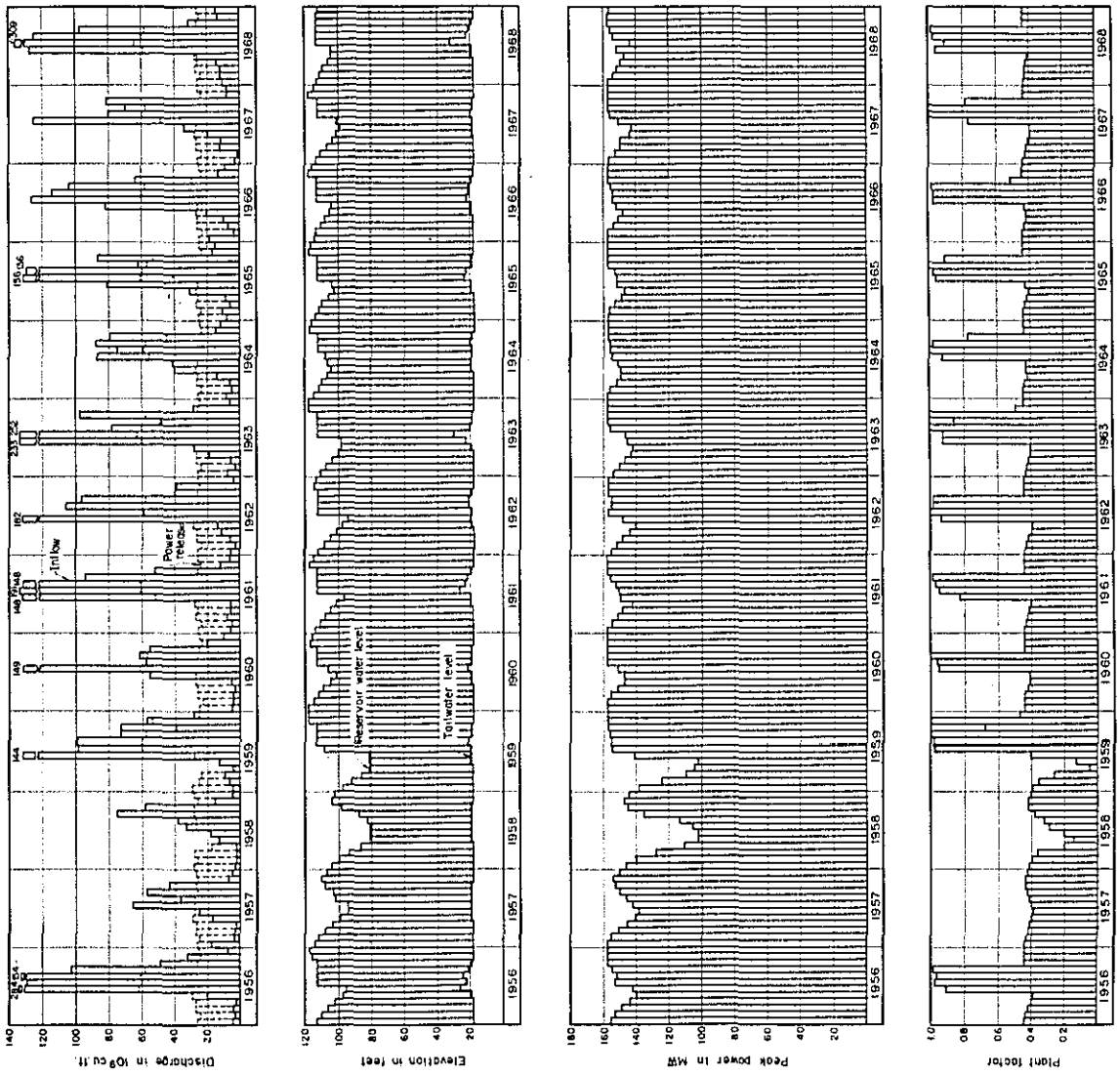


Fig. 5.3 RESERVOIR OPERATION, 3-UNIT OPERATION

Fig. 5.3 (CONTINUED)



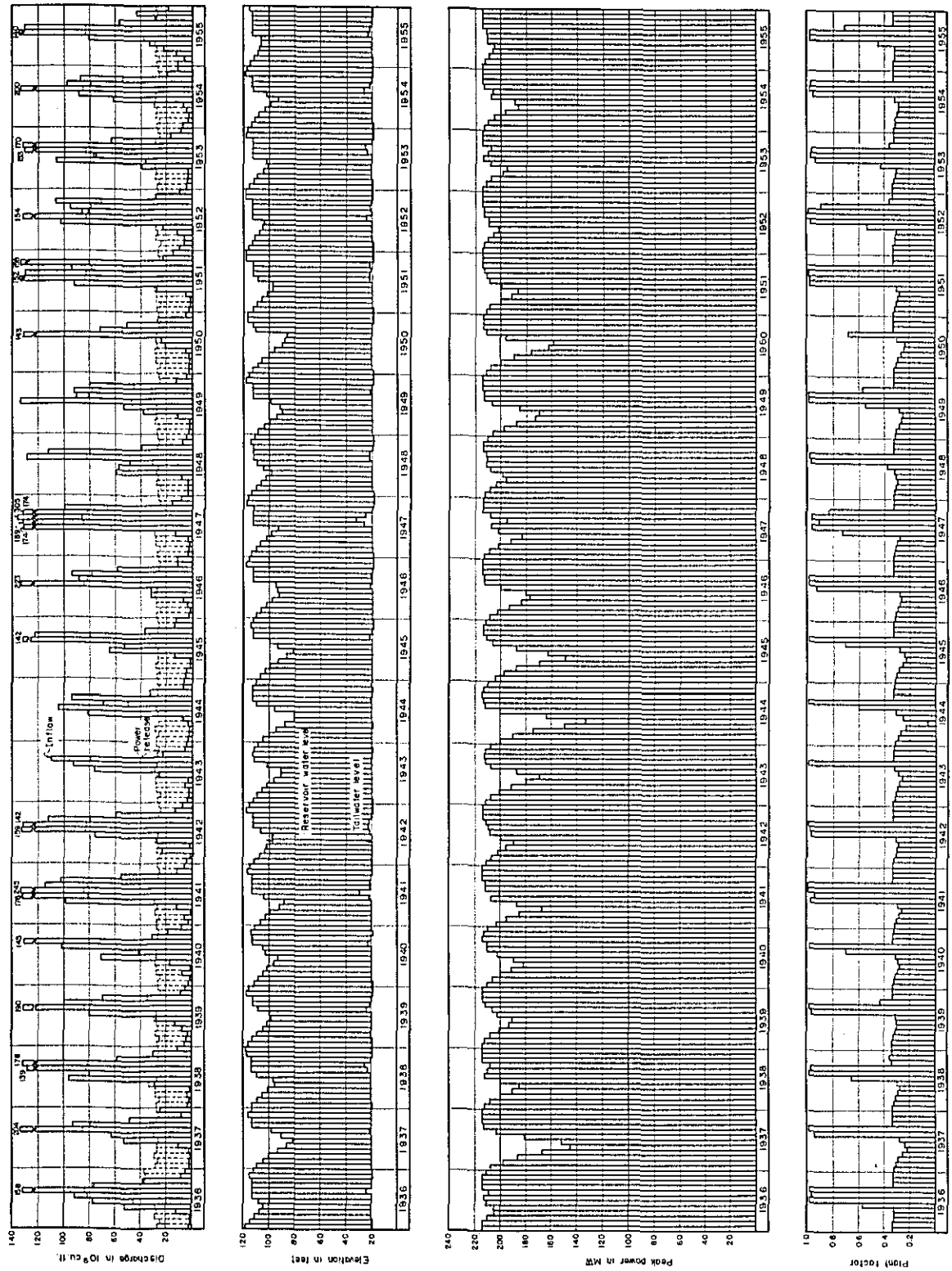
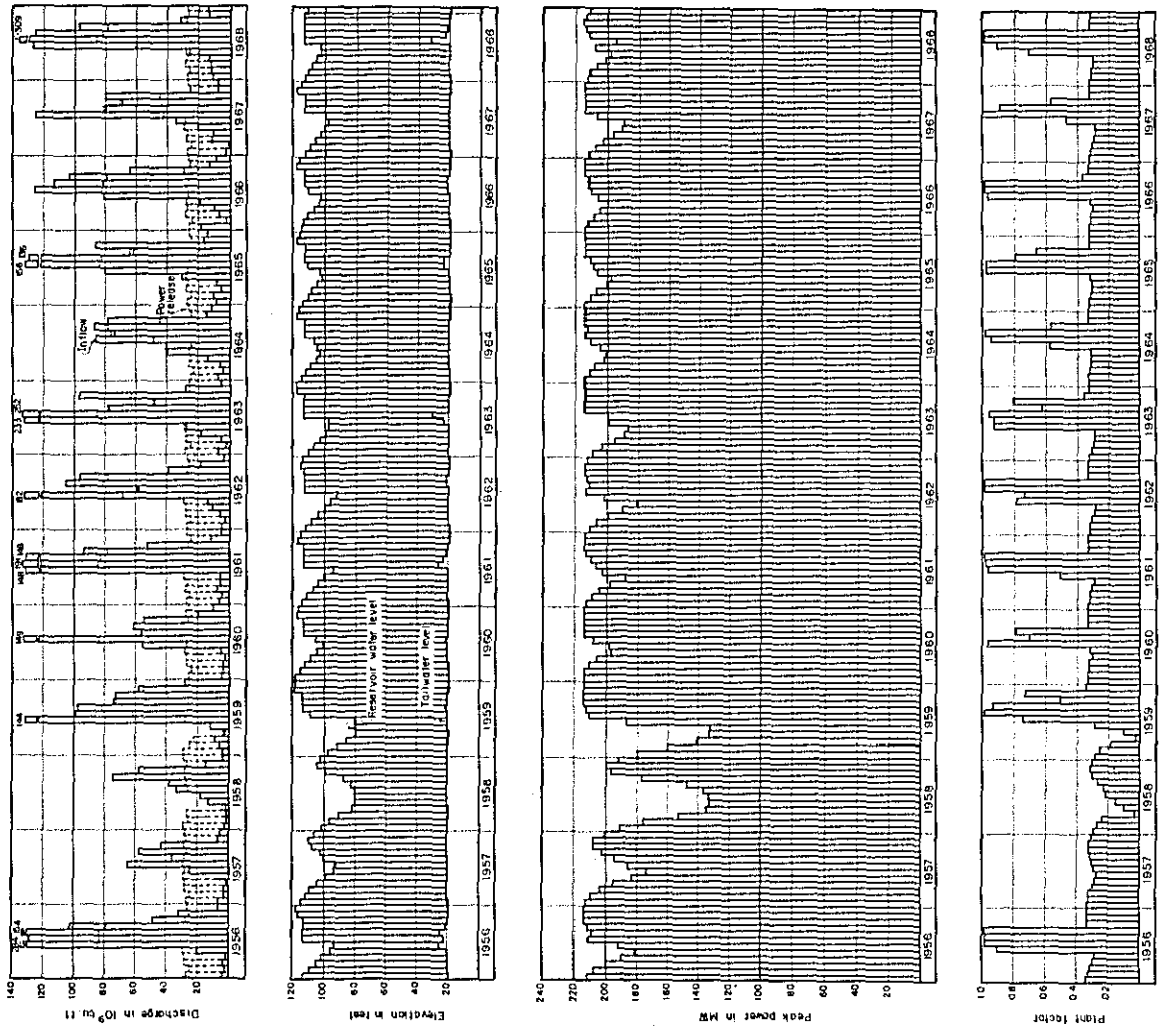


Fig. 5.4 RESERVOIR OPERATION, 4-UNIT OPERATION

Fig. 5.4 (CONTINUED)



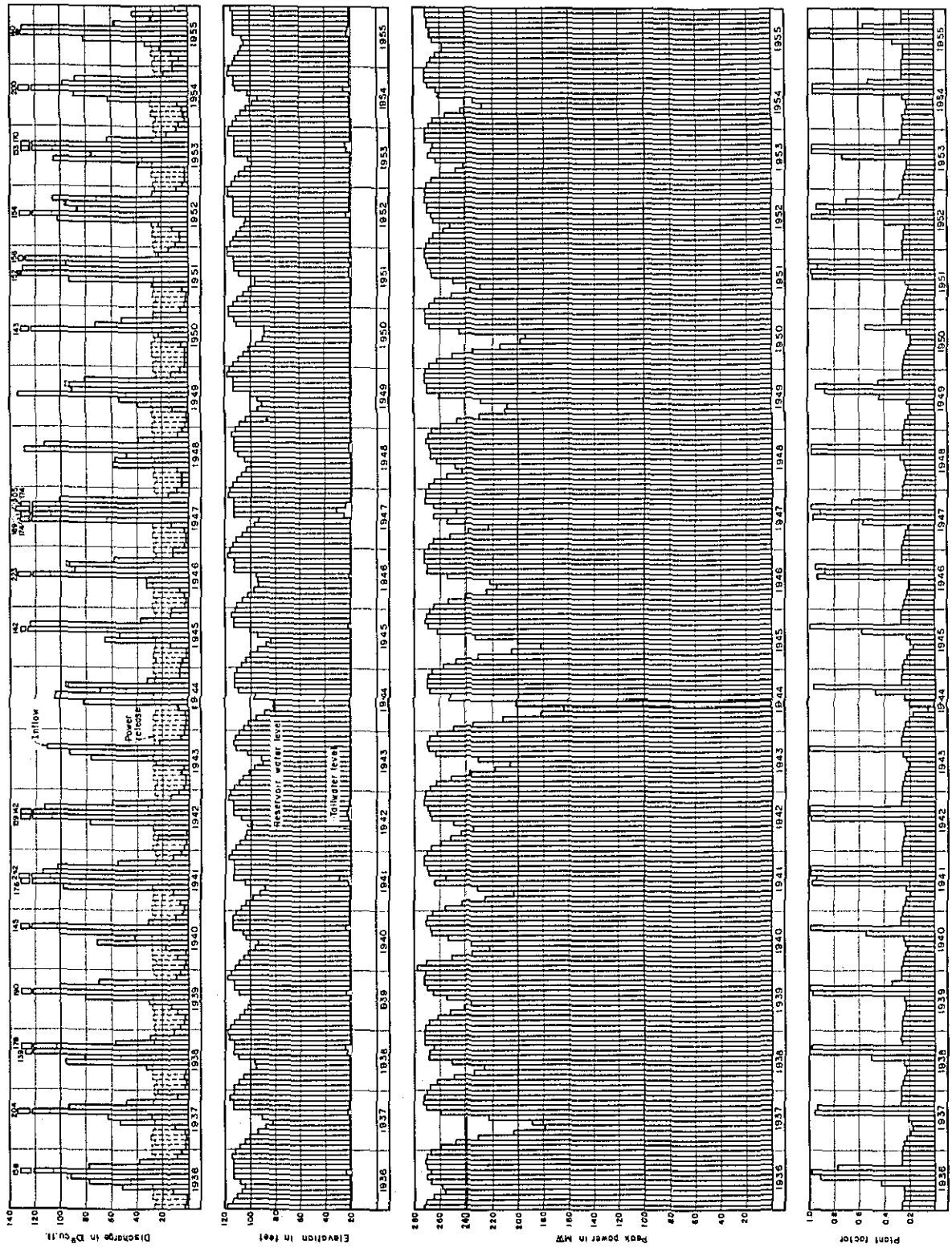


Fig. 5.5 RESERVOIR OPERATION-5-UNIT OPERATION

Fig. 5.5 (CONTINUED)

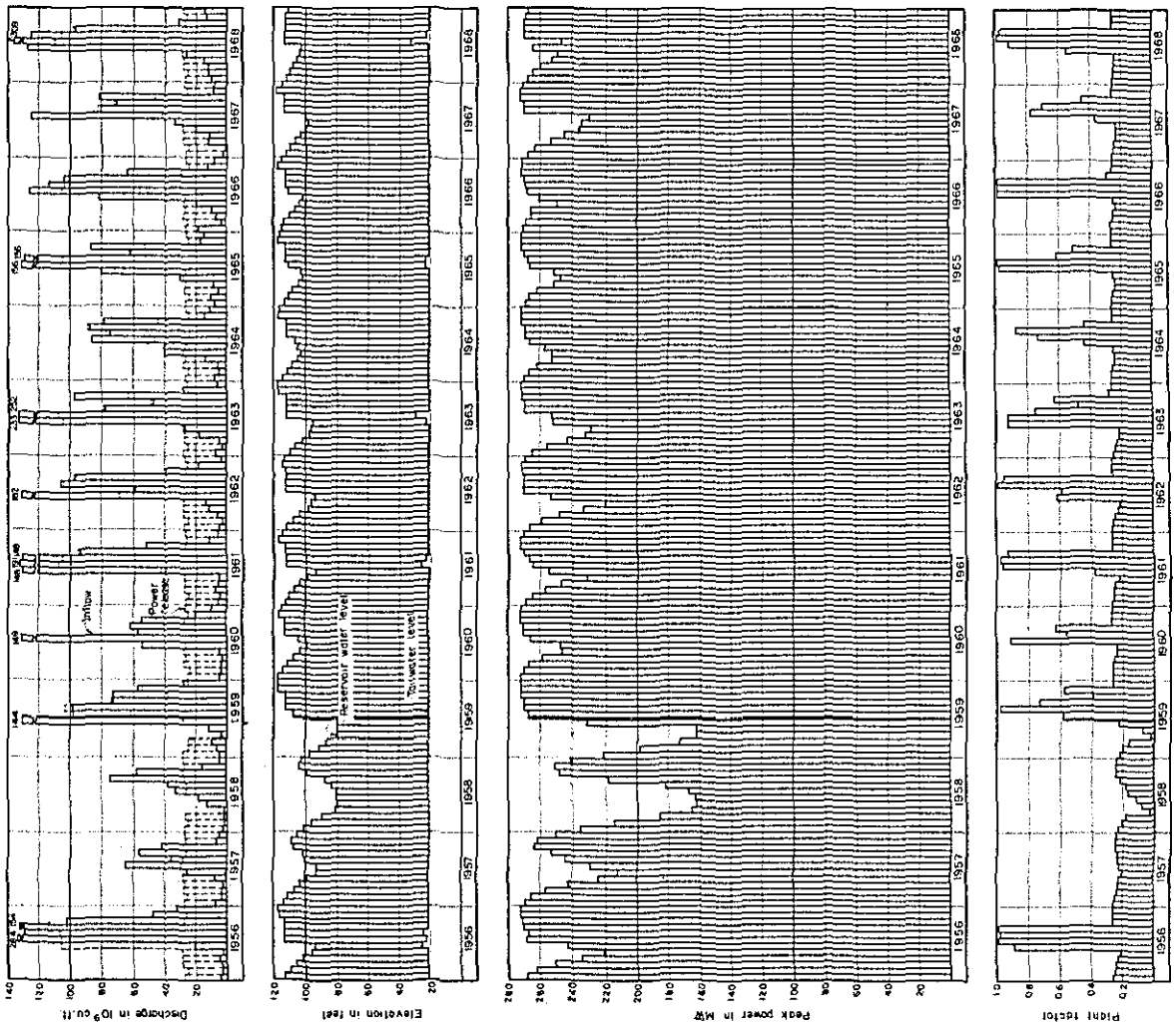


Fig. 5.6 RULE CURVE FOR 2-UNIT OPERATION

(NO.1 & NO.2 Generating Units)

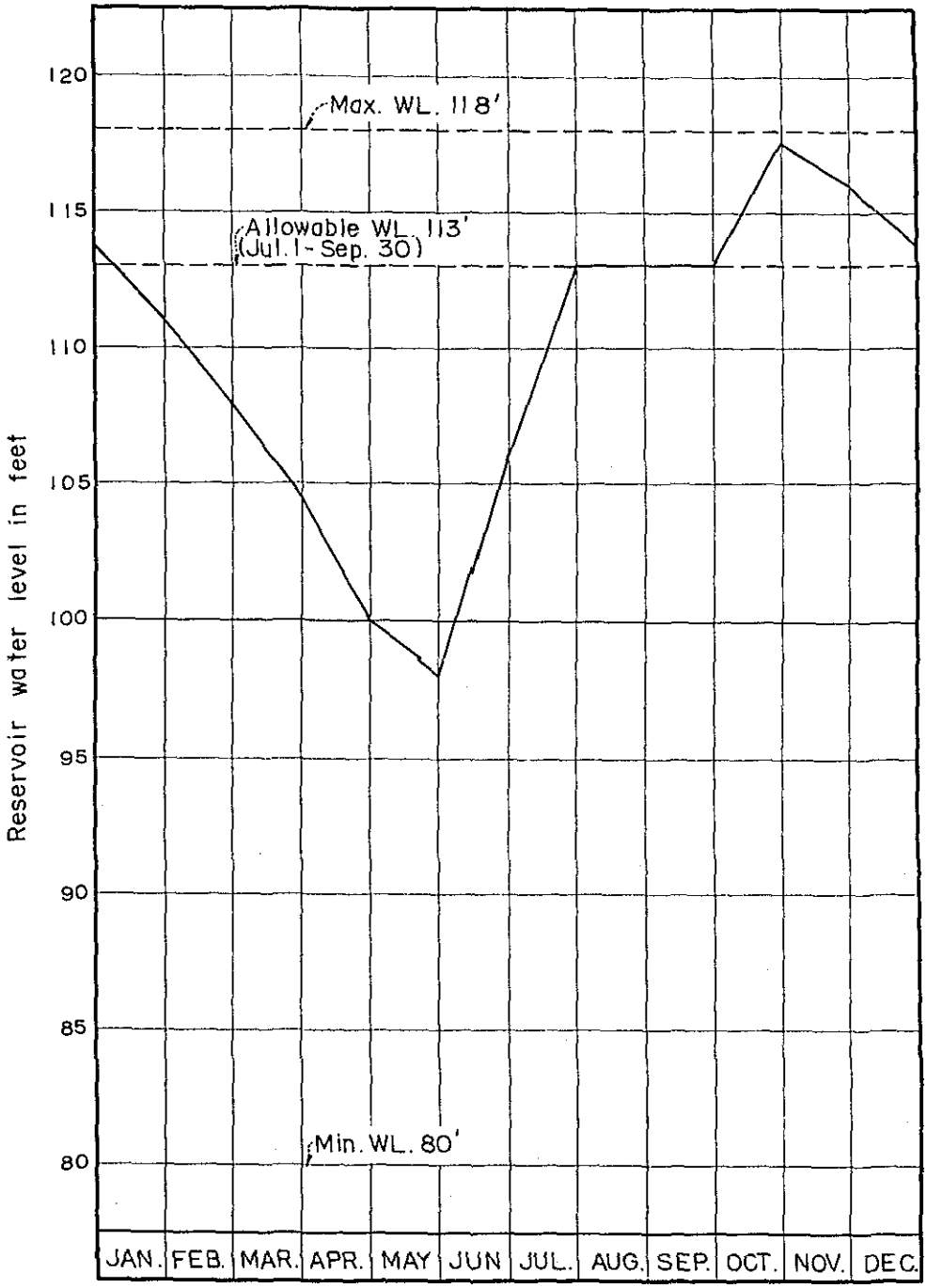


Fig. 5.7 RULE CURVE FOR 3-UNIT OPERATION

(NO.1, NO.2 & NO.3 Generating Units)

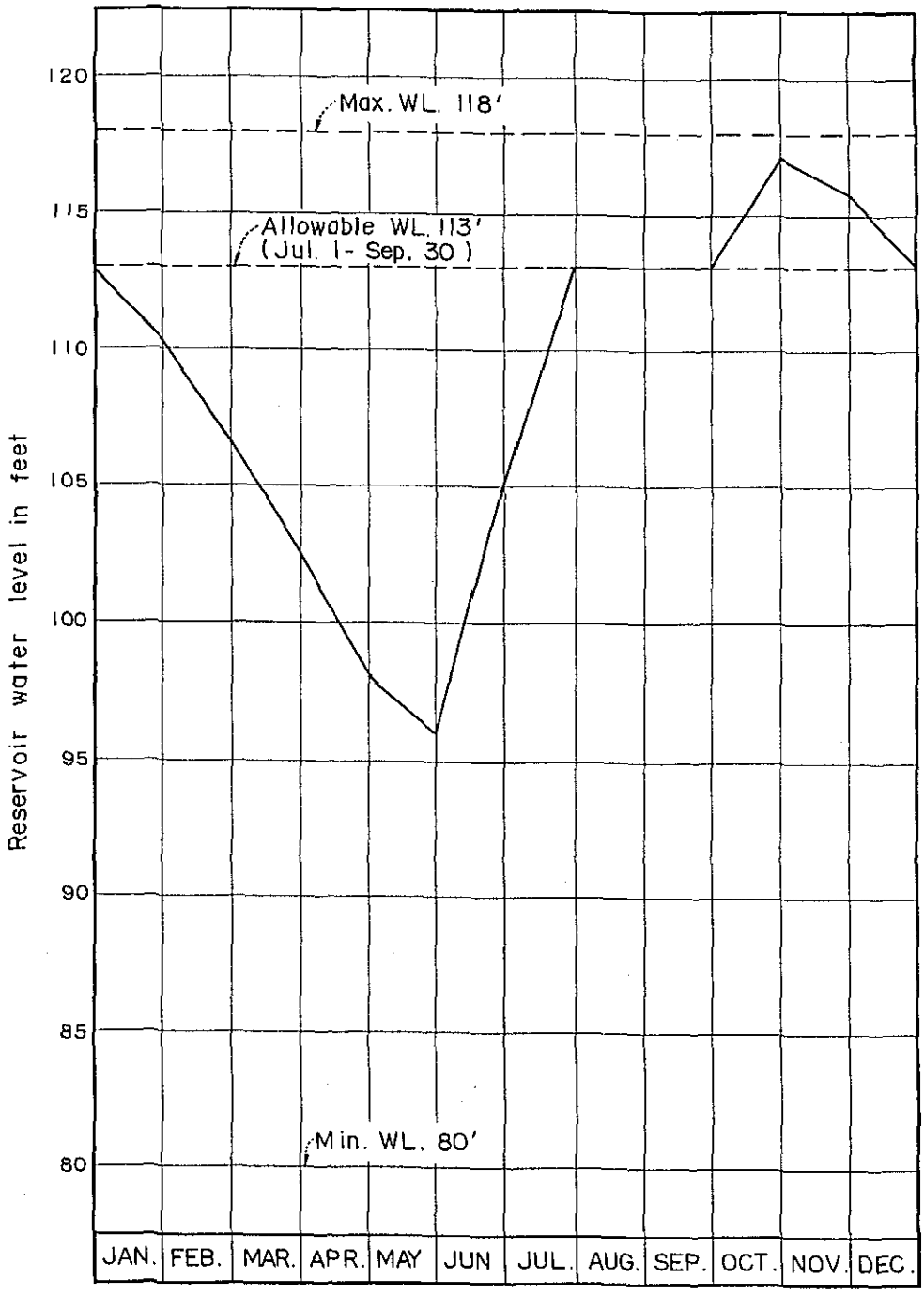


Fig. 5.8 RULE CURVE FOR 4-UNIT OPERATION

(NO. 1, NO. 2, NO.3 & NO.4 Generating Units)

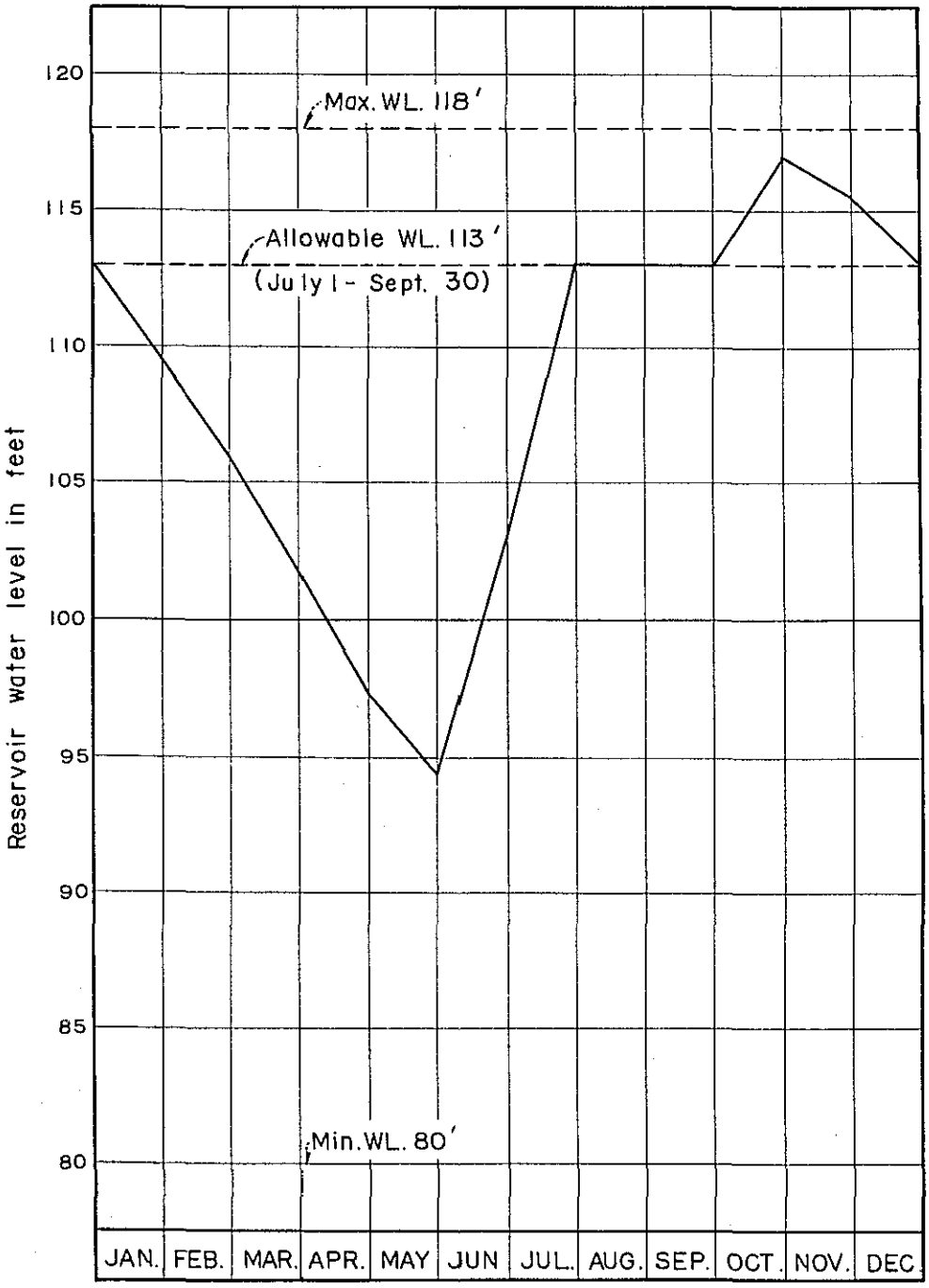
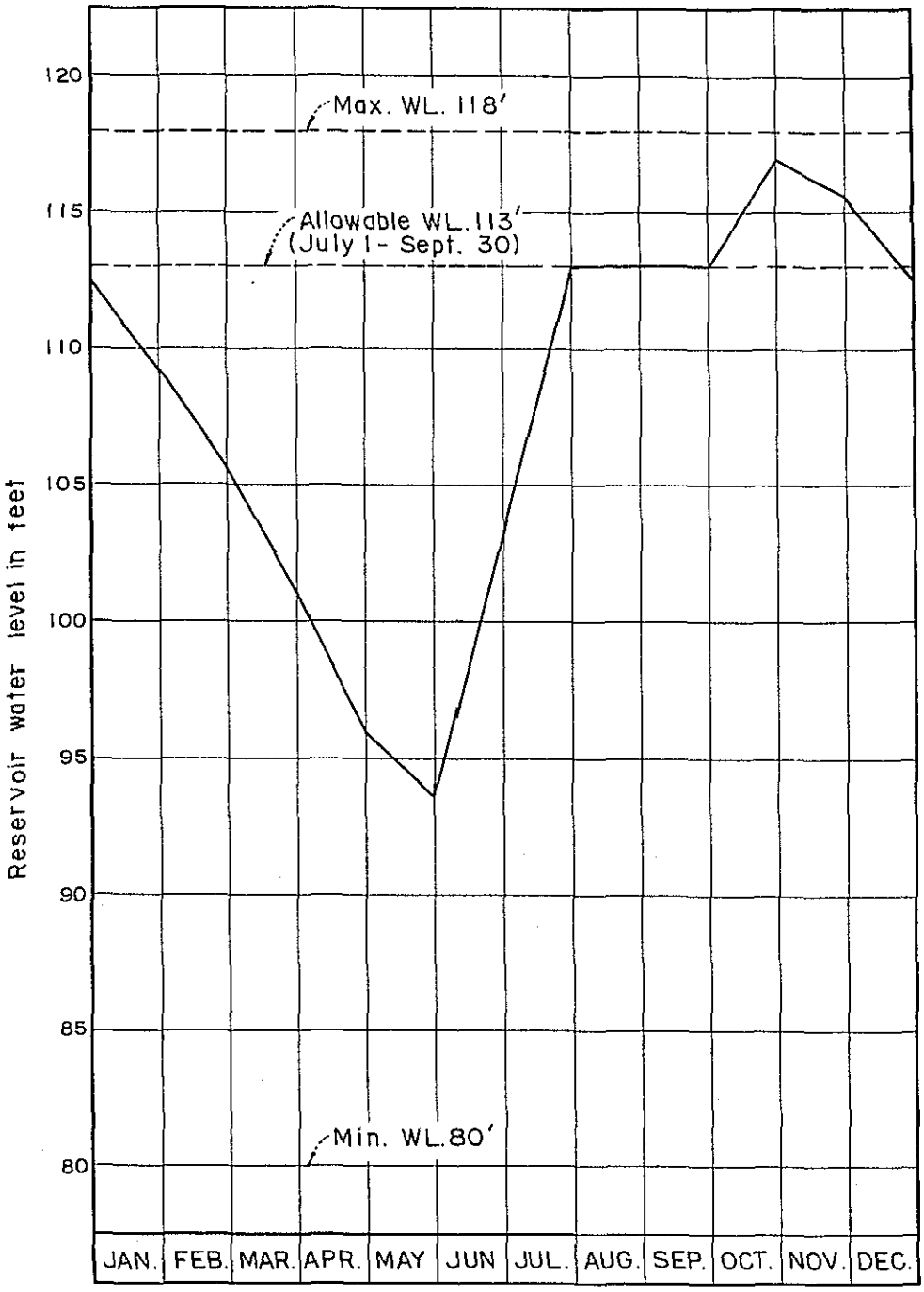


Fig. 5.9 RULE CURVE FOR 5-UNIT OPERATION

(NO.1, NO.2, NO.3, NO.4 & NO.5 Generating Units)



5.2. Power and Energy

The average monthly generation of energy based on the 33-year period of record can be summarized as follows for the respective categories:

Table 5.1. Average Monthly Energy Generated

(Unit: 10^6kwh)

Month	2 units	3 units	4 units	5 units
Jan.	42.3	51.3	52.9	52.7
Feb.	44.5	45.3	46.1	45.7
Mar.	49.3	48.8	49.0	48.2
Apr.	47.7	45.9	45.2	44.1
May	49.3	46.1	44.7	43.1
June	47.7	45.8	45.2	44.2
July	68.4	100.2	73.9	74.1
Aug.	68.4	114.5	116.2	207.5
Sep.	66.2	111.7	157.1	184.5
Oct.	49.3	51.3	54.4	55.4
Nov.	47.7	49.7	52.7	53.6
Dec.	49.3	51.3	54.4	54.5
Average annual energy	637.1	762.2	836.8	907.6

The maximum and minimum annual generation are listed as follows:

Minimum and Maximum Annual Energy

Installation	Minimum	Maximum
	Million kWh	Million kWh
2 units	485.9	684.9
3 units	448.0	907.2
4 units	421.9	1,051.4
5 units	413.0	1,125.5

5.3 Installed Capacity

Hydro power can be a valuable part of the total power generation in meeting short duration peak loads. In addition, from the viewpoint of long-range power development in East Pakistan, the study was made putting stress on the peaking operation of the Karnafuli power plant during the hour of peak demand.

Peaking can be defined in several way. In this study, it was defined as the area in the load duration curve above average power. From an estimated daily load duration curve shown in Fig. 5.12, a generalized peaking period of around 6 hours seems to be appropriate.

In view of the fact that the plant factor obtained from the reservoir operation is 26 per cent for 5-unit installation, the Karnafuli power station will be capable of meeting reasonably peak load requirement in the system.

The Karnafuli project is a hydro electric power project and an economic installation is to have an optimum size of power development including the existing generating units. Therefore, the final installed capacity should be realized so as to bring the highest annual net benefit. For this purpose, several assumed installed capacities to be extended such as 60,000 kW, 80,000 kW, 100,000 kW and 120,000 kW were assumed for estimating the costs and venefits. The benefit-cost ratio and anhual benefit to the respective capacities assumed have been evaluated. In this study, which was based on the size of 120 MW natural gas fired thermal, the annual costs for the existing facilities are also incorporated.

It is anticipated that the Karnafuli powerplant occupies a large part in the total demand in East Pakistan during period of coming decade even with a very optimistic forecast. In other words, there is a possibility that the power and energy produced in the Karnafuli powerplant would not be practically consumed to some period after completion if a large size generating capacity compared with the system demand should be planned.

On the other hand, for the purpose of accommodating the generating units to be installaed newly, the extension of the existing powerplant building to its longitudinal direction is planned. Accordingly, it would not be economically justified to plan so large capacity units as not to be installed in an extended space of building.

The results of this study proved the extension of 100,000 kW(230,000 kW in total installed capacity) is the most beneficial to this project, as the comparison of economical installed capacity is shown in Fig. 5.10.

Finally two units each of 50,000 kW capacity were chosen for the extension of the Karnafuli project.

The detailed evaluation for additional 100,000 kW is discussed in Chapter VIII. Project Evaluation.

5.4 Need and Opportunity for Power

East Pakistan is on her way of development, in particular industrialization. This meas the energy requirement will increase as the time advances. To meet growing demands, EPWAPDA is achieving a vigorous expansion of generating facility as mentioned Chapter IV. Fig. 5.11 shows the EPWAPDA's development schedule together with their future load projection.

If an estimated load duration curve is as shown on Fig. 5.12 which is based on the average of four-maximum peak day in 1968–69, and Karnafuli powerplant is fit into the top of peak of the duration curve, No.4 unit and No.5 unit installations would be justified when system peak reaches around 400,000 kW and 700,000 kW, respectively.

Supposing that the development of power stations will be completed in accordance with the scheduled program, No.4 unit extension of the Karnafuli powerplant would be needed to be constructed in the yar 1976 to 1977 and No.5 installation in around 1982 viewed from future load projection for the east zone if a margin capacity is assumed as 15 to 20 percent of total capacity. Even a very possimistic forecast, No.4 unit installation will be needed in the year 1979.

