9.2.4 The Optimal Development Plan

The project feature of the selected optimal plan through above study is shown below.

High Water Level	630.00 m
Low Water Level	610.00 m
Gross Storage Capacity	109.3×10^6 m^3
Effective Storage Capacity	24.7×10^6 m^3
Maximum Power Discharge	108 m^3/s
Standard Effective Head	284.4 m
Installed Capacity	270 MW
Number of Unit	2

The economic condition of the optimal plan at the first, second, and third stages was examined.

Because the profitability was clarified for operating the reservoir at a maximal water level, an energy calculation was redone employing the reservoir operational rule to maintain a high water level that increases spillage. Evaporation losses were considered in this calculation. A tail-water level of 321.80 meters' elevation -- which is given from a discharge of 122 m^3/s -- is adopted as the normal tail-water level. A discharge of 122 m^3/s is given as the sum of the maximum discharge of the Goktas Power Plant's 108 m^3/s, and the mean river runoff is 14 m^3/s between the dam and the powerhouse.

The inflow to the reservoir, the power discharge, the amount of evaporation, and the amount of spill in each stage, for a simulation of reservoir operation for the 43 years from 1940 to 1982, are shown in Table 9-12. The storage and the water supplement are shown in Fig. 9-11 - 13. The energy generation and monthly output of the Goktas Power Plant are shown in Table 9-13, 14, 15, 16, 17, 18 and Fig. 9-14, 15, 16.

Economic condition at each stage is shown in Table 9-19.

B/C at first stage is 1.65, which increase to 1.71 at second stage and decrease to 1.50 at third stage. B-C at first stage is 35,451 x

10^6 TL, which increase to 38,758 x 10^6 TL at third stage. Energy cost at first stage is 47.7 TL/kWh, which decrease 9.7% to 43.5 TL/kWh at second stage and increase 17.2% to 55.9 TL/kWh. The economical condition at third stage is the worst among three stages, but it is still very good.

Table 9-12 Summary of Operation Study of Goktas Reservoir

Unit: 10^6 m^3

Year	Stage I				Stage II				Stage III			
	Inflow	Evaporation	Power Discharge	Spill	Inflow	Evaporation	Power Discharge	Spill	Inflow	Evaporation	Power Discharge	Spill
1940	1,857.8	1.9	1,744.8	111.1	2,007.5	1.9	1,943.4	62.2	1,585.2	1.9	1,583.2	0.0
1941	1,748.9	2.0	1,716.8	30.1	1,894.9	2.0	1,892.9	0.0	1,412.8	2.0	1,410.8	0.0
1942	1,900.1	2.0	1,780.8	117.3	2,070.9	2.0	1,983.8	85.1	1,581.3	2.0	1,579.3	0.0
1943	1,844.8	2.0	1,674.6	168.3	2,035.1	2.0	1,899.2	134.0	1,572.6	2.0	1,536.5	34.2
1944	1,934.9	1.9	1,844.0	88.9	2,102.3	1.9	2,015.4	85.0	1,696.9	1.9	1,677.4	17.5
1945	1,444.5	2.0	1,442.5	0.0	1,583.2	2.0	1,581.2	0.0	1,228.5	2.0	1,239.4	0.0
1946	1,534.3	2.0	1,529.3	2.9	1,698.4	2.0	1,696.3	0.0	1,362.7	2.0	1,347.7	0.0
1947	1,642.8	2.1	1,640.6	0.0	1,807.4	2.1	1,805.2	0.0	1,471.7	2.1	1,469.6	0.0
1948	1,868.8	2.1	1,751.6	115.2	2,013.7	2.1	1,930.4	81.2	1,570.0	2.1	1,588.3	0.0
1949	1,391.8	1.8	1,390.0	0.0	1,529.7	1.8	1,527.8	0.0	1,161.0	1.8	1,154.7	0.0
1950	1,409.4	2.0	1,413.5	0.0	1,524.6	2.0	1,522.6	0.0	1,175.7	2.0	1,177.5	0.0
1951	1,219.3	2.0	1,211.1	0.0	1,359.7	2.0	1,357.7	0.0	1,042.3	2.0	1,020.5	0.0
1952	1,734.8	2.0	1,643.7	89.0	1,891.2	2.0	1,849.9	39.3	1,463.8	2.0	1,461.7	0.0
1953	2,027.5	1.9	1,764.4	264.9	2,234.4	1.9	1,994.3	238.2	1,807.9	1.9	1,697.4	116.5
1954	1,907.2	2.0	1,772.3	129.3	2,044.9	2.0	1,947.7	95.1	1,471.8	2.0	1,461.9	0.0
1955	1,366.6	2.1	1,364.5	0.0	1,529.1	2.1	1,527.0	0.0	1,157.5	2.1	1,176.7	0.0
1956	1,366.8	2.0	1,364.8	0.0	1,495.1	2.0	1,493.1	0.0	1,095.7	2.0	1,085.6	0.0
1957	1,320.1	2.1	1,318.0	0.0	1,458.0	2.1	1,455.9	0.0	1,148.8	2.1	1,133.4	0.0
1958	1,825.8	2.0	1,794.1	29.7	1,963.1	2.0	1,896.3	64.8	1,552.0	2.0	1,547.1	11.7
1959	1,437.2	1.9	1,435.3	0.0	1,584.9	1.9	1,583.1	0.0	1,229.7	1.9	1,219.0	0.0
1960	1,457.9	2.2	1,455.8	0.0	1,547.7	2.2	1,545.5	0.0	1,130.1	2.2	1,149.5	0.0
1961	1,190.1	2.0	1,188.0	0.0	1,358.7	2.0	1,356.7	0.0	1,072.9	2.0	1,049.2	0.0
1962	1,666.3	2.2	1,661.6	2.5	1,833.9	2.2	1,831.7	0.0	1,469.1	2.2	1,466.9	0.0
1963	2,038.3	2.0	2,021.6	14.6	2,162.2	2.0	2,155.6	4.6	1,671.7	2.0	1,669.7	0.0
1964	1,225.4	2.0	1,223.4	0.0	1,383.1	2.0	1,381.1	0.0	1,019.0	2.0	1,017.0	0.0
1965	1,869.2	2.0	1,829.8	37.5	2,062.2	2.0	2,045.5	14.8	1,602.3	2.0	1,600.3	0.0
1966	2,071.4	2.3	2,062.1	7.0	2,235.4	2.3	2,210.0	23.2	1,792.5	2.3	1,790.3	0.0
1967	2,010.5	1.9	1,925.6	83.0	2,199.7	1.9	2,147.5	50.3	1,678.1	1.9	1,676.2	0.0
1968	2,298.5	2.1	2,149.8	146.6	2,490.6	2.1	2,373.4	115.2	1,857.8	2.1	1,855.7	0.0
1969	2,616.1	2.0	2,252.0	362.0	2,792.8	2.0	2,443.6	347.1	2,138.4	2.0	2,086.6	49.7
1970	1,754.8	2.1	1,752.7	0.0	1,876.2	2.1	1,874.0	0.0	1,390.4	2.1	1,388.3	0.0
1971	1,447.8	2.0	1,445.8	0.0	1,573.7	2.0	1,571.7	0.0	1,212.4	2.0	1,210.4	0.0
1972	1,503.5	1.9	1,501.6	0.0	1,617.2	1.9	1,615.3	0.0	1,175.7	1.9	1,178.6	0.0
1973	1,114.4	2.0	1,130.9	0.0	1,239.1	2.0	1,237.1	0.0	903.3	2.0	909.8	0.0
1974	1,133.4	2.0	1,112.9	0.0	1,239.1	2.0	1,237.1	0.0	915.4	2.0	900.1	0.0
1975	1,892.2	2.1	1,694.8	195.3	2,010.0	2.1	1,854.1	153.8	1,467.4	2.1	1,465.3	0.0
1976	1,735.7	2.0	1,711.1	22.6	1,887.6	2.0	1,885.6	0.0	1,406.4	2.0	1,404.5	0.0
1977	1,835.9	2.2	1,810.3	23.4	1,976.6	2.2	1,974.4	0.0	1,483.9	2.2	1,481.6	0.0
1978	1,857.4	2.2	1,851.6	3.6	2,000.3	2.2	1,998.1	0.0	1,518.5	2.2	1,516.3	0.0
1979	1,680.5	2.2	1,678.3	0.0	1,818.0	2.2	1,815.8	0.0	1,370.0	2.2	1,367.8	0.0
1980	2,193.1	2.2	2,038.7	152.2	2,319.7	2.2	2,193.1	124.4	1,730.6	2.2	1,728.4	0.0
1981	2,337.8	2.3	2,279.1	56.4	2,483.5	2.3	2,427.6	53.7	1,938.4	2.3	1,936.1	0.0
1982	1,554.7	2.0	1,552.7	0.0	1,698.9	2.0	1,696.9	0.0	1,174.8	2.0	1,172.7	0.0
Average	1,703.9	2.1	1,649.4	52.4	1,852.0	2.1	1,808.7	41.2	1,416.4	2.1	1,409.0	5.3