Fig. 5.10 ECONOMICAL STUDY ON INSTALLED CAPACITY

(Based on size of 120 MW natural gas fired thermal)

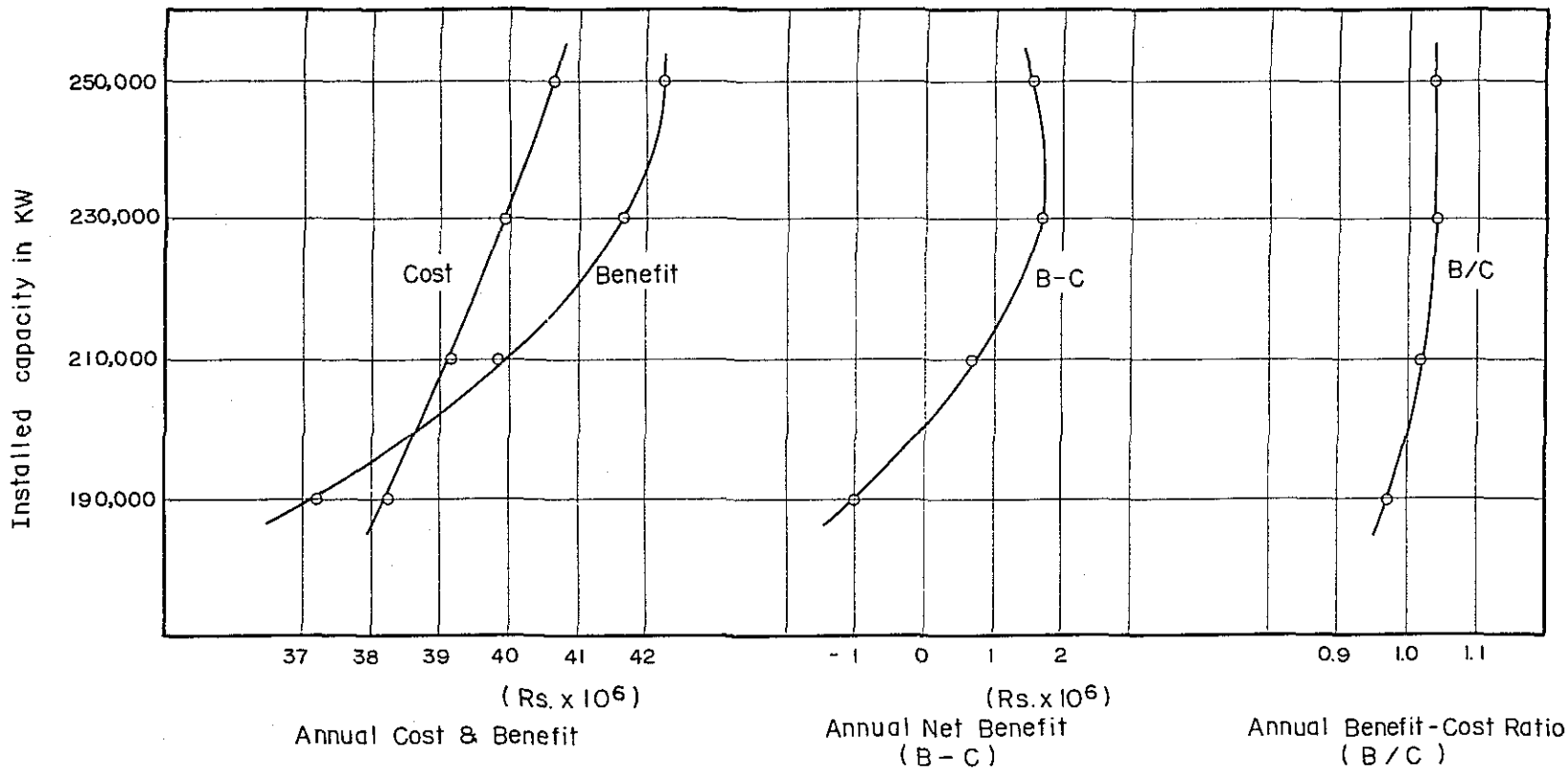
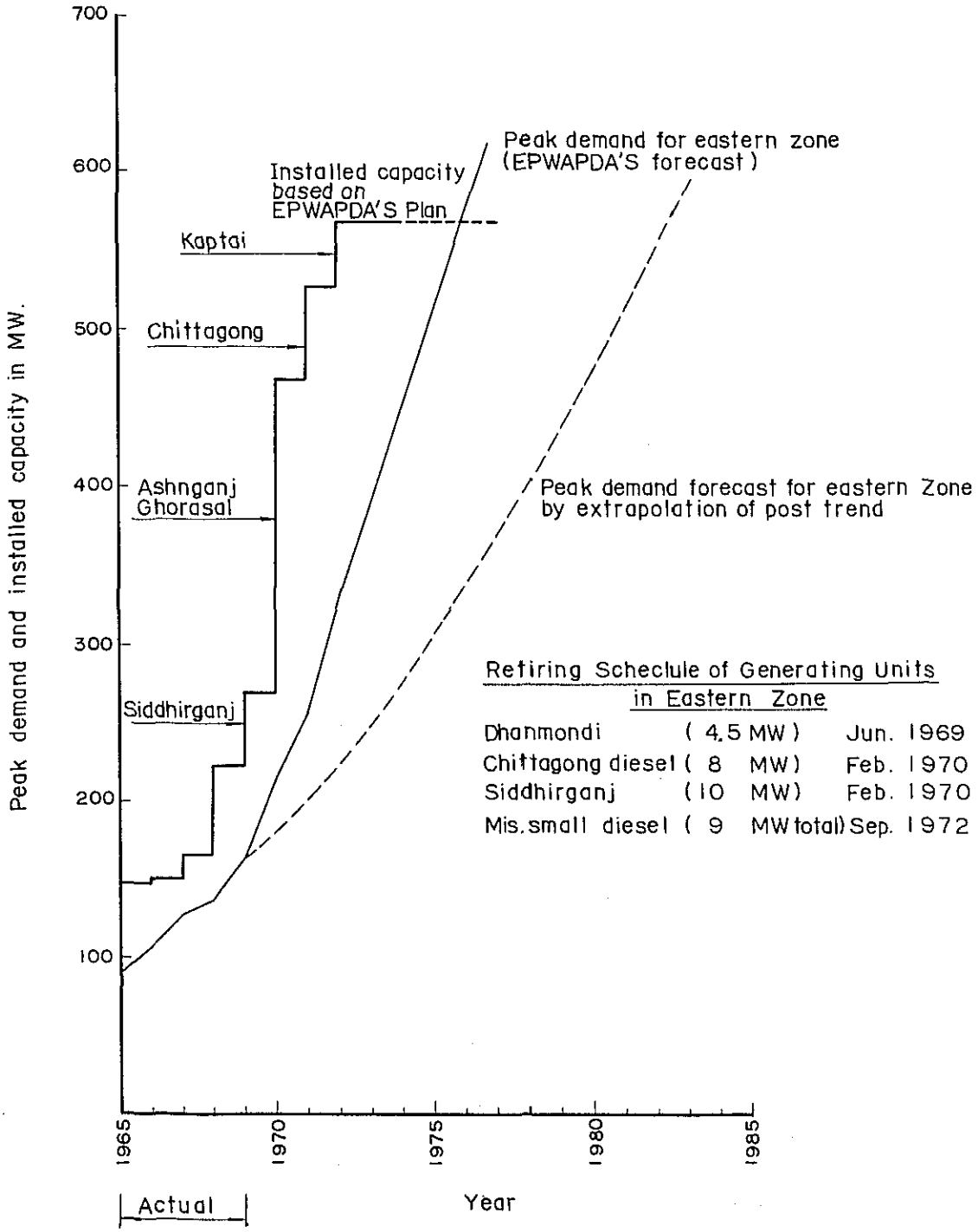


Fig. 5.11 EPWAPDA POWER DEVELOPMENT PROGRAM FOR EASTERN ZONE

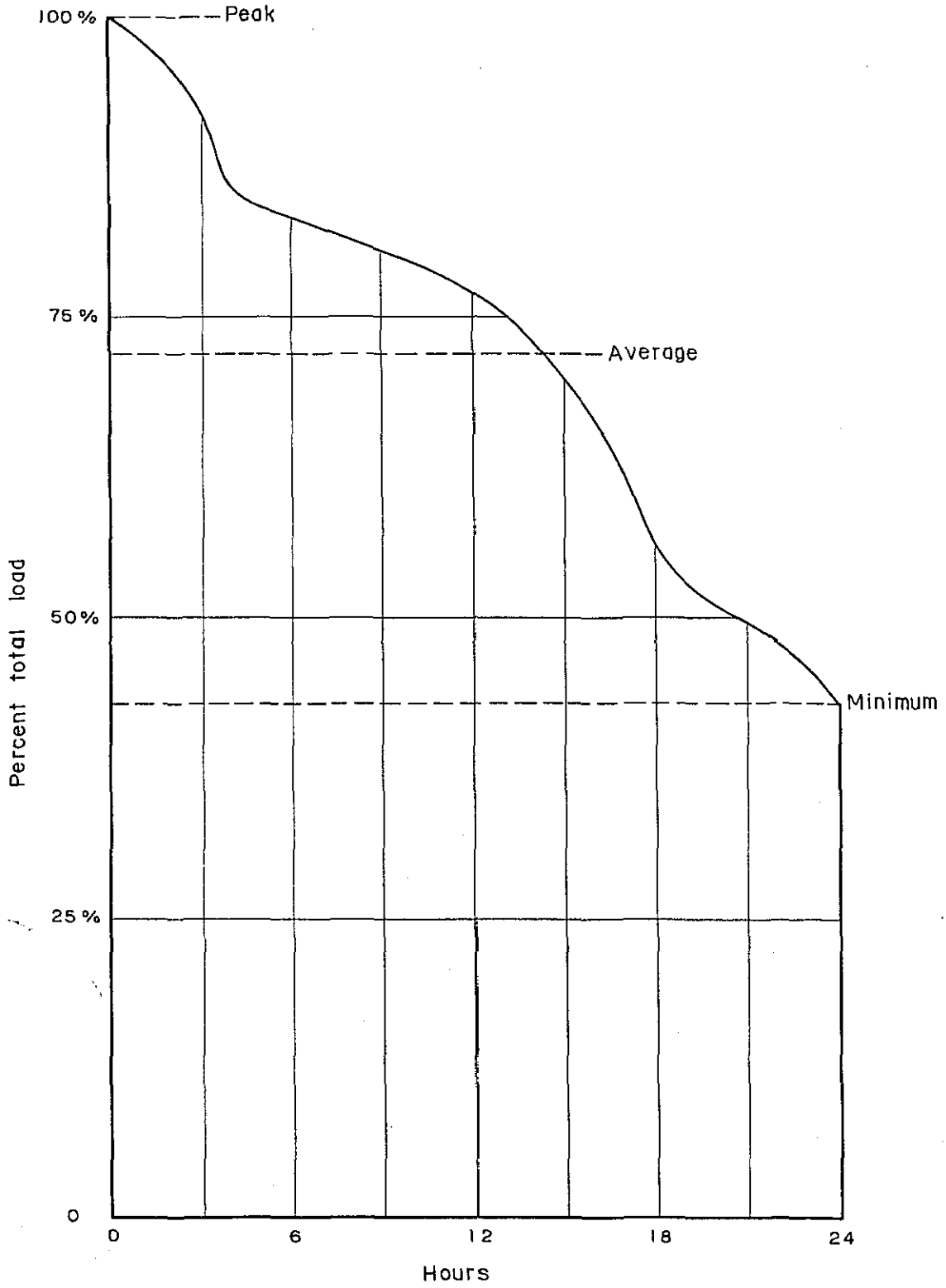


Retiring Schedule of Generating Units in Eastern Zone

Dhanmondi	(4.5 MW)	Jun. 1969
Chittagong diesel	(8 MW)	Feb. 1970
Siddhirganj	(10 MW)	Feb. 1970
Mis. small diesel	(9 MW total)	Sep. 1972

(Obtained from EPWAPDA)

Fig. 5.12 ESTIMATED DAILY LOAD DURATION CURVE



CHAPTER VI. PRELIMINARY DESIGN

6.1 Layout of Extension Work

General review of the topography of the area and a consideration of layout in relation to the existing power power station may lead to suggest three possible layouts, referred to as Site I, II and III.

At the Site I, the extension work is to be laid almost along the center line of the previous diversion tunnel. For the Site II, the extension is considered just annexed to the existing power station. At the Site III, the extension is considered at the present cargo transfer site.

Of the three layout, the Site III was discarded because it was apparent that a tremendous volume of dredging and underwater excavation would be involved to open up the approach and forebay channel to the intake. Besides a new cargo transfer facility to replace the present one would have to be constructed elsewhere in order to continue to provide the same convenience to the public.

As regards the Site I, it has an advantage that the construction can be carried out with less disturbance to the operation of the existing power station compared with the Site II.

However, according to the Design Report, Volume I by IECO, vide a drawing No.FL–10–403 – Power Plant & Diversion Tunnel, Geologic Sections, soft shale prevails in the area of the power house foundation, and it is naturally desirable to avoid such soft material for the power house foundation.

The Site I also requires a large volume of approach channel excavation, tailrace channel excavation, and longer power conduits compared with the Site II.

As regards the Site II, it is assessed that the same reliable compact shale as the foundation for the existing power house should exist in the area for the extension work, referring to the Design Report as mentioned above and also to the boring results carried out during the present investigation, vide Appendix of this report.

As there is already a forebay channel for the existing power station, the excavation for that purpose for the extension work can be made minimum. As the power house is extended straight from the existing one, such advantage as operational and maintenance convenience or the common use of travelling crane or the availability of the existing access road etc. can be expected.

The only concern with the Site II is the fact that the enlargement of the forebay channel and construction of intake structure is to be done very close to the existing power station and without completely drying out the reservoir.

As will be explained in the following chapter, such construction appeares not to be always impossible, and after various factors as mentioned above being weighed, it was decided to propose the Site II.

6.2. Description of Structures

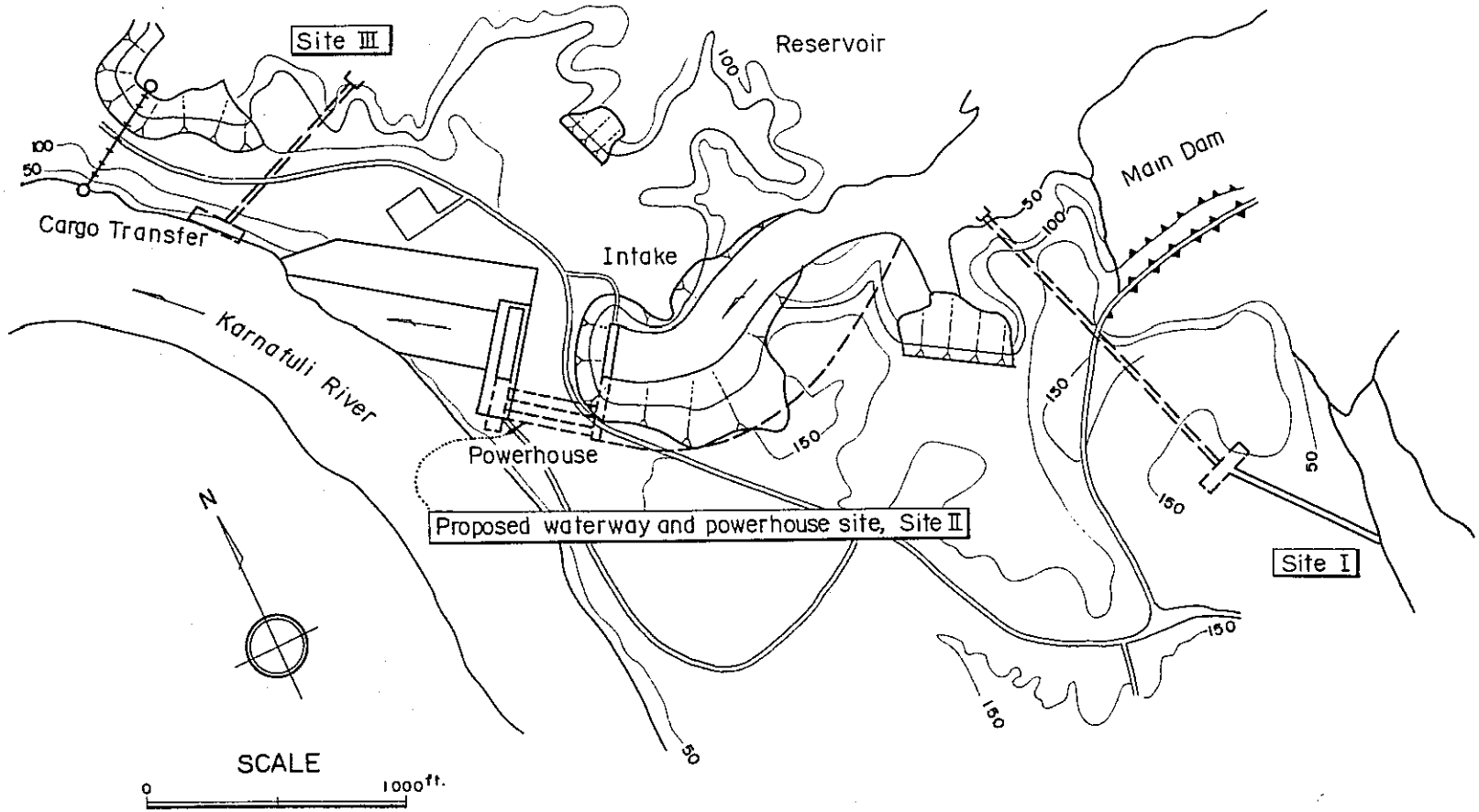
6.2.1. Intake and forebay channel

The existing forebay channel, 1,400 ft. long and 180 ft. wide at the bottom will be enlarged on the left bank side to make its bottom 270 ft. wide uniformly for a distance of 850 ft. on the upstream side, and then gradually varied to the full width of the extended intake front, which is 430 ft. wide.

The forebay channel bottom is levelled at EL. 49.0 for the most part upstream but in the last distance of 100 ft. it is sloped at 1 to 9 inclination to be ended at the intake sill whose elevation is EL. 35.38.

The velocity of water through the narrowest section of the forebay channel at the time of lowest water is about 0.7m/sec.

Fig. 6.1 PROPOSED AND ALTERNATIVE POWERHOUSE SITES



A vertical concrete training wall will be constructed on the left bank of the forebay for a length of 500 ft. in curved alignment to end at the intake structure.

The intake tower will be a free standing reinforced concrete construction independent from the existing intake. The old and new intake towers are connected by a bridge. The intake tower will be 168 ft. wide at the base and 101.5 ft. high above the base concrete.

The new intake front will consist of eight transhrack, screen fronts each four of which being allotted against respective power tunnel inlet. The power tunnel inlet is further divided into two sections each being provided with steel gates of fixed wheel type. Steel stop logs will also be provided, but only in numbers ficient to close one inlet.

6.2.2 Power tunnel

Two new power tunnels will be constructed in parallel alignment with the existing ones.

The each tunnel has a transition section of reinforced concrete construction, 60 ft. in a horizontal distance measured from the stop log face to the transition end, divided through its length with a center guide wall. Following the transition section comes a circular steel penstock measured 30 ft. in diameter through its length except for the tapering section at the end where the diameter reduces to 26 ft.

The spaces between the penstock and tunnel excavation is filled with concrete.

The section of power tunnel with steel penstock including the tapering end is 302 ft. in a horizontal distance and sloped downstream at 1 to 9 inclination.

The maximum discharge of each power tunnel is 8 ,300 cusecs. Pressure rise in the tunnel is specified to 45 percent of the maximum static water head.

6.2.3. Powerhouse

The powerhouse extension will be constructed to the left of the existing power house building. The extension building will be 190 ft. long, 100 ft. wide and 63 ft. high.

The generating units, each of 50,000 kw capacity, will be spaced at 80 ft. interval center to center. The center to center distance between the adjacent existing unit and No.4 unit is 146 ft. 7 inches.

The elevations of principal floors, foof and centerLine of distributors are set as follows.

Powerhouse roof	EL.110.50
Powerhouse crane rails	EL. 88.00
Transormer deck	EL. 49.00
Generator room, control room and office floors	EL. 36.00
Turbine room floor	EL. 22.50
Centerline of distributors	EL. 5.00

The rails of the existing overhead travelling crane will be extended to the new extension so that the existing 350-ton crane can be used for the erection of the units No.4 and No.5.

Six tailrace gates will be provided at the outlet of draft tubes, each to be handled by the existing travelling gantry crane.

6.2.4. Tailrace

The tailrace for No.4 and No.5 units will be constructed independently from the existing tailrace. Its trapezoid section has a width of 150 ft. at the bottom. The surfaces of the tailrace will be concrete wall for a length of 100 ft.

6.2.5 Power generating equipment

(1) Hydraulic turbine

Hydraulic turbine for the extension will be vertical shaft, Kaplan type, counter-clockwise rotation as looking down on the unit and with elbow type draft tube. Owing to the fluctuation in the reservoir water level, the effective head of the turbine will vary from a maximum head of 102 ft. to a minimum head of 59 ft. The turb turbine with 120 rpm rated speed under full gate opening and 87 ft. rated head will develop 59,000 kW (79.088 British HP) as a rated output, corresponding to 115 per cent overloading of the coupled generator. Under 78 ft. effective head at full gate opening, the output of the turbine will be 51,500 kW (69,035 BHP) corresponding to full load of the coupled generator (50,000 kW). This head is also called as the rated head.

The following are the items taking into consideration on the selection of hydraulic turbine for the extension.

(a) Basic data

Elevation of dam crest	EL. 127
Normal maximum reservoir water level	EL. 118
Minimum reservoir water level	EL. 80
Normal maximum tailwater level	EL. 24
Normal minimum tailwater level	EL. 14.5

(b) Type

Considering a head ranging from 59 ft. to 102 ft., Kaplan type hydraulic tubine can be efficiently employed.

(c) Head

The head for the best efficiency (design head) is determined at 87 ft. which is the average head for 5-unit operation obtained from the reservoir operation. The rated head was selected to give a high overall efficiency covering range of head variation.

(d) Speed

JEC (Japanese Electrotechnical Committee) formula based on the experience of hydraulic turbine installation was used to determine the speed:

$$Ns = \frac{20{,}000}{H_d + 20} + 50 \qquad Hd = 87 \text{ feet} = 26.5 \text{ m}$$

$$= \frac{20{,}000}{26.5 + 20} + 50$$

$$= 480 \text{ (m = kW)} \fallingdotseq 125 \text{ ft - HP}$$

$$N = \frac{N_s \cdot H_d^{5/4}}{HP^{1/2}} = \frac{480 \times 26.5^{5/4}}{59{,}000^{1/2}} = 120 \text{ rpm}$$

From the above calculation, 120 rpm turbine speed was chose. The number of poles of synchro nouse generator is therefore 50-pole for 50 Hz in the system frequency.

(e) Turbine setting

Draft head was determined as follows:

Atmospheric pressure	Ha = 10.33 m = 33.9 ft. (at sea level)
Vapor pressure	Hv = 0.32 m = 1.05 ft. (at 25°C)
Caviation factor	$\sigma = 0.28 + (\frac{1}{7.5})(\frac{Ns}{100})^3$
	$= 0.28 + (\frac{1}{7.5})(\frac{125}{100})^3$
	$= 0.54$

Centerline of runner blade below the spiral case center is assumed as about 7.5 ft.

Total draft head Hs is:

$$Hs = 33.9 - 1.05 - 0.54 \times 87 + 7.5 = -6.75 \text{ ft.}$$

From the result of above calculation theoretical centerline of turbine distributor will be set at about 7.0 ft. under normal niminum tailwater level of EL.14.5. However, the same setting level as the existing units would be desirable considering coordination between the existing civil and architectural structures and the extension. Hence, turbine setting level is selected at EL.5.

(2) Alternating Current Generator

Generator for the extension will be vertical shaft revolving field type to be coupled directly to the Kaplan turbine. It will therefore be 120 rpm and rated at 62,500 kVA 11 kv , 3-phase, 50 Hz and 0.8 power factor. In case the net head is above EL. 78 the generator will operate under 50,000 kW of full load with temperature rise not exceeding 60°C, and will continue overload operation to 15 per cent of the rated capacity with tempe perature rise limit up to 80°C when the net head is above elevation EL. 87 ft.

Owing to slow speed and large capacity of the unit, an umbrella tyep generator is adopted. The generator will be assembled and disassembled by means of the existing powerplant overhead crane.

The 0.8 power factor is selected for the Karnafuli powerplant considering the reactive power supply from the generator to nearby load center.

The terminal voltage of generator is chosen to be 11 kV. It would be the most economical voltage for the capacity planned.

(3) Main Transformer

Main transformer for the extension will be rated at 72,000kVA,50 Hz, 3-phase, two windings, 11 kV delta to 132 kV star connected, outdoor, forced-oil, forced-air cooled type. The neutral point of 132 kVwinding will be directly grounded.

The unit capacity of main transformer is rated at 72,000 kVA to coordinate with the capacity of the generator at 80°C temperature rise.

(4) Station Service Equipment

A.C. station service power will be supplied from two 500 kVA transformers, each of which is connected to each generator circuit. For an emergency use, the existing engine driven generating set is used. Station service transformer will be of the indoor, and self cooled type.

(5) Switchyard Equipment

Additional switchyard occupying a 150 ft. by 120 ft. area is extended adjacent to the existing switchyard. 132 kV single bus is also extended through bus sectioning curcuit breaker. A single circuit transmission line will depart from the new 132 kV bus. The circuit breakers will be rated at 132 kV, 800 A, 2,500 MVA interrupting capacity.

Due to a relative locaton of switchyard viewed from the location of main transformer, 132 kV O.F. cables are employed to connect 132 kV circuit from the main transformer to the bus.

No circuit breaker is provided between the generator and main transformer, therefore, circuit breaker on 132 kV side of the main transformer will be used for parallel operation of the generators.

6.2.6. Transmission Line and Substation

The main trunk of 230 kV transmission line connection two large load centers in East Pakistan, i.e. Ghorasal district and Chittagong districts, is under planning by EPWAPDA. This line will connect Ashuganj and Sikalbaba via Ghorasal and Comilla. Thus, the transmission line between the Karnafuli power station and Sikalbaha substation is introduced in the study.

The power transmission capability of the existing double circuit 13 kV line system from the Karnafuli power station to Sikalbaha substation including sending end transformers over about 34 miles is around 200.000 kW based on 5 per cent regulation and 85 per cent power factor. This capability is adequate enough to transmit the power generated at the Karnafuli power station by No.1, No.2 and No.3 units. But, this double-circuit line is not sufficient to meet the development of extension planned. An additional single circuit 132 kV transmission line is therefore to be constructed along the existing line from the Karnafuli power station and Sikalbaha substation.

The conductor size of transmission line is 636 MCM ACSR which is same as the existing outgoing transmission line from the Karnafuli power station.

Considering that the power from the Karnafuli power station is supplied to 132 kV system at the Sikalbaha substation the transformer at receiving end is not included. But necessary 132 kV switchgear equipment to be insta installed in the Sikalbaha substation is included in this cost study.

6.3. Construction

6.3.1 General

The contract awarding for the construction work, other than such equipments as gates, penstocks and generating units which may be supplied and installed by separate contracts, may be best timed when it is done allowing for the time for the contractor's mobilization so that the contractor can start the major construction operation with the beginning of dry season.

As shown in Fig. 6.2, Construciton Time Schedule, the construction work for the first stage to install No.4 unit may be completed in five years. As studied in Chapter V, Power Development Scheme, the second extension unit (Unit No.5) may be required to be installed several years later than the first extension unit (Unit No.4). The supply and installation of the No.5 unit may be completed in two years even the work is

started after interval. In the time schedule, however, it is shown as if No. 5 unit is to be installed successively after No.4 unit, just for the convenience.

In the proposed layout of the extension work the problem is the facts that the intake facilities is constructed just besides the present ones and that the reservoir water can not be lowered below EL.80 which is the crest elevation of the spillway ogee. As it is essential to keep the disturbance to the operation of the existing power station minimum, the construction program of the extension work needs to be carefully prepared. The following may be points to be considered.

1) The construction of the intake and forebay channel may need two dry seasons during which the reservoir water level can be lowered to EL.80 by opening the gate. The water level EL.80 is also the designed low water level for power generation.

   According to the records, the natural run-off is smaller than the power generation discharge under the minimum water head for about 7 months of the year, and therefore it is estimated that theoretically the construction can be carried out under the condition of the low water level for 7 months of each year.

   It must be noted however that the power generation will be restricted by the fluctuation of the natural run-off during these construction period.

2) The excavation above EL.80 is to be done as soon as the water is drawn down below that level.

3) The training wall along the forebay channel may be constructed dry by trench method.

4) For the construction of the intake structure a coffering work to withstand the water up to 45 ft. in depth will be required. Coffering by concrete caisons or by concrete walls with steel stressed anchoring may be possible solutions to the above.

5) The excavation under water EL.80 may be done applying underwater blasting in vertical holes, in which large diameter relief holes are drilled in between charge holes.

6.3.2. Quantity of major works and construction materials

The quantity of major construction works are estimated as follows:

Excavation, common	325,500 cubic yards
Excavation, rock, in open	275,000 cubic yards
Excavation, rock, in tunnel	25,000 cubic yards
Concreting	75,000 cubic yards
Grouting	5,000 feet
Metal works	5,150,000 pounds

The main construction materials required are estimated as follows.

Cement	17,000,000 pounds
Reinforcement steel	4,000,000 pounds
Structural steel	820,000 pounds
Aluminium plate	60,000 pounds
Gate, trashracks and penstock	5,150,000 pounds
Explosive	300,000 pounds
Timber	4,000 cubic yards
Fuel	450,000 gallons

A suitable source of fine aggregates for concrete is located at Kodala Chari some 16 miles downstream from the proposed powerhouse site as shown in Fig. 6.3. This deposit of medium fine to coarse, sharp, quarts sand has been used with excellent results in the concrete work for the existing structure. According to the IECO report, ample sand is available at Kodala Chari for the extension work concrete requirements and for other

uses as well.

The gravel at Silhet is of the best quality. For construction of the Karnafuli Project it was transported by the railway from the site to Chittagong and by vessel from Chittagong to Kaptai and used as the course aggregate for concrete. In the extension work, this gravel will be also used.

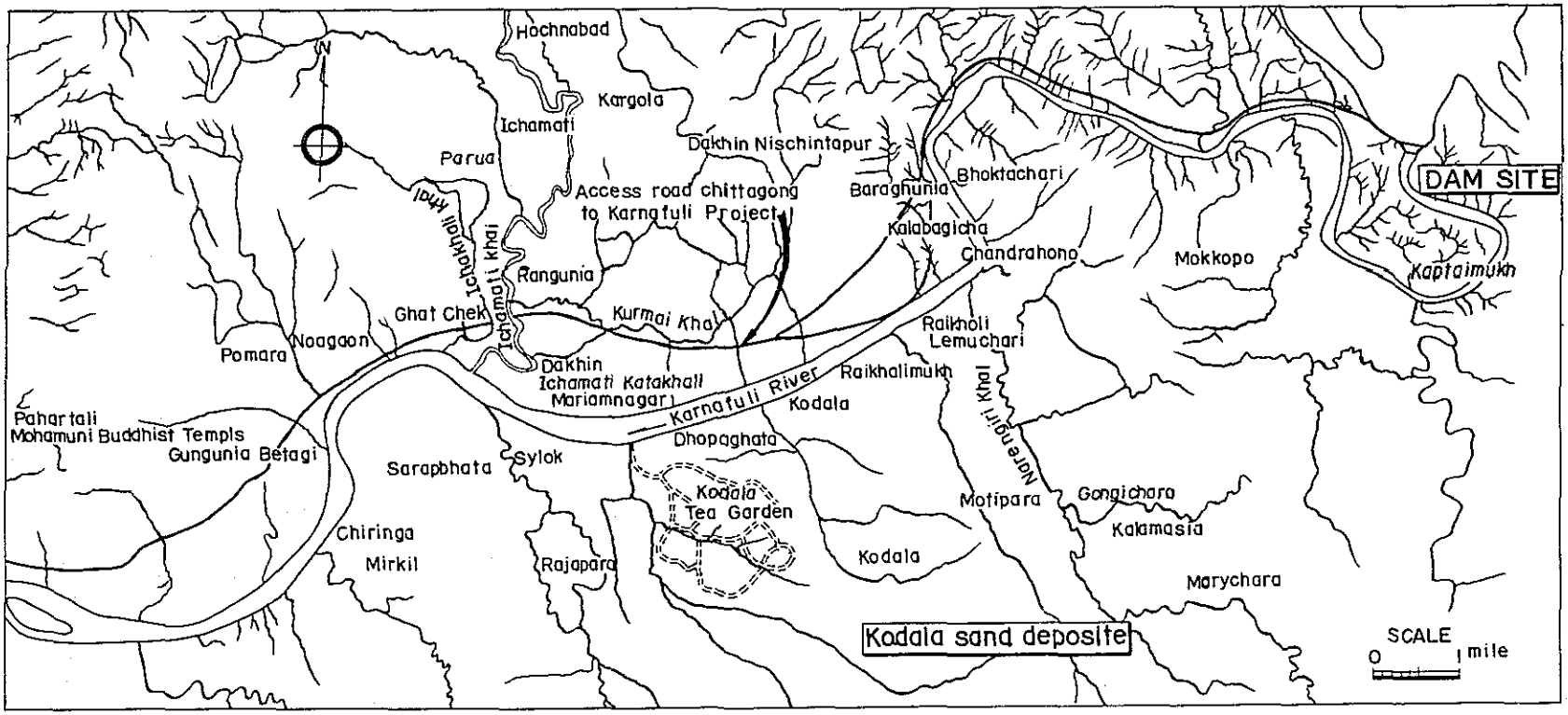
6.3.3. Transportation

All imported plant and materials are to be unloaded at Chittagong, a main port to East Pakistan which has sufficient unloading capacities for the project. The plant and materials imported through Chittagong or coming from other part of Pakistan are to be hauled by the existing road, 40 miles from Chittagong. The railway distance from Silhet, where the stone for the concrete aggregate is to be obtained, to Chittagong is 220 miles.

Fig. 6.2 CONSTRUCTION TIME SCHEDULE

	Stage / Year / Q'ty	First stage				Second stage	
		1	2	3	4	5	6
1. Project financing and contracting							
2. Preparatory works							
a. Contractor's mobilization							
b. Construction camp facilities							
C. Relocation of road							
3. Waterway and powerhouse							
a. Forebay channel							
Excavation	220,000cuyd						
Concrete	27,000 "						
b. Intake							
Coffering							
Excavation	48,000cuyd						
Concrete	13,000 "						
Clearing							
C. Penstock tunnel							
Excavation	23,000cuyd						
Concrete	6700 "						
d Powerhouse							
Excavation	73,000cuyd						
Concrete	17,000 "						
Superstructure							
e. Tailrace							
Excavation	78,000cuyd						
Concrete	900 "						
f Switch yard							
4. Metal work				Manufacture & transport.			
a. Intake gate and trashrack	1,330,000 ℓb						
b. Penstock pipe	2,650,000ℓb						
C. Tailrace gate	690,000ℓb						
5. Generating equipment							
6. Transmission line and substation							
a. Transmission line							
b. Substation							

Fig. 6.3 LOCATION OF FINE AGGREGATE DEPOSITS



CHAPTER VII PROJECT COST AND ANNUAL FUND REQUIREMENT

7.1 Project Cost

The total construction cost of the extension work is estimated at 25,400,000 U.S. dollars, including 7,550,000 U.S. dollars equivalent of local currency portion and 17,850,000 U.S. dollars of foreign currency portion, as summary and detail cost estimates are being given respectively in Table 7.1 and Table 7.2.

The cost estimate was prepared based on the prices as of September, 1969, information on labour wages and cost of local materials as furnished by EPWAPDA, and for the prices for gates, penstock, generating equipment, transmission line, substation and communication equipment referring to the price examples in Japanese market.

It was assumed that the custom duties on the imported plant and materials would be exempted.

The conversion rate between Rupee and U.S. dollar was taken as 4.76 Rupees against one U.S. dollar.

The construction cost of this project is tabulated in detail in the following Tables 7.1 and 7.2.

Table 7.1 Summary of Cost Estimate

(Unit: US$)

Item	Foreign currency	Local currency	Total
1. Preparatory Works	140,000	210,000	350,000
2. Waterway and Powerhouse	13,060,000	5,420,000	18,480,000
Forebay channel	1,010,000	1,440,000	2,450,000
Intake	920,000	680,000	1,600,000
Penstock tunnel	2,640,000	1,360,000	4,000,000
Powerhouse	980,000	920,000	1,900,000
Tailrace	210,000	320,000	530,000
Generating equipment	7,300,000	700,000	8,000,000
3. Transmission Line & Substation	690,000	360,000	1,050,000
4. Engineering and Administration	800,000	200,000	1,000,000
5. Contingency and Reserve	7,730,000	970,000	3,200,000
6. Interest during Construction	930,000	390,000	1,320,000
Total	17,850,000	7,550,000	25,400,000

Table 7.2 Detailed Cost Estimate

Item	Unit	Q'ty	Unit Price (US$)	Amount (US$)
I. Preparatory Works				
1. Access road	L.S.			100,000
2. Permanent and temporary camp facilities	"			150,000

Item	Unit	Q'ty	Unit price (US$)	Amount (US$)
3. Construction power and communication system	"			100,000
Total for I				350,000
II. Waterway and Powerhouse				
1. Forebay channel				
Excavation, common	cu.yd.	130,000	1.5	195,000
Excavation, rock	"	90,000	11.5	1,035,000
Concrete	"	27,000	30	810,000
Reinforcement steel	lb	1,690,000	0.13	219,700
Miscellaneous	L.S.			190,300
Sub-total				2,450,000
2. Intake				
Excavation, common	cu.yd.	25,000	1.5	37,500
Excavation, rock	"	23,000	8.4	193,200
Concrete	"	13,000	30	390,000
Reinforcement steel	lb	1,060,000	0.13	137,800
Gate	"	750,000	0.7	525,000
Screen	lb	580,000	0.4	232,000
Miscellaneous	L.S.			84,500
Sub-total				1,600,000
3. Penstock tunnel				
Excavation	cu.yd.	23,000	16	368,000
Concrete	"	6,700	29	194,300
Reinforcement steel	lb	760,000	0.13	98,800
Pipe shell	"	2,650,000	1.2	3,180,000
Miscellaneous	L.S.			158,900
Sub-total				4,000,000
4. Powerhouse				
Excavation, common	cu.yd.	15,000	1.5	22,500
Excavation, rock	"	58,000	8.4	487,200
Concrete	"	17,000	33	646,000
Reinforcement steel	lb	510,000	0.13	66,300
Structural steel	"	750,000	0.19	142,500
Aluminum plate	"	60,000	0.55	33,000
Gate	"	690,000	0.55	379,500
Miscellaneous	L.S.			123,000
Sub-total				6,900,000
5. Tailrace				
Excavation, common	cu.yd.	26,000	1.5	39,000

Item	Unit	Q'ty	Unit price (US$)	Amount (US$)
Excavation, rock	cu.yd.	26,000	8.4	436,800
Concrete		900	30	27,000
Miscellaneous	L.S.			27,200
Sub-total				530,000
6. Generating equipment				
Turbine	L.S.			2,200,000
Generator	L.S.			2,500,000
Transformer	L.S.			450,000
Switchgear and others	L.S.			1,100,000
Transformer and erection	L.S.			1,750,000
Sub-total				8,000,000
Total for II				20,590,000
III. Transmission Line and Substation				
1. Transmission line				
Kaptai-Sikalbaha 34 miles	L.S.			820,000
2. Extension of Sikalbaha substation				230,000
Total for III				1,050,000

7.2. Annual Fund Requirement

The fund requirement for each construction year is estimated on the basis of the construction time schedule given in Subparagraph 6.3.1. The annual fund requirement and the accumulative fund requirement during construction are as shown in Table 7.3.

Table 7.3 Annual Fund Requirement

(Unit: US$)

Stage	Year	Annual Fund Requirement		Accumulative Fund Requirement
I	1	(2,680,000)[1]	2,680,000	2,680,000
	2	(4,500,000)	4,647,400	7,327,400
	3	(6,800,000)	7,203,000	14,530,400
	4	(5,500,000)	6,197,600	(20,728,000)
II	5	(1,300,000)	1,300,000	1,300,000
	6	(3,300,000)	3,372,000	4,672,000

1) Annual fund requirement excluding interest of loan.

CHAPTER VIII PROJECT EVALUATION

8.1. General

In this chapter, the extension project is evaluated of its economic justification in terms of benefit-cost ratio.

Although the Karnafuli Project renders benefit due to its huge reservoir capacity, in various fields such as fishery, navigation, flood control and forest development, it is still dominantly power project. As the monetary value of benefit other than the power generation is rather difficult to assess reasonably and is also estimated to be very small compared with the power benefit, the benefit-cost evaluation is made only of the power generation.

In this evaluation, the following assumptions are made:

i) The interval of installation of No. 4 and No. 5 units will be 5 years.

ii) The power and energy generated at the Karnafuli Power Station will be consumed without restriction.

iii) A 132 kV transmission line from the Karnafuli to Sikalbaha will be provided before No. 4 unit is installed.

iv) In calculating the capital cost of generation equipment, 40 percent of import tax is assumed.

In conclusion, the benefit-cost ratio is calculated as 1.07, and although the figure is not so sufficiently high, it is still indicating that the project is worth to be implemented, and as studied in Chapter VII Power Development Scheme, the right moment for the implementation (in terms of completion date) is estimated to be around the years 1976 or 1977 for No. 4 unit and 1982 for No. 5 unit.

8.2. Benefit

The benefit of the hydro power project is measured based on the cost required to produce the equivalent power and energy by the cheapest alternative means. In the present case, such cheapest means would be natural gas fired steam plant and the case of the Ashganj power plant of the same type and with the capacity of 120,000 kW, which will be completed in 1970 by EPWAPDA, will be applied.

The Ashuganj power plant cost Rs. 86,925,000 for the foreign currency component and Rs. 48,146,000 for the local currency component, the total being Rs. 135,071,000. In this amount, Rs. 8,541,000 of import tax corresponding 12.5 per cent of direct cost Rs. 68,328,000 in foreign exchange component is included. In accordance with information obtained from EPWAPDA, the tax and duty imposed on imported equipment and materials are assumed as 40 per cent of C & F cost in the project evaluation. Therefore investment for Ashuganj thermal plant was adjusted by adding the amount of Rs. 18,790,000 (Rs. 68,328,000 x 0.275) to Rs. cost as if 40 per cent of import tax had been imposed.

An analysis of capacity and energy unit prices has been made as follows.

i) Investment

Foreign currency	Rs. 86,925,000
Local currency	Rs. 66,436,000 (= 48,146,000 + 18,790,000)
Total	Rs.153,861,000
Per kW installed	Rs. 1,282/kW (US$269.3/kW)

ii) Annual fixed cost

Interest	
4% for foreign currency	Rs. 3,477,000
6.25% for local currency	4,185,000
Depreciation 3% (30 year)	4,616,000
Fixed O & M 1.74%	2,678,000
	Rs. 14,956,000

Annual fixed cost per kW installed Rs. 124.6/kW
or US$ 26.18kW

The following adjustments are made because of difference between hydro and steam plant.

	Hydro (percent)	Steam (percent)
Loss at primary substation	4.0	2.0
Forced outage	—	2.0
Auxiliary power use	0.3	6.0
Overhaul	2.0	8.0

$$\text{Factor} = \frac{\text{Hydro}}{\text{Steam}} = \frac{(1 - 0.04)(1 - 0.003)(1 - 0.02)}{(1 - 0.02)(1 - 0.02)(1 - 0.06)(1 - 0.08)} = 1.12$$

Capacity benefit value = 124.6 x 1.12 = Rs. 139.6/kW
= US$ 29.3/kW

iii) Energy cost (Rs./kWh)

Energy fuel 1.2 Rs./1000 cu.ft x 12.5 cu.ft/kWh	Rs. 0.015
Variable O & M	0.003
	Rs. 0.018/kWh

Differences between hydro and steam plants are applied to fuel consumption:

	Hydro (percent)	Steam (percent)
Loss at primary substation	4.0	2.0
Auxiliary power use	0.3	6.0

$$\text{Factor} = \frac{\text{Hydro}}{\text{Steam}} = \frac{(1 - 0.04)(1 - 0.02)}{(1 - 0.003)(1 - 0.06)} = 1.04$$

Energy benefit value = 0.018 x 1.04 = Rs. 0.0187kWh
= US$0.00393/kWh

The annual benefit is calculated using the abovementioned capacity and energy benefit values and the :pectable power and energy output to be produced at the Karnafuli power station operating all five generating iits.

For calculation of benefit, the dependable peaking capacity is set at more than 90 per cent in the duration .rve shown in Fig. 8.1 which was obtained from the results of reservoir operation study. The dependable aking and annual energy by numbers of unit are listed as follows:

	4-unit (Nos. 1,2,3 and 4)	5-unit (Nos. 1,2,3,4 and 5)
Dependable peaking (kW)	182,000	223,000
Energy output (10^6 kWh)	836.8	907.6

In view of the energy demand for the coming decade, simultaneous installation of two units (No. 4 and No. 5) would not be economically justified. Although interval period between commissioning of No. 4 unit and No. 5 unit would be decided after due consideration, it would probably be three or five years.

Assuming that there be five-year interval between completion of installation of No. 4 and No. 5, the annual average benefits together with that for No. 5 unit converted to present worth is estimated at US$1,469,700 as computed below.

Dependable peaking of 4-unit operation:	182,000 kW
Capacity value 182,000 x US$ 29.3/kW	US$5,332,600
Energy output of 4-unit operation:	836.8 x 10^6 kWh
Available energy: (4% of transmission line loss excluded)	803.3 x 10^6 kWh
Energy value 803.3 x 10^6 x US$0.00393/kWh:	US$3,157,000
Annual benefit:	US$8,493,300
Incremental peaking by No. 5 unit:	41,000 kW
Incremental capacity value 41,000 x 29.3:	US$1,201,300
Incremental energy by No. 5 unit:	68.03 x 10^6 kWh
Incremental energy value 68.03 x 10^6 x 0.00393	US$267,400
Incremental annual benefit:	US$1,469,700

The incremental annual benefit is converted to present worth assuming that the interval of installation of No. 4 and No. 5 units would be 5 years, convertion period is to be 35 year[1] after the completion of No. 4 unit and the internal rate of return is to be 8 percent. The calculation is shown below.

$$\text{US\$1,469,700} \times \frac{1}{(1+0.08)^4} \times \frac{1-\frac{1}{(1+0.08)^{35}}}{0.08} \times \frac{0.05}{1-\frac{1}{(1+0.05)^{35}}} = \text{US\$768,800}$$

Therefore, average annual benefit is estimated at US$9,262,100.

8.3 Cost

Total annual costs are shown in Table 8.1.

1) Pakistani regulation for hydro electric plant.

Table 8.1. Table 8.1. Summary of Annual Equivalent Cost

(Unit: US$10^3)

Item	Foreign currency	Local currency	Total
Capital cost			
Construction cost[1]			
for No. 1 and No. 2 units installation	42,760	59,925	102,685
for No. 3 unit installation	6,297	5,129	11,426
Total investment for No. 1 No. 2 and No. 3 installation	49,057	65,054	114,111
Construction cost of extension			
for No. 4 unit installation	13,790	10,238	24,028
for No. 5 unit installation	4,060	1,912	5,972
Total investment for extension	17,850	12,150	30,000
Annual Cost			
Amortization of investment			
for No. 1 and No. 2 installation[2]			4,526
for No. 3 installation[3]			767
Sub-total			5,334
O & M			
for No. 1 and No. 2 installation[4]			1,235
for No. 3 installation			81
Sub-total			1,316
Amortization of investment for extension			
for No. 4 installation			
Interest[3]	552	640	1,192
Depreciation[5]		408	408
Sub-total			1,600
for No. 5 installation			
Interest[3]	162	118	280
Depreciation[6]		155	155
Sub-total			435
Converted to present worths[7]			229
Total of amortization of investment for extension			1,829
O & M			
for No. 4 installation			104
for No. 5 installation			81
converted to present worth[7]			42
Total of O & M for extension			146
Total amortization of investment			7,163
Total O & M			1,462
Total annual equivalent cost			Rs. 8,625

1) Obtained from EPWAPDA.

2) The rates are 4% for Dollar portion and 6.25% for Rupee portion. Interest was adjusted by ratio of construction cost to booked valued of Rs. 310,000,000. Average depreciation rate is 1.7% of construction cost.

3) The rates are as same as (b) avove.

4) Based on data obtained from EPWAPDA.

5) Average depreciation rate is 1.7%.

6) Depreciation rate is 2.6% for 35-year period.

7) Converted annual cost to present worth as applied to calculation of annual benefit.

The project investment for No. 1, No. 2 and No. 3 units installation was based on the data obtained from EPWAPDA, and the amounts for the extension of the Karnafuli powerplant are as referred to Chapter VII, Cost Estimate.

8.4. Benefit-cost Ratio

As wrought in the preceding sections the annual project benefit and cost are estimated as U.S.$9,262,100 and U.S.$8,625,000 respectively, and the benefit cost ratio is calculated as 1.07.