Fig. 9-11 Goktas Reservoir Operation (Stage I)

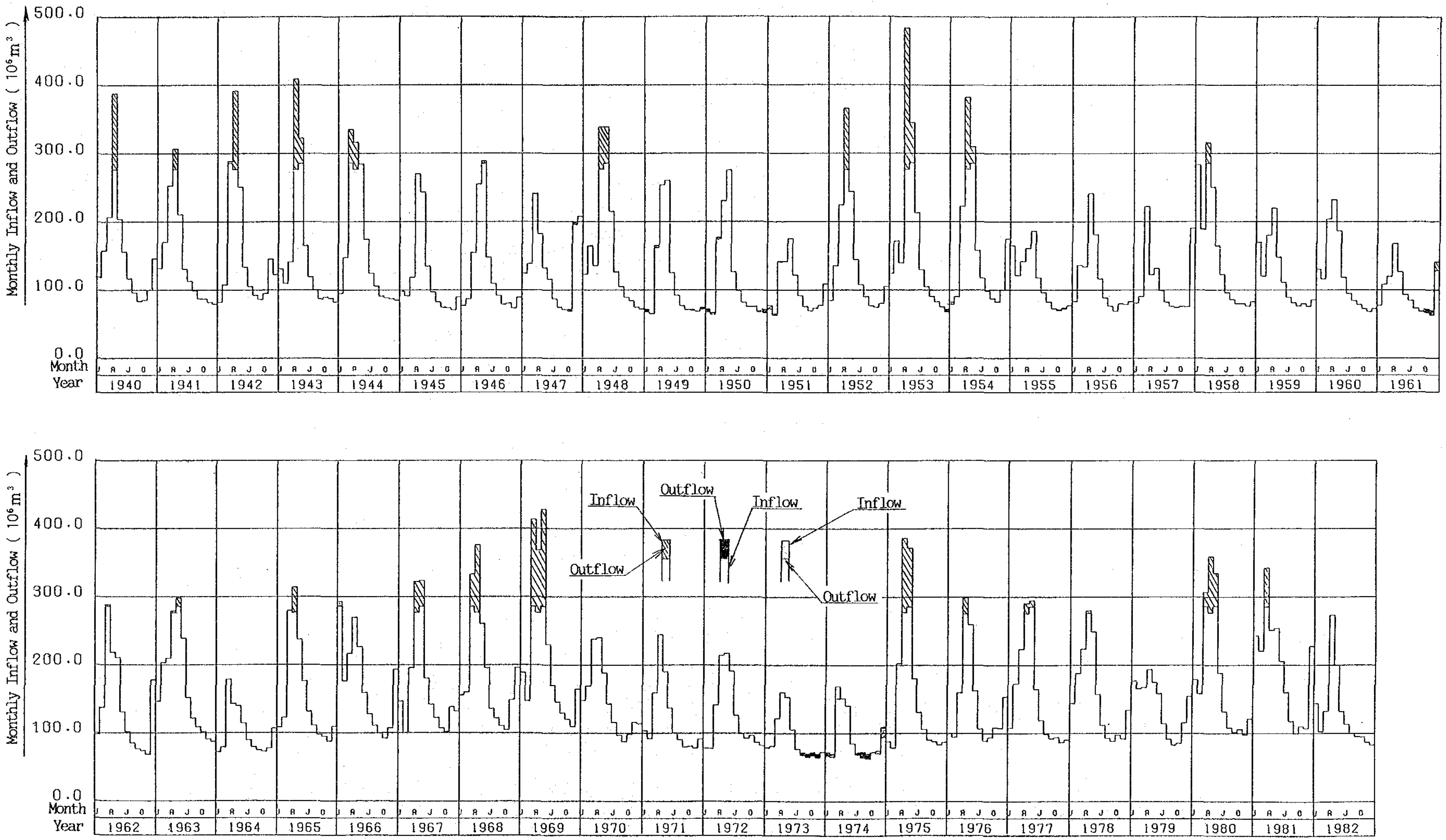
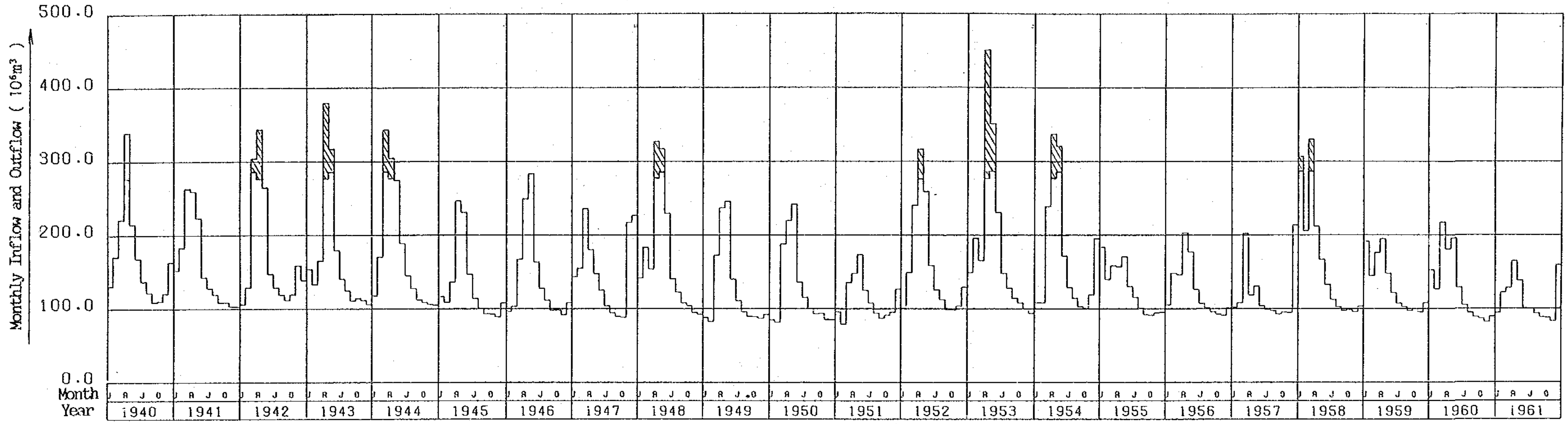


Fig. 9-12 Goktas Reservoir Operation (Stage II)



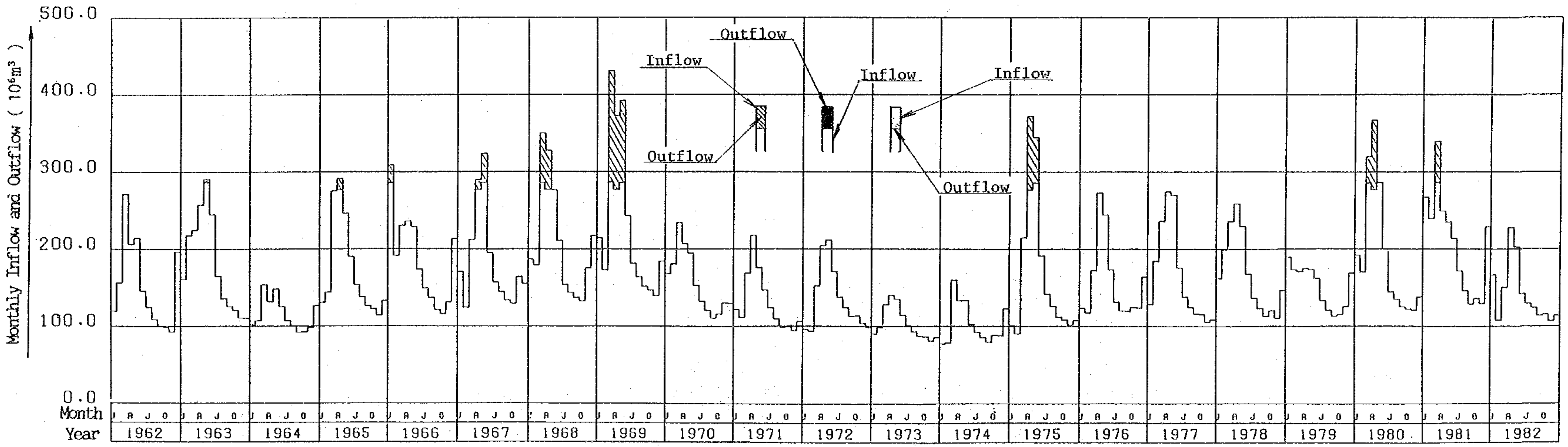


Fig. 9-13 Goktas Reservoir Operation (Stage III)