Fig. 8.1 DURATION CURVE OF DEPENDABLE PEAKING OUTPUT

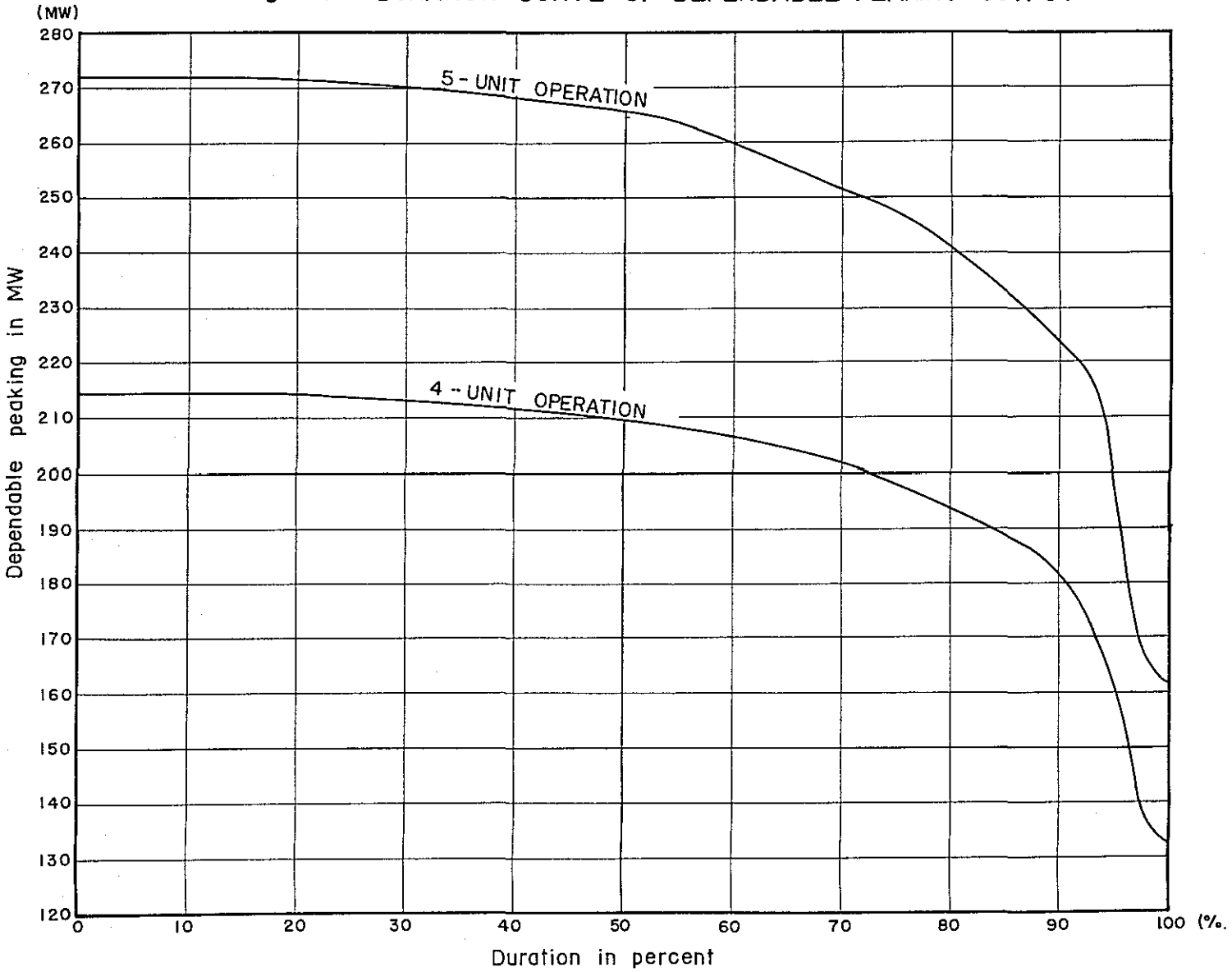


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Fig. A-1 LOCATION OF RAINFALL GAUGING STATION

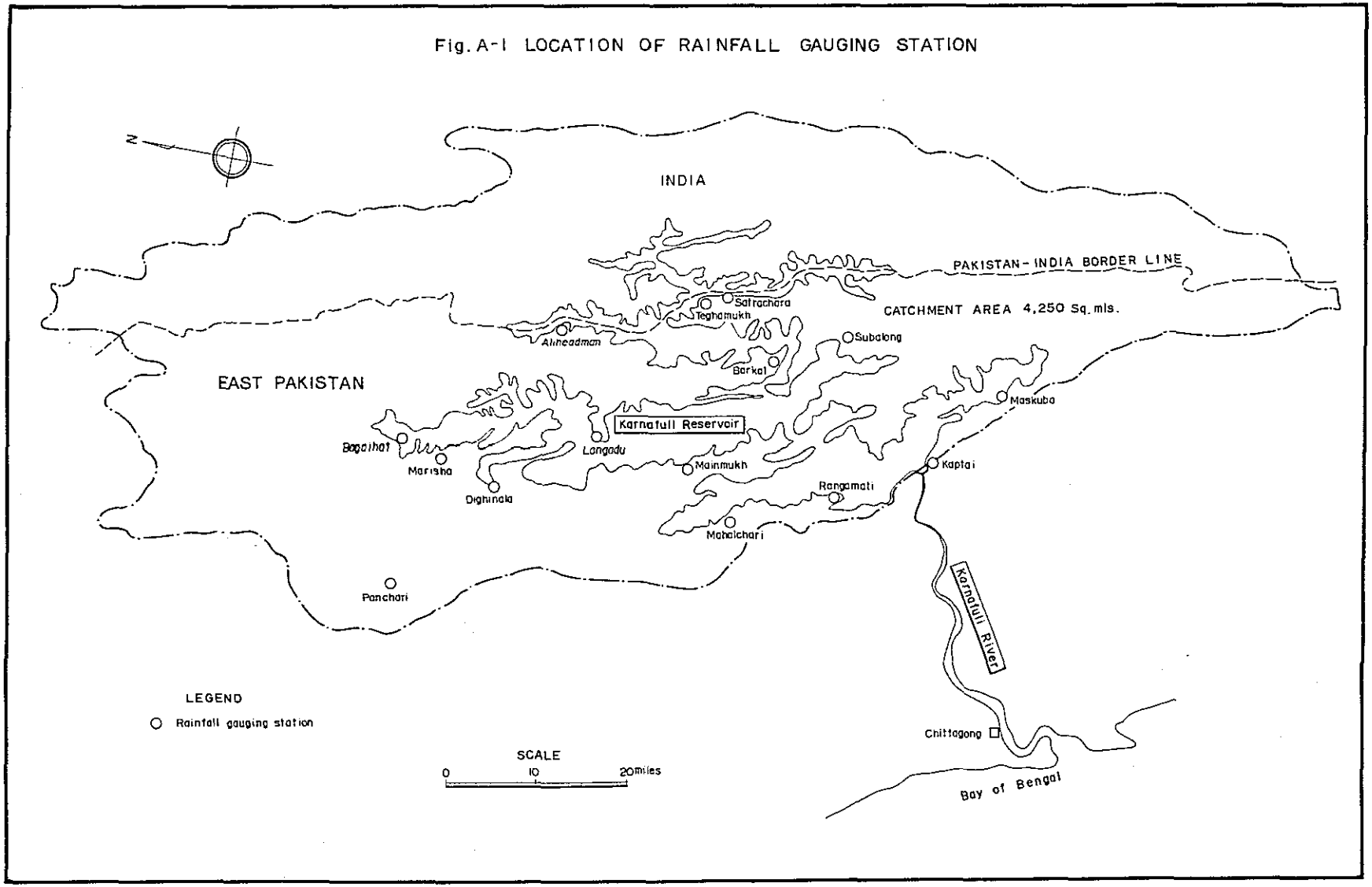


Table A-1 Monthly Rainfall in Catchment Area

(Unit: inch)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1936	0	1.00	1.67	3.06	15.69	19.87	17.06	25.69	10.70	4.46	0.49	4.94	104.63
1037	0.45	1.35	0.56	8.41	20.61	12.63	17.83	23.32	12.47	7.69	0.16	0.02	105.50
1938	0.47	0.31	0.99	3.53	16.94	24.34	10.44	16.89	21.12	6.11	4.84	0	105.98
1939	0.14	0.31	0.17	6.07	11.39	12.65	28.38	21.57	14.38	4.95	1.64	0	101.65
1940	0	3.17	6.81	0.02	18.90	19.93	11.09	13.96	22.34	5.21	0.04	0.79	102.26
1941	0.02	3.57	0.18	10.29	22.13	27.48	27.96	14.88	13.37	5.67	0.67	0.03	126.25
1942	0.03	0.08	1.89	8.48	9.39	16.13	11.19	14.75	17.86	0.90	5.92	0.16	86.78
1943	1.07	0.77	4.14	3.19	3.91	15.89	14.18	17.90	12.72	3.29	0	0	77.06
1944	2.80	0.23	2.19	3.27	7.79	21.32	15.07	14.65	13.11	1.96	0	0	82.39
1945	2.13	2.48	0.09	3.41	11.85	20.68	18.45	19.11	11.31	5.59	0.54	2.86	98.50
1946	0	0.20	7.16	7.53	14.09	11.52	30.95	13.04	14.78	10.51	0.23	4.64	114.65
1947	0	0.10	0.44	4.97	13.43	28.20	38.52	22.70	18.12	9.84	0	0.68	117.00
1948	0.10	2.50	2.44	11.49	18.42	14.00	15.47	16.14	15.50	3.61	1.08	0	100.75
1949	0.06	0	2.00	13.52	7.95	16.85	19.00	13.47	18.64	7.06	0.20	0	98.75
1950	0.18	0.94	1.83	3.95	9.96	12.62	10.67	29.36	5.94	4.78	1.61	0	81.84
1951	0	0	2.47	8.93	–	23.90	19.46	21.55	9.23	17.20	0.12	0.07	(102.93)
1952	0	0.19	2.31	6.85	11.74	25.41	16.98	11.90	7.88	12;94	3;11	0	99.51
1953	0	0.10	0.52	1.76	15.98	24.15	11.55	16.25	17.02	6.49	0.63	0	94.45
1954	0.09	1.73	1.18	1.74	6.98	27.34	16.97	24.38	7.94	11.17	0	0.34	99.86
1955	0	0	5.05	2.34	10.16	13.09	23.98	11.56	4.67	4.30	4.99	0.40	82.54
1956	0.23	0	2.51	1.76	10.79	32.28	14.28	21.99	15.75	4.57	4.97	0	109.13
1957	2.34	0.44	0	1.34	9.51	13.33	11.16	7.43	9.92	1.80	0	0	57.27
1958	0	0.05	0.38	0.52	8.78	8.70	8.12	16.98	18.21	6.99	0	0	68.73
1959	4.60	3.30	3.79	0.64	9.92	19.65	17.41	20.31	13.55	15.49	0	0.67	109.33
1960	0	0.78	0.60	1.34	7.17	16.54	35.28	6.36	9.99	4.92	1.68	0	84.66
1961	0.06	0.65	4.36	1.92	9.01	26.58	27.50	26.56	10.57	10.41	0.70	0	118.32
1962	0.12	0.55	0.20	2.08	6.97	27.29	10.41	16.18	9.76	6.36	0	0	79.92
1963	0	0	2.13	9.07	11.59	26.25	38.55	10.55	10.28	11.88	0	0.13	120.43
1964	0	0.26	0.03	8.85	5.33	12.25	18.81	14.47	11.79	9.99	1.75	0	83.53
1965	0	3.90	0.94	1.20	8.21	24.81	21.66	19.28	12.09	10.75	0.46	2.59	101.89
1966	0.27	0	1.21	1.95	7.93	18.05	14.40	15.92	12.07	8.35	0.97	2.84	83.96
1967	0.51	0	4.71	3.54	5.58	8.68	23.19	14.17	13.33	5.65	0	0	79.36
1968	0.28	0.58	3.57	3.82	8.23	23.81	41.93	15.30	10.29	2.89	0.29	0	110.99
1969	0.03	0	2.07	6.17	2.65	27.80	13.49						
Mean	0.47	0.81	2.08	4.62	10.88	19.82	19.55	17.23	12.93	7.08	1.13	0.64	97.18

TAble A-2 Monthly Rainfall at Kaptai

(Unit: inch)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1936	0	0.42	–	–	17.99	21.51	22.61	30.19	9.16	–	2.35	5.21	(115.67)
1937	0.75	0.53	0.22	4.25	20.04	17.67	14.07	27.91	12.73	7.05	0.75	0	105.97
1938	0	0.30	0	4.39	19.31	24.67	10.09	19.68	22.01	6.43	3.40	0	110.28
1939	0.04	0.01	0	4.65	12.31	16.03	31.14	22.41	15.63	–	2.45	0	106.94
1940	0	5.20	8.31	0	12.01	19.63	15.00	13.70	22.96	4.94	0	0.86	102.61
1941	0.02	4.00	0.01	13.82	18.52	33.56	35.54	17.64	16.36	6.89	0.99	0	147.35
1942	0	0.02	1.45	9.25	5.34	13.29	10.31	15.68	18.04	2.12	10.45	1.08	87.03
1943	0.81	–	5.55	3.01	3.48	19.67	18.34	16.35	12.37	7.27	0	0	86.87
1944	2.50	0.46	2.75	0.85	4.50	16.51	16.62	16.04	14.06	3.75	0	0	78.04
1945	–	–	–	1.65	9.57	26.99	17.21	26.22	18.51	6.56	1.48	–	–
1946	0	0.50	5.46	8.59	14.82	15.38	38.40	17.32	19.35	14.99	0	5.00	139.81
1947	0	0	0.50	6.12	14.42	36.45	48.91	–	20.51	4.33	0	2.58	(133.82)
1948	0.30	1.79	2.30	15.21	28.57	16.41	22.52	16.68	22.18	3.14	0	0	129.10
1949	0	0	1.67	14.96	0	30.12	23.56	27.06	29.38	9.83	0.68	0	(137.26)
1950	0.78	1.31	0.59	5.84	20.78	14.42	19.71	32.59	10.95	0	3.46	0	(110.43)
1951	–	–	–	–	–	–	–	30.33	19.77	18.06	0.28	–	–
1952	–	–	4.41	6.52	19.99	28.52	–	–	–	–	–	–	–
1953	0	0	0	2.77	30.81	28.62	15.73	20.63	18.43	43.30	0.30	0	131.67
1954	0	2.60	0.38	2.94	12.60	31.95	28.80	30.95	12.38	15.37	0	0	137.97
1955	0	–	7.24	3.21	1.99	14.29	37.76	17.99	7.53	5.86	–	–	(195.87)
1956	–	–	–	–	17.85	–	17.40	28.25	15.13	5.31	5.19	0	–
1957	2.35	0.49	0.18	0.44	7.99	27.33	7.64	8.35	13.16	6.53	0	0	74.46
1958	0.44	0.16	1.70	1.11	7.38	11.13	8.15	8.20	10.52	5.22	0.51	0.39	54.91
1959	0.04	4.02	6.65	0.65	5.49	19.21	10.27	19.91	12.97	8.68	0	3.12	91.01
1960	0	0	0.29	0	7.87	14.67	33.29	10.42	8.52	5.05	0.43	0.04	80.58
1961	0.06	0.27	1.37	1.15	5.66	26.59	31.27	25.89	10.11	15.65	0.62	0	118.73
1962	0.26	0.12	0	1.08	9.65	35.21	13.22	13.29	8.21	6.77	0	0	87.81
1963	0	0	7.30	11.80	14.12	28.82	44.04	9.37	12.08	9.86	–	–	(137.39)
1964	0	0.26	0.03	9.92	5.68	18.62	19.78	14.50	17.00	6.01	1.54	0	93.34
1965	0	3.56	0.35	1.20	7.53	26.19	31.87	20.27	20.94	9.48	0	4.05	124.55
1966	0.57	0	0.67	3.32	15.12	25.61	17.18	19.31	14.45	7.63	00.57	4.95	109.38
1967	0.87	0	8.97	2.87	3.09	7.42	30.42	16.00	13.03	9.00	0	0	91.67
1968	0.21	0.16	0.75	3.04	12.05	23.86	48.95	13.41	15.13	2.87	0.02	0	120.45
1969	0	0	3.08	5.99	1.85	48.98	22.59						
Mean	0.34	0.94	2.41	4.86	12.15	23.10	20.70	19.57	15.42	7.90	1.18	1.05	108.68

Table A-3 Monthly Rainfall at Rangamati

(Unit: inch)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Totla
1936	0	2.16	1.08	2.10	14.98	21.38	17.96	26.88	10.00	4.67	0.12	6.42	107.75
1937	0.21	0.92	0.21	7.47	21.84	11.37	16.58	25.82	10.15	9.19	0	0	103.76
1938	0.21	0.41	0.42	3.32	14.78	23.29	11.67	17.85	20.03	5.16	4.33	0	101.47
1939	0.08	0.06	0	5.80	11.20	11.83	31.84	23.88	12.93	4.55	1.02	0	103.19
1940	0	1.88	6.30	0	12.92	17.24	12.84	16.47	19.27	6.49	0	0.91	94.32
1941	0.01	1.18	0	12.96	18.90	29.21	33.28	14.27	15.29	4.50	0	0	129.70
1942	0	0.04	1.70	6.13	6.46	8.56	10.76	11.63	16.13	0.90	6.45	0.03	68.79
1943	1.03	0.23	5.05	2.98	2.41	11.55	16.63	11.68	13.97	2.10	0	0	67.63
1944	2.84	0.58	2.04	1.65	7.34	21.91	15.00	16.35	12.48	2.40	0	0	82.54
1945	2.14	2.40	0	5.00	10.85	22.89	19.68	18.38	15.94	5.54	1.34	3.53	107.69
1946	0	0	6.30	4.55	20.05	8.15	37.15	13.14	12.69	10.46	0	2.09	114.58
1947	0	0	0.12	3.83	4.86	–	41.61	33.07	25.16	13.17	–	1.27	(123.09)
1948	0	3.38	2.66	7.97	17.10	11.52	–	–	12.42	3.08	2.34	0	(60.47)
1949	0	0	1.35	10.11	6.42	18.80	22.93	11.75	–	6.20	0.36	0	(77.92)
1950	0	0.87	0.40	–	10.39	13.79	10.64	29.88	3.70	5.98	1.45	0	(77.10)
1951	0	0	3.25	7.73	–	26.60	23.30	21.13	7.90	11.91	0	0	(101.82)
1952	0	0.60	1.66	4.54	8.59	20.35	24.46	8.59	–	9.79	2.20	0	(80.78)
1953	0	0.30	0.14	1.15	18.44	15.77	10.86	13.26	16.14	6.37	0.28	0	82.71
1954	0	1.45	0.95	1.80	9.58	16.40	14.21	19.63	3.62	7.86	0	0.10	60.84
1955	0	0	6.27	1.58	12.96	12.19	22.13	9.17	6.30	8.10	6.08	0	84.78
1956	0	0	–	1.02	6.87	30.08	–	14.47	11.25	3.68	3.73	0	(71.10)
1957	2.20	0.44	0	1.58	10.29	16.27	10.01	14.04	19.12	3.23	0	0	56.09
1958	0	0.10	0.76	0.52	5.06	2.68	7.20	–	12.17	5.19	0	0.10	33.78
1959	4.60	4.86	5.80	0.28	10.58	16.49	11.82	23.47	8.71	15.52	0	1.72	103.85
1960	0	0	0.39	0.16	7.17	16.54	41.67	7.86	10.45	5.39	1.68	0	91.11
1961	–	–	–	–	–	–	–	–	–	–	–	–	–
1962	–	–	–	–	–	–	–	–	–	–	–	–	–
1963	–	–	–	–	–	–	–	–	–	–	–	–	–
1964	–	–	–	–	2.05	10.82	18.50	15.77	10.48	10.65	2.93	0	(71.20)
1965	0	2.89	3.01	1.31	10.67	28.84	24.75	17.62	14.07	9.43	0.60	2.92	116.11
1966	0.44	0	1.28	1.00	7.97	24.08	12.90	18.92	8.75	8.94	0.19	4.43	88.90
1967	0.58	0	3.69	2.49	5.63	8.73	28.68	19.46	16.15	6.18	0	0	91.59
1968	0.20	0.20	1.27	3.06	13.34	28.51	52.12	16.50	9.26	1.64	0.04	0	126.14
1969	0	0	1.91	7.59	7.00	35.02	13.68						
Mean	0.45	0.83	1.94	3.78	4.25	18.03	20.50	16.38	12.30	6.61	1.21	0.78	91.73

Table A-4 Monthly Rainfall at Mahalchari

(Unit: inch)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1936	0	0.89	2.45	5.65	12.43	18.70	16.82	23.71	11.59	3.38	0.15	4.51	100.28
1937	0.39	2.36	0.93	8.36	17.20	11.49	21.42	26.23	11.67	8.64	0.05	0.06	108.80
1938	0	0.56	1.41	3.03	21.04	25.92	9.02	15.13	23.54	9.44	6.06	0	115.15
1939	0.24	0.25	0.33	4.43	7.97	15.36	29.21	21.07	10.52	–	0.65	0	(96.49)
1940	0	3.47	4.19	0.13	28.02	22.43	10.90	14.76	22.97	3.34	0.03	11.02	111.26
1941	0	2.50	0	9.37	19.28	23.40	22.65	10.29	13.71	5.46	1.62	0	108.28
1942	0	0.13	2.36	9.19	6.81	19.78	8.03	18.04	18.32	1.47	5.89	0	90.02
1943	1.13	0.47	4.01	2.79	7.55	14.04	25.39	22.53	17.45	4.26	0	0	99.62
1944	2.35	0.37	2.23	4.96	9.52	27.84	24.01	18.25	19.87	4.13	0	0	113.53
1945	2.90	2.77	0.38	–	8.89	14.17	19.72	16.71	10.85	2.70	0.20	–	(79.29)
1946	0	0	10.00	8.62	11.03	11.34	26.36	8.58	11.99	8.03	0	3.72	99.67
1947	0	0	1.18	4.85	9.57	23.82	36.33	20.21	16.71	12.85	0	0	125.52
1948	–	–	2.61	7.21	9.79	11.27	17.13	17.28	–	2.38	0.70	0	(68.37)
1949	0.10	0	–	12.58	6.95	16.28	20.91	10.81	16.80	3.98	0	0	(88.41)
1950	0	1.58	2.74	5.30	9.05	10.16	9.67	31.36	7.60	6.92	1.25	0	85.90
1951	0	0	2.80	10.02	–	28.25	21.16	20.82	8.76	16.53	0	0	(108.34)
1952	0	–	1.26	4.23	12.29	26.04	16.00	12.10	8.75	15.33	6.22	0	(102.22)
1953	0	0	0	2.35	13.47	17.20	12.63	17.08	27.35	6.60	1.45	0	98.13
1954	0.69	2.11	–	2.15	–	36.73	15.37	19.64	6.55	12.97	0	–	(96.21)
1955	0	–	4.10	0.80	14.85	17.20	21.33	10.16	5.27	5.62	8.88	0	(88.21)
1956	0	0	0.31	2.80	–	26.38	–	27.31	26.30	5.97	5.71	0	(94.78)
1957	2.69	0.25	0	2.12	10.95	14.47	12.47	7.59	9.87	0	0	0	60.41
1958	0	0	0	1.57	–	–	–	–	11.10	–	–	0	—
1959	–	–	2.10	–	4.83	20.00	–	13.92	13.90	10.90	0	0.30	(65.95)
1960	0	0	0.80	–	–	–	28.88	4.85	9.52	4.45	–	0	–
1961	–	–	–	–	–	–	–	–	–	–	–	–	–
1962	–	–	–	–	–	–	–	–	–	–	–	–	–
1963	–	–	–	–	–	–	–	–	–	–	–	–	–
1964	–	–	–	–	1.95	15.98	25.58	12.90	9.99	12.60	1.35	0	(80.35)
1965	0	2.45	1.35	0.15	8.14	21.49	23.88	23.34	9.67	13.48	0	2.40	106.35
1966	–	–	–	–	–	–	–	–	–	–	–	–	–
1967	0.30	0.	5.28	2.30	10.50	12.10	22.55	13.04	7.65	6.90	0	0	80.62
1968	0.10	1.20	2.15	5.20	9.20	24.25	45.65	11.65	6.65	3.25	0.50	0	109.80
1969	0	0	3.15	9.02	1.80	42.60	16.35						
Mean	0.40	0.89	2.15	4.97	10.92	20.31	20.72	16.76	13.39	7.10	1.51	0.44	115.24

Table A-5 Monthly Rainfall at Barkal

(Unit: inch)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1936	0	0.88	2.85	5.05	12.79	20.55	18.46	29.87	13.44	2.80	0	5.85	112.53
1937	0.61	1.77	0.30	10.35	21.41	13.04	20.57	23.93	11.52	9.43	0.02	0	112.95
1938	0	0	0.12	2.12	15.27	24.93	10.21	20.28	21.95	3.93	3.87	0	102.58
1939	0	0.07	0.30	6.49	13.40	12.50	28.38	15.84	14.53	5.99	1.52	0	99.19
1940	0	2.81	8.58	0	17.66	17.85	11.70	16.96	23.39	6.51	0.14	0.90	106.50
1941	0.14	3.92	0.44	8.08	24.42	27.01	30.41	16.43	13.37	9.22	0.25	0.25	113.94
1942	0	0	0.93	7.81	8.20	15.47	10.42	13.46	15.67	0.33	9.04	0	81.33
1943	0	0.30	4.24	3.61	3.14	10.42	11.71	16.68	7.89	2.55	0	0	60.54
1944	1.51	0	2.26	1.43	7.46	17.35	7.89	9.11	11.21	0	0	0	58.22
1945	0.81	0.86	0	1.91	17.73	19.66	12.35	17.67	12.10	3.80	0.52	4.80	92.21
1946	0	0.44	6.95	–	12.91	9.47	34.34	15.19	8.47	12.15	0	5.18	(105.15)
1947	0	0	0.50	3.45	8.92	–	37.64	22.58	13.96	–	–	0	97.05
1948	–	2.10	1.20	14.13	20.64	20.64	–	15.81	17.98	2.55	1.72	0	(96.77)
1949	0	–	1.20	7.11	–	12.21	23.37	12.93	–	3.60	0.25	–	(60.67)
1950	0	1.60	1.18	2.59	11.44	11.87	10.60	18.00	4.93	4.30	1.35	0	67.86
1951	–	0	0.80	4.09	–	25.08	14.85	20.82	6.19	14.07	–	–	(85.90)
1952	–	0.14	1.23	8.58	8.55	–	17.88	11.02	–	–	0.35	–	(47.75)
1953	0	0.11	0	0.20	7.30	16.28	10.21	14.21	12.52	6.61	0.39	0	67.83
1954	0	–	0.21	–	5.56	–	11.43	33.19	9.67	14.62	0	0.10	(74.78)
1955	0	–	3.26	3.78	10.80	11.77	23.64	0	0	0	0	1.59	(54.84)
1956	–	–	–	2.54	11.19	30.20	–	17.70	11.81	4.29	4.52	–	(82.25)
1957	2.12	0.33	0.01	0.33	7.28	9.26	10.99	10.66	10.76	3.18	–	–	(54.92)
1958	–	–	–	–	–	–	–	–	–	–	–	–	–
1959	–	1.73	3.47	1.00	3.13	12.24	11.89	–	–	14.30	–	–	(47.76)
1960	–	–	–	–	–	–	–	–	–	–	–	–	–
1961	–	–	–	–	–	–	–	–	–	–	–	–	–
1962	–	–	–	–	–	–	–	–	–	–	–	–	–
1963	–	–	–	–	–	–	–	–	–	–	–	–	–
1964	–	–	–	–	6.21	13.61	16.21	14.00	13.84	6.57	1.61	0	(72.05)
1965	*0*	*2.18*	*0*	*2.04*	*7.48*	*21.55*	*25.57*	*15.23*	*14.90*	*9.95*	*0*	*2.90*	*101.80*
1966	0	0	1.00	1.49	7.73	19.57	12.98	16.20	8.55	4.95	0	0	72.47
1967	0	0	3.80	3.95	3.90	10.70	11.60	10.19	15.30	6.60	0	0	66.04
1968	0.55	1.50	1.20	4.60	6.20	16.20	36.05	12.70	6.90	1.00	0	0	86.90
1969	0	0	0.60	9.90	1.50	27.60	15.41						
Mean	0.25	0.86	1.73	4.31	10.43	16.56	18.03	16.32	12.03	5.89	1.06	0.98	88.23

Table A-6 Monthly Rainfall at Dighinala

(Unit: inch)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1936	0	0.80	1.00	1.58	19.30	19.61	12.51	21.64	16.58	7.29	0.50	3.16	103.97
1937	0.09	1.42	0.78	10.84	22.15	11.08	17.91	13.68	9.78	6.28	0	0	94.01
1938	1.20	0.25	2.05	3.87	–	19.73	10.15	15.45	18.53	5.21	–	0	(76.44)
1939	0	0.61	0.29	5.14	11.01	10.90	21.40	14.01	13.54	3.20	1.50	0	81.60
1940	0	3.73	5.44	0	16.70	17.53	9.45	10.41	16.91	5.09	0	0.27	85.53
1941	0	4.23	0.64	6.48	24.06	19.98	24.98	17.24	10.35	2.88	0	0	110.74
1042	0	0.19	2.18	8.45	14.39	15.14	16.92	16.42	24.21	0.04	0	0	98.94
1943	1.47	0.96	5.17	2.85	4.27	15.49	14.37	23.98	11.27	3.46	0	0	80.29
1944	2.70	0	1.99	5.27	7.37	24.10	16.67	15.83	9.91	1.16	0	0	85.04
1945	2.72	3.29	0	5.07	10.87	21.45	17.60	15.46	6.71	6.44	0.22	2.44	92.27
1946	0	0	5.96	7.74	12.26	11.04	21.35	10.75	14.24	–	0.40	1.48	(90.65)
1947	0	0.50	0.21	5.41	19.28	–	28.08	15.56	14.06	9.55	0	0	(92.65)
1948	0	2.51	3.83	–	18.67	12.70	–	14.82	17.35	2.99	0.44	0	(73.31)
1949	–	0	1.20	13.46	9.00	16.55	14.73	14.25	13.77	7.10	0.10	0	(94.16)
1950	0	0	4.94	3.81	5.32	9.52	8.40	25.82	2.62	2.38	1.25	0	64.06
1951	0	0	2.16	10.39	–	19.24	15.88	20.01	6.01	19.78	–	0	(93.47)
1952	0	0	1.16	10.54	5.39	26.48	14.30	10.47	6.57	–	4.26	0	(79.17)
1953	0	0	1.50	2.31	15.87	22.01	3.40	6.55	0	0	0	0	51.64
1954	–	0.70	3.18	1.23	4.55	21.32	11.83	22.89	7.00	9.98	0	0	82.68
1955	0	0	7.73	3.14	9.56	16.38	19.82	14.56	–	3.21	–	0	(74.40)
1956	0.70	0	4.21	0	–	–	–	–	–	–	–	–	–
1957	–	–	–	–	–	–	–	–	–	–	–	–	–
1958	–	–	0	–	12.50	11.59	9.25	19.42	24.25	10.87	–	–	87.88
1959	–	–	–	–	–	–	12.54	–	18.40	15.80	–	–	(97.77)
1960	–	–	–	–	–	–	–	–	–	–	–	–	–
1961	–	–	–	–	–	–	–	–	–	–	–	–	–
1962	–	–	–	–	–	–	–	–	–	–	–	–	–
1963	–	–	–	–	–	–	–	–	–	–	–	–	–
1964	–	–	–	–	–	–	–	–	–	–	–	–	–
1965	–	–	–	–	–	–	–	–	–	–	–	–	–
1966	0.02	0	0.82	1.08	13.37	23.96	10.44	11.14	11.27	16.27	0	1.52	89.69
1967	0	0	3.10	2.00	6.06	9.88	24.12	6.54	6.34	6.66	0	0	64.70
1968	0	0	3.71	4.71	7.48	22.15	22.73	9.78	13.40	0.73	0	0	84.75
1969	0	0	3.71	6.16	3.77	21.30	11.99						
Mean	0.39	0.77	2.58	5.06	24.84	17.46	15.63	15.28	12.21	6.36	0.43	0.39	84.86

Table A-7 Monthly Rainfall at Mainmukh

(Unit: inch)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1936	0	1.83	1.29	2.85	12.45	19.19	18.44	22.68	7.72	–	0.31	5.88	96.76
1937	0.65	1.45	6.55	8.72	23.20	8.53	16.40	26.39	14.52	8.13	0.29	0.06	108.89
1938	0.58	0.40	1.95	–	14.59	26.54	13.07	17.37	–	7.85	5.37	0	(87.72)
1939	0.63	0.54	0.28	3.27	10.59	9.39	22.67	26.53	11.48	–	1.26	0	(92.22)
1940	0	2.35	6.06	0	15.99	22.47	9.60	16.97	24.00	4.86	0.13	1.15	103.58
1941	0	4.10	0	12.97	23.98	25.55	30.10	12.78	12.43	6.17	0.76	0	128.84
1942	0	0	1.40	9.63	9.09	24.49	12.23	18.19	16.43	0.55	6.07	0	98.28
1943	1.63	0	2.11	3.57	4.00	12.87	16.96	16.57	14.80	0	0	0	74.74
1944	3.81	0	1.98	3.28	7.63	21.63	13.08	7.22	12.03	0.50	0	0	71.16
1945	2.10	2.70	0	2.90	11.96	16.38	28.52	18.73	8.19	5.11	0	1.25	97.84
1946	0	0	8.10	–	16.63	11.35	35.70	13.73	19.44	6.83	0.74	3.74	116.26
1947	0	0	0	3.98	12.91	–	42.39	28.57	19.94	10.12	0	0.90	118.81
1948	–	2.73	2.04	17.25	20.52	10.19	6.77	–	7.84	5.55	0.18	0	(73.07)
1949	0.26	0	3.08	19.34	–	9.50	8.51	4.33	17.74	12.63	0	0	75.39
1950	0	0	1.12	2.20	5.52	17.51	7.42	40.89	7.08	4.30	0.10	0	86.14
1951	–	–	–	11.24	–	22.45	26.49	22.62	11.42	22.81	0.32	0.27	(117.62)
1952	–	–	–	–	17.02	27.84	17.87	15.23	–	–	4.72	–	(82.68)
1953	0	0.30	0.60	2.25	18.42	28.13	12.84	27.37	25.13	5.50	0.90	0	121.52
1954	0.45	1.77	–	2.25	6.17	32.99	18.14	29.92	12.78	10.94	0	1.50	116.91
1955	0	0	6.25	3.70	12.95	–	–	–	–	–	–	–	–
1956	–	0	3.00	2.42	14.14	43.09	17.13	22.22	15.24	4.35	5.90	0	(127.59)
1957	–	0.75	–	–	–	–	–	–	–	–	–	0	–
1958	–	–	–	–	–	11.84	7.90	14.53	–	4.90	–	0	–
1959	–	–	–	–	21.15	29.88	16.91	23.55	13.18	20.95	0	0	(74.59)
1960	–	2.35	–	2.51		–	–	–	–	–	–	–	–
1961	–	–	3.39	2.37	–	35.95	27.26	–	–	–	–	–	–
1962	–	–	–	3.74	4.10	32.65	–	–	–	–	–	–	–
1963	–	–	–	–	9.38	36.50	39.59	10.58	8.95	12.64	–	–	–
Mean	0.60	1.01	2.73	5.74	13.29	22.37	19.42	20.81	14.75	7.73	1.35	0.70	108.86

Table A-8 Monthly Rainfall at Panchari

(Unit: inch)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1936	0	0.05	1.35	1.14	20.07	18.17	12.59	24.84	6.39	4.18	0	3.57	92.35
1937	0	1.03	0.91	8.88	18.41	15.24	17.90	19.29	16.91	5.13	0	0	103.82
1938	1.28	0.22	0	4.46	16.64	–	8.88	12.47	20.64	4.75	6.00	0	75.34
1939	0	0.63	0.26	12.70	13.27	12.54	33.75	27.23	22.06	6.04	3.10	0	131.58
1940	0	2.78	8.80	0	29.02	22.33	8.17	9.45	26.91	5.22	0	0.40	112.38
1941	0	5.08	0.20	8.37	25.72	33.66	18.68	15.50	12.06	4.57	1.09	0	124.93
1942	0.24	0.20	3.24	8.89	15.43	16.15	9.63	9.86	16.20	0.89	3.53	0	84.26
1943	1.44	2.63	2.17	3.53	2.50	17.08	21.27	17.50	11.30	3.37	0	0	83.49
1944	3.87	0.18	2.05	5.38	10.70	19.93	12.21	19.76	12.25	1.80	0	0	88.13
1945	–	2.83	0.17	3.94	12.91	23.24	14.05	20.57	6.81	8.97	0	2.30	(95.87)
1946	0	0.43	7.33	8.45	10.94	13.93	23.34	12.85	16.29	10.57	0.24	2.01	107.38
1947	0	0.20	0.55	7.15	14.06	24.32	34.70	16.21	16.51	9.00	0	0	122.70
1948	–	–	–	7.18	13.67	15.27	–	16.11	15.21	5.57	–	0	(73.01)
1949	0	0	3.50	17.07	9.41	14.49	–	13.94	15.52	6.11	0	0	(80.04)
1950	–	–	–	–	7.23	11.06	8.28	26.94	4.72	4.77	2.38	0	(65.38)
1951	–	–	3.36	10.09	–	21.75	15.09	15.09	4.56	17.26	–	–	(87.20)
1952	0	0	4.12	6.68	10.35	23.22	11.40	13.97	8.51	13.39	2.73	0	94.17
1953	0	0	1.40	1.30	7.56	16.88	15.19	14.67	19.55	5.93	1.50	0	83.98
1954	–	–	–	0.05	3.40	24.65	19.00	14.45	3.58	6.45	0	–	(71.58)
1955	0	–	0.50	0.49	8.00	6.69	19.19	17.50	4.25	3.00	–	–	(59.62)
1956	–	–	–	–	14.70	31.63	8.30	–	–	–	–	–	–
1957	–	–	–	–	–	–	–	–	–	–	–	–	–
1958	–	–	–	–	–	–	–	–	–	–	–	–	–
1959	–	–	–	–	–	–	–	–	–	–	–	–	–
1960	–	–	–	–	–	–	–	–	–	–	–	–	–
1961	–	1.23	1.79	2.19	9.20	30.42	28.11	–	5.80	2.62	0	0	(81.36)
1962	0	0	0	–	7.88	30.02	10.76	13.22	8.77	10.45	0	0	(81.10)
1963	0	0.02	0.66	8.01	13.46	31.62	65.50	17.24	6.53	19.16	–	–	(161.60)
Mean	0.43	0.97	2.15	6.00	12.81	20.62	18.91	16.76	12.23	6.92	1.09	0.44	100.27

Table A-9 Monthly Rainfall at Maskuba

(Unit: inch)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1961	–	–	0.60	1.90	11.40	–	23.85	20.55	–	15.15	1.83	0	(75.28)
1962	0	0	0	0.56	7.64	38.72	11.92	18.62	8.36	5.60	0	–	(91.42)
1963	–	–	0.70	11.37	15.64	28.30	26.54	9.43	13.86	8.77	–	–	(114.61)
1964	–	–	–	7.78	3.60	11.52	13.92	14.55	–	8.37	0.83	0	(60.57)
1965	0	0.68	0	0.25	5.70	25.05	26.65	21.90	17.30	10.25	0.20	3.20	111.18
1966	0.18	0	2.05	2.38	6.76	17.23	15.15	13.06	6.81	6.13	0.43	3.65	73.86
1967	1.52	0	2.26	5.34	7.20	8.83	24.33	17.79	21.19	9.55	0	0	98.01
1968	0.51	0.25	1.23	5.06	10.70	26.98	37.89	22.39	9.97	4.06	–	–	(119.04)
1969	–	–	1.60	5.20	3.48	30.07	16.19						
Mean	0.44	0.19	1.06	5.54	8.01	23.34	20.72	17.29	12.92	8.49	0.72	1.37	94.35

Table A-10 Monthly Rainfall at Marisha

(Unit: inch)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1964	–	–	–	–	9.27	10.93	22.51	14.40	11.22	10.44	2.06	0	(80.83)
1965	0	1.02	1.87	0.62	9.95	27.26	19.07	11.24	5.99	8.30	0.35	1.56	87.23
1966	0.43	0	1.66	2.87	11.24	24.91	14.57	18.82	15.79	8.97	1.05	3.54	103.85
1967	0.46	0	4.27	5.28	5.08	12.00	20.68	16.92	9.56	8.60	0	0	82.80
1968	0	0.22	4.82	4.36	9.03	25.36	53.82	15.44	11.27	6.35	0.47	0	131.14
1969	0.22	0	2.46	5.01	3.34	14.90							
Mean	0.22	0.25	3.02	3.63	7.98	19.23	21.77	13.36	10.77	8.53	0.77	1.02	101.26

Table A-11 Monthly Rainfall at Longadu

(Unit: inch)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1964	–	–	–	–	9.39	8.34	17.62	13.03	11.66	11.38	2.27	0	(73.69)
1965	0	0.21	0.46	2.52	9.30	24.03	23.96	22.05	6.73	12.56	0	2.00	101.82
1966	0.36	0	0.15	1.10	9.57	17.43	16.85	16.76	13.17	7.94	0.83	2.93	86.09
1967	0.58	0	3.75	2.43	4.27	10.56	22.18	15.74	8.43	5.13	0	0	73.07
1968	0.50	1.96	14.16	3.25	4.98	21.63	38.33	14.30	5.52	–	0	0	(104.63)
1969	0	0	0	0.60	1.32	23.73	16.66						
Mean	0.29	0.43	3.70	1.98	6.47	17.62	22.60	16.38	9.10	9.25	0.62	0.97	86.99

Table A-12 Monthly Rainfall at Teghamukh

(Unit: inch)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1964	–	–	–	–	–	9.11	17.42	11.50	11.14	13.87	1.38	0	(64.42)
1965	0	2.19	0.46	1.52	6.92	24.07	19.20	22.55	7.13	12.57	2.55	1.70	100.86
1966	0.18	0	2.05	2.38	6.76	17.23	15.14	13.09	6.81	6.13	0.43	3.65	73.85
1967	0.25	0	2.58	5.21	4.55	7.87	24.18	11.82	22.34	6.00	0	0	84.80
1968	0.28	0.70	2.82	2.05	11.11	25.31	41.82	21.52	14.48	3.23	1.25	0	124.57
1969	0	0	2.15	6.08	3.13	35.97	11.22						
Mean	0.14	0.58	2.01	3.45	6.49	19.93	21.49	16.10	12.38	8.36	1.12	1.07	96.02

Table A-13 Monthly Rainfall at Bagaihat

(Unit: inch)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1961	–	0.44	4.63	2.00	9.78	31.91	20.42	22.05	17.85	9.15	0.12	0	(118.35)
1962	0	2.30	1.09	3.45	4.50	39.05	10.84	17.25	11.74	5.82	0	0	107.78
1963	0	0	1.10	7.80	6.51	30.95	35.14	5.75	–	–	–	–	(87.25)
1964	–	–	–	–	4.46	11.31	15.44	9.55	8.98	13.90	–	0	(63.64)
Mean	0	0.91	2.27	4.42	6.31	28.31	20.46	13.65	12.86	9.62	0.06	0	107.78

Table A-14 Monthly Rainfall at Aliheadman

(Unit: inch)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1961	–	–	–	–	–	8.03	34.23	20.79	10.67	11.57	0.45	0	(85.54)
1962	0	0.87	0.11	1.96	6.27	29.18	6.59	17.76	–	3.05	0	0	(65.79)
1963	0	0	2.09	4.78	10.91	32.77	35.49	9.30	9.23	14.79	0	–	(119.46)
Mean	0	0.44	1.10	3.37	8.59	23.33	25.44	15.95	9.90	9.80	0.15	0	–

TAble A-15 Monthly Rainfall at Satrachara

(Unit: inch)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1961	–	–	–	–	¼	4.02	22.32	13.97	7.69	5.42	0.02	0	(53.44)
1962	0.04	0	0	4.71	3.12	29.35	10.33	9.66	9.34	4.33	0	0	70.88
1963	0	0	1.86	13.41	12.71	36.46	22.81	3.62	5.18	4.91	–	0	(100.96)
Mean	0.02	0	0.93	9.06	7.92	23.27	18.49	9.08	7.40	4.89	0.01	0	70.80

Table A-16 Monthly Rainfall at Subalong

(Unit: inch)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1961	–	–	–	–	–	–	–	16.94	8.42	8.33	0.56	0	–
1962	0.46	0	0	1.68	8.78	24.88	9.14	16.91	11.73	6.47	0	0	(80.05)
1963	0	0	0.94	10.63	11.11	27.59	24.00	12.15	11.04	6.05	0	0.13	103.64
Mean	0.43	0	0.47	6.16	9.95	26.24	16.57	15.33	10.39	6.95	0.19	0.04	103.64

Table A-17 Monthly Mean Temperature of Kaptai

(Unit: °F)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1964	69	72	83	80	85	85	83	80	83	86	82	84	81
1965	72	72	77	83	82	80	80	83	83	81	81	74	79
1966	67	77	77	84	82	83	83	82	82	81	81	74	79
1967	66	72	77	81	83	86	82	84	81	80	75	71	78
1968	63	62	76	82	81	82	83	83	84	82	78	71	77
1969	67	76	78	84	91	84	83	81	85	82			–
Mean	67	72	78	82	84	83	82	82	83	82	79	75	79

Table A-18 Monthly Mean Humidity at Kapitai

(Unit: %)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1964	78	71	72	80	78	81	86	82	85	69	70	57	76
1965	67	81	73	66	79	85	86	82	84	78	71	73	77
1966	78	76	74	70	78	85	86	90	88	88	86	88	82
1967	79	86	79	68	81	84	92	90	88	87	82	78	83
1968	70	73	81	66	83	90	86	90	84	83	84	84	81
1969	77	81	80	80	73	88	82	89	90	88			–
Mean	75	78	77	72	79	86	86	87	87	82	79	76	80

TAble A-19 Monthly evaporation at Kaptai

(Unit: inch)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1963	3.455	4.582	6.276	6.658	6.179	4.055	3.551	4.205	4.941	–	4.253	3.913	(52.068)
1964	4.033	4.969	7.396	5.966	7.080	4.036	4.367	5.241	5.923	4.804	–	3.547	(57.362)
1965	4.332	4.291	6.055	8.346	7.763	3.473	4.558	4.003	4.448	4.381	4.079	3.091	58.820
1966	3.414	5.577	6.386	8.062	8.027	3.040	4.468	4.656	4.401	4.659	4.126	2.773	59.589
1967	2.951	4.099	4.808	6.843	7.109	5.694	4.936	5.198	4.303	5.045	4.398	5.169	60.463
1968	3.688	4.736	6.956	4.544	5.065	3.552	4.992	4.526	3.850	4.709	4.659	3.314	54.591
1969	3.648	4.182	7.000	7.146	8.512	4.475	5.205						
Mean	3.646	4.621	6.411	6.795	7.105	4.046	4.582	4.638	4.628	4.720	4.303	4.361	59.856
From free water surface	2.55[1]	3.23	4.49	4.76	4.97	2.83	3.21	3.25	3.24	3.30	3.01	3.05	41.89

Remarks: 1) 0.70 of pan evaporation.