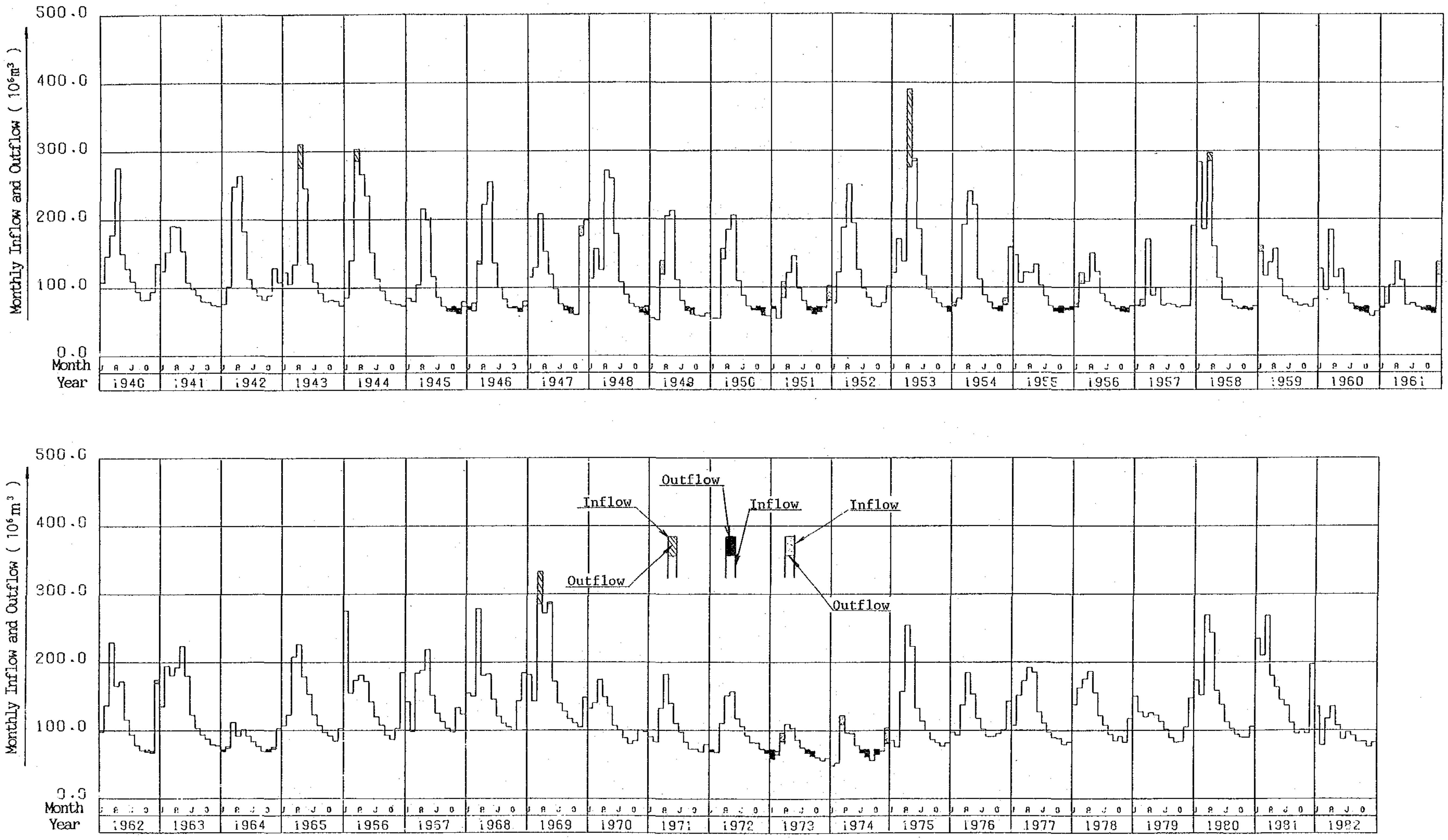


Table 9-13 Energy Generation of Goktas Power Plant (Stage I)

(Unit: GWh)

Year \ Month	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1940	83.7	110.8	145.5	194.4	143.0	109.5	81.8	67.2	58.4	59.8	70.1	102.5	1,226.9
1941	92.8	119.8	177.9	194.4	147.7	91.6	79.0	69.3	61.0	60.8	57.5	55.7	1,207.5
1942	57.8	75.7	200.9	194.4	176.1	93.6	73.6	64.7	60.4	66.7	102.2	86.1	1,252.1
1943	92.1	77.2	99.2	194.4	200.7	115.9	83.6	70.4	61.1	63.0	61.6	58.1	1,177.4
1944	66.8	103.9	200.9	194.4	199.9	122.4	87.4	74.3	63.8	62.2	61.1	59.7	1,296.8
1945	68.8	64.4	83.4	189.9	171.0	94.7	67.9	57.7	52.2	51.8	49.7	63.1	1,014.6
1946	54.3	61.1	108.8	179.3	200.9	103.8	76.6	64.4	55.4	56.6	51.6	62.7	1,075.5
1947	87.6	97.5	169.5	128.0	92.9	81.2	61.1	52.3	49.8	50.2	137.3	146.3	1,153.6
1948	86.7	115.9	95.6	194.4	200.9	150.9	88.8	73.5	62.6	59.1	52.7	50.7	1,231.7
1949	50.2	45.4	113.4	178.7	183.2	88.0	64.6	53.7	50.0	50.2	48.6	50.9	976.8
1950	50.2	45.3	122.5	162.0	193.6	88.6	69.1	57.3	52.9	53.1	48.6	50.2	993.4
1951	50.3	45.3	98.5	99.6	123.2	85.5	64.3	53.1	48.7	51.6	54.6	76.6	851.5
1952	59.4	95.5	158.0	194.4	171.3	101.5	75.6	63.2	53.9	52.4	56.5	74.1	1,155.8
1953	87.6	120.7	98.3	194.4	200.8	149.5	90.9	73.3	63.5	58.0	53.0	50.2	1,240.1
1954	55.1	63.5	156.6	194.4	200.8	110.9	82.5	68.9	61.3	58.0	70.8	123.1	1,246.0
1955	116.0	85.3	99.9	113.3	130.9	82.8	67.5	57.8	50.9	50.2	50.5	54.4	959.6
1956	58.6	95.8	94.3	169.6	127.2	81.5	61.9	53.4	48.6	55.6	55.2	58.3	959.9
1957	56.8	63.6	156.2	86.0	92.5	69.3	57.5	53.1	51.9	53.2	52.9	133.9	927.0
1958	199.2	132.9	200.9	175.9	155.8	86.0	67.3	60.1	55.9	56.0	53.6	58.2	1,261.9
1959	119.5	84.7	126.7	154.3	103.9	78.1	62.6	56.9	53.6	55.9	53.4	60.0	1,009.6
1960	91.6	81.7	143.5	163.2	131.1	83.1	66.4	59.0	55.0	50.7	48.6	50.2	1,024.0
1961	54.3	76.2	84.2	118.0	88.8	65.3	59.2	51.1	48.6	50.2	48.4	89.3	833.6
1962	68.8	96.6	200.9	153.3	147.8	91.7	71.3	59.6	53.6	51.8	48.6	124.6	1,168.5
1963	103.1	143.2	147.6	194.4	200.9	168.1	106.5	85.2	76.3	71.4	63.8	61.3	1,421.8
1964	50.9	55.7	125.6	100.4	98.2	80.0	62.5	55.3	52.0	50.7	54.3	74.8	860.4
1965	76.1	86.1	196.7	194.4	166.9	123.5	92.2	77.6	68.4	66.5	61.7	76.9	1,286.9
1966	200.9	124.1	152.2	189.7	159.1	111.7	89.7	77.7	69.7	64.5	75.2	136.1	1,450.5
1967	103.2	70.2	137.6	194.4	200.9	126.5	99.5	85.7	75.0	71.4	97.2	92.6	1,354.2
1968	109.8	112.4	200.9	194.4	182.7	137.4	95.1	85.4	77.5	73.5	104.7	137.9	1,511.7
1969	132.8	103.6	200.9	194.3	200.9	161.1	119.4	102.2	90.9	84.5	77.1	115.8	1,583.3
1970	104.2	119.2	167.6	169.0	132.4	100.3	81.0	67.9	61.4	68.9	81.4	79.9	1,233.1
1971	72.8	64.7	112.0	171.9	133.5	96.1	70.6	63.4	55.8	56.8	55.1	64.4	1,017.0
1972	54.9	54.7	99.6	150.9	152.8	134.0	88.6	69.4	64.9	67.9	60.7	57.9	1,056.3
1973	55.4	57.1	85.8	112.4	107.4	73.9	53.9	50.2	48.6	49.9	47.7	49.1	791.3
1974	48.9	44.1	104.3	106.5	98.9	59.5	50.2	50.2	47.9	49.1	47.7	65.8	773.1
1975	61.7	55.3	142.5	194.4	200.8	126.6	91.8	74.1	63.3	61.5	58.4	61.3	1,191.7
1976	70.8	66.6	112.5	194.4	182.5	114.1	74.7	62.3	66.0	76.3	75.6	108.1	1,203.8
1977	76.1	121.7	157.4	194.4	200.9	115.8	83.5	68.9	64.6	65.9	60.9	63.4	1,273.6
1978	101.3	132.2	157.2	194.4	175.2	110.2	78.4	64.9	61.9	68.3	64.6	94.1	1,302.6
1979	124.5	116.5	117.8	136.2	122.9	111.2	80.0	63.9	58.0	60.0	81.2	108.6	1,180.7
1980	125.9	111.4	200.9	194.4	200.9	132.4	92.6	75.8	71.3	74.2	68.8	85.2	1,433.7
1981	170.9	155.2	200.9	176.5	178.7	144.5	112.3	82.4	69.6	77.1	75.3	160.0	1,603.3
1982	101.2	72.1	93.0	192.4	140.1	92.4	79.3	69.5	66.9	66.4	61.0	58.2	1,092.5
TOTAL	3,753.5	3,824.8	6,048.4	7,270.3	6,780.4	4,544.6	3,362.1	2,846.3	2,582.9	2,601.8	2,759.3	3,490.6	49,865.0
AVERAGE	87.3	88.9	140.7	169.1	157.7	105.7	78.2	66.2	60.1	60.5	64.2	81.2	1,159.7