Table A-20 Monthly Evaporation from Reservoir

(Unit: inch)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1936	2.55	2.89	3.76	3.41	-1.97	-5.91	-4.30	-8.08	-1.47	1.34	2.79	0.88	-4.11
1937	2.35	2.64	4.24	1.06	-5.10	-2.72	-4.64	-7.01	-2.25	-0.09	2.94	3.04	-5.54
1938	2.34	3.09	4.05	3.21	-2.48	-7.88	-1.38	-4.18	-6.05	0.61	0.88	3.05	-4.74
1939	2.49	3.09	4.42	2.09	-0.04	-2.74	-9.28	-6.24	-3.09	1.12	2.29	3.05	-2.84
1940	2.55	1.84	1.49	4.75	-3.35	-5.94	-1.67	-2.89	-6.59	1.01	2.99	2.70	-3.11
1941	2.54	1.65	4.41	0.23	-4.77	-9.26	-9.09	-3.30	-2.64	0.81	3.01	3.04	-13.37
1942	2.54	3.19	3.66	1.03	0.84	-2.13	-1.71	-3.24	-4.62	2.90	0.41	2.98	5.85
1943	2.08	2.89	2.67	3.36	3.05	-4.16	-3.03	-4.63	-2.35	1.85	3.01	3.05	7.79
1944	1.32	3.13	3.53	3.32	1.54	-6.55	-3.42	-3.20	-2.53	2.44	3.01	3.05	5.64
1945	1.61	2.14	4.45	3.25	-0.24	-6.27	-4.91	-5.16	-1.76	9.84	2.77	1.26	-2.02
1946	2.55	3.13	1.34	1.45	-1.23	-0.10	-10.41	-2.49	-3.26	-1.32	2.91	1.01	-6.42
1947	2.55	3.19	4.30	2.57	-0.94	-9.57	-13.73	-6.75	-4.73	-1.13	3.01	2.75	-18.48
1948	2.51	2.13	3.42	-0.30	-3.14	-3.33	-3.60	-3.86	-3.58	1.65	2.53	3.05	-2.52
1949	2.29	3.23	3.61	-1.20	1.47	-4.59	-5.15	-2.68	-4.98	0.29	2.92	3.05	-1.74
1950	2.47	2.82	3.68	3.02	0.58	-2.67	-1.59	-9.57	0.62	1.19	2.30	3.05	5.90
1951	2.55	3.23	3.40	0.83	-0.75	-7.70	-5.35	-6.24	-0.83	-4.27	2.96	3.02	-9.15
1952	2.55	3.15	3.37	1.74	-0.20	-8.36	-4.26	-1.98	-0.23	-1.65	1.51	3.05	-1.31
1953	2.55	3.19	5.26	3.98	-2.07	-8.79	-1.97	-3.90	-4.25	0.44	2.73	3.05	0.22
1954	2.51	2.47	3.97	3.99	1.90	-9.22	-4.26	-7.48	-0.25	-1.62	3.01	2.90	-2.08
1955	2.55	3.23	2.27	3.73	0.50	-2.93	-7.35	-1.73	1.18	1.41	0.82	2.87	6.55
1956	2.45	3.23	3.38	3.98	0.22	-11.39	-3.08	-6.44	-3.69	1.29	0.82	3.05	-6.18
1957	1.52	3.04	4.49	4.17	0.78	-3.03	-1.70	-0.02	-1.13	2.51	3.01	3.05	16.69
1958	2.55	3.21	4.32	4.53	1.10	-1.10	-0.36	-4.22	-4.78	0.22	3.01	3.05	11.53
1959	0.52	1.78	2.72	4.48	0.60	-6.83	-4.45	-5.69	-2.73	-2.52	3.01	2.76	-6.35
1960	2.55	2.89	4.23	4.17	1.81	-4.45	-12.32	0.43	-1.16	1.14	2.27	3.05	4.61
1961	2.52	2.94	2.57	0.80	6.73	-9.28	-8.47	-1.41	-1.34	-1.28	2.70	3.05	-0.47
1962	2.02	2.99	4.40	3.84	1.90	-9.20	-1.37	-3.87	-1.06	0.50	3.01	3.05	6.21
1963	2.55	3.23	4.55	0.77	-0.13	-9.72	-13.75	-1.41	-1.29	-1.93	3.01	2.99	-11.13
1964	2.55	3.12	4.48	1.37	2.72	-2.56	-6.07	-3.12	-1.94	-1.10	2.24	3.05	4.74
1965	2.55	2.39	4.07	4.23	1.36	-8.68	-6.32	-5.24	-2.08	-1.87	2.81	1.94	-4.84
1966	2.43	3.23	3.96	3.90	1.48	-5.11	-3.13	-3.76	-2.08	-0.37	2.58	1.80	4.93
1967	3.33	3.23	2.42	3.20	2.51	-1.69	-7.90	-2.98	-2.63	0.81	3.01	3.05	6.36
1968	2.43	0.68	2.92	3.08	1.34	-7.64	-15.23	-3.48	-1.29	1.97	2.88	3.05	-9.29
1969	2.54	3.23	3.58	2.04	3.30	-9.40	-2.73						
Mean	2.35	2.81	3.60	2.65	0.27	-5.88	-0.76	-0.94	-2.45	0.22	2.52	3.06	-0.87

Table A-21 Monthly Runoff at Kaptai
(From Irrigation Department)

(Unit: million cu. ft.)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1913						149,677	204,783	111,604	42,189	51,374	18,394	10.588	
1914	10,588	15,689	12,651	33,504	57,981	112,656	90,828	176,387	32,534	51,960	10,682	39,647	645,107
1915	8,591	8,591	10,617	22,939	63,325	57,532	90,121	115,138	44,289	53,084	11,443	6,397	492,067
1916	6,397	6,397	6,397	40,007	17,376	71,510	109,785	88,674	87,436	165,555	10,699	7,446	617,679
1917	7,446	7,641	7,446	60,015	13,402	40,842	40,283	146,891	47,328	18,198	15,967	5,736	441,195
1918	5,736	5,736	8,870	19,666	56,837	153,944	211,243	124,579	68,906	13,678	16,558	11,847	707,600
1919	11,847	11,487	11,847	16,494	21,235	42,154	82,562	47,221	61,816	10,899	16,328	4,870	339,120
1920	4,870	7,351	26,810	6,543	26,894	46,046	38,862	86,804	80,253	17,237	5,360	5,249	352,279
1921	7,900	5,437	54,106	12,497	22,341	47,296	139,466	59,527	115,117	123,317	8,093	7,529	602,626
1922	7,529	7,529	7,529	22,269	37,154	110,324	55,227	104,488	60,041	46,268	6,876	6,876	472,110
1923	6,876	7,861	6,876	14,405	81,460	108,700	30,836	99,646	155,427	67,228	39,321	8,221	626,857
1924	8,221	16,767	8,221	16,879	78,128	192,419	54.205	113,479	33,003	28,935	15,620	8,191	574,158
1925	16,087	8,191	8,191	36,892	74,295	90,210	74,389	102,880	37,069	15,704	33,932	6,344	504,184
1926	6,470	8,312	18,550	34,097	34,536	67,452	107,025	87,947	47,774	45,852	15,664	11,447	485,063
1927	6,573	21,783	8,415	133,755	76,021	113,200	52,788	91,204	164,543	65,521	9,483	8,786	753,072
1928	8,786	8,786	8,786	9,079	46,470	62,224	65,289	86,436	68,039	21,917	6,794	5,791	398,397
1929	5,791	5,791	5,791	48,965	24,622	444,981	53,117	75,790	34,917	19,457	12,683	12,683	744,588
1930	12,683	12,683	31,134	15,856	93,693	104,105	96,747	32,487	37,896	11,847	33,235	5,650	488,016
1931	5,650	5,650	8,124	9,485	52,985	67,008	76,438	33,557	84,346	44,558	12,859	5,611	407,271
1932	5,444	6,036	6,322	11,347	61,440	235,707	149,080	79,602	55,694	15,337	51,128	10,835	687,972
1933	10,835	10,835	11,978	33,433	53,740	61,102	97,683	115,683	51,247	19,999	6,785	6,785	480,105
1934	6,785	18,062	6,785	17,994	44,177	70,074	197,804	41,994	53,113	51,619	28,972	7,562	544,941
1935	7,562	8,073	7,562	29,760	23,278	49,218	55,571	185,642	100,125	29,863	10,6y54	7,254	514,562
1936	5,495	4,822	4,270	19,553	34,214	76,951	93,727	149,933	90,631	47,800	13,468	7,402	548,266
1937	5,249	4,423	4,069	4,612	13,543	58,115	64,687	179,619	90,466	50,109	12,374	22,045	509,311
1938	6,807	4,927	5,246	4,952	34,527	91,499	80,563	128,518	159,565	59,541	34,855	14,576	626,576
1939	9,906	5,407	6,416	12,375	17,484	35,097	78,169	170,636	98,813	64,900	12,915	9,619	521,737
1940	6,069	5,030	12,288	6,125	20,712	72,128	44,591	102,116	122,443	34,331	12,928	8,303	459,064
1941	5,764	8,248	4,495	13,832	97,275	161,537	209,323	108,630	81,695	57,195	15,684	9,839	773,517
1942	7,063	4,891	5,583	4,020	19,800	78,100	62,700	104,500	129,800	8,800	63,800	8,800	497,857
1943	7,700	5,500	7,700	7,700	90,038	34,930	75,208	88,087	107,947	27,034	9,894	7,160	468,898
1944	6,437	5,454	4,983	7,512	14,776	79,210	103,427	70,363	94,049	35,353	11,705	9,183	442,452
1945	9,247	8,100	5,481	5,219	17,284	63,774	54,123	126,763	118,481	42,351	15,725	17,296	483,844
1946	6,860	4,845	8,527	12,075	33,455	36,552	193,593	88,357	95,348	58,885	16,397	14,159	569,053
1947	8,144	5,729	5,758	6,819	17,343	159,531	162,434	260,737	158,755	93,436	21,719	12,645	913,050
1948	8,566	8,287	7,004	12,117	55,026	59,839	53,746	115,734	110,854	42,339	12,969	8,607	495,088
1949	6,209	4,511	5,428	16,344	37,372	75,546	126,269	88,870	93,777	79,531	17,960	9,707	561,524
1950	7,135	6,016	6,635	7,416	9,125	31,720	36,325	117,925	66,834	54,907	28,173	9,982	382,193
1951	6,657	5,026	5,682	17,319	18,968								
Mean	7,664	6,060	10,068	21,155	41,903	95,077	95,082	108,117	83,752	45,972	18,371	10,018	543,328

Table A-22 Monthly Runoff at Kaptai
(From IECO)

(Unit: million cu.ft.)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1935										26,000	7,050	3,260	
1936	1,660	1,320	899	11,500	50,400	79,000	90,000	155,000	88,500	44,000	8,450	5,100	535,829
1937	1,450	1,150	760	1,300	10,200	53,500	60,500	1981000	92,000	47,000	8,680	18,600	493,140
1938	2,810	1,400	1,550	1,510	31,600	97,600	79,500	135,500	179,000	57,000	30,600	10,700	628,770
1939	6,100	3,650	2,150	8,400	13,200	30,200	78,800	185,000	101,000	68,800	9,490	5,620	512,770
1940	2,140	1,340	8,180	2,310	16,100	71,200	40,800	107,000	146,000	30,000	9,080	4,350	438,500
1941	1,900	6,600	1,080	12,200	94,800	177,000	239,000	112,000	104,000	56,000	12,300	6,110	822,990
1942	3,130	1,480	1,990	1,670	26,500	77,600	102,500	138,000	114,000	59,000	14,400	8,020	548,290
1943	3,660	2,730	2,590	5,540	3,750	26,800	75,700	91,800	112,000	22,600	6,330	3,150	356,650
1944	2,460	1,880	1,530	3,710	7,810	82,300	101,500	68,300	95,500	31,600	7,900	5,560	410,050
1945	5,390	4,570	1,730	1,880	13,700	65,000	52,700	139,000	124,000	37,500	12,200	13,500	471,170
1946	*2,730*	*1,380*	*4,600*	*7,940*	*31,200*	*32,600*	*218,000*	*87,000*	*94,100*	*56,600*	*12,400*	*11,200*	*559,750*
1947	4,020	1,990	1,600	3,030	13,100	174,000	184,000	298,000	175,000	99,000	17,100	8,680	979,520
1948	4,480	4,400	2,800	9,140	57,900	57,700	50,100	120,000	114,000	38,400	8,770	4,230	471,920
1949	1,960	1,030	1,530	12,300	36,400	78,500	131,000	88,900	93.500	79,300	13,200	5,200	542,820
1950	2,830	2,140	2,520	3,460	4,870	22,600	20,900	139,000	72,500	50,700	26,100	5,690	353,310
1951	2,360	1,310	1,660	5,540	26,500	92,400	148,000	126,000	95,400	154,000	23,300	15,100	691,570
1952	10,300	7,010	6,230	12,300	21,800	102,000	150,000	84,000	95,300	103,000	28,400	9,300	629,640
1953	4,490	2,510	2,080	2,530	37,600	107,000	73,600	149,000	171,000	61,200	17,600	9,030	637,640
1954	5,700	3,850	3,300	4,450	6,532	63,302	86,609	195,087	109,157	86,007	19,764	10,830	594,588
1955	10,830	7,351	11,839	21,292	31,402	80,920	136,463	126,265	57,784	36,704	43,585	8,177	572,612
1956	3,960	2,277	2,465	1,696	19,381	286,026	125,612	147,959	102,305	47,402	31,467	7,737	778,287
1957	7,731	3,522	2,118	1,545	7,030	24,945	62,328	35,366	56,775	41,249	6,472	4,515	253,596
1958	*3,273*	*2,617*	*1,730*	*1,439*	*12,814*	*18,673*	*32,061*	*37,184*	*74,328*	*57,052*	*14,894*	*4,368*	*260,433*
1959	3,264	5,726	9,250	3,274	11,676	87,731	95,795	95,880	73,128	71,272	57,465	36,220	550,681
1960	5,667	3,528	3,457	2,983	5,420	55,041	145,825	57,066	61,985	55,033	20,570	10,040	426,615
1961	5,720	4,751	8,602	6,006	5,768								
Mean	4,231	3,135	3,394	5,729	22,976	81,746	103,252	124,652	104,090	58,324	17,983	9,357	540,846

Table A-23 Monthly Mean Runoff at Rangamati
(From Karnafuli Power Station)

(Unit: cusec)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1954					3,040	22,740	32,830	90,290	38,790	28,600	8,500	2,870	
1955	2,880	2,100	3,500	–	9,060	25,950	53,600	37,200	19,700	13,120	16,470	3,600	(11,560)
1956	2,070	1,460	1,600	1,260	7,700	154,900	44,300	62,760	34,800	16,400	11,800	3,400	28,540
1957	1,845	1,065	710	629	2,010	7,810	19,760	12,590	21,640	15,290	2,056	1,260	7,220
1958	929	846	639	606	3,775	9,530	10,920	18,890	14,080	3,600	1,130	5,890	
1959	945												
Mean	1,734	1,368	1,612	832	8,528	43,420	32,010	42,750	26,760	17,500	8,490	2,450	13,880

Fig. A-2 TAILWATER RATING CURVE

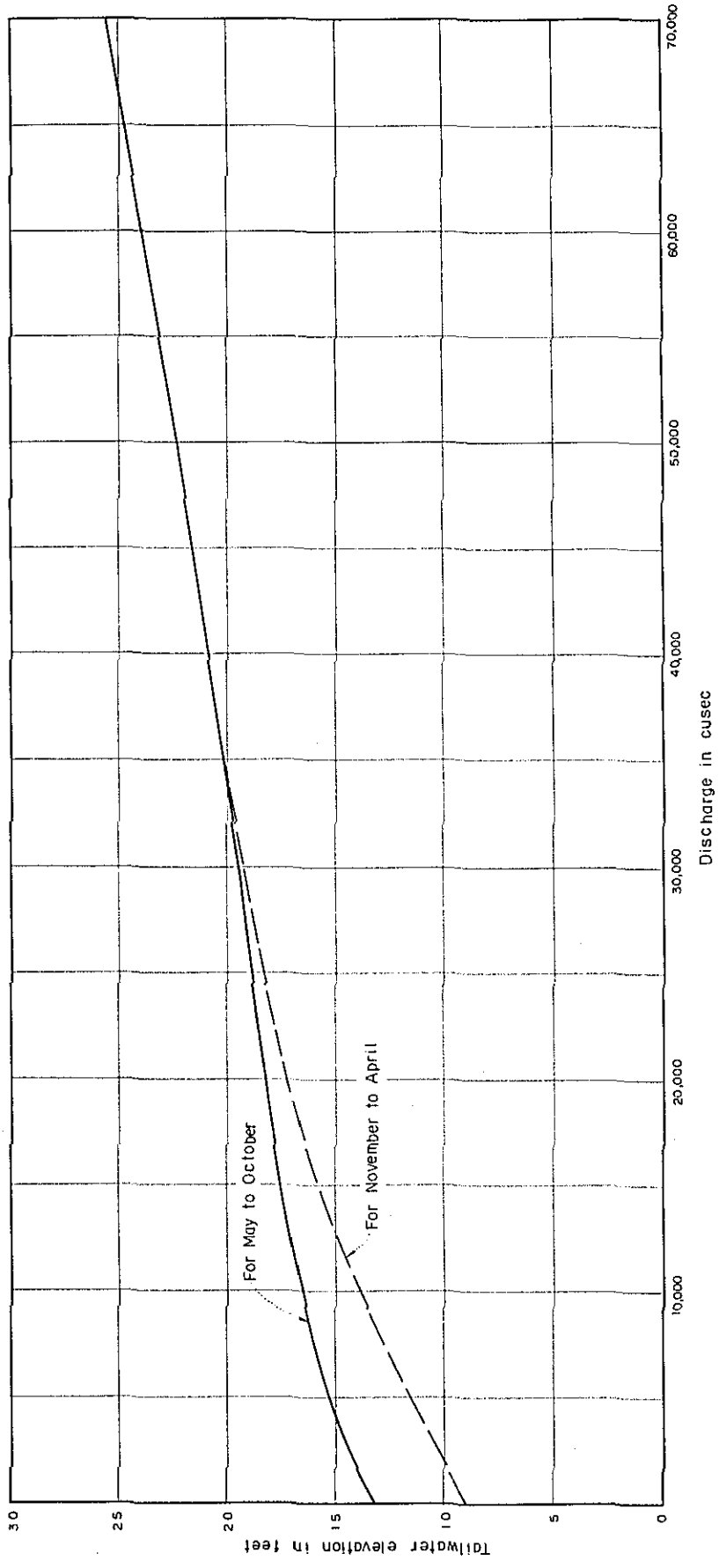
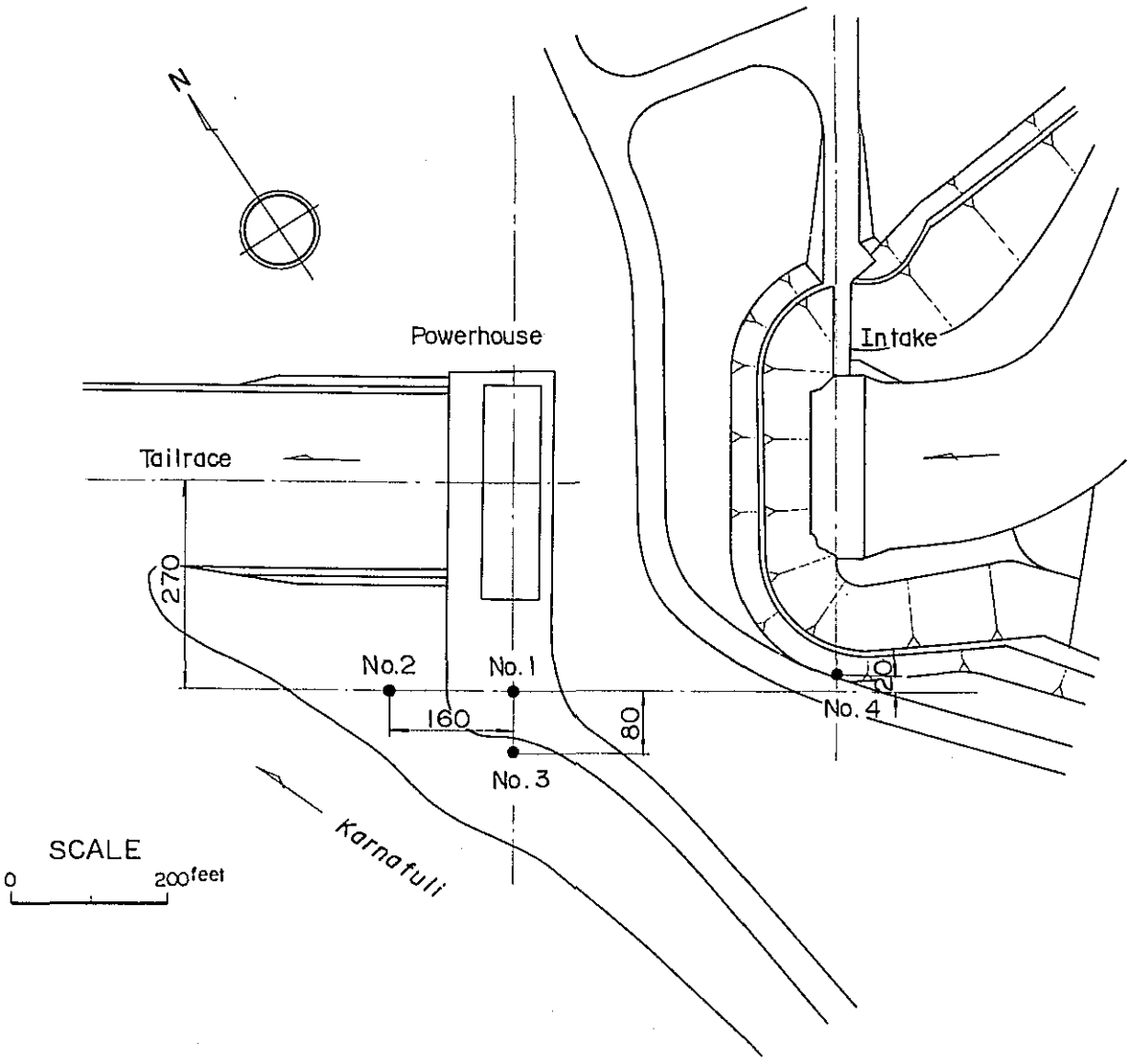


Fig. A-3 LOCATION OF DRILL HOLES (EPWAPDA)



		Depth
No. 1	EL. 49.0 ~ - 70.0 feet	119 feet
No. 2	" 49.0 ~ - 21.0 "	70 "
No. 3	" 49.0 ~ - 70.0 "	119 "
No. 4	" 140.0 ~ - 28.0 "	112 "

Fig. A-4 GEOLOGICAL LOG OF DRILL HOLE (1)

HOLE NO. 1

PROJECT ; KARNAFULI
LOCATION ; KAPTAI
DATE STARTED ; 29 JAN. 1968
DATE COMPLETED ; 29 JAN. 1968
DIAMETER OF HOLE ; 3 inches
MACHINE ;

ELEVATION OF SURFACE 49 ft.
ELEV. BOTTOM OF HOLE, -70 ft.
INCLINATION OF HOLE, VERT.
DRLLED BY EPWAPDA
GEOLOG. LOGGED BY M.M. BAIG

DATE	DEPTH	ELEV. TOP OF STRATUM	CLASSIFICATION OF ROCKS	COLUMNAR SECTION	THICKNESS OF STRATUM	ACCUM. THICKNESS OF STRATA	CORE RECOVERY	DESCRIPTION
	ft.	ft.			ft.	ft	%	
		42	Silt, little Clay		7	7		
	10	37	Siltstone-Sandstone		5	12		Grey-brown Very fine
		33	Siltstone-Sandstone		4	16	70.7	Brown Very fine
	20	29	Siltstone-Sandstone		4	20		Grey Very fine
		19	Siltstone-Sandstone		10	30	80.8	Grey-brown Very fine
	30		Siltstone				81	Grey
	40						60.4	
	50						100	
	60						80	
	70						60.4	
	80							

Fig. A-4 GEOLOGICAL LOG OF DRILL HOLE (1)
(CONTINUED)

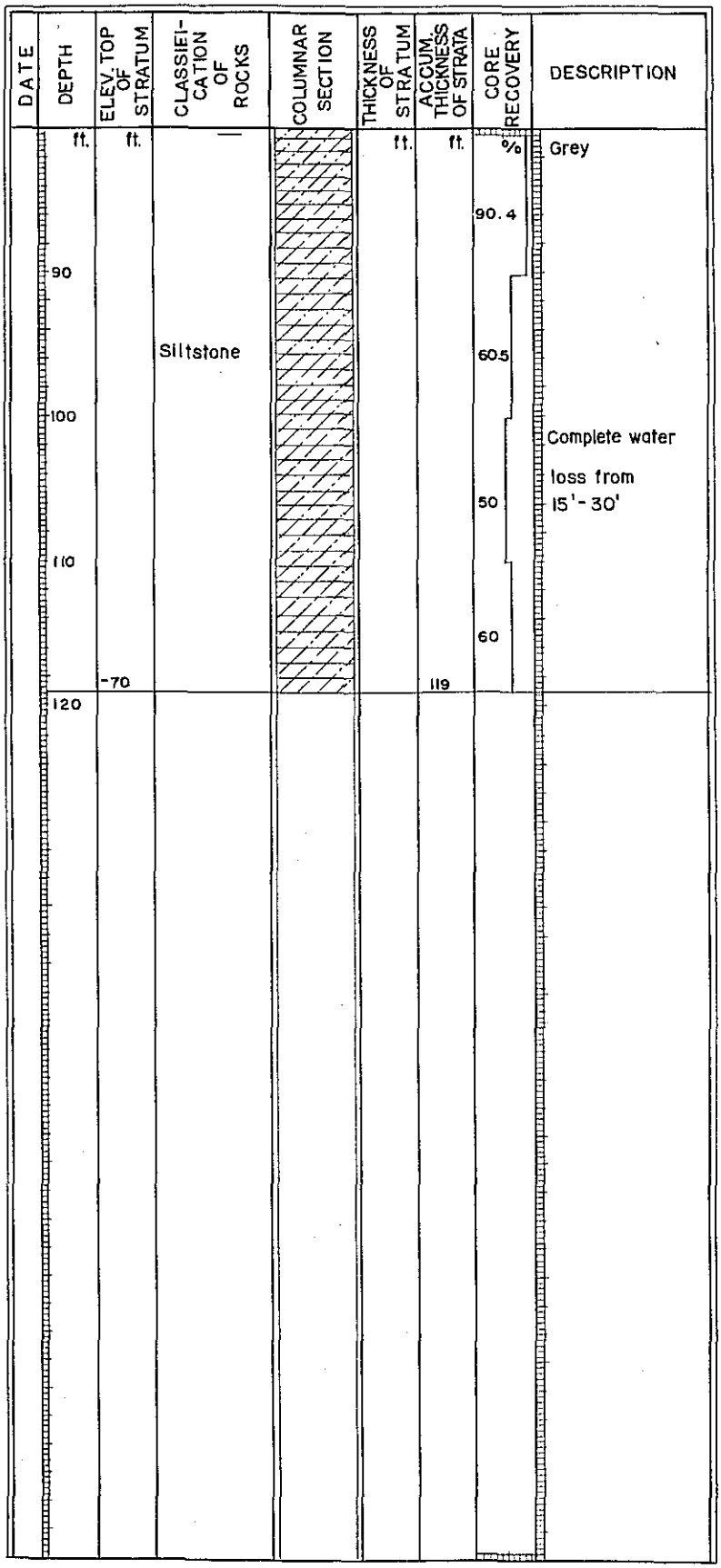


Fig. A-5 GEOLOGICAL LOG OF DRILL HOLE (2)

HOLE NO. 2

PROJECT ; KARNAFULI
LOCATION ; KAPTAI
DATE STARTED ; 29 JAN. 1968
DATE COMPLETED ; 30 JAN. 1968
DIAMETER OF HOLE ; 3 inches
MACHINE ;

ELEVATION OF SURFACE, 49 ft.
ELEV. BOTTOM OF HOLE, -21 ft.
INCLINATION OF HOLE, VERT
DRLLED BY EPWAPDA
GEOLOG. LOGGED BY M.M. BAIG

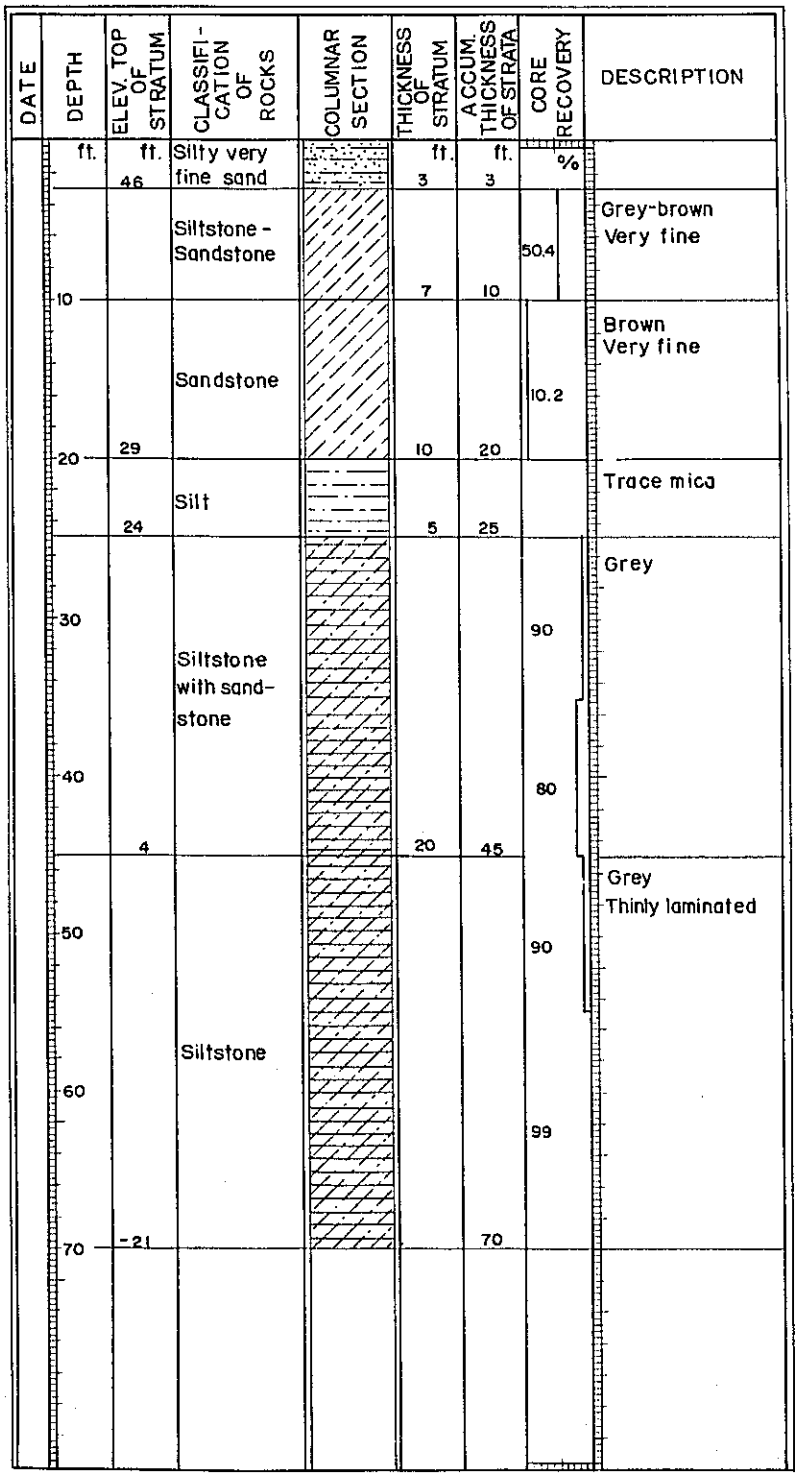


Fig. A-6 GEOLOGICAL LOG OF DRILL HOLE (3)

HOLE NO. 3

PROJECT; KARNAFULI
LOCATION ; KAPTAI
DATE STARTED ; 24 JAN 1968
DATE COMPLETED ; 26 JAN 1968
DIAMETER OF HOLE ; 3 inches
MACHINE;

ELEVATION OF SURFACE, 49 ft.
ELEV. BOTTOM OF HOLE, -70 ft.
INCLINATION OF HOLE ; VERT.
DRLLED BY EPWAPDA
GEOLOG. LOGGED BY M.M. BAIG

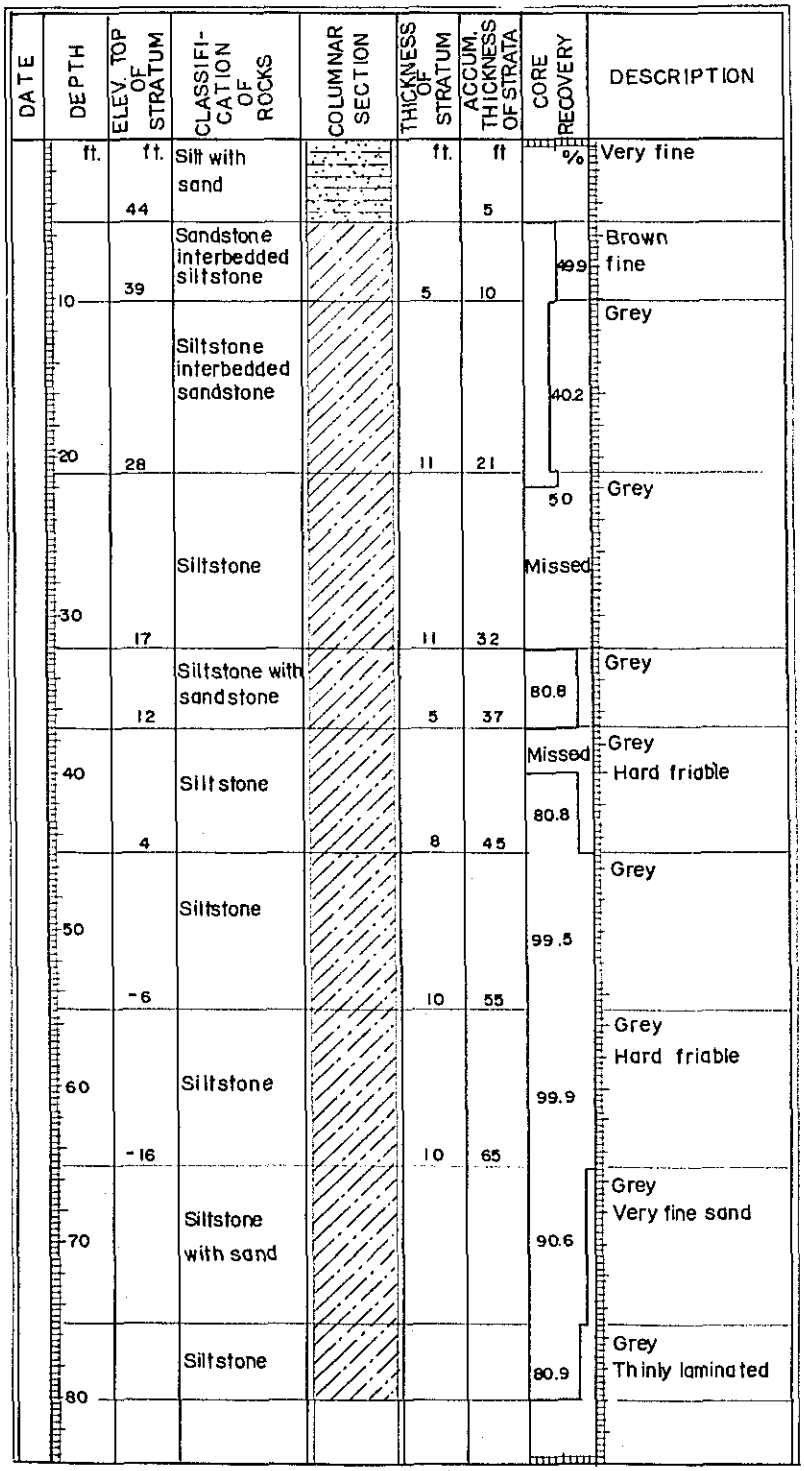


Fig. A-6 GEOLOGICAL LOG OF DRILL HOLE (3)
(CONTINUED)

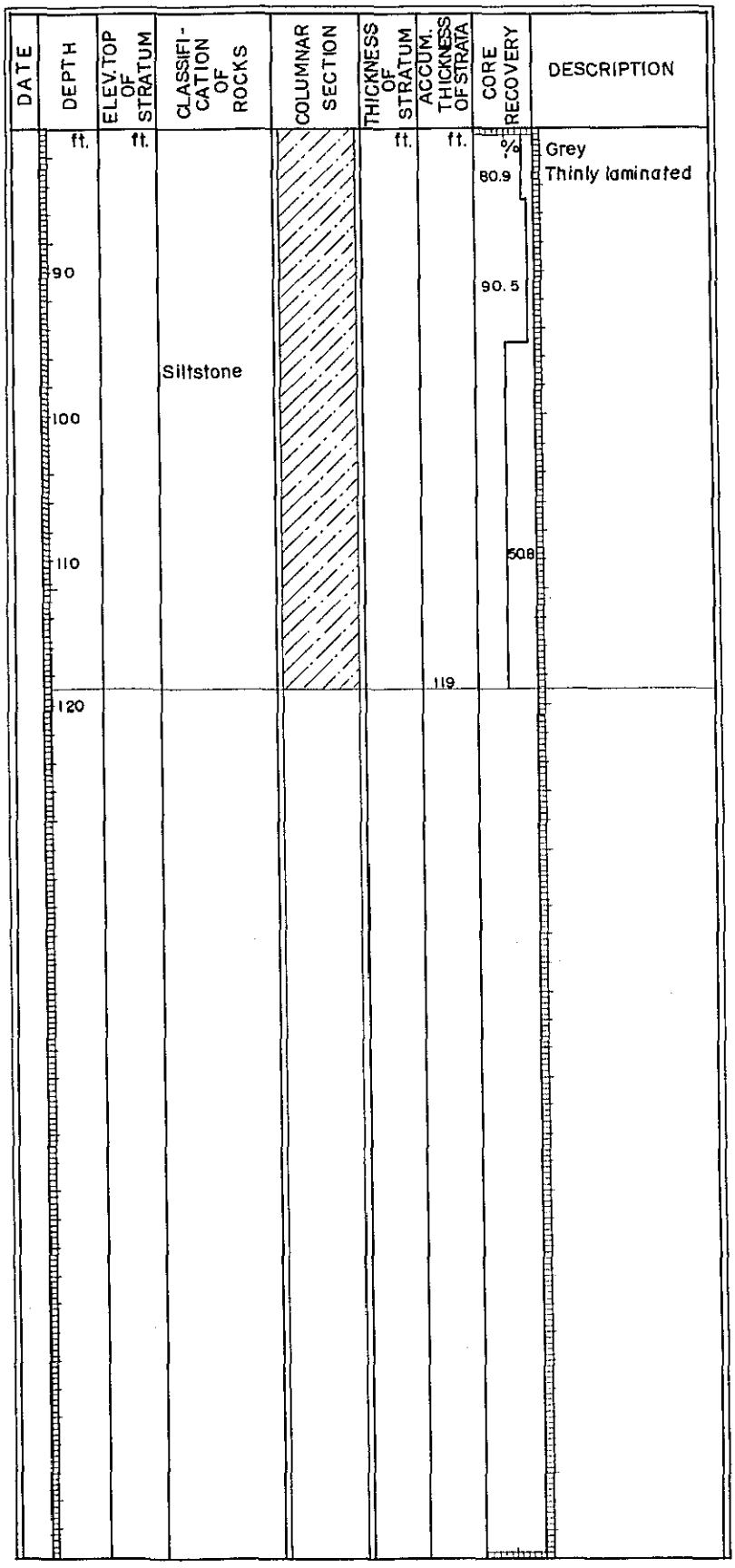


Fig. A-7 GEOLOGICAL LOG OF DRILL HOLE (4)

HOLE NO.4

PROJECT ; KARNAFURI
LOCATION ; KAPTAI
DATE STARTED ; 21 JAN.1968
DATE COMPLETED ; 23 JAN 1968
DIAMETER OF HOLE ; 3 inches
MACHINE ;

ELEVATION OF SURFACE, 140ft.
ELEV. BOTTOM OF HOLE, -28ft.
INCLINATION OF HOLE, VERT.
DRLLED BY EPWAPDA
GEOLOG LOGGED BY M.M. BAIG