Table 9-14 Energy Generation of Goktas Power Plant (Stage II)

(Unit: GWh)

Year \ Month	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1940	92.1	120.1	155.5	194.4	150.8	118.1	96.3	85.6	76.6	77.5	85.0	114.9	1,366.8
1941	107.2	128.8	185.0	182.4	156.8	100.2	89.7	83.6	76.2	76.4	72.7	72.4	1,331.6
1942	74.6	90.7	200.9	194.4	185.9	103.3	90.4	83.4	78.4	83.9	111.6	97.6	1,395.1
1943	108.0	93.7	116.1	194.4	200.8	125.8	98.6	87.3	77.8	80.2	78.3	74.4	1,335.5
1944	82.7	119.8	200.9	194.4	192.8	132.5	101.8	89.4	78.6	76.1	74.5	73.7	1,417.3
1945	82.1	76.4	95.9	173.2	162.1	103.0	79.9	70.8	65.2	65.2	62.5	75.9	1,112.2
1946	67.7	72.6	117.8	175.2	199.1	114.7	89.6	78.2	68.6	68.9	64.5	76.2	1,193.2
1947	101.1	109.0	166.0	126.5	103.8	87.8	72.8	66.1	62.7	61.9	152.7	159.5	1,269.8
1948	99.5	128.8	108.3	194.4	200.9	161.0	98.6	85.8	75.6	73.1	66.6	64.8	1,357.6
1949	61.8	58.0	121.4	166.6	172.7	98.4	77.7	67.1	62.8	62.4	60.9	64.9	1,074.7
1950	59.5	57.4	132.3	154.5	170.0	95.5	80.9	70.0	65.3	65.8	60.0	59.8	1,071.0
1951	67.3	55.7	95.4	104.2	121.9	87.7	75.6	65.8	61.0	64.2	67.0	89.1	954.9
1952	70.2	105.0	169.1	194.4	181.9	111.4	88.1	78.6	69.1	69.1	73.0	91.0	1,301.0
1953	104.8	137.6	116.5	194.4	200.8	162.0	104.0	89.9	80.2	75.8	70.2	65.9	1,402.1
1954	76.0	76.1	167.9	194.4	200.9	120.5	90.2	80.0	72.1	70.6	83.6	137.3	1,369.7
1955	129.0	98.3	111.4	110.4	120.0	91.3	80.9	70.9	64.5	63.9	66.4	67.0	1,074.0
1956	74.0	104.2	102.7	142.6	124.5	88.6	75.1	71.1	67.2	65.0	63.9	71.2	1,050.2
1957	71.7	75.9	142.1	83.2	91.6	72.8	69.4	68.2	65.1	67.0	66.7	150.3	1,024.0
1958	200.9	144.8	200.9	148.6	117.2	93.1	78.8	71.7	68.4	69.2	67.3	72.6	1,333.5
1959	134.5	101.6	123.6	136.7	103.7	85.2	75.3	71.8	68.2	70.0	67.0	75.8	1,113.5
1960	107.3	89.0	152.8	127.1	137.5	90.3	73.5	66.3	62.2	60.6	57.6	63.0	1,087.0
1961	66.4	85.8	90.2	115.7	96.9	70.6	69.6	65.5	61.9	61.5	58.2	111.9	954.2
1962	84.1	109.8	190.7	144.9	150.4	102.2	87.3	76.2	70.4	69.2	65.1	138.3	1,288.4
1963	113.0	153.1	158.0	181.0	200.9	171.9	115.6	95.2	87.8	84.5	77.7	77.5	1,516.2
1964	71.6	75.3	107.9	92.6	104.2	87.8	74.9	69.9	64.4	64.9	69.0	88.8	971.3
1965	91.8	101.1	193.6	194.4	173.0	133.4	107.5	96.5	88.5	85.8	79.9	93.3	1,438.7
1966	200.9	134.4	162.0	165.8	160.6	121.8	104.5	96.0	85.0	81.4	92.2	150.2	1,554.4
1967	119.9	87.4	149.4	194.4	200.9	137.1	110.3	101.5	93.8	90.9	115.4	109.3	1,510.3
1968	131.3	126.1	200.9	194.4	194.2	148.2	107.9	100.7	96.3	93.1	123.3	152.9	1,669.2
1969	150.8	121.5	200.9	194.3	200.8	170.6	127.4	114.9	106.4	103.0	98.1	129.7	1,718.3
1970	118.1	127.2	164.8	145.4	136.9	107.2	92.8	84.5	77.6	81.4	91.4	91.2	1,318.4
1971	85.5	78.4	118.6	153.0	123.4	103.1	86.9	76.7	69.1	69.8	66.3	74.6	1,105.6
1972	67.3	65.7	107.0	143.6	148.9	119.8	96.3	87.0	79.1	79.7	72.6	69.2	1,136.2
1973	63.4	69.3	90.0	98.4	94.9	80.0	70.6	65.0	61.1	60.4	57.0	60.1	870.1
1974	54.2	55.2	112.2	93.3	93.4	71.5	64.5	59.9	55.8	61.9	61.7	86.3	870.1
1975	71.1	63.4	151.2	194.4	200.8	134.2	99.3	88.1	78.2	75.7	71.6	75.7	1,303.8
1976	86.8	82.5	121.2	192.0	171.8	121.7	92.2	84.3	83.9	87.6	87.2	115.4	1,326.6
1977	90.4	129.6	166.1	192.9	189.8	123.4	96.7	87.2	81.4	80.9	74.3	76.3	1,389.1
1978	113.8	140.0	165.9	181.8	161.1	117.7	95.8	86.2	78.9	84.3	77.4	102.8	1,405.7
1979	133.2	121.5	119.8	122.8	121.5	113.6	93.3	84.6	79.3	80.8	88.2	118.8	1,277.3
1980	134.8	119.8	200.9	194.4	200.9	140.2	101.4	94.6	87.8	85.8	84.9	97.0	1,542.4
1981	187.8	168.2	200.9	174.9	165.0	150.2	120.4	102.5	90.5	95.5	90.8	160.9	1,707.7
1982	117.1	75.7	105.5	160.2	142.4	99.6	90.7	86.9	79.7	81.0	74.9	80.0	1,193.8
TOTAL	4,325.5	4,334.4	6,259.9	6,910.7	6,728.2	4,869.3	3,893.2	3,505.5	3,222.7	3,226.0	3,349.2	4,077.5	54,702.2
AVERAGE	100.6	100.8	145.6	160.7	156.5	113.2	90.5	81.5	75.0	75.0	77.9	94.8	1,272.1