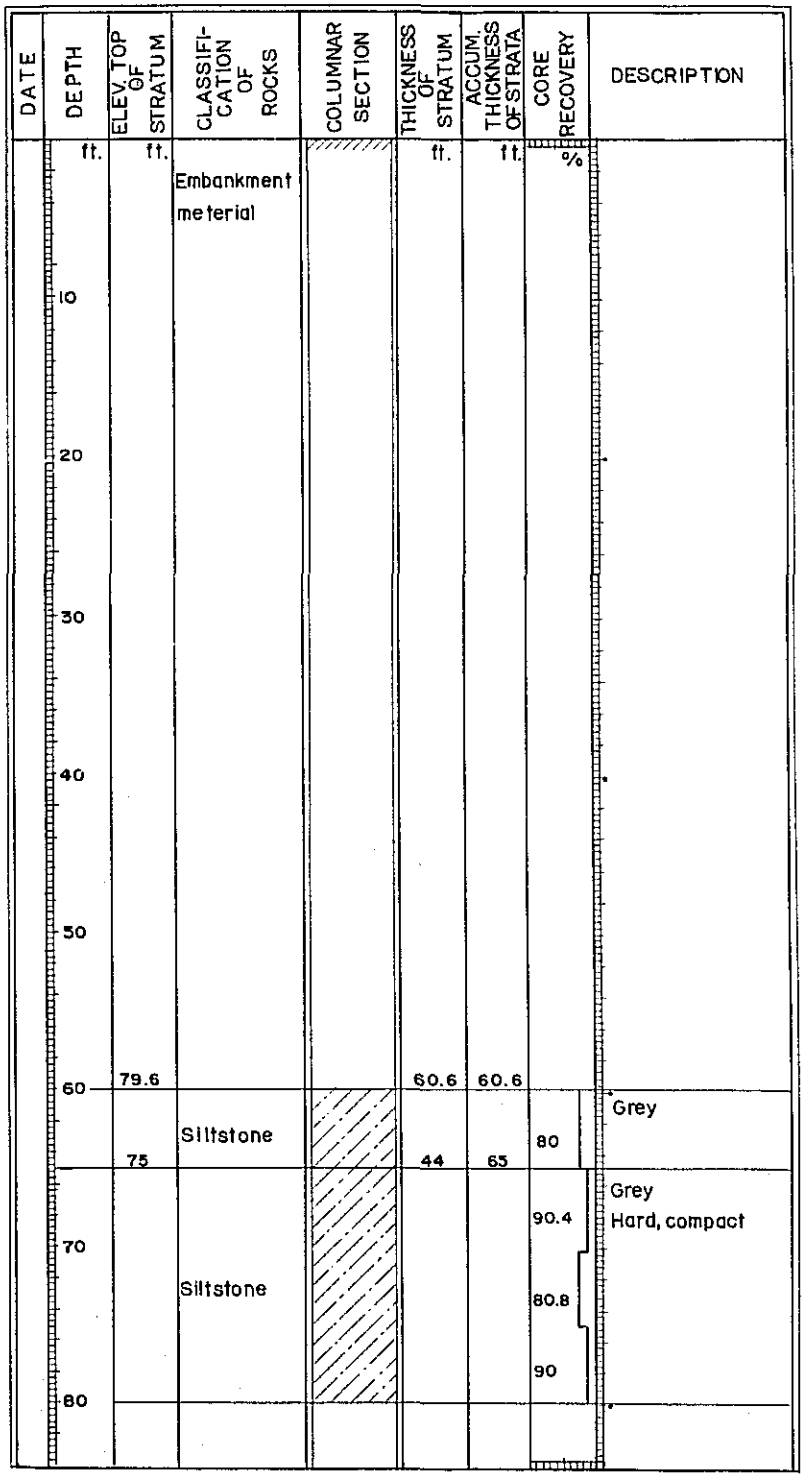


Fig. A.7 GEOLOGICAL LOG OF DRILL HOLE (4)
(CONTINUED)

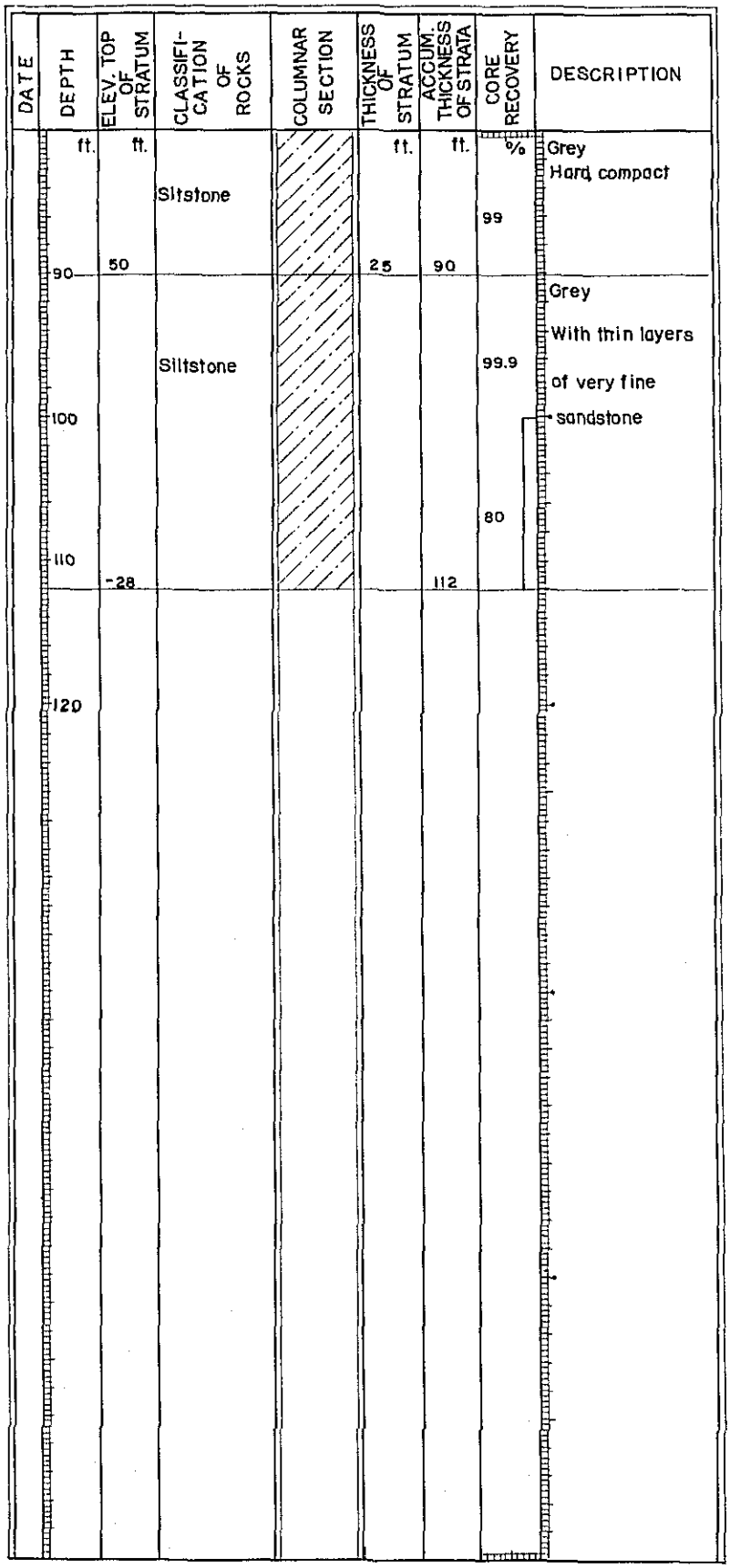


Fig. A - 8 LOCATION OF DRILL HOLES AT POWERHOUSE AND INTAKE SITES (IECO)

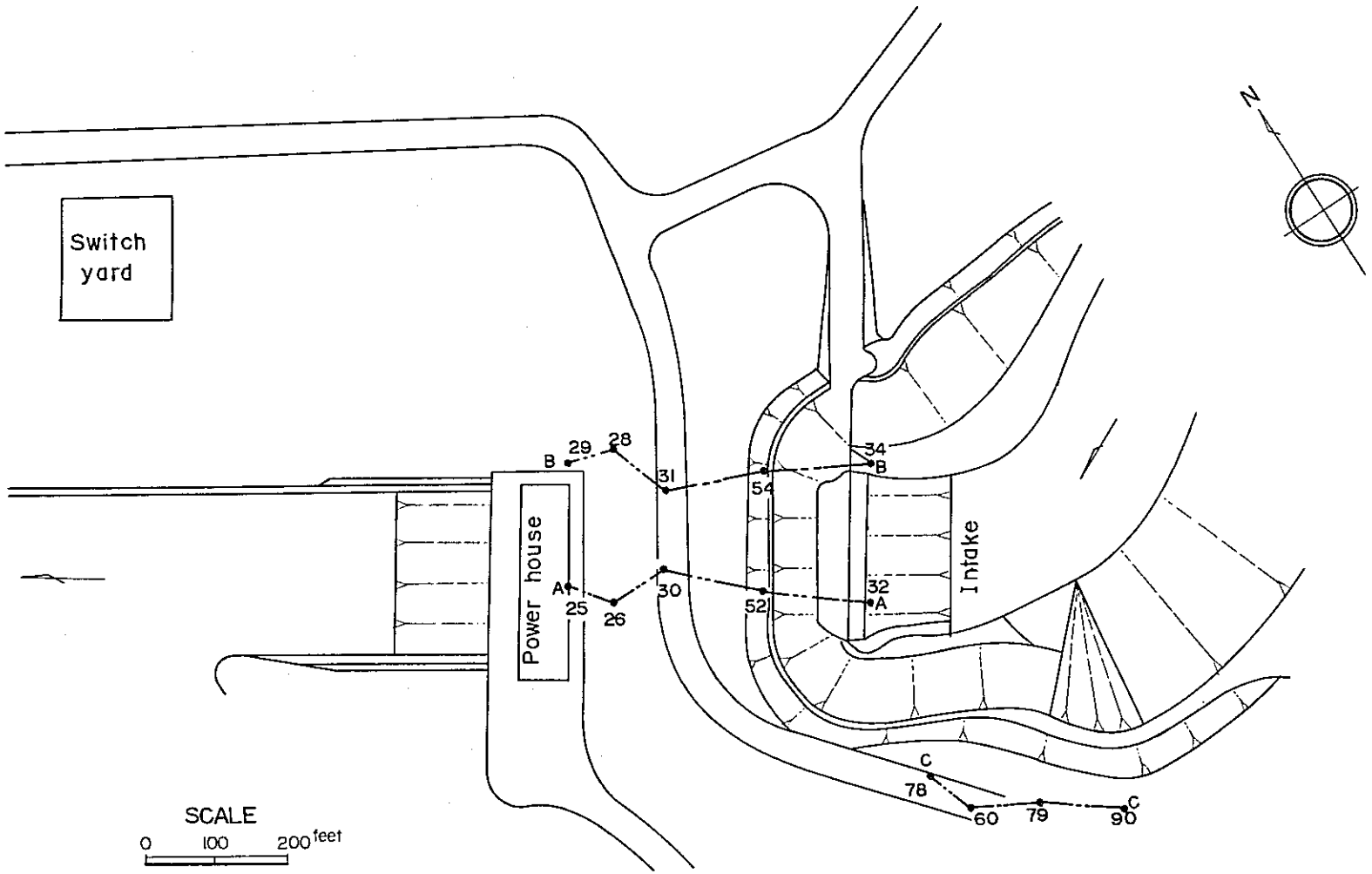
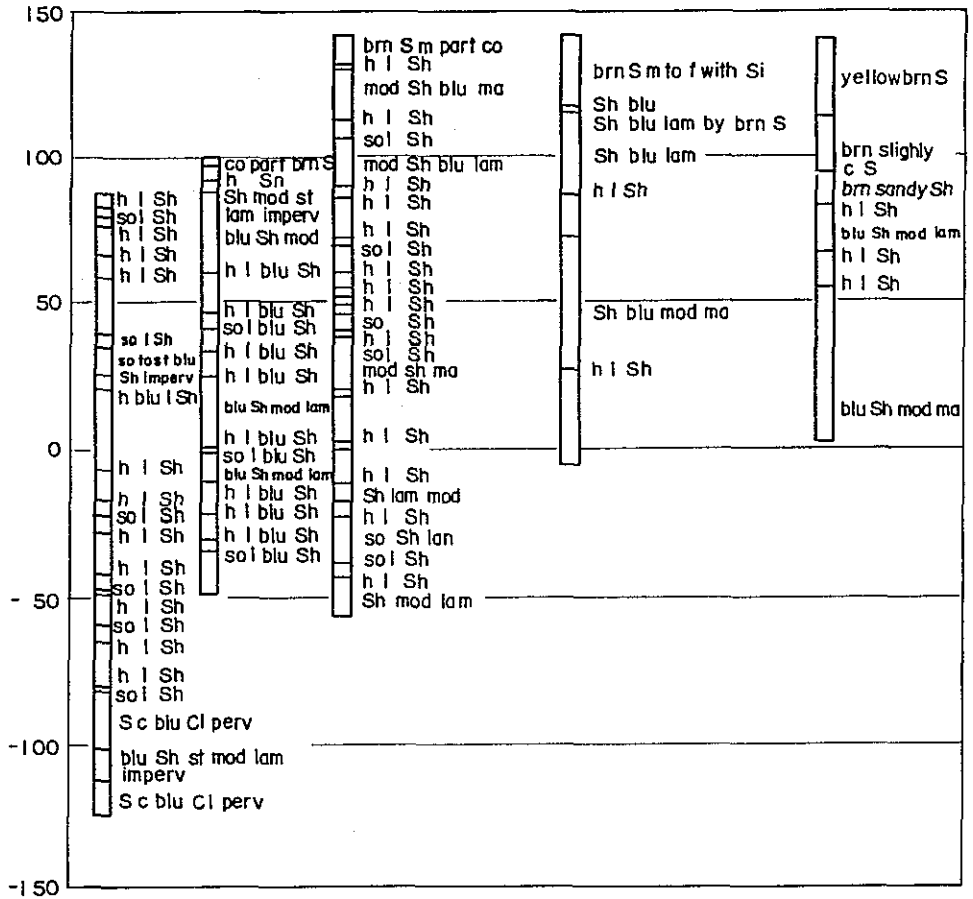


Fig. A-9 GEOLOGICAL LOG OF DRILL HOLE (1)

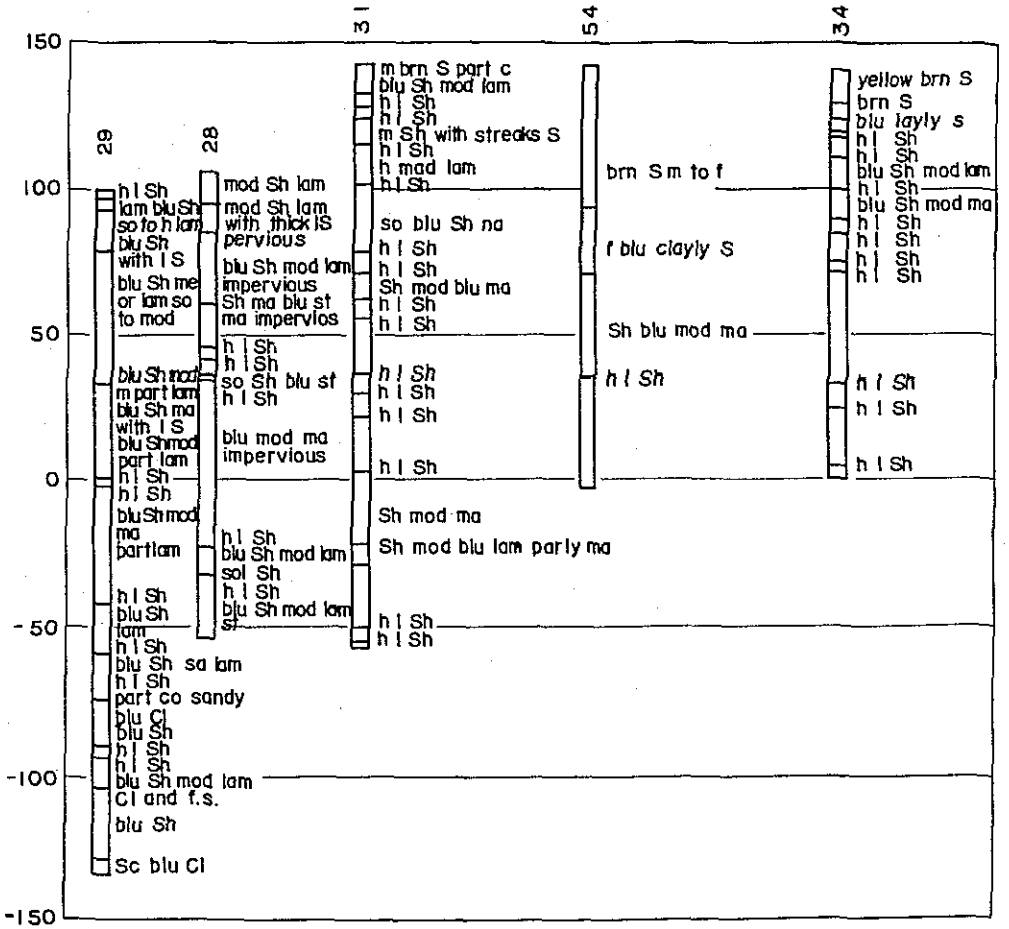


SECTION A-A

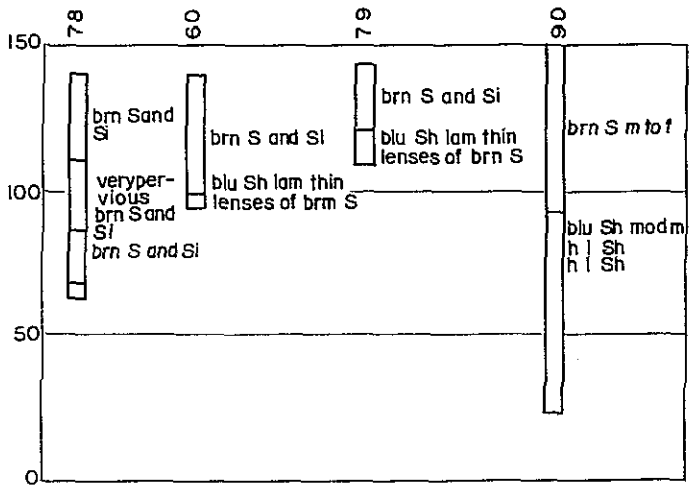
LEGEND

Sand	S
Shale	Sh
Clay	Cl
Silt	Si
Blue	blu
Brown	brn
Grey	gry
Fine grained	f
Medium grained	m
Coarse grained	cg
Soft	so
Moderatly	mod
Hard	h
Stiff	st
Partially	part
Compacted	co
Layers	l
Massive	ma
Laminated	lam

Fig. A-10 GEOLOGICAL LOG OF DRILL HOLE (2)



SECTION B-B



SECTION C-C

Table A-24 Monthly Inflow

(Unit: 10^9cu.ft.)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1936	2.1	1.5	0.9	11.9	52.2	77.8	92.4	158.0	77.4	38.1	8.0	5.1
1937	2.1	1.6	1.0	2.0	10.3	53.5	62.7	203.6	92.5	47.8	8.0	23.8
1938	3.5	2.3	3.1	2.5	32.8	96.4	81.0	139.0	177.8	57.9	30.3	11.0
1939	6.2	3.7	3.1	8.0	13.3	30.3	80.6	190.2	100.8	70.2	8.9	6.2
1940	2.6	1.9	8.2	2.5	17.4	71.5	42.1	109.8	145.2	30.8	8.0	3.6
1941	2.6	5.6	1.0	12.4	98.6	176.0	245.1	114.9	103.2	56.0	12.4	6.2
1942	3.6	1.9	23.6	2.0	27.7	77.0	158.8	141.7	113.3	60.0	13.9	7.7
1943	3.6	2.8	2.9	6.2	4.1	26.3	77.4	94.3	111.2	23.1	6.0	3.6
1944	2.6	1.9	1.5	3.0	7.2	81.9	104.7	69.9	95.4	32.8	7.5	6.7
1945	6.2	5.1	2.1	2.0	13.8	65.6	53.8	142.5	123.8	38.4	12.4	13.3
1946	2.6	1.9	4.1	7.5	32.8	32.8	223.1	89.2	93.8	58.9	12.4	12.3
1947	3.5	2.3	2.1	3.0	13.3	173.9	188.8	305.4	173.7	101.2	16.4	8.7
1948	4.1	3.7	3.6	8.8	60.0	57.5	49.0	128.6	113.3	39.5	8.4	4.7
1949	2.6	1.4	2.1	12.4	38.6	54.2	134.2	90.8	92.8	80.9	13.2	5.1
1950	3.1	2.6	3.1	3.5	4.6	20.8	24.2	142.8	72.6	51.8	27.2	5.1
1951	3.1	1.9	2.1	5.0	27.7	92.5	151.9	129.9	94.9	158.0	23.3	15.4
1952	10.3	6.5	6.2	12.4	22.6	101.9	154.3	85.7	95.4	105.5	27.8	9.2
1953	4.1	2.8	2.6	3.0	38.6	106.3	75.9	152.9	169.8	63.6	16.8	9.2
1954	6.7	3.2	3.1	4.5	6.7	62.5	89.2	200.4	98.2	88.1	19.4	10.8
1955	10.8	6.5	12.3	21.8	32.8	80.9	140.4	129.9	57.0	27.8	43.2	8.2
1956	4.1	2.8	3.6	2.5	20.0	283.8	129.2	154.3	102.4	48.2	31.8	6.7
1957	6.7	3.2	2.6	2.0	6.7	24.8	64.6	36.4	56.6	42.6	6.9	4.6
1958	3.1	2.3	2.1	1.8	13.3	17.9	33.3	38.0	74.7	57.9	15.4	4.1
1959	4.1	5.6	9.2	4.0	12.3	143.9	98.0	98.6	72.6	72.9	56.6	27.8
1960	5.1	3.7	4.1	3.5	5.1	54.6	149.5	57.4	61.6	54.9	20.0	10.3
1961	5.9	4.6	8.2	6.2	6.2	148.3	191.0	148.4	93.8	52.4	11.7	6.3
1962	4.8	3.4	5.6	10.5	13.6	182.0	59.5	105.8	96.9	39.9	18.8	4.0
1963	8.2	2.7	6.4	19.0	27.9	233.3	251.8	77.7	48.2	98.0	28.4	5.9
1964	8.0	4.9	6.1	14.2	39.7	40.5	86.8	75.3	87.9	79.3	14.7	11.7
1965	8.3	10.9	5.5	9.4	31.1	80.9	156.2	135.8	61.7	86.8	17.0	15.5
1966	18.7	2.7	7.0	9.9	19.8	82.2	126.2	114.1	103.7	64.3	12.8	8.7
1967	2.8	1.2	11.7	11.2	19.8	34.1	124.6	80.1	69.7	81.2	8.1	8.0
1968	10.6	11.8	12.1	13.8	26.3	127.0	309.4	125.1	96.9	31.3	12.5	14.3

Table A-25 Power Release, 2-unit Operation

(Unit: 10^9 cu. ft.)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1936	23.3	21.7	25.0	25.1	26.2	34.3	35.5	37.0	34.1	24.4	23.2	24.6
1937	25.6	24.2	28.6	30.4	30.6	29.7	31.3	38.9	34.4	24.2	22.8	23.9
1938	24.3	22.8	26.3	26.9	29.4	25.9	35.3	36.5	36.4	24.1	28.0	23.1
1939	23.7	22.0	25.3	25.5	27.9	27.3	26.5	37.8	34.5	33.4	22.4	23.7
1940	24.5	23.0	26.5	26.9	30.0	27.6	26.7	36.1	35.6	24.6	23.4	25.0
1941	26.1	24.6	29.1	30.7	29.6	36.7	39.4	35.9	34.6	24.1	22.5	23.8
1942	24.5	23.0	26.1	26.0	28.2	26.0	37.0	36.5	34.8	24.1	22.3	23.5
1943	*24.2*	*22.6*	*26.1*	*26.5*	*29.9*	*30.5*	*29.3*	*34.4*	*34.7*	*24.7*	*23.8*	*25.5*
1944	26.7	25.5	30.6	29.9	10.1	30.2	27.6	35.2	34.4	24.6	23.4	24.9
1945	25.8	24.2	28.5	30.2	30.8	30.3	30.0	37.3	35.0	24.4	23.1	24.3
1946	24.9	23.5	27.3	28.0	30.5	29.2	39.4	35.4	34.4	24.6	22.3	23.5
1947	24.1	22.5	26.0	26.5	29.6	37.1	37.9	40.8	36.3	34.0	22.3	23.4
1948	24.1	22.5	25.9	26.1	27.1	24.6	34.7	36.2	34.8	24.4	23.1	24.6
1949	25.5	24.2	28.5	29.6	31.9	29.2	37.1	35.4	34.4	33.6	22.3	23.6
1950	24.4	22.8	26.4	27.0	30.8	30.6	31.2	28.1	34.1	24.2	22.3	23.4
1951	24.1	22.6	26.1	26.5	29.0	25.9	36.8	36.3	34.4	35.1	22.2	23.1
1952	23.5	21.7	24.7	24.6	26.5	34.9	36.8	35.3	34.4	34.1	26.8	23.1
1953	23.8	22.2	25.5	25.9	27.8	35.2	35.1	36.8	36.2	28.2	22.3	23.4
1954	24.0	22.3	25.7	26.1	29.3	27.8	30.8	38.1	34.5	33.8	22.2	23.3
1955	23.8	22.0	25.0	24.6	25.9	34.3	36.5	36.2	33.7	24.6	22.9	23.6
1956	24.3	22.7	26.3	26.8	29.8	40.2	36.2	36.9	34.6	24.3	22.4	23.3
1957	24.0	22.3	25.6	26.1	29.4	29.6	29.2	27.6	25.7	25.4	24.1	25.8
1958	27.1	26.1	31.8	23.2	13.1	18.1	29.4	29.9	30.7	29.1	26.8	29.3
1959	31.9	25.2	8.8	3.2	12.2	29.2	35.9	35.6	34.0	33.5	31.6	25.9
1960	23.2	21.6	24.7	24.9	27.5	26.5	37.1	34.8	33.8	24.1	22.4	23.4
1961	24.1	22.4	25.6	25.7	28.6	36.4	37.8	36.6	34.4	24.1	22.5	23.9
1962	24.6	23.0	26.6	26.9	29.9	37.3	34.8	35.7	34.5	24.4	22.9	24.2
1963	24.9	23.3	27.0	27.1	29.1	38.5	39.6	35.2	33.5	34.0	26.4	23.2
1964	23.9	22.1	25.3	25.3	26.8	25.2	35.6	35.1	34.3	33.6	22.3	23.4
1965	24.0	22.1	25.2	25.3	27.2	31.4	36.9	36.4	33.8	33.8	22.3	23.3
1966	23.5	21.7	24.8	24.8	26.8	31.9	36.2	35.9	34.6	29.4	22.3	23.5
1967	24.2	22.7	26.1	26.0	28.3	27.5	36.8	35.2	33.9	33.6	22.4	23.7
1968	24.3	22.4	25.4	25.2	27.0	35.5	40.9	36.1	34.5	24.6	23.3	24.6

Table A-26 Reservoir Water Level, 2-unit Operation

(Unit: EL. ft.)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1936	118.0	114.7	111.7	107.9	105.6	109.7	113.0	113.0	113.0	113.0	114.8	112.5
1937	109.7	105.9	102.1	95.9	88.6	82.3	90.1	98.0	113.0	113.0	116.3	113.9
1938	113.7	110.7	107.4	103.3	98.4	99.2	111.5	113.0	113.0	113.0	117.8	118.0
1939	116.0	113.3	110.6	106.8	103.8	101.4	102.2	111.3	113.0	113.0	118.0	115.8
1940	113.1	109.9	106.5	103.5	98.4	96.0	104.9	107.5	113.0	113.0	113.8	111.4
1941	108.1	104.2	100.7	94.2	89.6	104.6	113.0	113.0	113.0	113.0	117.5	115.7
1942	113.0	109.9	106.4	105.7	101.8	101.6	109.9	113.0	113.0	113.0	117.9	116.6
1943	114.0	111.1	107.9	104.0	100.0	94.2	93.5	103.7	113.0	113.0	112.6	110.0
1944	106.3	102.4	97.4	89.9	81.1	80.0	95.6	109.6	113.0	113.0	113.9	111.5
1945	108.7	105.5	102.3	96.4	89.1	83.9	94.2	99.8	113.0	113.0	114.9	113.2
1946	111.6	108.1	104.4	100.2	95.8	96.4	97.2	113.0	113.0	113.0	118.0	116.3
1947	114.6	111.6	108.4	104.3	99.7	96.5	113.0	113.0	113.0	113.0	118.0	116.9
1948	114.5	111.6	108.7	104.9	102.2	107.7	112.7	113.0	113.0	113.0	115.0	112.7
1949	109.7	106.0	102.1	96.3	92.2	93.7	99.6	113.0	113.0	113.0	118.0	116.4
1950	113.5	110.4	107.1	103.1	98.3	92.2	89.9	88.1	111.2	113.0	116.8	117.3
1951	114.4	111.3	108.0	103.9	99.9	99.7	111.2	113.0	113.0	113.0	118.0	117.9
1952	116.5	114.3	112.0	109.1	107.1	106.5	113.0	113.0	113.0	113.0	118.0	118.0
1953	115.7	112.7	109.8	105.9	102.0	103.8	113.0	113.0	113.0	113.0	118.0	117.0
1954	114.6	112.1	109.2	105.3	101.4	96.5	104.0	113.0	113.0	113.0	118.0	117.3
1955	115.2	113.2	110.9	108.8	108.1	109.1	113.0	113.0	113.0	113.0	113.3	116.1
1956	113.7	110.8	107.5	103.6	98.7	96.6	113.0	113.0	113.0	113.0	116.3	117.5
1957	114.9	112.4	109.5	105.5	101.1	96.3	95.5	102.8	104.2	109.2	111.4	108.7
1958	105.2	100.8	95.5	87.6	80.0	80.0	80.0	81.3	84.6	96.7	102.5	99.9
1959	94.2	87.0	80.0	80.0	80.0	80.0	107.3	113.0	113.0	113.0	118.0	118.0
1960	118.0	115.1	112.4	109.2	105.5	101.8	106.7	113.0	113.0	113.0	117.3	116.7
1961	114.5	111.9	109.1	106.2	103.0	98.1	113.0	113.0	113.0	113.0	117.1	115.3
1962	112.6	109.7	106.5	102.8	99.2	95.6	113.0	113.0	113.0	113.0	115.1	114.2
1963	111.3	108.6	105.1	101.41	99.5	99.3	113.0	113.0	113.0	113.0	118.0	118.0
1964	115.2	112.8	110.2	106.9	105.0	106.9	109.4	113.0	113.0	113.0	118.0	116.7
1965	114.7	112.3	110.7	107.4	104.5	105.0	113.0	113.0	113.0	113.0	118.0	117.0
1966	115.7	114.7	111.9	109.0	106.4	105.2	113.0	113.0	113.0	113.0	118.0	116.4
1967	114.1	110.9	107.5	105.0	102.4	100.4	102.0	113.0	113.0	113.0	118.0	115.7
1968	113.2	111.1	109.6	107.3	105.2	105.0	113.0	113.0	113.0	113.0	113.7	112.1

Table A-27 Tailwater level, 2-unit Operation

(Unit: EL. ft.)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1936	14.7	14.9	15.1	15.3	17.3	18.6	20.4	24.0	19.6	17.1	14.9	15.0
1937	15.2	15.5	15.8	16.2	17.7	17.7	17.7	21.3	20.4	17.1	14.8	14.9
1938	14.9	15.1	15.4	15.6	17.6	17.4	19.1	22.7	25.4	17.1	14.7	14.7
1939	14.8	15.0	15.1	15.4	17.5	17.5	17.3	25.0	20.9	17.2	14.7	14.8
1940	15.0	15.2	15.4	15.6	17.6	17.5	17.4	19.2	23.5	17.1	14.9	15.1
1941	15.3	15.5	15.8	16.3	17.6	22.0	29.1	21.4	21.0	17.1	14.7	14.8
1942	15.0	15.2	15.3	15.5	17.5	17.4	22.5	22.9	21.6	17.1	14.7	14.8
1943	14.9	15.1	15.3	15.6	17.6	17.7	17.6	17.3	21.4	17.2	15.0	15.2
1944	15.4	15.7	16.1	16.1	17.6	17.7	17.4	17.9	20.6	17.1	14.9	15.1
1945	15.2	15.5	15.7	16.2	17.7	17.7	17.6	18.7	22.0	17.1	14.8	14.9
1946	15.1	15.3	15.5	15.8	17.7	17.6	22.2	20.1	20.5	17.1	14.7	14.8
1947	14.9	15.1	15.3	15.6	17.6	19.7	25.9	31.9	25.1	18.9	14.7	14.8
1948	14.9	15.1	15.3	15.5	17.4	17.2	18.0	22.1	21.5	17.1	14.9	15.0
1949	15.2	15.5	15.7	16.1	17.8	17.6	18.3	20.2	20.5	17.9	14.7	14.8
1950	15.0	15.1	15.4	15.6	17.7	17.8	17.7	17.5	18.7	17.1	14.7	14.8
1951	14.9	15.1	15.3	15.6	17.6	17.4	22.8	22.3	20.5	21.9	14.6	14.7
1952	14.8	14.9	15.0	15.2	17.3	18.8	23.6	19.9	20.5	19.2	14.6	14.7
1953	14.8	15.0	15.2	15.5	17.5	18.1	19.4	23.5	24.8	17.1	14.7	14.8
1954	14.9	15.0	15.2	15.5	17.6	17.5	17.3	26.4	20.7	18.3	14.7	14.7
1955	14.8	15.0	15.1	15.2	17.3	18.5	22.9	22.1	18.6	17.2	14.8	14.8
1956	14.9	15.1	15.3	15.6	17.6	25.9	22.2	23.7	20.9	17.1	14.7	14.7
1957	14.9	15.0	15.2	15.5	17.6	17.7	17.6	17.4	17.3	17.2	15.1	15.3
1958	15.5	15.8	16.3	16.0	17.6	17.6	17.6	17.6	17.8	17.6	15.6	15.9
1959	16.3	16.0	15.9	15.9	17.6	17.7	18.7	20.7	19.4	17.5	17.6	14.6
1960	14.7	14.9	15.0	15.2	17.4	17.4	21.2	18.51	18.8	17.1	14.7	14.8
1961	14.9	15.0	15.2	15.4	17.5	18.8	25.9	23.2	20.5	17.1	14.7	14.8
1962	15.0	15.2	15.4	15.6	17.6	19.8	18.7	21.0	20.6	17.1	14.8	14.9
1963	15.1	15.3	15.5	15.7	17.6	23.7	29.6	19.5	18.1	18.8	14.6	14.7
1964	14.8	15.0	15.2	15.3	17.4	17.3	18.8	19.4	20.2	17.8	14.7	14.8
1965	14.9	15.0	15.1	15.3	17.4	17.3	23.8	22.6	18.8	18.3	14.7	14.7
1966	14.8	14.9	15.0	15.2	17.4	17.3	22.0	21.4	21.0	17.1	14.7	14.8
1967	14.9	15.1	15.3	15.5	17.5	17.5	18.4	19.7	19.3	17.8	14.7	14.8
1968	14.9	15.0	15.2	15.3	17.4	19.6	32.0	21.9	20.6	17.1	14.9	15.0

Table A-28 Maximum Power, 2-unit Operation

(Unit: MW)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1936	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1937	92.0	92.0	92.0	92.0	80.0	81.4	92.0	92.0	92.0	92.0	92.0	92.0
1938	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1939	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1940	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1941	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1942	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1943	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1944	92.0	92.0	92.0	83.0	70.7	85.0	92.0	92.0	92.0	92.0	92.0	92.0
1945	92.0	92.0	92.0	92.0	81.5	86.3	92.0	92.0	92.0	92.0	92.0	92.0
1946	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1947	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1948	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1949	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1950	92.0	92.0	92.0	92.0	92.0	88.9	85.4	92.0	92.0	92.0	92.0	92.0
1951	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1952	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1953	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1954	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1955	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1956	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1957	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1958	92.0	92.0	92.0	79.5	69.8	69.8	71.0	74.7	89.1	92.0	92.0	92.0
1959	91.0	78.7	72.8	72.7	69.8	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1960	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1961	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1962	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1963	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1964	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1965	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1966	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1967	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0
1968	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0	92.0

Table A-29 Monthly Energy Output, 2-unit Operation

(Unit: 10^6kWh)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1936	49.3	44.5	49.3	47.7	49.3	66.2	68.4	68.4	66.2	49.3	47.7	49.3	655.7
1937	49.3	44.5	49.3	47.7	42.8	42.2	49.3	68.4	66.2	49.3	47.7	49.3	606.1
1938	49.3	44.5	49.3	47.7	49.3	47.7	68.4	68.4	66.2	49.3	60.3	49.3	649.7
1939	49.3	44.5	49.3	47.7	49.3	47.7	49.3	68.4	66.2	68.4	47.7	49.3	637.1
1940	49.3	44.5	49.3	47.7	49.3	47.7	49.3	68.4	66.2	49.3	47.7	49.3	618.0
1941	49.3	44.5	49.3	47.7	49.3	66.2	68.4	68.4	66.2	49.3	47.7	49.3	655.7
1942	49.3	44.5	49.3	47.7	49.3	47.7	68.4	68.4	66.2	49.3	47.7	49.3	637.1
1943	49.3	44.5	49.3	47.7	49.3	47.7	49.3	65.4	66.2	49.3	47.7	49.3	614.9
1944	49.3	44.5	49.3	43.0	13.0	44.1	49.3	68.4	66.2	49.3	47.7	49.3	573.4
1945	49.3	44.5	49.3	47.7	43.7	44.8	49.3	68.4	66.2	49.3	47.7	49.3	609.4
1946	49.3	44.5	49.3	47.7	49.3	47.7	68.4	68.4	66.2	50.4	47.7	49.3	638.2
1947	49.3	44.5	49.3	47.7	49.3	66.2	68.4	68.4	66.2	68.4	47.7	49.3	674.9
1948	49.3	44.5	49.3	47.7	49.3	47.7	68.4	68.4	66.2	49.3	47.7	49.3	637.1
1949	49.3	44.5	49.3	47.7	49.3	47.7	68.4	68.4	66.2	68.4	47.7	49.3	656.3
1950	49.3	44.5	49.3	47.7	49.3	46.1	45.7	49.3	66.2	49.3	47.7	49.3	593.7
1951	49.3	44.5	49.3	47.7	49.3	47.7	68.4	68.4	66.2	68.4	47.7	49.3	656.3
1952	49.3	44.5	49.3	47.7	49.3	66.2	68.4	68.4	66.2	68.4	57.7	49.3	684.9
1953	49.3	44.5	49.3	47.7	49.3	66.2	68.4	68.4	66.2	57.8	47.7	49.3	664.2
1954	49.3	44.5	49.3	47.7	49.3	47.7	58.7	68.4	66.2	68.4	47.7	49.3	646.5
1955	49.3	44.5	49.3	47.7	49.3	66.2	68.4	68.4	66.2	49.6	47.7	49.3	655.7
1956	49.3	44.5	49.3	47.7	49.3	66.2	68.4	68.4	66.2	49.3	47.7	49.3	655.7
1957	49.3	44.5	49.3	47.7	49.3	47.7	49.3	49.3	47.7	49.3	47.7	49.3	580.3
1958	49.3	44.5	49.3	32.4	16.8	23.2	38.0	40.0	46.2	49.3	47.7	49.3	485.9
1959	48.7	35.0	11.6	4.2	15.6	47.7	68.4	68.4	66.2	68.4	66.2	55.9	556.5
1960	49.3	44.5	49.3	47.7	49.3	47.7	68.4	68.4	66.2	49.3	47.7	49.3	537.1
1961	49.3	44.5	49.3	47.7	49.3	66.2	68.4	68.4	66.2	49.3	47.7	49.3	655.7
1962	49.3	44.5	49.3	47.7	49.3	66.2	68.4	68.4	66.2	49.3	47.7	49.3	655.7
1963	49.3	44.5	49.3	47.7	49.3	66.2	68.4	68.4	66.2	68.4	56.9	49.3	684.1
1964	49.3	44.5	49.3	47.7	49.3	47.7	68.4	68.4	66.2	68.4	47.7	49.3	656.3
1965	49.3	44.5	49.3	47.7	49.3	60.1	68.4	68.4	66.2	68.4	47.7	49.3	668.7
1966	49.3	44.5	49.3	47.7	49.3	61.2	68.4	68.4	66.2	60.2	47.7	49.3	661.6
1967	49.3	44.5	49.3	47.7	49.3	47.7	68.4	68.4	66.2	68.4	47.7	49.3	656.3
1968	49.3	44.5	49.3	47.7	49.3	66.2	68.4	68.4	66.2	49.3	47.7	49.3	655.7

Table A-30 Power Release, 3-unit Operation

(Unit: 10^9 cu. ft.)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1936	26.0	23.9	27.0	26.7	27.6	25.8	59.7	60.7	57.6	25.8	24.9	26.2
1937	26.7	24.6	28.2	27.8	27.5	26.9	28.8	62.0	57.8	25.6	24.4	25.7
1938	26.1	24.0	27.1	27.0	28.4	26.3	59.6	60.3	59.2	25.4	26.7	24.7
1939	25.4	23.6	26.6	26.2	27.6	26.9	27.0	61.3	57.9	34.3	23.9	25.4
1940	26.2	24.1	27.1	26.9	28.7	27.1	27.0	60.1	58.6	25.9	25.1	26.4
1941	26.9	24.8	28.4	27.8	28.3	59.4	62.4	60.0	57.9	25.4	24.0	25.5
1942	26.2	24.1	27.0	26.5	27.9	26.3	60.7	60.4	58.1	25.4	23.9	25.3
1943	26.1	23.9	29.0	26.8	28.8	27.9	28.3	29.9	58.0	26.1	25.4	26.6
1944	27.2	25.3	29.1	26.8	10.7	27.3	27.3	50.3	57.8	25.9	25.1	26.4
1945	26.8	24.7	28.1	27.9	27.7	27.5	28.3	60.9	58.2	25.8	24.7	26.1
1946	26.4	24.3	27.6	27.5	29.0	27.8	62.5	59.6	57.8	25.3	23.9	25.2
1947	25.9	23.9	27.0	26.8	28.6	59.7	61.3	63.5	59.1	57.8	23.8	25.1
1948	25.9	23.8	26.9	26.5	27.3	25.7	39.4	60.2	58.1	25.8	24.8	26.2
1949	26.7	24.6	23.2	28.2	28.8	27.6	52.6	59.6	57.8	45.6	23.8	25.3
1950	26.1	24.0	27.1	27.0	29.1	27.5	28.2	27.5	57.5	25.5	23.9	25.1
1951	26.0	23.9	27.0	26.8	28.3	26.3	60.6	60.2	57.8	59.4	23.6	24.7
1952	25.2	23.4	26.4	25.9	27.0	51.4	60.6	59.6	57.8	57.9	26.8	24.7
1953	25.5	23.7	26.7	26.4	27.6	42.7	59.4	60.6	59.0	28.2	23.8	25.1
1954	25.8	23.8	26.8	26.5	28.4	27.2	26.7	61.5	57.8	53.9	23.7	24.9
1955	25.6	23.6	26.5	25.8	26.8	44.2	60.4	60.2	56.3	26.0	24.6	25.4
1956	26.1	24.0	27.1	27.0	28.7	62.0	60.2	60.6	57.9	25.6	24.0	25.0
1957	25.8	23.8	26.8	26.6	28.5	28.2	28.3	27.5	26.1	26.5	25.6	26.9
1958	27.6	25.8	28.4	16.6	13.1	18.0	26.6	27.3	28.0	27.6	26.4	27.9
1959	29.0	25.4	22.6	3.2	12.2	27.6	59.9	59.8	57.5	39.2	53.7	25.9
1960	24.8	23.2	26.3	25.9	27.4	26.5	60.8	57.1	57.3	25.4	23.9	25.2
1961	25.9	23.8	26.8	26.4	28.1	52.0	61.3	60.5	57.8	25.5	24.1	25.6
1962	26.3	24.1	27.2	27.0	28.7	59.9	59.1	59.8	57.8	25.7	24.6	26.0
1963	26.4	24.3	27.4	27.1	28.3	60.7	62.6	59.5	49.0	57.7	26.4	24.8
1964	25.6	23.7	26.6	26.1	27.1	25.9	56.3	59.4	57.7	44.8	23.8	25.1
1965	25.8	23.7	26.6	26.2	27.3	25.8	60.7	60.3	57.3	52.7	23.8	24.9
1966	25.3	23.4	26.4	25.9	27.2	25.8	60.1	60.0	57.9	29.4	23.8	25.2
1967	26.1	24.0	27.0	26.5	27.9	27.1	48.3	59.5	57.5	45.5	23.9	25.5
1968	26.1	23.8	26.7	26.1	27.3	58.6	63.5	60.1	57.8	25.9	25.1	26.2

Table A-31 Reservoir Water Level, 3-unit Operation

(Unit: EL. ft.)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1936	114.0	110.6	107.0	102.5	99.2	104.0	112.3	113.0	113.0	113.0	114.6	112.1
1937	109.0	104.9	100.7	94.5	87.8	82.3	90.8	99.0	113.0	113.0	116.1	113.5
1938	113.0	109.7	106.1	102.0	96.6	97.8	110.4	113.0	113.0	113.0	117.6	118.0
1939	115.7	112.8	109.8	105.8	102.8	99.9	101.0	110.4	113.0	113.0	118.0	115.6
1940	112.7	109.2	105.5	102.4	97.1	94.7	104.1	106.6	113.0	113.0	113.6	111.0
1941	107.4	103.3	99.5	93.0	89.1	104.5	113.0	113.0	113.0	113.0	117.3	115.3
1942	112.4	109.0	105.2	104.4	99.9	99.7	108.5	113.0	113.0	113.0	117.7	116.2
1943	113.4	110.2	106.7	102.7	98.3	92.3	92.3	103.0	113.0	113.0	112.5	109.5
1944	105.7	101.6	96.4	89.2	81.3	80.0	96.2	110.1	113.0	113.0	113.7	111.1
1945	108.0	104.6	101.1	95.1	88.2	83.9	94.9	100.8	113.0	113.0	114.7	112.8
1946	110.9	107.2	103.3	98.7	94.1	95.2	96.3	113.0	113.0	113.0	117.9	116.0
1947	114.0	110.8	107.3	103.0	98.1	94.8	113.0	113.0	113.0	113.0	118.0	116.6
1948	114.0	110.9	107.7	103.7	100.6	106.4	111.4	113.0	113.0	113.0	114.8	112.3
1949	109.0	105.1	100.8	94.9	91.1	93.4	99.7	113.0	113.0	113.0	118.0	116.2
1950	113.1	109.7	106.2	102.1	96.9	90.9	89.4	88.4	111.4	113.0	116.6	116.9
1951	113.7	110.5	106.8	102.6	98.1	98.1	110.0	113.0	113.0	113.0	118.0	117.7
1952	116.0	113.7	111.2	107.9	105.6	104.9	113.0	113.0	113.0	113.0	118.0	118.0
1953	115.5	112.3	109.1	105.0	100.6	102.8	113.0	113.0	113.0	113.0	118.0	116.7
1954	114.2	111.4	108.2	104.1	99.7	95.0	103.0	112.7	113.0	113.0	118.0	117.1
1955	114.8	112.5	109.9	107.6	106.6	107.6	113.0	113.0	113.0	113.0	113.0	115.7
1956	113.0	109.8	106.3	102.3	96.9	94.9	113.0	113.0	113.0	113.0	116.1	117.1
1957	114.2	111.5	108.3	104.1	99.1	94.3	93.7	101.8	103.3	108.2	110.4	107.3
1958	103.5	98.7	93.1	85.6	80.0	80.0	80.0	82.3	86.5	98.4	104.0	102.1
1959	96.9	90.8	85.0	80.0	80.0	80.0	107.6	113.0	113.0	113.0	118.0	118.0
1960	118.0	114.9	112.0	108.5	104.6	100.6	105.8	113.0	113.0	113.0	117.1	116.3
1961	113.9	111.0	107.9	104.8	101.3	96.1	113.0	113.0	113.0	113.0	116.9	114.9
1962	112.0	108.8	105.3	101.3	97.6	93.9	113.0	113.0	113.0	113.0	114.9	113.8
1963	110.6	107.7	104.0	99.7	98.1	98.0	113.0	113.0	113.0	113.0	118.0	118.0
1964	115.0	112.3	109.5	105.9	103.9	105.7	108.2	113.0	113.0	113.0	118.0	116.5
1965	114.2	111.7	109.7	106.1	103.1	103.6	112.6	113.0	113.0	113.0	118.0	116.8
1966	115.2	114.0	111.0	107.8	104.9	103.6	112.5	113.0	113.0	113.0	118.0	116.2
1967	113.6	110.2	106.5	103.8	100.9	99.0	100.5	113.0	113.0	113.0	118.0	115.4
1968	112.7	110.5	108.6	106.1	103.9	103.6	113.0	113.0	113.0	113.0	113.6	111.7

Table A-32 Tailwater Level, 3-unit Operation

(Unit: EL' ft.)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1936	17.8	17.9	18.0	18.1	18.7	18.7	20.0	24.0	19.6	18.6	17.7	17.9
1937	17.9	18.0	18.2	18.3	18.7	18.8	18.9	21.6	20.4	18.6	17.7	17.7
1938	17.8	17.9	18.0	18.1	18.8	18.7	18.7	22.7	25.4	18.5	17.5	17.5
1939	17.7	17.8	17.9	18.0	18.7	18.8	18.7	24.6	20.9	18.5	17.5	17.7
1940	17.8	17.9	18.0	18.1	18.9	18.8	18.7	19.0	23.5	18.6	17.8	17.9
1941	18.0	18.1	18.2	18.3	18.8	22.0	29.1	21.4	21.0	18.5	17.6	17.7
1942	17.9	17.9	18.0	18.0	18.8	18.7	22.0	22.9	21.6	18.5	17.5	17.7
1943	17.8	17.9	18.0	18.1	18.9	18.9	18.8	18.7	21.4	18.6	17.8	17.9
1944	18.0	18.1	18.4	18.1	18.6	18.8	18.7	18.6	20.6	18.6	17.8	17.9
1945	17.9	18.0	18.2	18.3	18.7	18.8	18.8	18.9	22.0	18.6	17.7	17.8
1946	17.9	18.0	18.1	18.2	18.9	18.9	22.0	20.1	20.5	18.5	17.5	17.6
1947	17.8	17.9	18.0	18.1	18.8	19.3	25.9	31.9	25.1	18.9	17.5	17.6
1948	17.8	17.9	18.0	18.0	18.7	18.7	18.6	22.1	21.5	18.6	17.7	17.9
1949	17.9	18.0	18.2	18.4	18.9	18.8	18.7	20.2	20.5	18.5	17.5	17.7
1950	17.8	17.9	18.0	18.1	18.9	18.8	18.8	18.7	18.7	18.5	17.5	17.6
1951	17.8	17.9	18.0	18.1	18.8	18.7	22.3	22.3	20.5	21.9	17.5	17.5
1952	17.7	17.8	17.9	17.9	18.7	18.7	23.6	19.9	20.5	19.2	17.5	17.5
1953	17.7	17.9	17.9	18.0	18.7	18.7	19.4	23.5	24.8	18.5	17.5	17.6
1954	17.8	17.9	18.0	18.1	18.8	18.8	18.7	26.2	20.7	18.5	17.5	17.6
1955	17.7	17.8	17.9	17.9	18.7	18.6	22.9	22.1	18.6	18.6	17.7	17.7
1956	17.8	17.9	18.0	18.1	18.9	25.5	22.2	23.7	20.9	18.6	17.6	17.6
1957	17.8	17.9	18.0	18.1	18.8	18.9	18.8	18.7	18.7	18.6	17.9	18.0
1958	18.1	18.3	18.2	18.0	18.6	18.6	18.7	18.7	18.9	18.7	18.0	18.1
1959	18.4	18.2	18.0	17.9	18.6	18.8	18.7	20.7	19.4	18.5	17.6	17.5
1960	17.6	17.7	17.9	17.9	18.7	18.7	20.9	18.6	18.8	18.5	17.5	17.6
1961	17.8	17.9	17.9	18.0	18.8	18.7	25.9	23.2	20.5	18.5	17.6	17.7
1962	17.9	17.9	18.0	18.1	18.9	19.5	18.7	21.0	20.6	18.6	17.7	17.8
1963	17.9	18.0	18.1	18.1	18.8	23.3	29.6	19.5	18.6	18.8	17.5	17.6
1964	17.7	17.8	17.9	18.0	18.7	18.7	18.6	19.4	20.2	18.5	17.5	17.6
1965	17.8	17.9	17.9	18.0	18.7	18.7	23.6	22.6	18.8	18.5	17.5	17.6
1966	17.7	17.8	17.9	17.9	18.7	18.7	21.8	21.4	21.0	18.5	17.5	17.5
1967	17.8	17.9	18.0	18.0	18.8	18.8	18.7	19.7	19.3	18.5	17.5	17.7
1968	17.8	17.9	17.9	18.0	18.7	19.1	32.0	21.9	20.6	18.6	17.8	17.9

Table A-33 Maximum Power, 3-unit Operation

(Unit: MW)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1936	156.8	153.5	149.2	145.2	145.6	152.2	155.3	151.6	156.1	156.8	156.8	155.4
1937	151.6	147.4	142.0	132.4	115.6	120.1	139.1	147.5	155.2	156.8	156.8	156.8
1938	156.3	152.6	148.5	143.5	140.9	148.3	155.7	152.8	150.1	156.8	156.8	156.8
1939	156.8	156.3	152.5	148.7	145.2	144.1	149.6	149.5	154.8	156.8	156.8	156.8
1940	155.8	152.0	148.4	144.0	139.7	143.3	149.1	153.6	152.1	156.8	156.8	154.0
1941	149.9	146.0	140.8	131.9	141.4.	149.5	146.3	154.2	154.7	156.8	156.8	156.8
1942	155.6	151.7	149.3	146.8	143.4	148.21	151.4	152.7	154.0	156.8	156.8	156.8
1943	156.8	153.2	149.2	144.8	139.3	133.6	141.7	152.2	154.2	156.8	155.9	152.3
1944	148.1	143.2	136.7	118.2	103.4	125.5	147.6	155.6	155.1	156.8	156.8	154.3
1945	150.8	147.3	142.4	133.7	118.0	127.4	141.6	150.9	153.6	156.8	156.8	156.8
1946	153.8	149.7	145.5	140.8	138.5	139.5	146.1	155.6	155.1	156.8	156.8	156.8
1947	156.8	153.8	149.6	145.0	140.3	148.3	149.5	143.5	150.4	156.8	156.8	156.8
1948	156.8	154.1	150.3	146.7	147.4	152.9	156.3	153.4	154.1	156.8	156.8	155.6
1949	151.7	147.5	142.2	137.0	133.6	140.5	150.8	155.5	155.1	156.8	156.8	156.8
1950	156.3	152.6	148.5	143.6	137.9	128.0	124.7	145.9	156.2	156.8	156.8	156.8
1951	156.8	153.3	149.2	144.7	141.7	148.3	151.8	153.3	155.1	156.3	156.8	156.8
1952	156.8	156.8	154.3	151.4	149.1	153.1	151.9	155.8	155.1	156.8	156.8	156.8
1953	156.8	155.6	151.7	147.3	145.5	152.1	156.3	152.0	150.7	156.8	156.8	156.8
1954	156.8	154.6	150.7	146.6	141.2	142.7	152.0	149.1	155.0	156.8	156.8	156.8
1955	156.8	156.1	153.4	151.7	150.9	154.4	152.6	153.4	156.8	156.8	156.8	156.8
1956	156.3	152.7	148.7	143.8	139.7	142.1	153.4	151.8	154.7	156.8	156.8	156.8
1957	156.8	154.7	150.7	146.3	140.6	138.0	141.6	146.2	149.5	153.2	153.6	149.9
1958	145.7	140.3	128.0	110.3	101.8	101.8	104.6	113.4	135.1	145.2	147.4	143.7
1959	138.4	124.2	109.4	103.7	101.8	140.6	154.3	155.0	156.3	156.8	156.8	156.8
1960	156.8	156.8	155.2	151.2	146.5	147.0	151.2	156.8	156.8	156.8	156.8	156.8
1961	156.8	154.2	150.9	147.5	142.3	149.4	149.6	152.4	155.2	156.8	156.8	156.8
1962	155.3	151.7	147.8	143.6	139.6	147.8	156.8	154.7	155.01	156.8	156.8	156.8
1963	153.9	150.4	146.5	143.1	141.7	145.4	145.8	156.2	156.8	156.8	156.8	156.8
1964	156.8	155.8	152.4	149.4	148.6	150.8	154.8	156.3	155.5	156.8	156.8	156.8
1965	156.8	155.6	152.6	149.1	147.0	152.2	151.7	153.0	156.8	156.8	156.8	156.8
1966	156.8	156.8	154.2	150.9	148.0	152.2	153.6	154.2	154.7	156.8	156.8	156.8
1967	156.8	153.0	149.6	146.9	143.5	143.3	151.1	156.1	156.5	156.8	156.8	156.8
1968	156.5	154.3	152.0	149.4	147.4	152.0	143.4	153.7	155.0	156.8	156.8	155.6

Table A-34 Month Energy Output, 3-unit Operation

(Unit: 10^6kWh)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1936	51.3	45.4	48.8	46.0	47.7	48.2	115.5	112.8	112.4	51.3	49.7	50.9	780.0
1937	49.6	43.6	46.5	41.9	37.8	38.1	45.5	109.8	111.8	51.3	49.7	51.3	676.9
1938	51.2	45.1	48.6	45.5	46.1	47.0	115.8	113.7	108.1	51.3	56.1	51.3	779.8
1939	51.3	46.2	49.9	47.1	47.5	45.6	49.0	111.3	111.5	69.6	49.7	51.3	730.1
1940	51.0	44.9	48.6	45.6	45.7	45.4	48.8	114.3	109.5	51.3	49.7	50.4	705.3
1941	49.1	43.2	46.1	41.8	46.3	107.6	108.9	114.7	111.4	51.3	49.7	51.3	821.3
1942	50.9	44.9	48.9	46.5	46.9	46.9	112.6	113.6	110.9	51.3	49.7	51.3	774.6
1943	51.3	45.3	48.8	45.9	45.6	42.3	46.4	55.9	111.1	51.3	49.4	49.8	643.2
1944	48.5	42.3	44.7	37.4	13.7	39.8	48.3	97.7	111.7	51.3	49.7	50.5	635.7
1945	49.4	43.6	46.6	42.4	38.6	40.4	46.4	112.3	110.6	51.3	49.7	51.3	682.5
1946	50.4	44.3	47.6	44.6	45.4	44.2	108.7	115.7	111.7	51.3	49.7	51.3	764.9
1947	51.3	45.5	49.0	45.9	45.9	106.8	111.3	106.8	108.3	116.7	49.7	51.3	888.4
1948	51.3	45.6	49.2	46.5	48.2	48.4	77.1	114.2	110.9	51.3	49.7	50.9	743.4
1949	49.7	43.6	46.6	43.4	43.7	44.5	96.9	115.7	111.7	92.4	49.7	51.3	789.2
1950	51.2	45.1	48.6	45.5	45.2	40.6	40.8	47.7	112.5	51.3	49.7	51.3	629.5
1951	51.3	45.3	48.8	45.8	46.4	47.0	112.9	114.1	111.7	116.3	49.7	51.3	840.7
1952	51.3	46.4	50.5	48.0	48.8	97.2	113.0	115.9	111.7	116.7	56.3	51.3	907.2
1953	51.3	46.0	49.7	46.7	47.6	79.7	116.3	113.1	108.5	57.2	49.7	51.3	817.1
1954	51.3	45.7	49.3	46.4	46.2	45.2	49.8	110.9	111.6	109.4	49.7	51.3	767.0
1955	51.3	46.2	50.2	48.1	49.4	84.8	113.6	114.2	111.1	51.3	49.7	51.3	821.2
1956	51.2	45.2	48.7	45.6	45.7	102.3	114.2	113.0	111.4	51.3	49.7	51.3	829.5
1957	51.3	45.7	49.3	46.4	46.0	43.7	46.3	47.9	47.4	50.2	48.7	49.1	572.0
1958	47.7	41.5	41.9	22.1	16.6	22.8	34.3	37.1	42.8	47.5	46.7	47.0	448.0
1959	45.3	36.7	30.0	4.1	15.4	44.5	114.8	115.3	112.6	79.6	112.9	54.6	765.8
1960	51.3	46.4	50.8	47.9	47.9	46.6	112.5	112.7	112.9	51.3	49.7	51.3	781.3
1961	51.3	45.6	49.4	46.7	46.6	94.1	111.3	113.4	111.7	51.3	49.7	51.3	822.5
1962	50.8	44.8	48.4	45.5	34.7	106.4	116.7	115.1	111.6	51.3	49.7	51.3	837.4
1963	50.4	44.5	48.0	45.3	46.4	104.7	108.4	116.2	96.6	116.7	55.5	51.3	884.1
1964	51.3	46.1	49.9	47.3	48.6	47.8	108.3	116.3	112.0	90.9	49.7	51.3	819.3
1965	51.3	46.0	49.9	47.2	48.1	48.2	112.9	113.8	112.9	107.0	49.7	51.3	838.4
1966	51.3	46.4	50.5	47.8	48.5	48.2	114.2	114.8	111.4	59.6	49.7	51.3	793.6
1967	51.3	45.3	49.0	46.5	47.0	45.4	89.3	116.1	112.7	92.3	49.7	51.3	795.8
1968	51.2	45.6	49.7	47.3	48.3	109.4	106.7	114.3	111.6	51.3	49.7	50.9	836.2

Table A-35 Power Release, 4-unit Operation

(Unit: 19^9 cu. ft.)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1936	25.9	24.2	27.5	27.1	28.0	45.8	81.6	83.5	78.2	26.7	25.9	27.2
1937	28.0	25.5	28.8	27.2	26.8	26.4	28.9	85.1	79.0	26.5	25.5	26.8
1938	27.1	25.1	28.2	27.7	28.9	27.3	53.8	82.9	81.6	26.3	25.8	25.7
1939	26.5	24.5	27.8	27.2	28.4	27.6	28.1	84.7	79.2	34.3	24.9	26.6
1940	27.2	25.2	28.2	27.7	28.9	27.7	28.1	59.1	80.6	26.8	26.0	27.5
1941	28.1	25.6	28.9	27.2	28.8	82.0	85.3	82.1	79.3	26.3	25.1	26.7
1942	27.2	25.3	28.1	27.4	28.6	27.3	83.7	82.9	79.6	26.2	24.9	26.4
1943	27.0	25.0	28.1	27.6	28.8	27.3	28.8	27.8	79.5	26.9	26.3	27.8
1944	28.2	25.9	28.5	26.2	7.7	27.0	28.1	49.6	79.1	26.8	26.0	27.4
1945	28.0	25.5	28.7	27.3	27.0	27.0	28.7	62.4	79.8	26.7	25.8	27.0
1946	27.6	25.4	28.4	28.0	28.7	28.0	85.4	81.5	79.1	26.2	24.9	26.3
1947	26.9	24.9	28.1	27.6	29.0	63.9	84.7	86.0	81.5	66.8	24.7	26.2
1948	26.9	24.8	28.1	27.4	28.2	26.8	31.1	82.5	79.6	26.7	25.8	27.2
1949	28.0	25.5	28.8	27.5	28.3	28.0	48.1	81.5	79.1	45.5	24.8	26.4
1950	27.1	25.1	28.2	27.7	28.6	27.0	27.6	28.4	55.1	26.4	24.9	26.2
1951	27.0	25.0	28.1	27.6	28.8	27.3	83.5	82.6	79.1	81.1	24.6	25.7
1952	26.4	24.3	27.5	27.1	28.1	44.4	83.3	81.4	79.1	71.4	26.8	25.7
1953	26.6	24.6	28.0	27.3	28.4	36.3	77.0	83.3	81.3	28.2	24.7	26.1
1954	26.9	24.8	28.0	27.4	28.9	27.8	27.9	84.8	79.1	53.9	24.7	26.0
1955	26.7	24.5	27.7	27.1	28.0	36.7	83.0	82.5	56.3	26.8	25.6	26.5
1956	27.1	25.1	28.2	27.7	28.9	83.7	82.5	83.4	79.3	26.5	25.0	26.1
1957	26.9	24.8	28.0	27.5	29.0	27.6	28.8	28.4	27.2	27.8	26.9	28.2
1958	28.6	25.9	27.3	3.8	13.2	18.0	26.3	27.0	27.7	28.3	27.3	28.5
1959	28.8	25.0	21.8	3.2	12.2	27.9	62.2	81.8	74.2	39.3	54.5	25.9
1960	25.8	24.1	27.3	27.1	28.3	27.3	83.8	57.0	62.2	26.3	25.0	26.3
1961	26.9	24.8	28.0	27.4	28.7	44.3	84.6	83.1	79.0	26.3	25.2	26.8
1962	27.3	25.3	28.2	27.7	28.9	69.4	60.2	81.9	79.1	26.6	25.6	26.9
1963	27.5	25.3	28.4	27.8	28.8	82.8	85.5	78.5	48.9	64.0	26.4	25.8
1964	26.7	24.5	27.8	27.2	28.1	27.1	48.8	77.1	78.9	44.8	24.8	26.2
1965	26.8	24.6	27.8	27.2	28.3	27.0	83.5	82.8	62.9	52.8	24.7	26.0
1966	26.4	24.3	27.5	27.1	28.2	27.0	82.5	82.1	79.3	29.4	24.8	26.3
1967	27.0	25.0	28.1	27.4	28.6	27.7	41.5	81.3	71.2	45.4	24.9	26.6
1968	27.1	24.8	27.9	27.2	28.2	60.5	86.0	82.4	79.1	26.8	26.0	27.2

Table A-36 Reservoir Water Level, 4-unit Operation

(Unit: El. ft.)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1936	118.0	114.3	111.0	106.7	104.0	108.0	113.0	113.0	113.0	113.0	114.5	111.8
1937	108.5	104.3	99.6	93.2	86.4	80.9	89.8	98.3	113.0	113.0	116.0	113.3
1938	112.6	109.1	105.3	100.7	95.0	96.1	109.1	113.0	113.0	113.0	117.4	118.0
1939	115.6	112.5	109.4	105.2	102.0	98.8	99.5	109.2	113.0	113.0	118.0	115.5
1940	112.4	108.7	104.9	101.5	95.7	93.2	103.0	105.3	113.0	113.0	113.5	110.8
1941	107.0	102.7	98.6	91.7	87.8	103.7	113.0	113.0	113.0	113.0	117.1	115.0
1942	112.0	108.4	104.4	103.4	98.4	98.2	107.2	113.0	113.0	113.0	117.5	115.9
1043	113.0	109.6	105.9	101.6	96.9	90.6	90.6	102.0	112.4	113.0	112.3	109.3
1944	105.2	100.7	95.4	88.2	80.2	80.0	96.3	110.0	113.0	113.0	113.6	110.9
1945	107.5	103.9	100.0	93.8	86.9	82.3	94.0	99.9	113.0	113.0	114.5	112.5
1946	110.6	106.5	102.5	97.6	92.6	93.7	94.9	113.0	113.0	113.0	117.8	115.7
1947	113.6	110.2	106.5	102.0	96.7	93.0	113.0	113.0	113.0	113.0	118.0	116.5
1948	113.7	110.5	107.1	102.9	99.3	105.3	110.3	113.0	113.0	113.0	114.6	112.0
1949	108.6	104.4	99.7	93.6	89.8	92.3	98.7	113.0	113.0	113.0	118.0	116.0
1950	112.8	109.2	105.5	101.0	95.6	89.5	88.1	87.3	110.7	113.0	116.5	116.6
1951	113.3	109.9	106.0	101.5	96.7	96.5	108.7	113.0	113.0	113.0	118.0	117.5
1952	115.8	113.3	110.6	107.1	104.6	103.7	113.0	113.0	113.0	113.0	118.0	118.0
1953	115.3	112.0	108.6	104.3	99.5	101.9	113.0	113.0	113.0	113.0	118.0	116.6
1954	113.9	111.0	107.6	103.3	98.5	93.3	101.8	111.6	113.0	113.0	118.0	116.9
1955	114.5	112.1	109.3	106.8	105.6	106.4	113.0	113.0	113.0	113.0	113.0	115.4
1956	112.6	109.2	105.5	101.1	95.4	93.2	113.0	113.0	113.0	113.0	115.9	116.9
1957	113.8	111.0	107.5	103.1	97.8	92.5	92.0	100.2	101.9	106.7	108.8	105.4
1958	101.2	95.6	89.5	81.0	80.0	80.0	80.0	82.4	86.7	98.6	104.1	102.0
1959	96.6	90.5	84.7	80.0	80.0	80.0	107.5	113.0	113.0	113.0	118.0	118.0
1960	118.0	114.8	111.7	108.0	104.0	99.5	104.8	113.0	113.0	113.0	117.0	116.0
1961	113.5	110.5	107.2	103.8	99.8	94.3	113.0	113.0	113.0	113.0	116.8	114.6
1962	111.6	108.1	104.4	100.0	96.1	92.2	113.0	113.0	113.0	113.0	114.8	113.6
1063	110.2	107.1	103.2	98.6	96.7	96.5	113.0	113.0	113.0	113.0	118.0	118.0
1964	114.8	112.1	109.0	105.3	103.1	104.7	107.1	113.0	113.0	113.0	118.0	116.3
1965	114.0	111.3	109.1	105.3	102.1	102.5	111.4	113.0	113.0	113.0	118.0	116.6
1966	114.9	113.6	110.5	107.0	103.9	102.5	111.4	113.0	113.0	113.0	118.0	116.0
1967	113.4	109.8	105.8	103.0	99.6	97.7	99.0	113.0	113.0	113.0	118.0	115.3
1968	112.5	110.0	108.0	105.2	102.9	102.5	113.0	113.0	113.0	113.0	113.5	111.4

Table A-37 Tailwater Level, 4-unit Operation

(Unit: EL. ft.)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1936	19.2	19.4	19.5	19.6	19.8	19.7	20.4	24.0	19.6	19.6	19.3	19.4
1937	19.5	19.6	19.7	19.6	19.6	19.7	19.9	21.4	20.4	19.6	19.3	19.3
1938	19.4	19.5	19.6	19.7	19.9	19.8	19.7	22.7	25.4	19.6	19.1	19.1
1939	19.3	19.4	19.5	19.6	19.8	19.9	19.8	24.2	20.9	19.5	19.1	19.3
1940	19.4	19.5	19.6	19.7	19.9	19.9	19.8	19.7	23.5	19.6	19.4	19.5
1941	19.6	19.6	19.7	19.6	19.9	21.7	29.1	21.4	21.0	19.6	19.2	19.3
1942	19.4	19.5	19.6	19.6	19.9	19.8	21.5	22.9	21.6	19.6	19.1	19.3
1943	19.4	19.5	19.6	19.7	19.9	19.8	19.9	19.7	21.1	19.6	19.4	19.5
1944	19.6	19.7	19.6	19.4	19.5	19.8	19.8	19.7	20.6	19.6	19.4	19.5
1945	19.6	19.6	19.7	19.6	19.7	19.8	19.9	19.8	22.0	19.6	19.3	19.4
1946	19.5	19.6	19.6	19.8	19.9	19.9	21.7	20.1	20.5	19.5	19.1	19.3
1947	19.4	19.5	19.6	19.7	19.9	19.8	25.9	31.9	25.1	19.5	19.1	19.2
1948	19.4	19.5	19.6	19.6	19.8	19.7	19.7	22.1	21.5	19.6	19.3	19.4
1949	19.5	19.6	19.7	19.6	19.8	19.9	19.8	20.2	20.5	19.5	19.1	19.3
1950	19.4	19.5	19.6	19.7	19.9	19.8	19.7	19.8	19.7	19.6	19.1	19.2
1951	19.4	19.5	19.6	19.7	19.9	19.8	21.8	22.3	20.5	21.9	19.1	19.1
1952	19.3	19.4	19.5	19.6	19.8	19.7	23.6	19.9	20.5	19.5	19.0	19.1
1953	19.3	19.4	19.5	19.6	19.8	19.8	19.6	23.5	24.8	19.5	19.1	19.2
1954	19.4	19.5	19.6	19.6	19.9	19.9	19.8	25.7	20.7	19.5	19.1	19.2
1955	19.3	19.4	19.5	19.5	19.8	19.7	22.9	22.1	19.6	19.6	19.3	19.3
1956	19.4	19.5	19.6	19.7	19.9	25.1	22.2	23.7	20.9	19.6	19.1	19.2
1957	19.4	19.5	19.6	19.6	19.9	19.8	19.9	19.8	19.8	19.7	19.5	19.6
1958	19.7	19.7	19.4	19.2	19.5	19.5	19.6	19.7	19.9	19.8	19.6	19.7
1959	19.7	19.5	19.3	19.2	19.5	19.9	19.7	20.7	19.6	19.5	19.0	19.0
1960	19.1	19.3	19.4	19.5	19.8	19.8	20.6	19.6	19.6	19.6	19.1	19.2
1961	19.4	19.5	19.6	19.7	19.9	19.8	19.6	21.0	20.6	19.6	19.3	19.4
1962	19.4	19.5	19.6	19.7	19.9	19.8	19.6	21.0	20.6	19.6	19.3	19.4
1963	19.5	19.6	19.6	19.7	19.9	22.8	29.6	19.6	19.6	19.5	19.0	19.1
1964	19.3	19.4	19.5	19.6	19.8	19.8	19.7	19.6	20.2	19.5	19.1	19.2
1965	19.4	19.4	19.5	19.6	19.8	19.8	23.1	22.6	19.6	19.5	19.1	19.2
1966	19.3	19.4	19.5	19.6	19.8	19.8	21.4	21.4	21.0	19.5	19.1	19.3
1967	19.4	19.5	19.6	19.6	19.9	19.9	19.8	19.7	19.6	19.5	19.1	19.3
1968	19.4	19.5	19.5	19.6	19.8	19.8	32.0	21.9	20.6	19.6	19.4	19.4

Table A-38 Maximum Power, 4-unit Operation

(Unit: MW)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1936	24.33	213.5	209.5	204.5	205.4	211.1	212.8	209.1	213.6	214.3	214.0	210.9
1937	206.7	198.2	187.1	166.9	144.9	152.3	181.2	202.9	212.7	214.3	214.3	213.8
1938	211.7	207.8	200.0	189.6	184.7	200.0	211.6	210.3	207.6	214.3	214.3	214.3
1939	214.3	211.8	207.8	200.8	193.8	191.4	202.7	207.0	212.3	214.3	214.3	214.3
1940	211.4	207.3	200.1	190.8	181.9	190.2	201.6	209.7	209.6	213.8	212.9	209.5
1941	203.4	195.0	184.7	166.6	187.0	206.7	200.7	211.7	212.2	214.3	214.3	214.3
1942	210.9	206.6	201.5	195.9	189.9	199.5	208.7	210.2	211.5	214.3	214.3	214.3
1943	212.1	208.3	201.3	191.9	179.6	168.6	186.9	207.7	211.7	213.2	211.6	207.8
1944	199.9	189.9	173.7	148.7	132.9	163.8	201.0	212.0	212.6	213.9	213.1	209.8
1945	205.3	198.1	188.0	168.9	148.7	162.5	187.8	207.3	211.1	214.3	214.3	212.3
1946	209.1	202.8	193.6	184.3	177.2	181.2	199.8	213.1	212.6	214.3	214.3	214.3
1947	212.7	208.9	202.2	192.1	183.4	202.3	207.0	195.1	207.9	214.3	214.3	214.3
1948	212.9	209.4	203.8	196.2	198.5	208.1	212.1	210.9	211.6	214.3	214.2	211.1
1949	206.9	198.4	187.5	173.0	170.2	185.0	206.5	213.0	212.6	214.3	214.3	214.3
1950	211.8	207.9	200.4	190.3	175.5	162.4	158.4	195.8	212.4	214.3	214.3	214.3
1951	212.4	208.5	201.3	191.6	186.6	199.8	209.2	210.8	212.6	213.8	214.3	214.3
1952	214.3	212.7	209.5	205.5	201.6	208.9	209.4	213.3	212.6	214.3	214.3	214.3
1953	214.3	211.1	206.8	198.1	194.5	208.0	213.6	209.5	208.2	214.3	214.3	214.3
1954	213.3	209.9	204.6	195.8	185.7	188.9	207.1	206.0	212.5	214.3	214.3	214.3
1955	214.2	211.5	208.6	206.2	205.3	210.2	210.1	210.9	213.6	2136	214.3	214.3
1956	211.7	207.9	200.4	190.2	181.2	192.0	210.9	209.3	212.2	214.3	214.3	214.3
1957	213.2	209.9	204.3	194.6	184.0	174.1	186.3	195.3	201.9	208.0	207.6	200.5
1958	190.5	176.0	152.6	135.2	132.5	132.5	136.4	148.2	176.9	196.5	199.7	192.0
1959	179.5	159.7	140.8	133.7	132.5	187.1	210.8	212.5	213.6	214.3	214.3	214.3
1960	214.3	214.1	210.6	205.9	197.4	198.2	208.5	213.6	213.6	214.3	214.3	214.3
1961	212.8	209.4	204.7	197.8	187.9	203.3	207.1	209.9	212.7	214.3	214.3	214.0
1962	210.6	206.5	198.6	189.9	180.9	201.9	213.6	212.2	212.5	214.3	214.3	212.7
1963	209.2	204.0	195.7	189.1	186.6	198.6	199.6	213.6	213.6	214.3	214.3	214.3
1964	214.3	211.3	207.7	202.0	201.1	205.1	210.6	213.6	213.0	214.3	214.3	214.3
1965	213.5	210.9	207.7	201.0	197.8	207.3	209.1	210.5	213.6	214.3	214.3	214.3
1966	214.3	212.8	209.3	204.7	199.7	207.3	210.9	211.7	212.2	214.3	214.3	214.3
1967	212.4	208.3	202.6	196.7	190.5	190.0	206.8	213.6	213.6	214.3	214.3	214.3
1968	212.0	209.6	207.1	201.8	198.6	208.3	194.9	211.2	212.5	213.8	213.3	211.1

Table A-39 Monthly Energy Output, 4-unit Operation

(Unit: 10^6kWh)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1936	52.6	47.4	51.4	48.6	50.4	87.2	158.3	155.5	153.0	52.6	50.8	51.8	959.8
1937	50.8	44.0	45.9	39.7	35.6	36.2	44.5	150.9	153.2	52.6	50.9	52.5	756.7
1938	52.0	46.1	49.1	45.1	45.4	17.5	102.9	156.5	149.5	52.6	53.4	52.6	852.6
1939	52.6	47.0	51.0	47.7	47.6	45.5	49.8	154.0	152.9	69.0	50.9	52.6	820.6
1940	51.9	46.0	49.1	45.3	44.7	45.2	49.5	110.9	150.9	52.5	50.6	51.4	748.0
1941	49.9	43.3	45.3	39.6	45.9	148.8	149.3	157.5	152.8	52.6	50.9	52.6	988.6
1942	51.8	45.8	49.5	46.5	46.6	47.4	155.3	156.4	152.3	52.6	50.9	52.6	907.8
1943	52.1	46.2	49.4	45.6	44.1	40.1	45.9	51.0	152.4	52.4	50.3	51.0	680.4
1944	49.1	42.1	42.6	35.3	9.6	38.9	49.4	95.4	153.1	52.5	50.6	51.5	670.2
1945	50.4	43.9	46.2	40.1	36.5	38.6	46.1	113.8	152.0	52.6	50.9	52.1	723.3
1946	51.3	45.0	47.5	43.8	43.5	43.1	148.7	158.5	153.1	52.6	50.9	52.6	890.6
1947	52.2	46.3	49.6	45.7	45.0	112.9	154.0	145.1	149.7	134.2	50.9	52.6	1038.4
1948	52.3	46.4	50.0	46.6	48.7	49.4	60.0	156.9	152.3	52.6	50.9	51.8	818.2
1949	50.8	44.0	46.0	41.1	41.8	44.0	87.3	158.4	153.1	91.5	50.9	52.6	861.5
1950	52.0	46.1	49.2	45.2	43.1	38.6	38.9	48.1	106.4	52.6	50.9	52.6	623.7
1951	52.2	46.2	49.4	45.5	45.8	47.5	155.6	156.8	153.1	159.1	50.9	52.6	1014.8
1952	52.6	47.2	51.4	48.8	49.5	82.6	155.8	158.7	153.1	143.5	55.5	52.6	1051.4
1953	52.6	46.8	50.8	47.1	47.8	66.8	150.6	155.9	149.9	56.6	50.9	52.6	928.3
1954	52.4	46.6	50.2	46.5	45.6	44.9	50.8	153.2	153.0	108.4	50.9	52.6	855.2
1955	52.6	46.9	51.2	49.0	50.4	69.2	156.3	156.9	110.1	52.4	50.9	52.6	898.6
1956	52.0	46.1	49.2	45.2	44.5	138.2	156.9	155.8	152.8	52.6	50.9	52.6	996.8
1957	52.3	46.5	50.2	46.2	45.2	41.4	45.7	47.9	48.0	51.1	49.3	49.2	573.1
1958	46.8	39.0	37.5	4.9	16.5	22.5	33.5	36.4	42.0	48.3	47.4	47.1	421.9
1959	44.1	35.4	28.4	4.0	15.3	44.5	118.1	158.1	145.0	78.9	113.1	53.7	838.6
1960	52.6	47.5	51.7	48.9	48.5	47.1	155.1	111.5	121.6	52.6	50.9	52.6	840.8
1961	52.2	46.4	50.3	47.0	46.1	78.7	154.1	156.1	153.1	52.6	50.9	52.5	940.2
1962	51.7	45.8	48.8	45.1	44.4	122.4	117.7	157.9	153.0	52.6	50.9	52.2	942.6
1963	51.4	45.2	48.1	44.9	45.8	143.0	148.5	153.5	95.6	128.7	54.8	52.6	1012.0
1964	52.6	46.9	51.0	48.0	49.4	48.7	92.4	150.8	153.4	90.1	50.9	52.6	886.8
1965	52.4	46.8	51.0	47.8	48.6	49.3	155.6	156.6	123.0	106.2	50.9	52.6	940.7
1966	52.6	47.2	51.4	48.6	49.0	49.3	156.9	157.5	152.8	59.0	50.9	52.6	927.9
1967	52.1	46.2	49.7	46.7	46.8	45.1	75.4	158.9	139.3	91.4	50.9	52.6	855.2
1968	52.1	46.5	50.8	47.9	48.8	111.7	145.0	157.1	153.0	52.5	50.7	51.8	967.9

Table A-40 Power Release, 5-unit Operation

(Unit: 10^9 cu.ft.)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1936	26.2	24.5	27.9	27.2	28.1	44.7	94.9	106.4	78.2	26.9	26.1	27.6
1937	28.1	25.5	28.5	26.5	26.2	25.8	28.3	108.2	93.9	26.7	25.8	27.0
1938	27.4	25.4	28.2	27.5	28.4	27.3	53.1	105.4	104.1	26.5	25.5	26.0
1939	26.8	24.8	28.1	27.3	28.3	27.4	28.2	108.1	100.6	34.3	25.2	26.8
1940	27.5	25.4	28.2	27.5	28.2	27.5	28.2	59.3	102.5	27.0	26.3	27.9
1941	28.2	25.5	28.4	26.5	28.4	104.6	108.3	104.3	100.6	26.6	25.4	26.9
1942	27.6	25.4	28.2	27.4	28.4	27.3	106.6	105.5	101.1	26.5	25.2	26.7
1943	27.4	25.4	28.2	27.4	28.1	26.6	28.5	28.1	101.0	27.1	26.6	28.1
1944	28.2	25.6	27.7	25.5	8.4	26.4	28.2	50.4	96.9	26.9	26.3	27.8
1945	28.1	25.5	28.4	26.6	26.4	26.3	28.4	64.2	101.4	26.8	26.0	27.3
1946	28.0	25.4	28.3	27.4	28.0	27.3	108.3	90.6	95.8	26.5	25.2	26.7
1947	27.2	25.3	28.2	27.4	28.2	63.8	108.0	108.6	103.8	66.7	25.1	26.5
1948	27.2	25.2	28.2	27.4	28.2	27.2	29.3	104.9	101.1	26.8	26.1	27.6
1949	28.1	25.5	28.5	26.8	27.6	27.6	49.4	92.3	95.8	45.6	25.1	26.7
1950	27.4	25.4	28.2	27.5	27.9	26.3	27.0	28.2	56.2	26.7	25.3	26.6
1951	27.3	25.4	28.2	27.4	28.5	27.3	106.3	105.0	95.4	102.8	24.9	26.1
1952	26.7	24.6	27.9	27.2	28.2	42.3	106.1	86.8	95.5	71.4	26.8	26.1
1953	26.9	24.9	28.1	27.3	28.3	35.8	77.1	106.0	103.6	28.2	25.1	26.5
1954	27.1	25.1	28.1	27.4	28.5	27.5	28.1	108.1	98.4	54.0	25.0	26.4
1955	27.0	24.8	28.1	27.2	28.1	34.8	105.5	104.9	56.3	27.0	25.9	26.8
1956	27.4	25.4	28.2	27.5	28.2	105.3	104.9	106.1	100.6	26.7	25.3	26.5
1957	27.2	25.2	28.1	27.4	28.3	26.9	28.5	28.3	27.3	28.1	27.2	28.2
1958	28.4	25.2	26.6	4.9	13.2	18.1	25.7	26.4	27.1	28.2	27.3	28.3
1959	28.2	24.5	25.2	3.2	12.2	27.5	62.4	102.0	74.2	39.2	54.5	25.9
1960	26.2	24.3	27.7	27.2	28.2	27.3	99.9	57.1	62.2	26.6	25.3	26.7
1961	27.2	25.2	28.1	27.3	28.4	42.8	108.0	105.7	94.6	26.6	25.5	27.0
1962	27.7	25.4	28.2	27.5	28.1	69.1	60.2	104.0	97.6	26.8	25.9	27.2
1963	28.0	25.4	28.3	27.5	28.5	104.9	108.3	78.5	48.9	64.0	26.4	26.1
1964	26.9	24.8	28.1	27.3	28.2	27.2	47.5	77.0	89.0	44.7	25.1	26.5
1965	27.1	24.9	28.1	27.3	28.2	27.2	106.3	105.2	62.9	52.7	25.1	26.4
1966	26.8	24.6	28.0	27.2	28.2	27.2	104.9	104.3	100.6	29.3	25.1	26.7
1967	27.3	25.4	28.2	27.3	28.4	27.5	40.6	81.8	71.2	45.5	25.2	26.8
1968	27.4	25.2	28.1	27.3	28.2	59.3	108.6	104.7	97.7	27.0	26.2	27.6

Table A-41 Reservoir Water Level, 5-unit Operation

(Unit: EL. ft.)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1936	118.0	114.3	110.9	106.6	103.8	107.8	113.0	113.0	113.0	113.0	114.4	111.7
1937	108.4	104.1	99.5	93.0	86.5	81.2	90.2	98.7	113.0	113.0	116.0	113.2
1938	112.5	109.0	105.1	100.4	94.8	96.0	109.0	113.0	113.0	113.0	117.4	118.0
1939	115.5	112.5	109.3	105.0	101.7	98.5	99.3	109.0	113.0	113.0	118.0	115.4
1940	112.3	108.5	104.7	101.2	95.5	93.2	103.0	105.3	113.0	113.0	113.4	110.7
1941	106.9	102.6	98.4	91.7	87.9	103.9	113.0	113.0	113.0	113.0	117.1	114.9
1942	111.8	108.2	104.2	103.2	98.2	98.0	107.0	113.0	113.0	113.0	117.5	115.8
1943	112.9	109.4	105.7	101.3	96.5	90.4	90.6	102.0	112.4	113.0	112.3	109.2
1944	105.1	100.5	95.2	88.3	80.5	80.0	06.4	110.1	113.0	113.0	113.6	110.8
1945	107.4	103.8	99.8	93.6	87.0	82.5	94.4	100.3	113.0	113.0	114.5	112.4
1946	110.5	106.4	102.4	97.3	92.5	93.8	95.1	113.0	113.0	113.0	117.7	115.6
1947	113.5	110.0	106.2	101.7	96.3	92.8	113.0	113.0	113.0	113.0	118.0	116.5
1948	113.7	110.4	106.9	102.7	99.0	105.1	110.1	113.0	113.0	113.0	114.6	112.0
1949	108.5	104.3	99.5	93.4	89.9	92.6	99.0	113.0	113.0	113.0	118.0	116.0
1950	112.7	109.1	105.3	100.7	95.3	89.5	88.2	87.5	110.9	113.0	116.5	116.5
1951	113.2	109.7	105.8	101.1	96.3	96.2	108.5	113.0	113.0	113.0	118.0	117.5
1952	115.7	113.1	110.4	106.8	104.3	103.4	113.0	113.0	113.0	113.0	118.0	118.0
1953	115.3	111.9	108.5	104.1	99.3	101.7	113.0	113.0	113.0	113.0	118.0	116.6
1954	113.8	110.9	107.4	103.1	98.3	93.1	101.6	111.5	113.0	113.0	118.0	116.9
1955	114.4	112.0	109.1	107.5	105.3	106.0	113.0	113.0	113.0	113.0	113.0	115.3
1956	112.5	109.0	105.3	100.8	95.1	93.1	113.0	113.0	113.0	113.0	115.9	116.8
1957	113.6	110.8	107.3	102.8	97.5	92.2	91.9	100.2	102.0	106.7	108.8	105.3
1958	101.1	95.6	89.6	81.4	80.0	80.0	80.0	82.6	87.0	98.9	104.4	102.3
1959	97.1	91.2	85.9	80.0	80.0	80.0	107.6	113.0	113.0	113.0	118.0	118.0
1960	118.0	114.7	111.7	107.9	103.8	99.3	104.7	113.0	113.0	113.0	116.9	115.9
1961	113.3	110.3	106.9	103.5	99.4	94.0	113.0	113.0	113.0	113.0	116.8	114.5
1962	111.5	108.0	104.2	99.7	95.8	92.1	113.0	113.0	113.0	113.0	114.8	113.5
1963	110.1	106.9	103.0	98.3	96.5	96.4	113.0	113.0	113.0	113.0	118.0	118.0
1964	114.8	112.0	108.9	105.1	102.9	104.5	106.9	113.0	113.0	113.0	118.0	116.3
1965	113.9	111.1	108.9	105.0	101.8	102.2	111.2	113.0	113.0	113.0	118.0	116.6
1966	114.8	113.5	110.3	106.7	103.6	102.2	111.1	113.0	113.0	113.0	118.0	116.0
1967	113.3	109.6	105.6	102.8	99.3	97.5	98.8	113.0	113.0	113.0	118.0	115.2
1968	112.4	109.9	107.8	105.0	102.6	102.2	113.0	113.0	113.0	113.0	113.4	111.4

Table A-42 Tailwater Level, 5-unit Operation

(Unit: EL.ft.)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1936	20.6	20.7	20.9	21.0	21.0	20.8	20.8	24.0	20.8	20.7	20.7	20.8
1937	21.0	21.0	21.0	20.8	20.6	20.7	21.0	21.5	20.8	20.7	20.7	20.7
1938	20.8	21.0	21.0	21.0	21.0	21.0	20.8	22.7	25.4	20.7	20.5	20.5
1939	20.7	20.8	21.0	21.0	21.0	21.0	21.0	24.1	20.9	20.7	20.5	20.7
1940	20.8	21.0	21.0	21.0	21.0	21.0	21.0	20.9	23.5	20.7	20.8	20.9
1941	21.0	21.0	21.0	20.8	21.0	21.8	29.1	21.4	21.0	20.7	20.6	20.7
1942	20.9	21.0	21.0	21.0	21.0	21.0	21.5	22.9	21.6	20.7	20.5	20.7
1943	20.8	20.9	21.0	21.0	20.9	20.8	21.0	20.9	21.1	20.8	20.8	21.0
1944	21.0	21.0	20.9	20.6	20.5	20.8	21.0	20.8	20.8	20.7	20.8	20.9
1945	21.0	21.0	21.0	20.8	20.6	20.8	21.0	21.0	22.0	20.7	20.7	20.8
1946	20.9	21.0	21.0	21.0	20.9	21.0	21.7	20.8	20.8	20.7	20.5	20.7
1947	20.8	20.9	21.0	21.0	21.0	21.0	25.9	31.9	25.1	20.7	20.5	20.6
1948	20.8	20.9	21.0	21.0	21.0	20.9	20.8	22.1	21.5	20.7	20.7	20.8
1949	21.0	21.0	21.0	20.9	20.9	21.0	21.0	20.8	20.8	20.7	20.5	20.7
1950	20.8	21.0	21.0	21.0	20.9	20.8	20.7	21.0	20.8	20.7	20.6	20.7
1951	20.8	20.9	21.0	21.0	21.0	21.0	21.7	22.3	20.8	21.9	20.5	20.5
1952	20.7	20.8	20.9	21.0	21.0	20.9	23.6	20.8	20.8	20.7	20.5	20.5
1953	20.7	20.8	21.0	21.0	21.0	20.9	20.8	23.5	24.8	20.7	20.5	20.6
1954	20.8	20.9	21.0	21.0	21.0	21.0	21.0	25.7	20.8	20.7	20.5	20.6
1955	20.7	20.8	20.9	21.0	21.0	20.9	22.9	22.1	20.8	20.8	20.7	20.7
1956	20.8	21.0	21.0	21.0	21.0	25.0	22.2	23.7	20.9	20.7	20.6	20.6
1957	20.8	20.9	21.0	21.0	21.0	20.9	21.0	21.0	21.0	20.9	21.0	21.0
1958	21.0	20.8	20.5	20.4	20.5	21.0	20.8	20.8	20.8	20.7	20.5	20.5
1959	21.0	20.8	20.5	20.4	20.5	21.0	20.8	20.8	20.8	20.7	20.5	20.5
1960	20.6	20.7	20.9	21.0	21.0	21.0	20.9	20.8	20.8	20.7	20.6	20.7
1961	20.8	20.9	21.0	21.0	21.0	21.0	25.9	23.2	20.8	20.7	20.6	20.7
1962	20.9	21.0	21.0	21.0	21.0	21.0	20.8	21.0	20.8	20.7	20.7	20.8
1963	20.9	21.0	21.0	21.0	21.0	22.8	29.6	20.8	20.8	20.7	20.5	20.6
1964	20.7	20.8	21.0	21.0	21.0	21.0	20.9	20.8	20.8	20.7	20.5	20.6
1965	20.7	20.9	21.0	21.0	21.0	21.0	23.0	22.6	20.8	20.7	20.5	20.6
1966	20.7	20.8	20.9	21.0	21.0	21.0	21.3	21.4	21.0	20.7	20.5	20.7
1967	20.8	20.9	21.0	21.0	21.0	21.0	21.0	20.8	20.8	20.7	20.5	20.7
1968	20.8	20.9	21.0	21.0	21.0	21.0	32.0	21.9	20.8	20.7	20.8	20.8

Table A-43 Maximum Power, 5-unit Operation

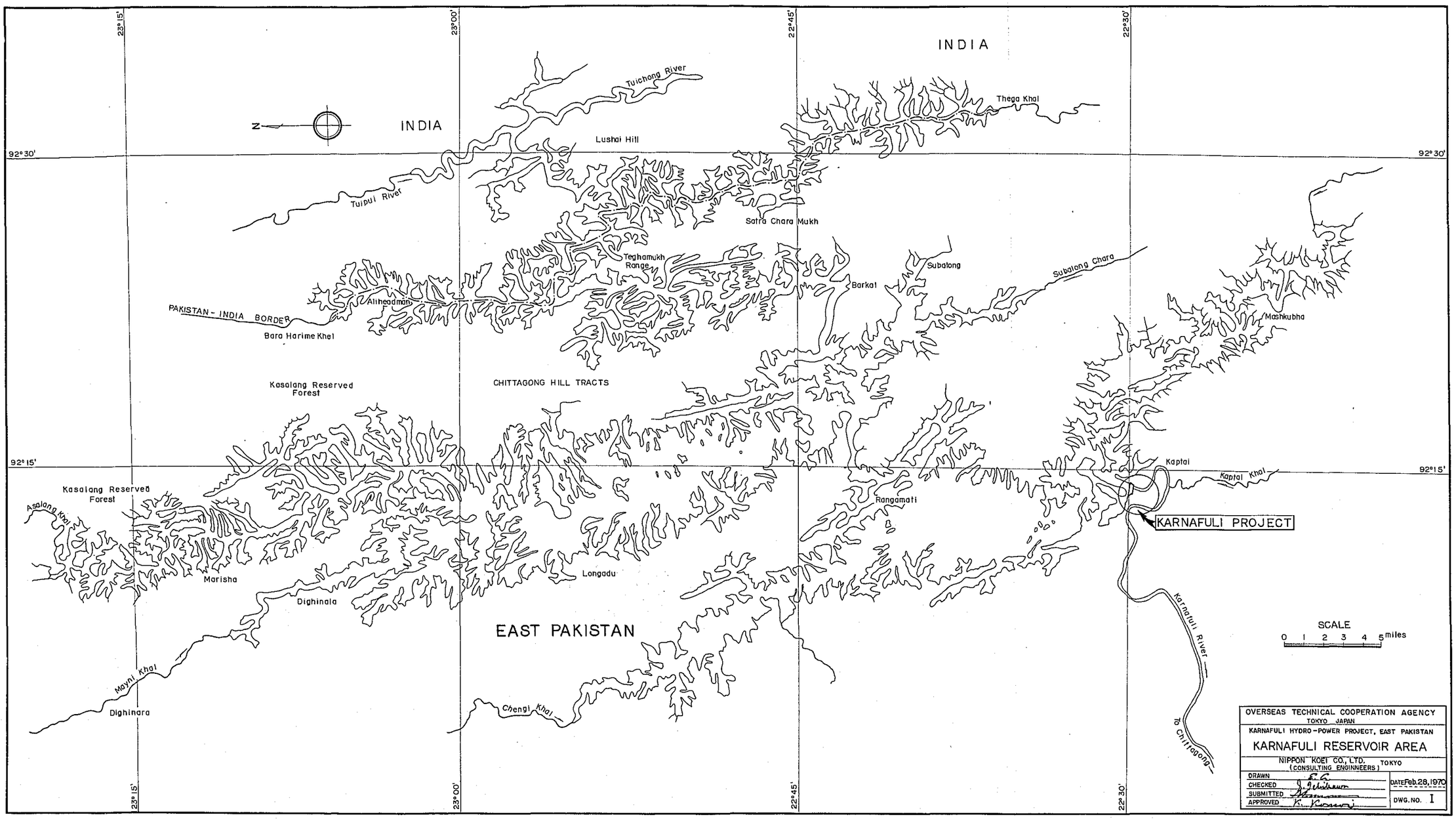
(Unit: MW)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1936	271.8	269.5	265.4	256.0	257.9	267.3	269.9	266.6	269.9	270.7	270.0	266.0
1937	259.4	246.8	230.5	202.8	177.7	187.5	223.3	258.5	269.9	271.5	271.6	269.8
1938	267.6	261.7	249.2	234.0	226.2	250.1	267.8	267.8	265.1	271.8	271.8	271.8
1939	271.0	267.7	262.0	250.5	240.5	237.4	254.0	264.5	269.8	271.8	271.8	270.8
1940	267.3	260.4	249.5	235.9	221.7	236.0	252.8	266.0	267.1	270.1	268.9	265.4
1941	254.5	242.0	225.7	202.7	231.7	264.1	255.1	269.2	269.7	271.8	271.8	270.3
1942	266.8	259.0	251.4	242.9	235.0	249.2	266.2	267.7	269.0	271.8	271.8	271.4
1943	268.0	263.3	251.0	237.2	218.4	205.5	231.2	262.9	269.2	269.5	267.6	262.1
1944	249.4	234.7	211.1	181.2	162.6	200.5	252.4	268.4	269.9	270.2	269.1	265.8
1945	257.2	246.7	231.8	205.1	182.0	199.7	233.5	262.1	268.6	270.7	270.4	268.2
1946	265.0	253.4	239.8	224.5	216.5	222.1	253.8	269.9	269.9	271.8	271.8	271.6
1947	268.6	264.7	252.3	237.5	222.9	253.8	264.5	246.7	265.4	271.8	271.8	271.8
1948	268.9	265.2	254.8	243.3	247.7	263.3	268.3	268.4	269.1	270.7	270.2	267.0
1949	259.6	247.1	231.1	210.4	208.4	228.9	260.5	269.9	269.9	271.8	271.8	271.4
1950	267.7	262.2	249.9	235.1	213.8	198.3	194.2	244.9	268.7	271.7	271.8	271.8
1951	268.3	263.7	251.0	236.8	229.8	249.7	266.7	268.3	269.9	271.3	271.8	271.8
1952	271.4	268.6	265.2	257.2	252.0	265.0	266.9	269.9	269.9	271.8	271.8	271.8
1953	270.5	267.0	259.5	246.6	241.8	263.5	269.9	267.0	265.7	271.8	271.8	271.8
1954	269.2	265.8	256.1	242.8	228.2	233.7	260.7	262.9	269.9	271.8	271.8	271.8
1955	270.1	267.4	264.0	258.2	257.5	266.3	267.6	268.4	269.9	269.9	271.2	270.9
1956	267.6	262.1	249.9	234.9	220.6	242.0	268.4	266.8	269.7	271.4	271.8	271.8
1957	269.1	265.6	255.5	240.9	224.3	212.2	230.2	243.6	253.4	263.7	261.8	250.4
1958	235.9	214.6	186.4	164.6	161.5	161.5	166.8	182.3	217.9	246.6	250.3	239.3
1959	221.3	197.7	173.3	161.8	161.6	231.7	267.1	269.9	269.9	271.8	271.8	271.8
1960	271.8	270.1	266.5	258.0	246.1	247.4	265.7	269.9	269.9	271.8	271.8	271.7
1961	268.6	265.2	256.0	245.6	231.6	255.0	264.6	267.4	269.9	271.8	271.8	269.9
1962	266.4	258.8	247.2	234.4	220.3	253.2	269.9	269.7	269.9	270.8	271.1	268.7
1963	265.1	255.2	242.8	233.3	230.2	251.8	253.4	269.9	269.9	271.8	271.8	271.8
1964	270.3	267.3	261.6	252.3	251.5	257.4	266.8	269.9	269.9	271.8	271.8	271.8
1965	269.4	266.7	261.5	250.7	246.6	261.0	266.6	268.0	269.9	271.8	271.8	271.8
1966	271.2	268.7	265.1	256.0	249.2	260.9	268.4	269.2	269.7	271.8	271.8	271.7
1967	268.3	263.5	253.0	244.0	235.8	235.2	260.3	269.9	269.9	271.8	271.8	270.8
1968	267.9	265.4	259.7	251.8	247.7	264.2	246.4	268.7	269.9	270.1	269.3	267.0

Table A-44 Monthly Energy Output, 5-unit Operation

(Unit: 10^6kWh)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1936	52.6	47.1	51.3	47.9	49.9	84.1	183.5	198.3	151.2	52.4	50.5	51.6	1020.5
1937	50.2	43.1	44.6	38.0	34.4	35.1	43.2	192.3	181.5	52.5	50.8	52.2	817.9
1938	51.8	45.7	48.2	43.8	43.8	46.8	100.4	199.3	190.9	52.6	52.1	52.6	927.9
1939	52.4	46.8	50.7	46.9	46.5	44.4	49.1	196.8	194.3	68.1	50.9	52.4	899.3
1940	51.7	45.5	48.3	44.2	42.9	44.2	48.9	109.8	192.3	52.3	50.3	51.3	781.7
1941	49.2	42.3	43.7	38.0	44.8	190.2	189.8	200.3	194.2	52.6	50.9	52.3	1148.1
1942	51.6	45.3	48.6	45.5	45.5	46.7	198.1	199.2	193.7	52.6	50.9	52.5	1030.0
1943	51.8	46.0	48.6	44.4	52.2	38.5	44.7	50.9	193.8	52.1	50.1	50.7	713.8
1944	48.2	41.0	40.8	33.9	10.4	37.5	48.8	95.8	187.3	52.3	50.4	51.4	698.0
1945	49.8	43.1	44.8	38.4	35.2	37.4	45.2	115.8	193.4	52.4	50.6	51.9	757.9
1946	51.3	44.3	46.4	42.0	41.9	41.6	188.8	175.3	185.2	52.6	50.9	52.5	972.7
1947	52.0	46.3	48.8	44.5	43.1	111.3	196.8	183.5	191.1	132.7	50.9	52.6	1153.4
1948	52.0	46.3	49.3	45.5	47.9	49.3	55.7	199.7	193.7	52.4	50.6	51.7	894.2
1949	50.2	43.2	44.7	39.4	40.3	42.9	88.6	178.5	185.2	90.6	50.9	52.5	90y.9
1950	51.8	45.8	48.3	44.0	41.4	37.1	37.6	47.4	107.4	52.6	50.9	52.6	616.8
1951	51.9	46.1	48.5	44.3	44.5	46.7	198.4	199.6	184.4	201.9	50.9	52.6	1169.8
1952	52.5	46.9	51.3	48.1	48.8	77.5	198.6	167.9	184.6	142.0	54.8	52.6	1125.5
1953	52.3	46.7	50.2	46.2	46.8	64.9	149.0	198.7	191.3	56.0	50.9	52.6	1005.4
1954	52.1	46.4	49.5	45.4	44.1	43.8	50.4	195.6	190.2	107.4	50.9	52.6	928.5
1955	52.2	46.7	51.1	48.3	49.8	64.8	199.1	199.7	108.8	52.2	50.9	52.4	976.0
1956	51.8	45.8	48.3	44.0	42.7	174.2	199.7	198.5	194.2	52.5	50.9	52.6	1155.2
1957	52.0	46.4	49.4	45.1	43.4	39.7	44.5	47.1	47.4	51.0	49.0	48.4	563.6
1958	45.6	37.5	36.1	6.2	16.2	22.2	32.3	35.3	40.8	47.7	46.9	46.3	413.0
1959	42.8	34.5	32.5	4.0	15.0	43.4	117.1	197.2	143.4	77.9	111.5	53.0	872.2
1960	52.6	47.2	51.6	48.3	47.6	46.3	184.4	110.4	120.3	52.6	50.9	52.6	864.7
1961	52.0	46.3	49.5	46.0	44.8	74.9	196.9	198.9	182.9	52.6	50.9	52.2	1047.8
1962	51.5	45.2	47.8	43.9	42.6	120.1	116.5	200.7	188.7	52.4	50.8	52.0	1012.1
1963	51.3	44.6	47.0	43.7	44.5	181.3	188.5	151.8	94.6	127.2	54.0	52.6	1081.1
1964	52.3	46.7	50.6	47.2	48.6	48.2	88.7	149.0	172.2	89.0	50.9	52.6	896.0
1965	52.1	46.6	50.6	46.9	47.7	48.9	198.4	199.4	121.6	104.7	50.9	52.6	1020.4
1966	52.5	47.0	51.3	47.9	48.2	48.8	199.7	200.3	194.2	58.2	50.9	52.6	1051.5
1967	51.9	46.0	48.9	45.7	45.6	44.0	72.6	158.2	137.8	90.4	50.9	52.4	844.5
1968	51.8	46.4	50.2	47.1	47.9	107.9	183.3	199.9	188.9	52.3	50.4	51.7	1077.7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Teghamukh Range
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Bara Harime Khel
Mashkubha
Kasalang Reserved Forest
CHITTAGONG HILL TRACTS
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Kasalang Reserved Forest
Asalang Khal
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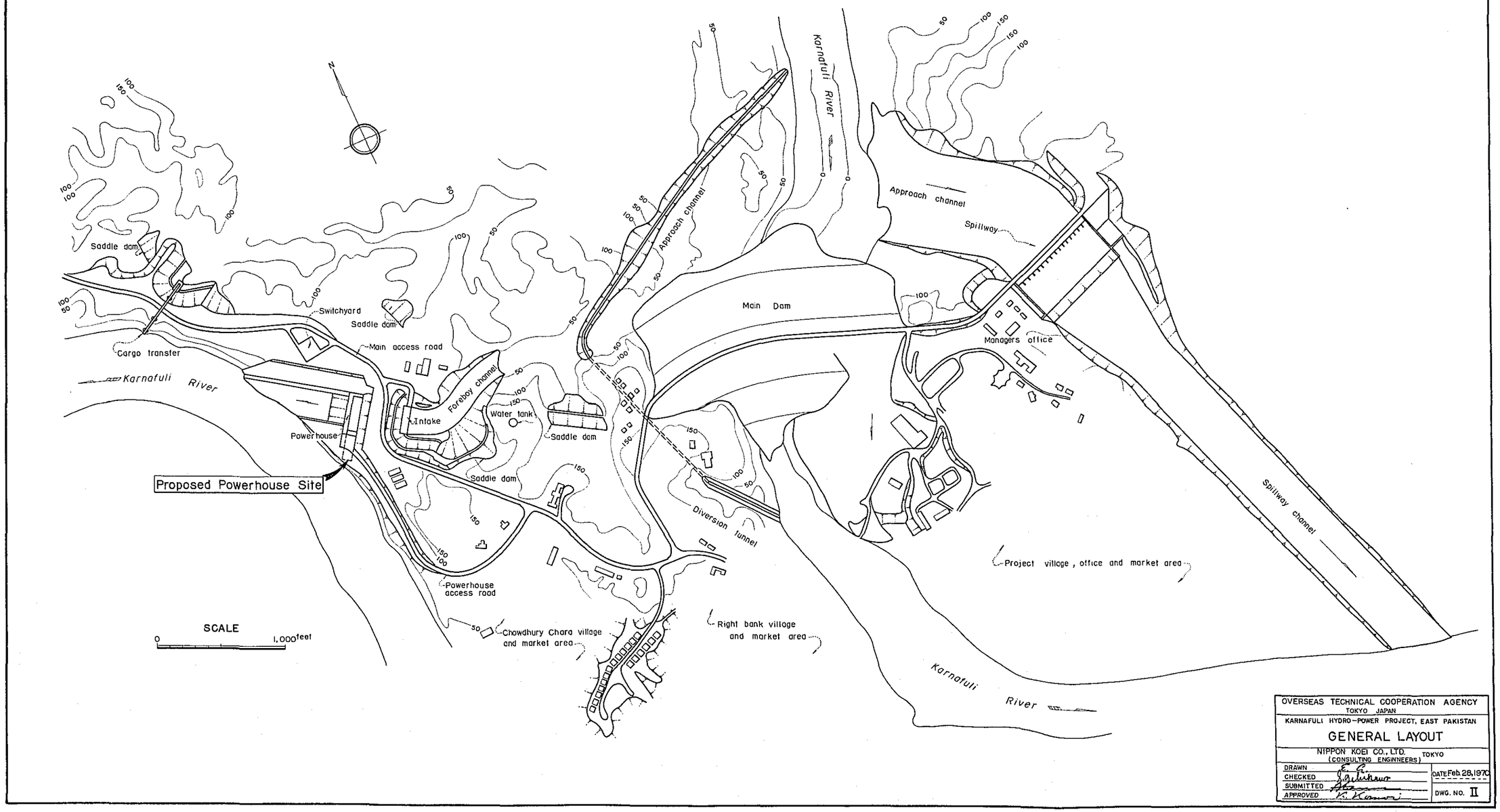
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Saddle dam
Switchyard
Saddle dam
Main access road
Cargo transfer
Karnafuli River
Forebay channel
Intake
Water tank
Saddle dam
Powerhouse
Proposed Powerhouse Site
Saddle dam
Powerhouse access road
Chowdhury Chara village and market area
Approach channel
Karnafuli River
Main Dam
Approach channel
Spillway
Managers office
Diversion tunnel
Right bank village and market area
Project village, office and market area
Spillway channel
Karnafuli River
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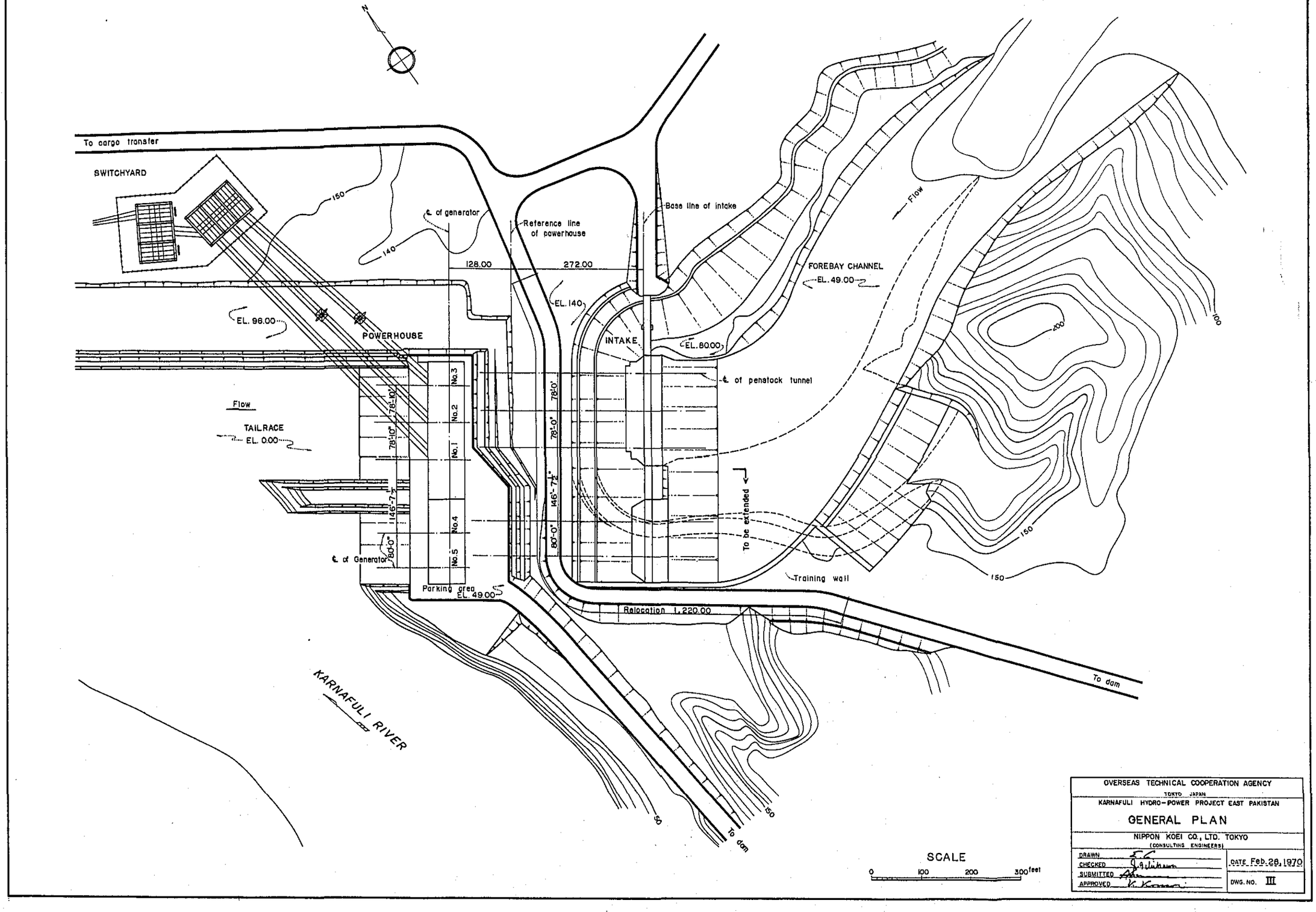
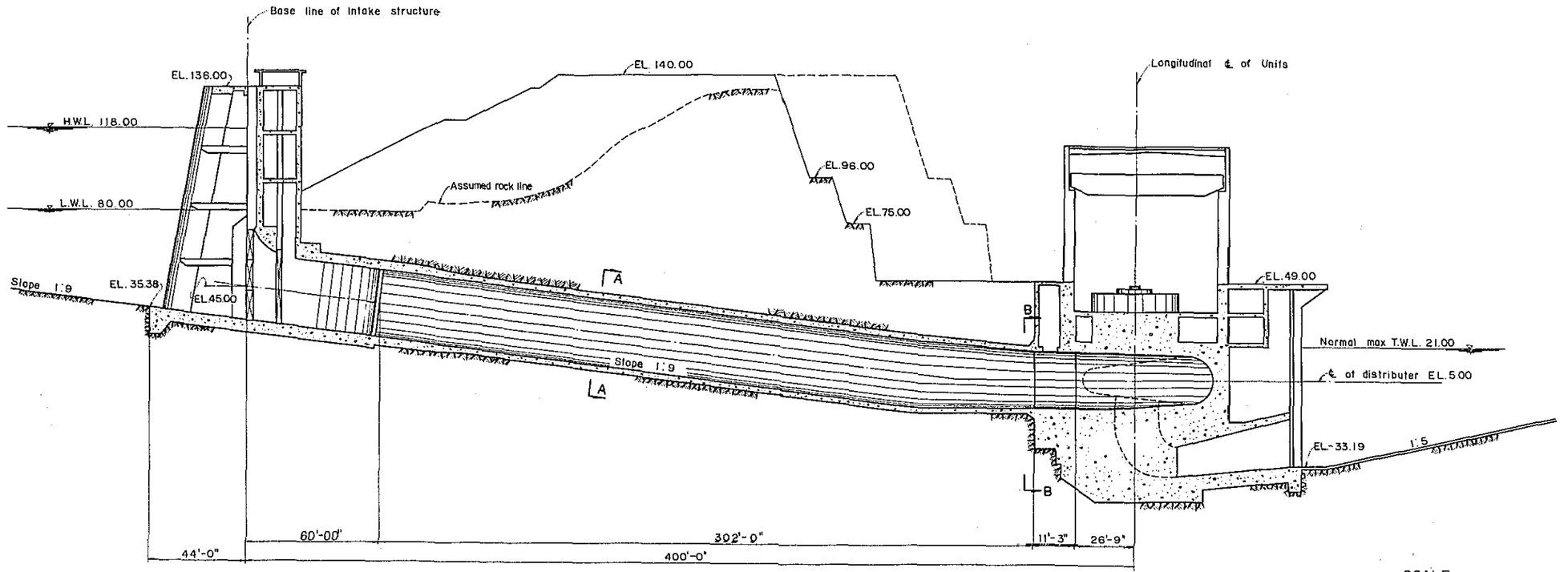
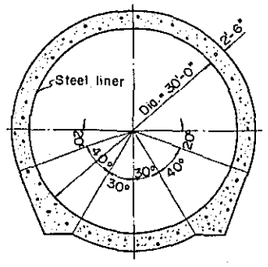
SUBMITTED
APPROVED
DATE Feb. 28, 1970
DWG. NO. II

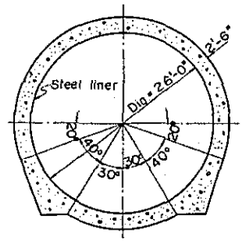

To cargo transfer
SWITCHYARD
150
140
℄ of generator
Reference line of powerhouse
Base line of intake
128.00
272.00
EL. 140
EL. 96.00
POWERHOUSE
INTAKE
EL. 80.00
FOREBAY CHANNEL
EL. 49.00
Flow
400
100
℄ of penstock tunnel
Flow
TAILRACE
EL. 0.00
No.3
No.2
No.1
No.4
No.5
78'-10"
78'-10"
78'-0"
78'-0"
146'-7½"
146'-7"
80'-0"
80'-0"
To be extended
℄ of Generator
Parking area
EL. 49.00
Training wall
150
150
Relocation L. 220.00
To dam
KARNAFULI RIVER
50
150
To dam
SCALE
0 100 200 300 feet
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN
KARNAFULI HYDRO-POWER PROJECT EAST PAKISTAN
GENERAL PLAN
NIPPON KOEI CO., LTD. TOKYO
(CONSULTING ENGINEERS)
DRAWN
CHECKED
SUBMITTED
APPROVED
DATE Feb. 28, 1970
DWG. NO. III



PROFILE



SECTION A-A

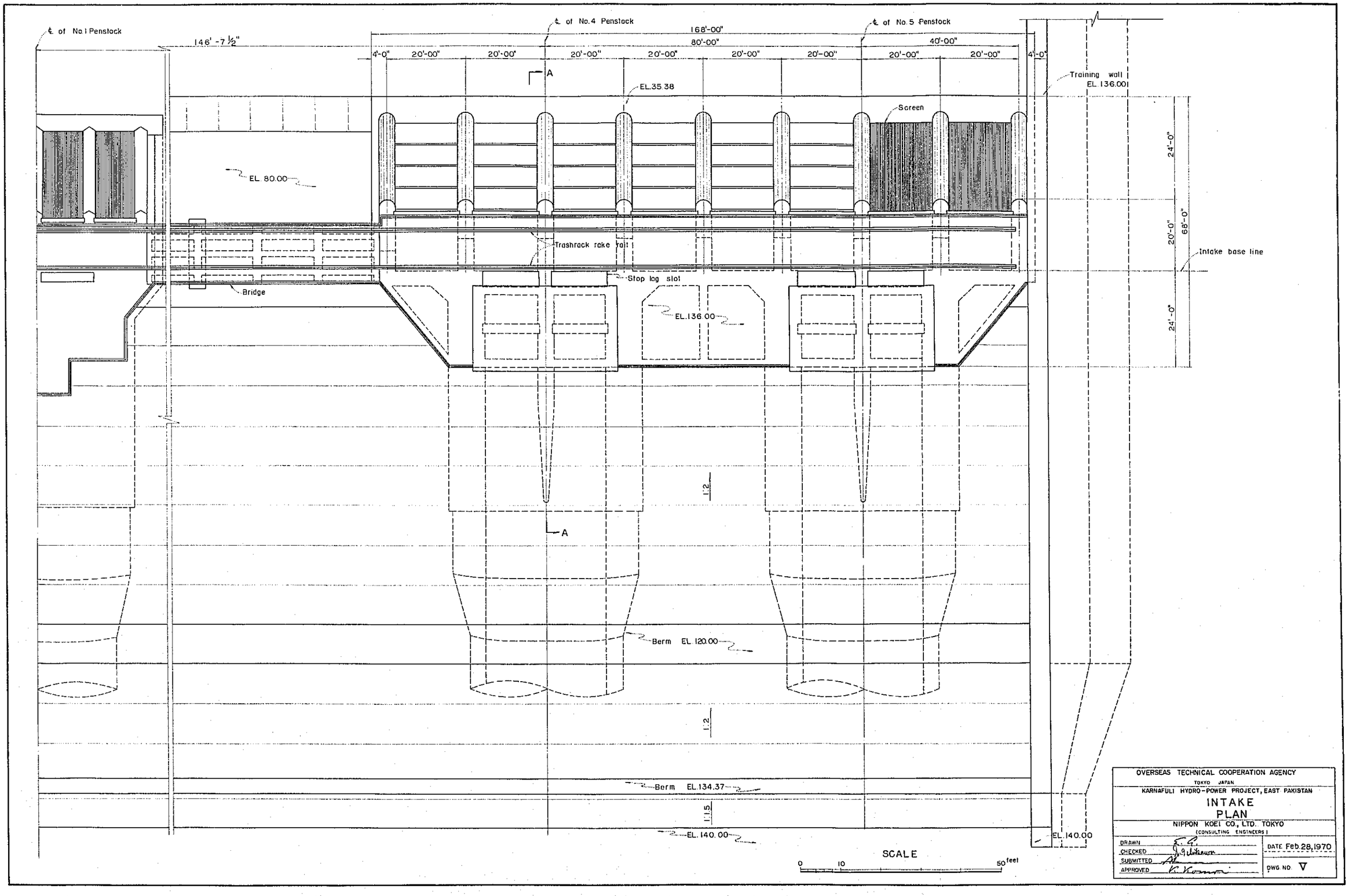


SECTION B-B

SCALE
0
30 feet

TYPICAL SECTION OF PENSTOCK TUNNEL

OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO JAPAN	
KARNAFULI HYDRO-POWER PROJECT, EAST PAKISTAN	
PROFILE OF WATERWAY	
NIPPON KOEI CO., LTD. TOKYO (CONSULTING ENGINEERS)	
DRAWN T. C.	DATE Feb. 28, 1970
CHECKED S. Ishihara	
SUBMITTED	DWG. NO. IV
APPROVED K. Kisanuki	



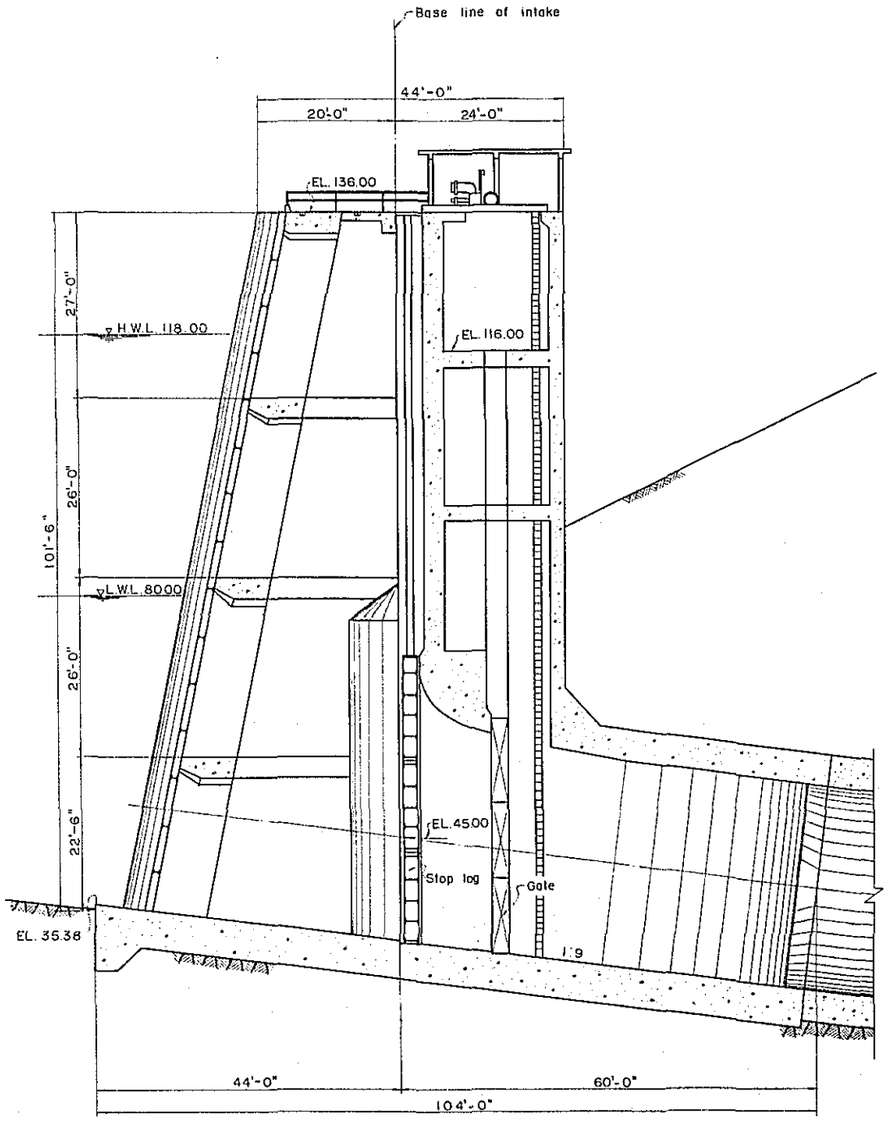
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

KARNAFULI HYDRO-POWER PROJECT, EAST PAKISTAN

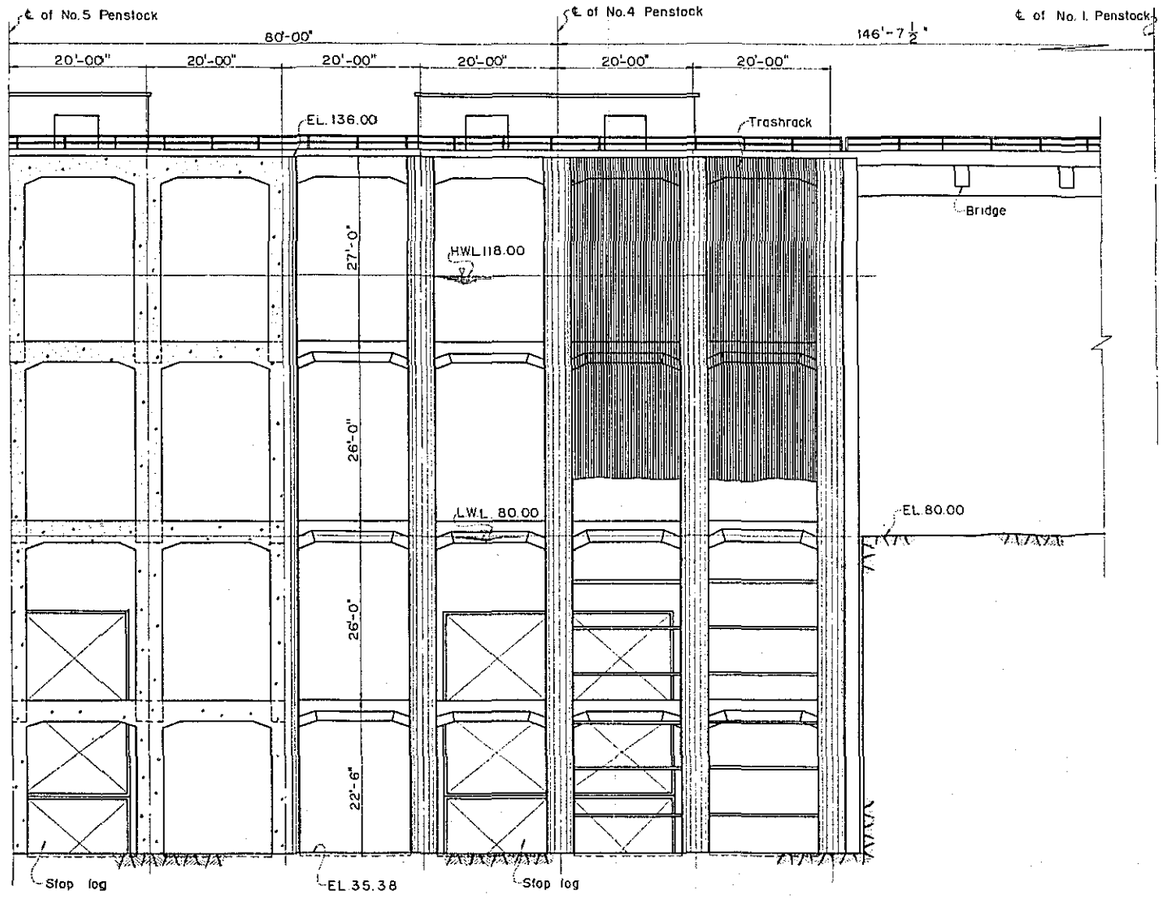
INTAKE PLAN

NIPPON KOEI CO., LTD. TOKYO
(CONSULTING ENGINEERS)

DRAWN		DATE Feb.28,1970
CHECKED		
SUBMITTED		
APPROVED		DWG NO. V



SECTION A-A



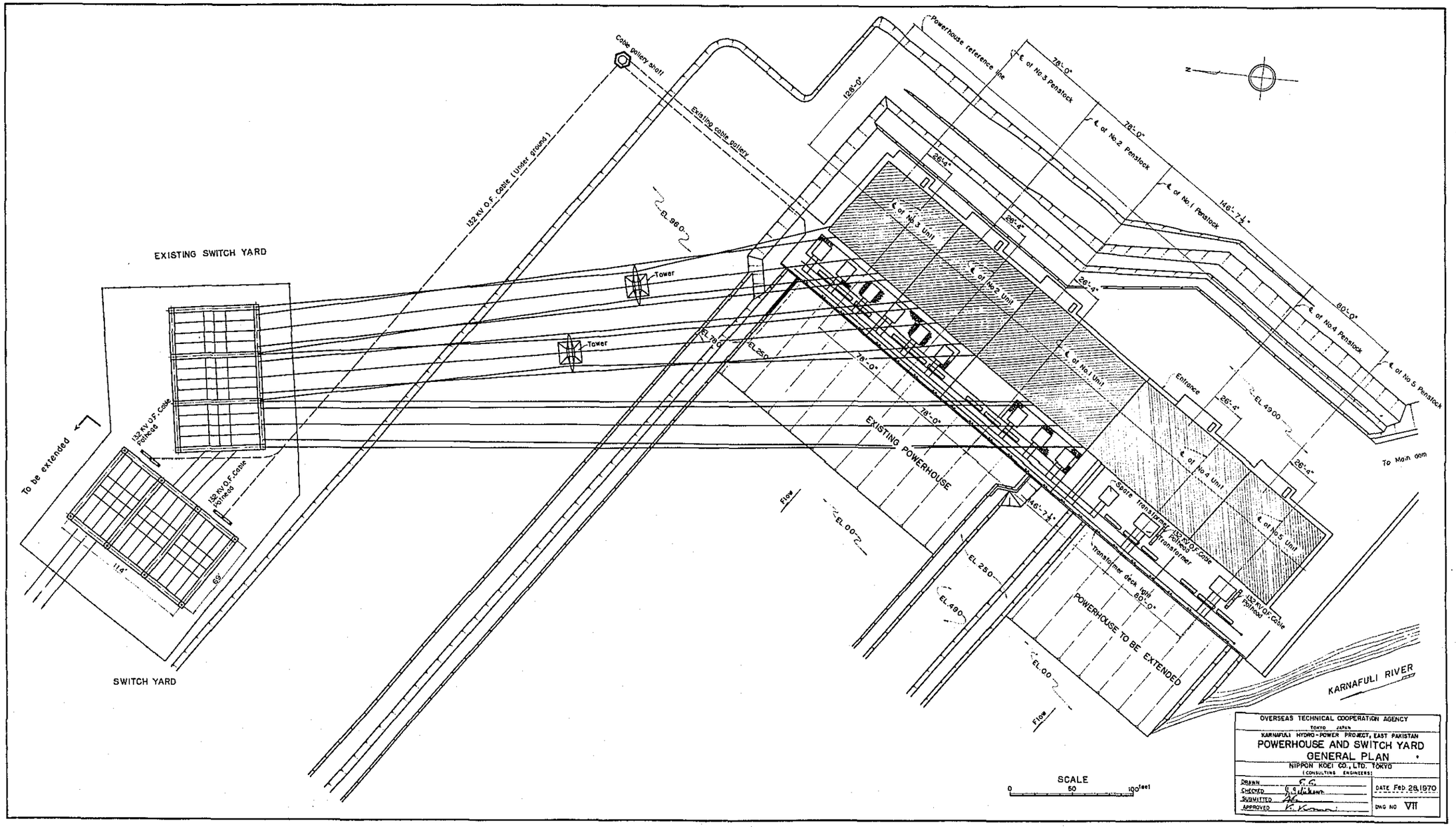
UPSTREAM ELEVATION

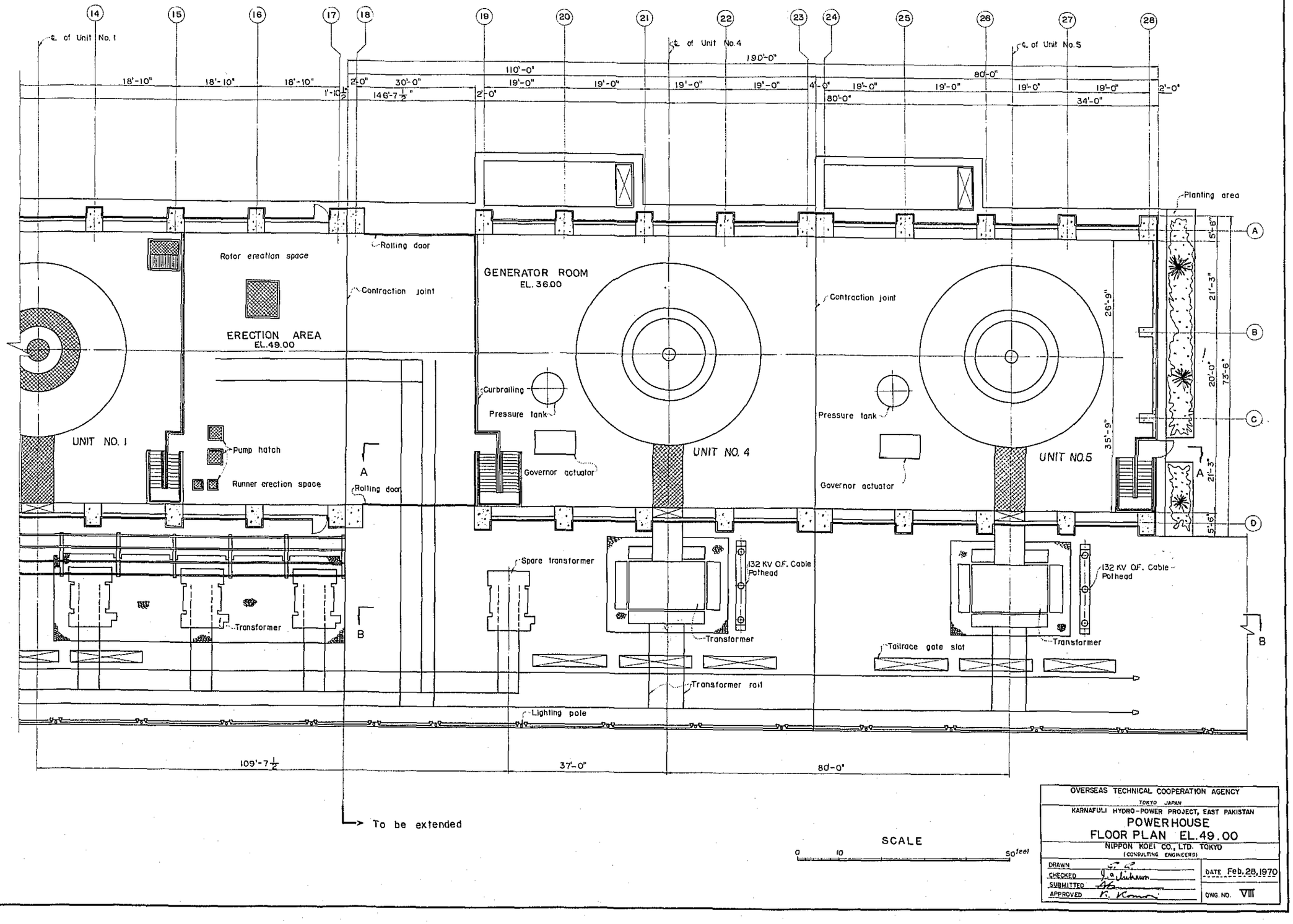
SCALE

0 10 50 feet

OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN
KARNAFULI HYDRO-POWER PROJECT, EAST PAKISTAN
INTAKE
ELEVATION AND SECTION
NIPPON KOEI CO, LTD. TOKYO
(CONSULTING ENGINEERS)

DRAWN		DATE	Feb. 28, 1970
CHECKED			
SUBMITTED		DWG. NO.	VI
APPROVED			


Cable gallery shaft
132 KV O.F. Cable (Under ground)
Existing cable gallery
EL 960
EXISTING SWITCH YARD
Tower
Tower
EL 780
EL 250
To be extended
132 KV O.F. Cable Pothead
132 KV O.F. Cable Pothead
114'
69'
SWITCH YARD
128'-0"
Powerhouse reference line
℄ of No.3 Penstock
78'-0"
℄ of No.2 Penstock
78'-0"
℄ of No.1 Penstock
146'-7½"
80'-0"
℄ of No.4 Penstock
℄ of No.5 Penstock
26'-4"
℄ of No.3 Unit
℄ of No.2 Unit
℄ of No.1 Unit
78'-0"
EXISTING POWERHOUSE
Entrance
EL 490
℄ of No.4 Unit
℄ of No.5 Unit
Spare transformer
132 KV O.F. Cable Pothead
Transformer deck top 80'-0"
132 KV O.F. Cable Pothead
EL 250
EL 490
EL 00
POWERHOUSE TO BE EXTENDED
Flow
Flow
To Main dam
KARNAFULI RIVER
SCALE
0 50 100 feet
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN
KARNAFULI HYDRO-POWER PROJECT, EAST PAKISTAN
POWERHOUSE AND SWITCH YARD
GENERAL PLAN
NIPPON KOEI CO., LTD. TOKYO
(CONSULTING ENGINEERS)
DRAWN
CHECKED
SUBMITTED
APPROVED
DATE Feb 28,1970
DWG NO VII



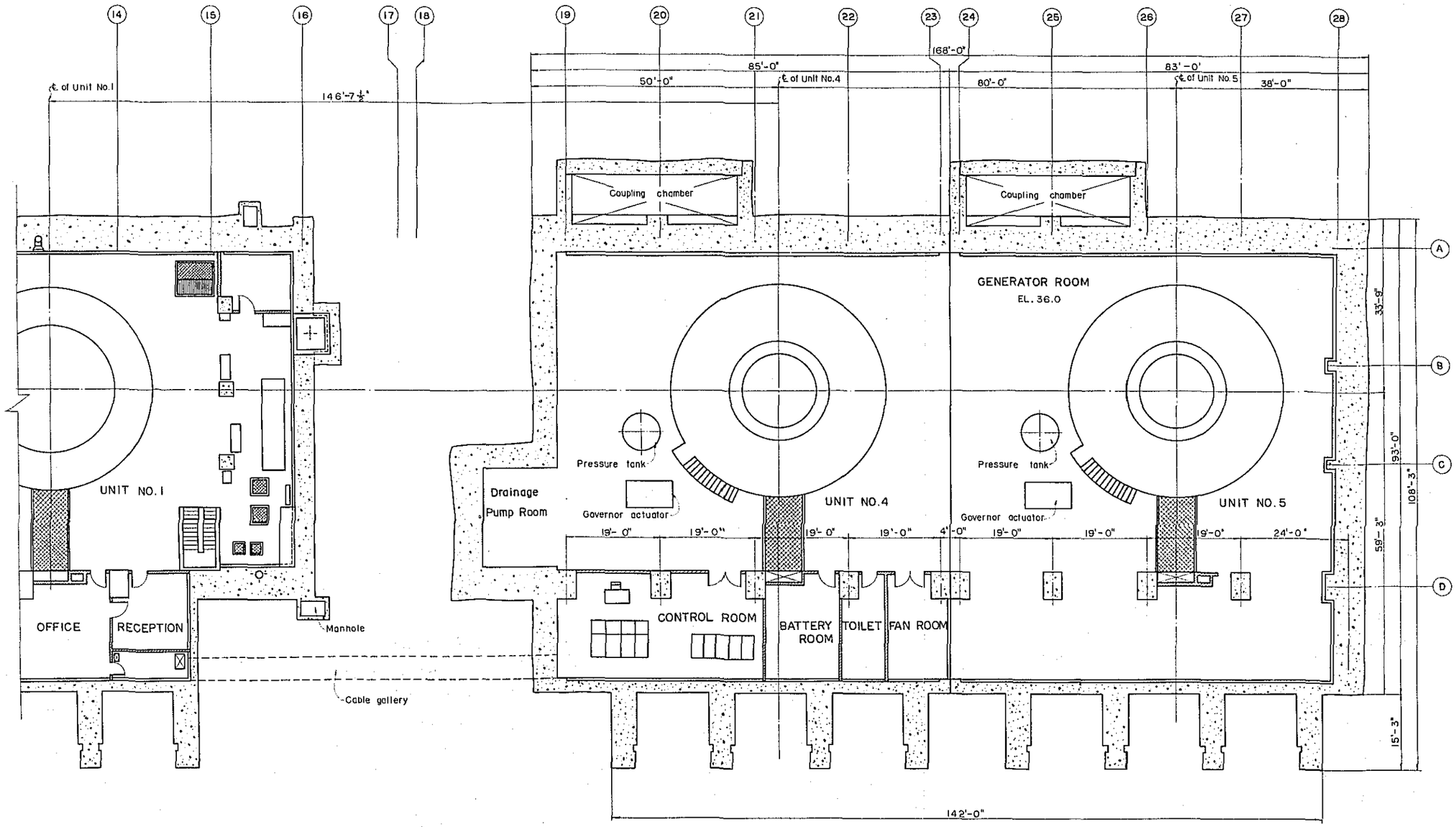
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

KARNAFULI HYDRO-POWER PROJECT, EAST PAKISTAN

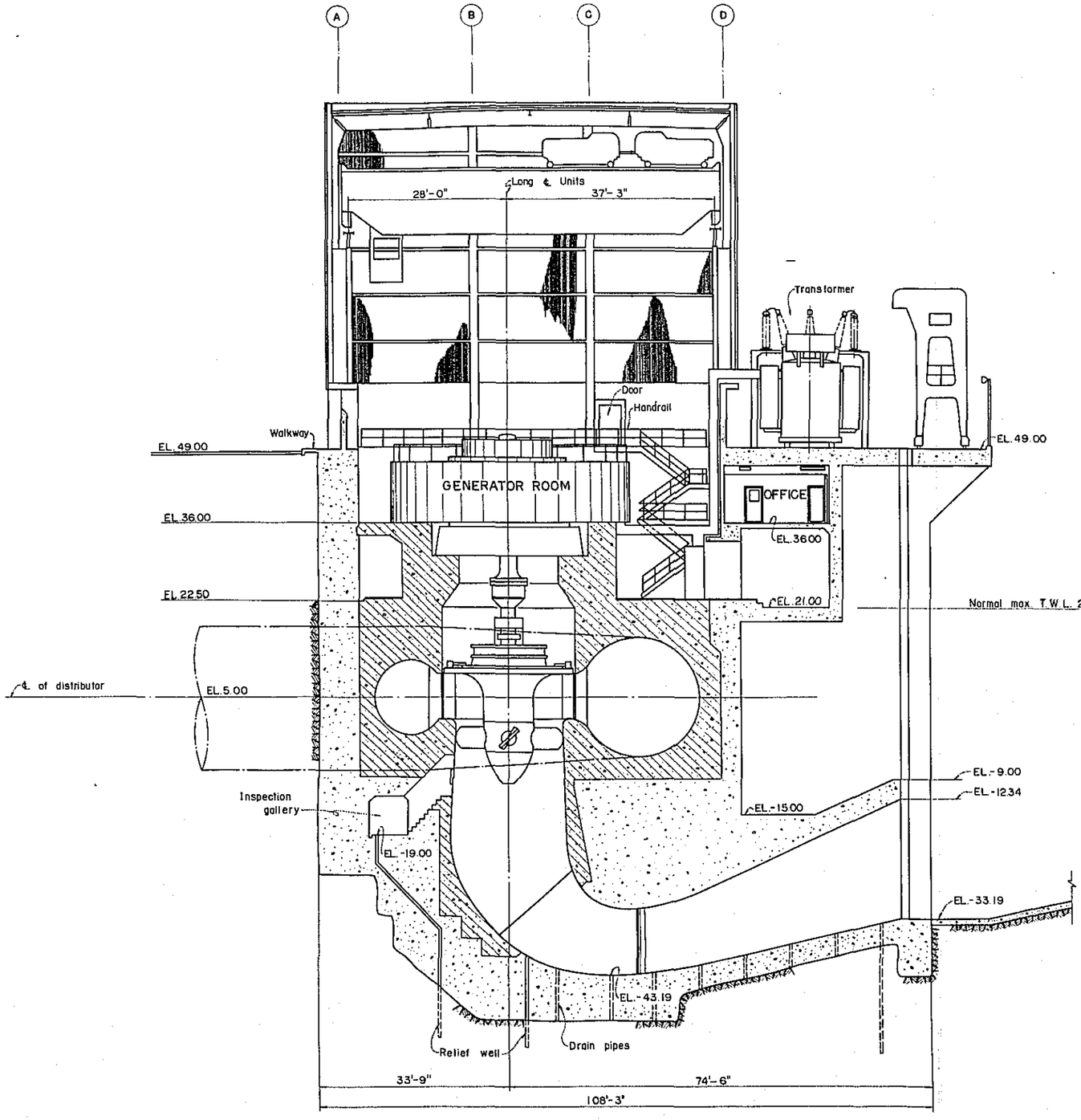
POWERHOUSE
FLOOR PLAN EL. 49.00

NIPPON KOEI CO., LTD. TOKYO
(CONSULTING ENGINEERS)

DRAWN		DATE	Feb. 28, 1970
CHECKED			
SUBMITTED			
APPROVED		DWG. NO.	VIII



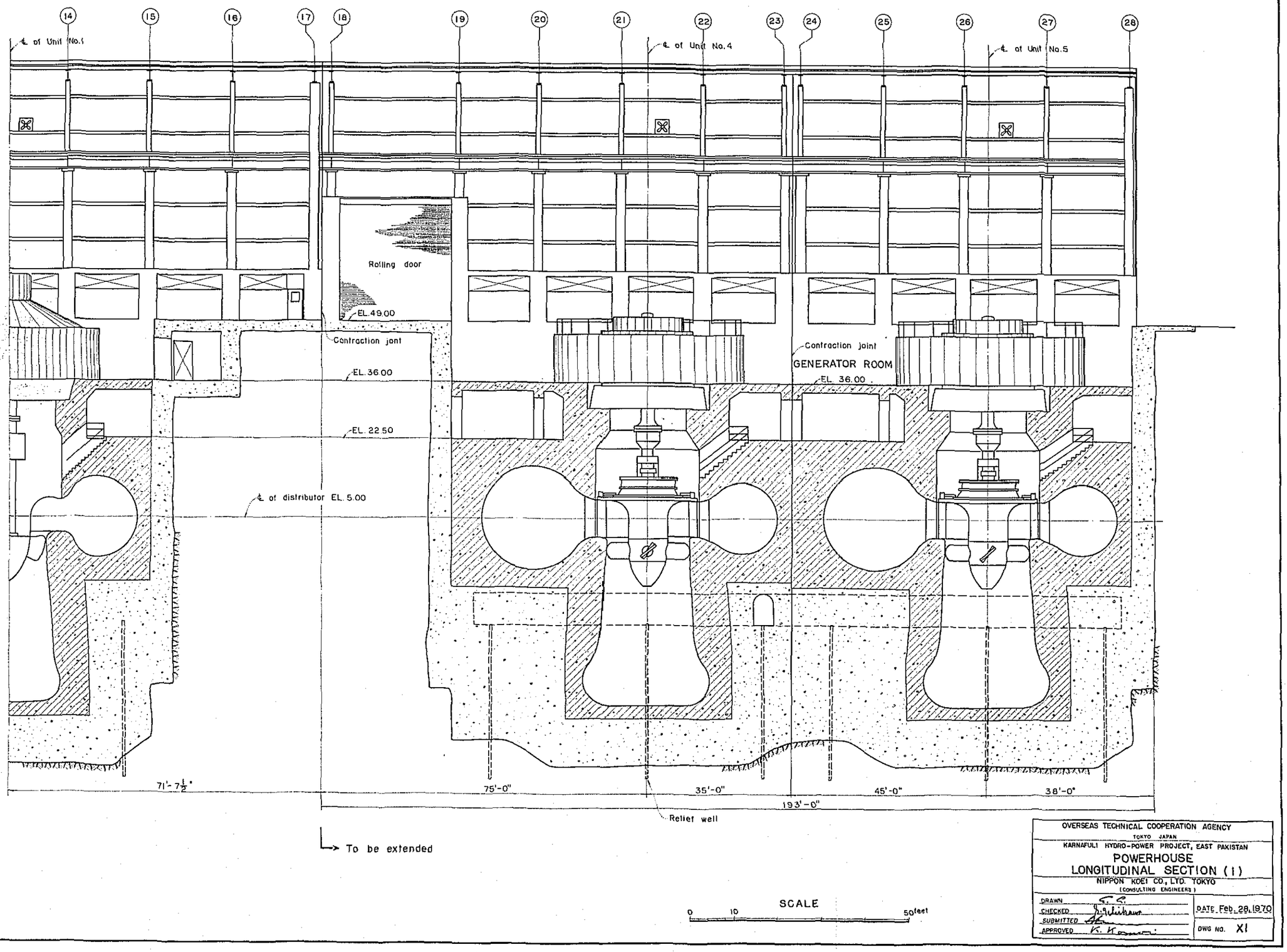
OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO JAPAN	
KARNAFULI HYDRO-POWER PROJECT, EAST PAKISTAN	
POWERHOUSE FLOOR PLAN EL. 36.00	
NIPPON KOEI CO., LTD. TOKYO (CONSULTING ENGINEERS)	
DRAWN	DATE Feb. 28, 1970
CHECKED	
SUBMITTED	
APPROVED	DWG. NO. IX



SCALE

0 10 50 feet

OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO JAPAN	
KARNAFULI HYDRO-POWER PROJECT, EAST PAKISTAN	
POWERHOUSE TRANSVERSE SECTION	
NIPPON KOEI CO., LTD. TOKYO (CONSULTING ENGINEERS)	
DRAWN E. C.	DATE Feb. 28. 1970
CHECKED J. Ishihara	
SUBMITTED	DWG. NO. X
APPROVED K. Komai	



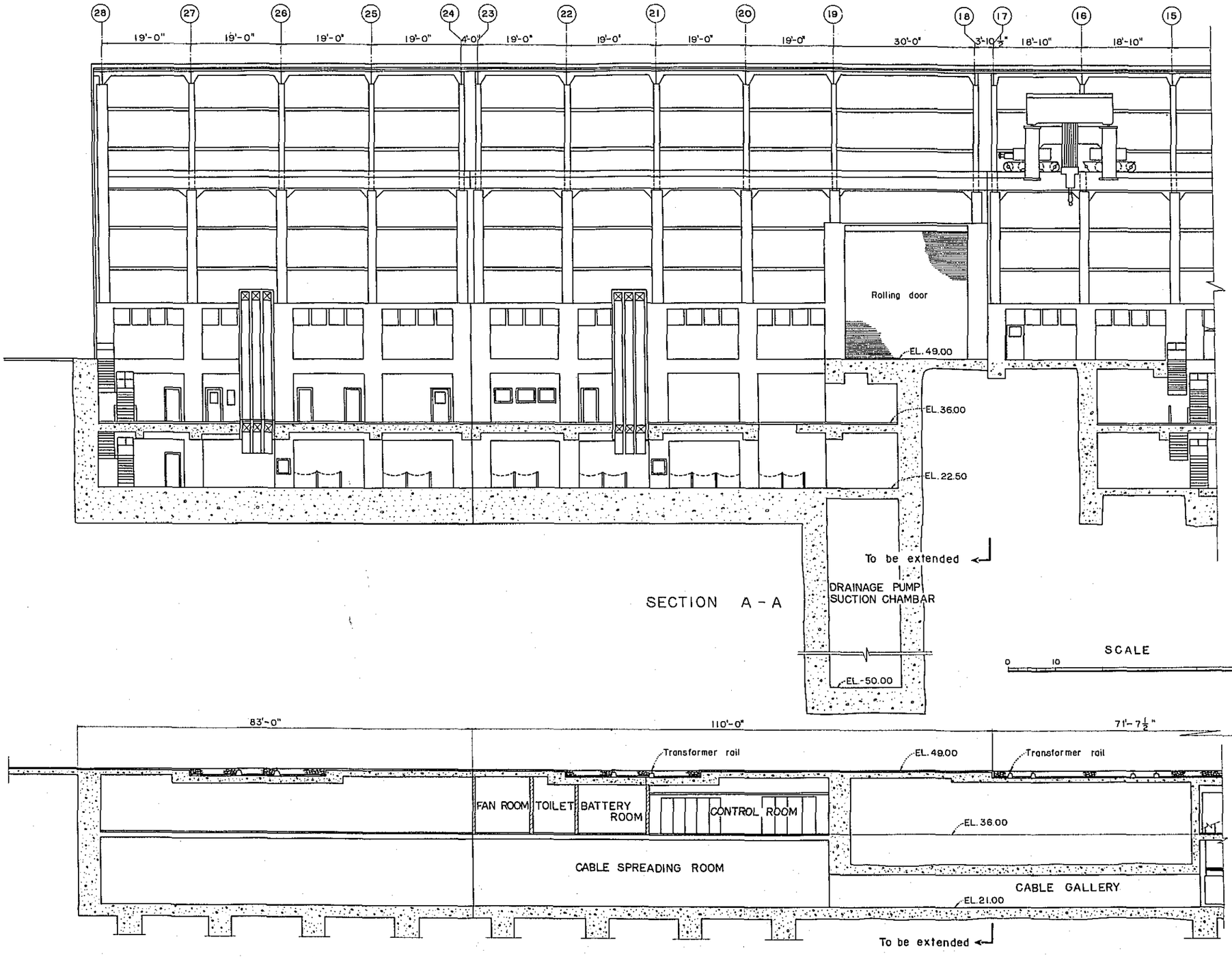
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

KARNAFULI HYDRO-POWER PROJECT, EAST PAKISTAN

POWERHOUSE
LONGITUDINAL SECTION (1)

NIPPON KOEI CO., LTD. TOKYO
(CONSULTING ENGINEERS)

DRAWN	T. S.	DATE Feb. 28, 1970
CHECKED	[illegible]	
SUBMITTED	[illegible]	DWG NO. X1
APPROVED	K. Kawai	



OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

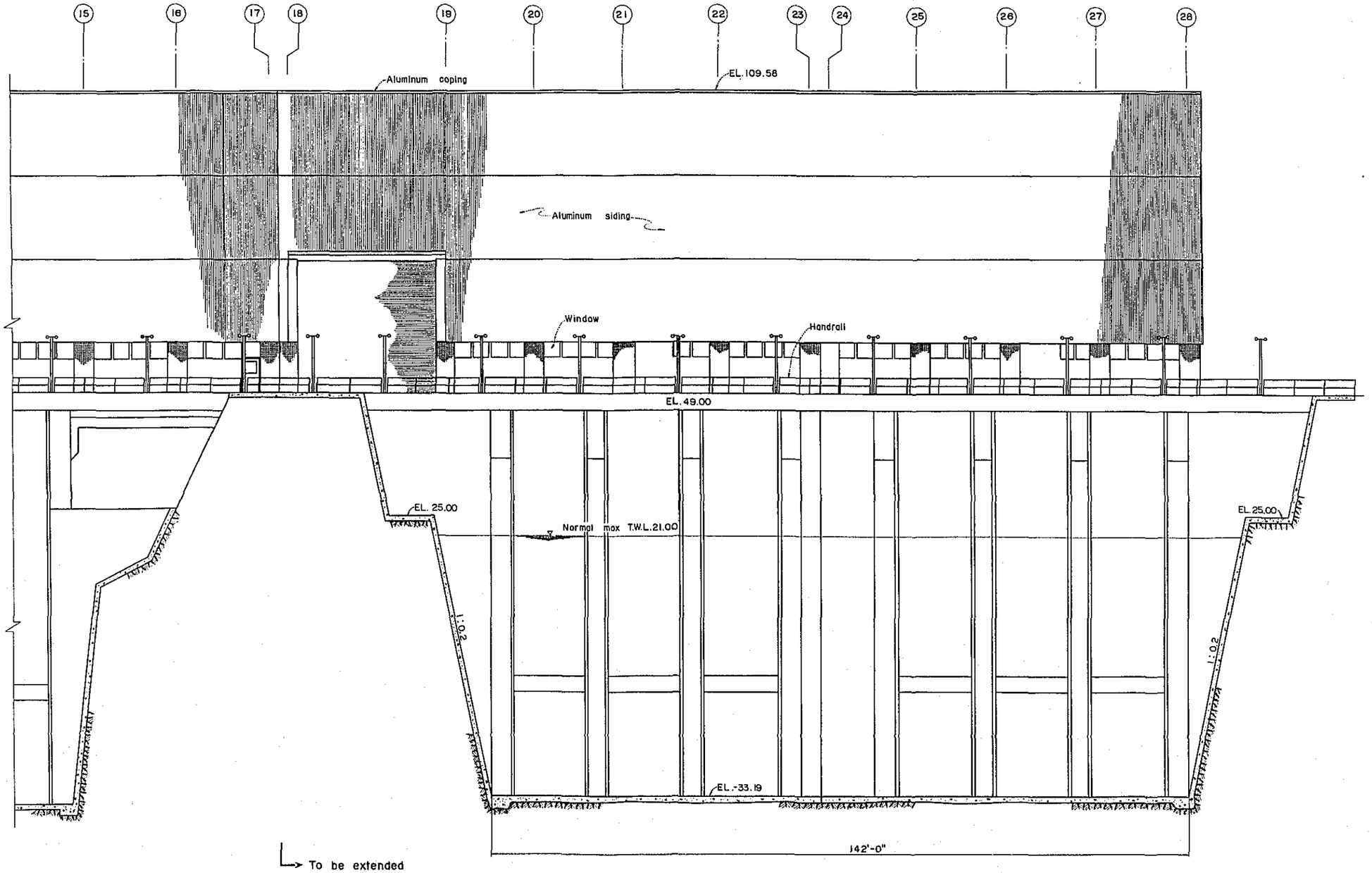
KARNAFULI HYDRO-POWER PROJECT, EAST PAKISTAN

POWERHOUSE

LONGITUDINAL SECTION (2)

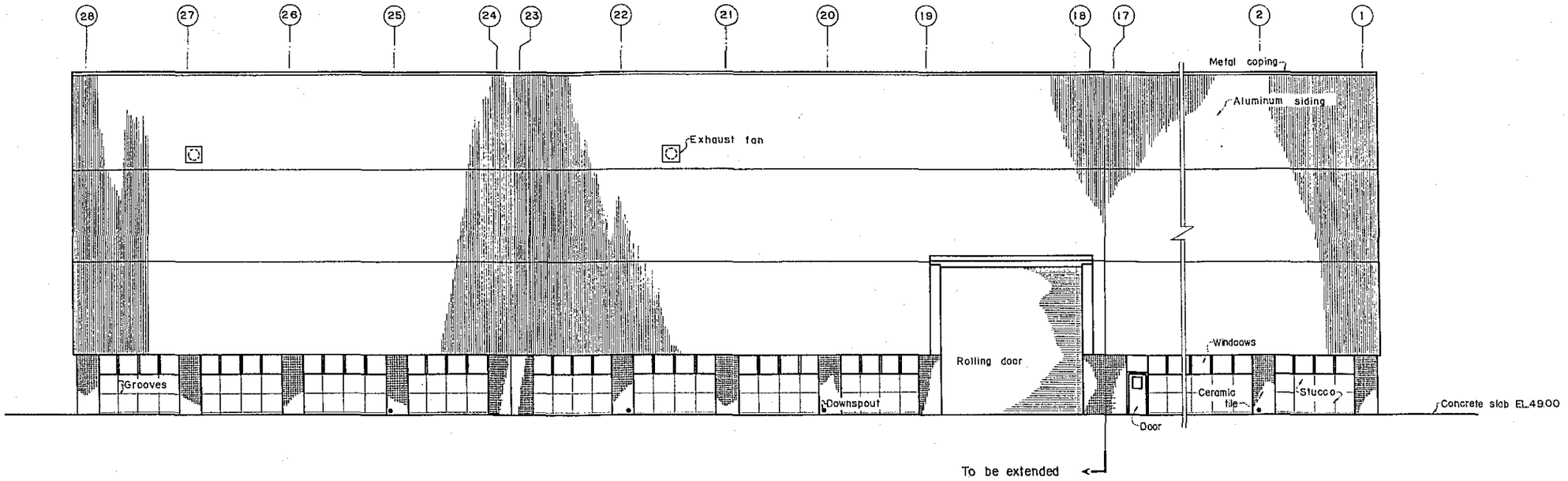
NIPPON KOEI CO., LTD. TOKYO
(CONSULTING ENGINEERS)

DRAWN	E. C.	DATE Feb. 28, 1970
CHECKED	S. Ishihara	
SUBMITTED		DWG. NO. XII
APPROVED	K. Kawai	

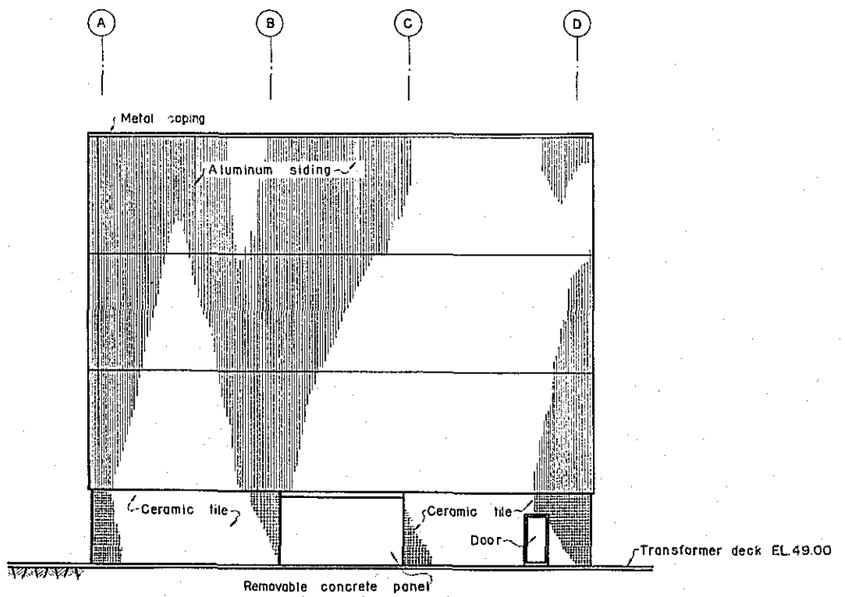


OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN
KARNAFULI HYDRO-POWER PROJECT, EAST PAKISTAN
POWERHOUSE
DOWNSTREAM ELEVATION
NIPPON KOEI CO., LTD. TOKYO
(CONSULTING ENGINEERS)

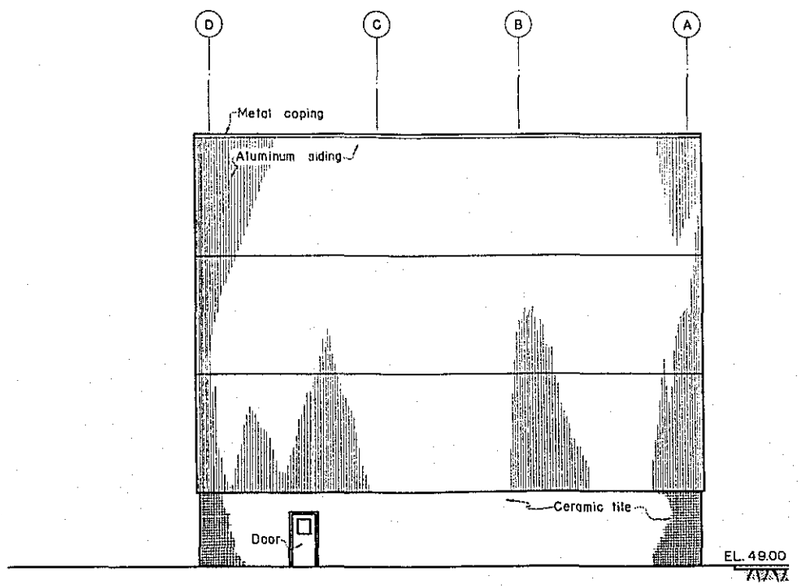
DRAWN		DATE	Feb. 28, 1970
CHECKED			
SUBMITTED		DWG. NO.	XII
APPROVED			



UPSTREAM ELEVATION



NORTH END ELEVATION



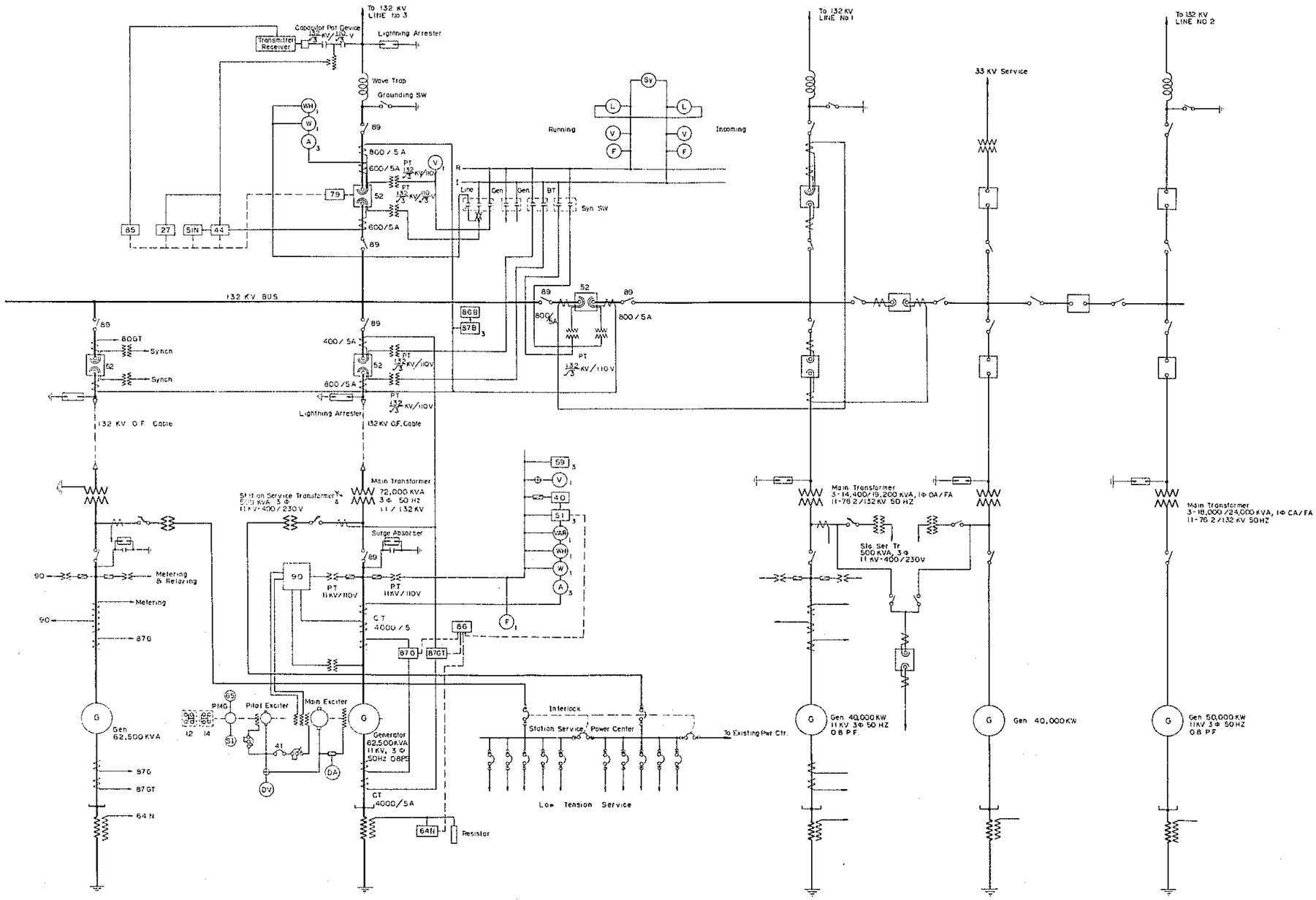
SOUTH END ELEVATION

SCALE

0 10 50 feet

OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN
KARNAFULI HYDRO-POWER PROJECT EAST, PAKISTAN
POWERHOUSE
ELEVATIONS
NIPPON KOEI CO., LTD. TOKYO
(CONSULTING ENGINEERS)

DRAWN	E.C.	DATE Feb. 28, 1970
CHECKED	J. Ishihara	
SUBMITTED		
APPROVED	K. Komura	DWG. NO. XIV



GENERATOR UNIT NO.5 (New)

GENERATOR UNIT NO.4 (New)

GENERATOR UNIT NO. 1 (Existing)

GENERATOR UNIT NO. 2 (Existing)

GENERATOR UNIT NO. 3 (Under construction)

Japanese standard device numbers and symbols are used for relays and instruments.

Relay suffix letters indicate location or condition to which device responds as follows:

B	Bus
G	Generator
GT	Generator-Transformer Unit
N	Neutral

Instrument letters are defined as follows:

A	A.C. Ammeter
DA	D.C. Ammeter
DV	D.C. Voltmeter
F	Frequency Meter
L	Lamp
PMG	Permanent Magnet Generator.
SI	Speed Indicator
Sy	Synchroscope
V	A.C. Voltmeter
VAR	Varmeter
W	Wattmeter
WH	Watthmeter
⊖	Instrument switch

Device numbers are defined as follows:

12	Overspeed
14	Underspeed
27	Undervoltage relay
40	Loss-of-field relay
41	Field switch
44	Distance relay
51	A.C. Overcurrent relay
52	A.C. Circuit breaker
59	Overvoltage relay
64	Ground relay
65	Governor
79	Reclosing relay
85	Carrier relay
86	Lock out relay
87	Differential relay
89	Disconnecting switch
90	Voltage regulator

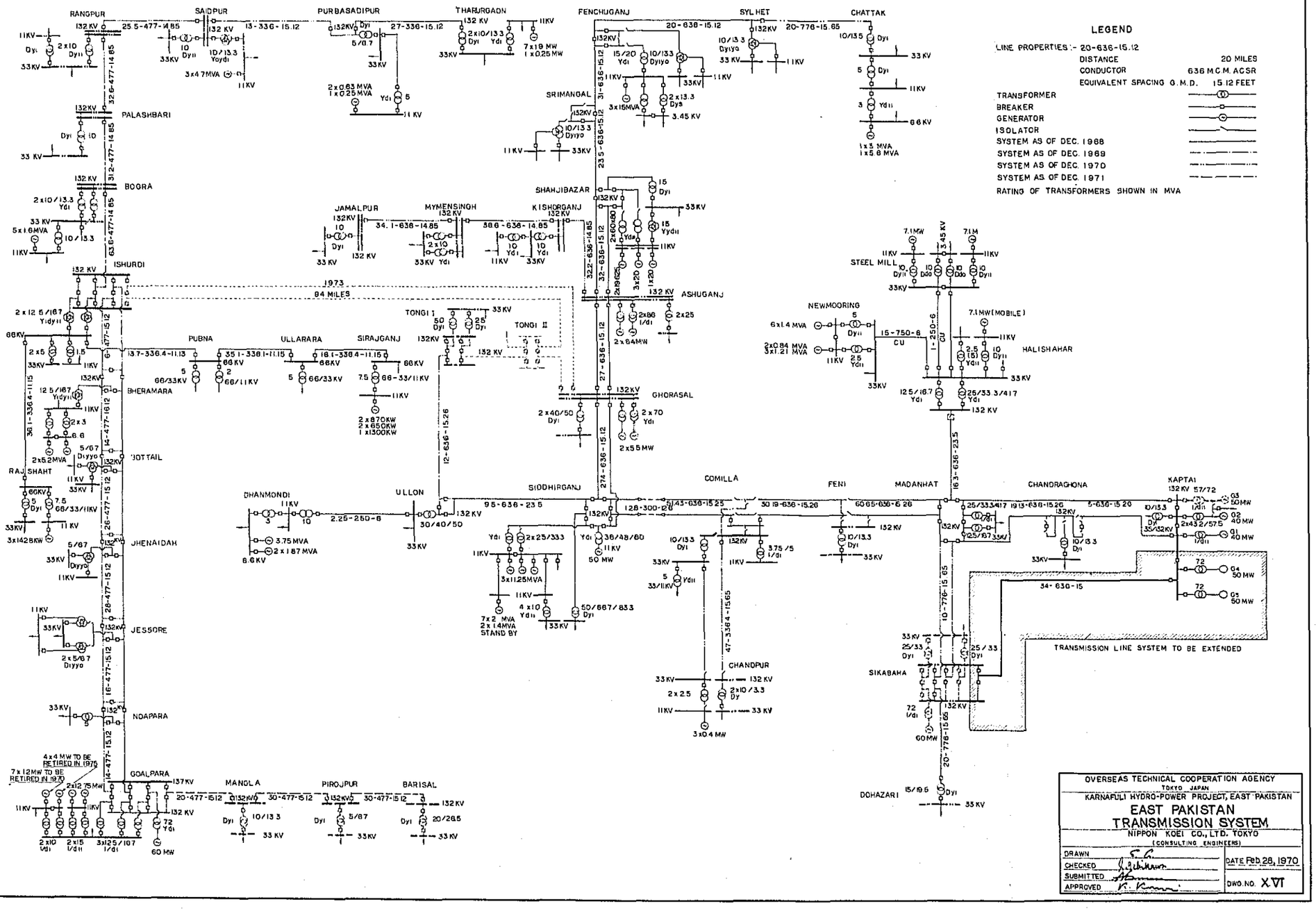
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

KARNAFULI HYDRO-POWER PROJECT, EAST PAKISTAN

SKELETON CONNECTION DIAGRAM

NIPPON KOEI CO., LTD. TOKYO
(CONSULTING ENGINEERS)

DRAWN	DATE Feb. 28, 1970
CHECKED	
SUBMITTED	
APPROVED	DWG NO. XV


RANGPUR
SAIDPUR
PURBASADIPUR
THAKURGAON
FENCHUGANJ
SYLHET
CHATTAK
PALASHBARI
BOGRA
ISHURDI
JAMALPUR
MYMENSINGH
KISHORGANJ
SHAHJIBAZAR
SRIMANGAL
ASHUGANJ
STEEL MILL
NEWMOORING
HALISHAHAR
PUBNA
ULLARARA
SIRAJGANJ
BHERAMARA
TONGI I
TONGI II
GHORASAL
RAJSHAHI
JHENAIDAH
JESSORE
NOAPARA
GOALPARA
DHANMONDI
ULLON
SIDDHIRGANJ
COMILLA
FENI
MADANHAT
CHANDRAGHONA
KAPTAI
SIKABAHA
CHANDPUR
DOHAZARI
MANGLA
PIROJPUR
BARISAL
1973
64 MILES
TRANSMISSION LINE SYSTEM TO BE EXTENDED
4x4 MW TO BE RETIRED IN 1975
7x12MW TO BE RETIRED IN 1970
LEGEND
LINE PROPERTIES :- 20-636-15.12
DISTANCE 20 MILES
CONDUCTOR 636 M.C.M. ACSR
EQUIVALENT SPACING G.M.D. 15.12 FEET
TRANSFORMER
BREAKER
GENERATOR
ISOLATOR
SYSTEM AS OF DEC. 1968
SYSTEM AS OF DEC. 1969
SYSTEM AS OF DEC. 1970
SYSTEM AS OF DEC. 1971
RATING OF TRANSFORMERS SHOWN IN MVA
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN
KARNAFULI HYDRO-POWER PROJECT, EAST PAKISTAN
EAST PAKISTAN
TRANSMISSION SYSTEM
NIPPON KOEI CO., LTD. TOKYO
(CONSULTING ENGINEERS)
DRAWN
CHECKED
SUBMITTED
APPROVED
DATE Feb. 28, 1970
DWG. NO. X-VI