Table 9-15 Energy Generation of Goktas Power Plant (Stage III)

(Unit: GWh)

Month / Year	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
1940	75.8	103.0	125.0	194.3	105.5	89.9	76.8	66.1	57.7	58.0	66.1	95.3	1,113.5
1941	87.7	107.2	134.2	133.2	108.0	75.6	68.7	62.6	55.9	55.4	52.4	51.4	992.2
1942	53.6	71.7	174.8	185.7	128.4	79.2	68.9	61.9	57.6	62.3	90.8	76.1	1,110.8
1943	86.5	74.3	94.5	194.4	172.6	95.2	76.1	64.8	56.0	57.7	56.5	51.8	1,080.4
1944	60.2	98.7	200.9	187.0	164.9	106.5	79.4	67.1	57.0	53.8	52.9	51.3	1,179.7
1945	59.7	56.2	73.5	151.5	139.7	81.5	59.8	50.7	48.6	50.2	47.7	49.3	868.4
1946	49.5	45.1	93.9	155.8	179.0	95.3	69.5	58.1	49.2	50.2	48.6	50.6	944.9
1947	81.0	90.8	145.9	107.0	83.7	68.4	52.8	50.2	48.4	42.3	121.6	139.4	1,031.5
1948	79.5	110.1	88.3	190.8	182.5	125.3	75.4	62.5	53.1	50.2	48.6	49.6	1,115.8
1949	38.4	37.0	82.5	144.0	149.4	77.9	56.5	50.2	48.3	41.6	40.8	43.9	810.5
1950	38.5	38.6	97.9	129.7	144.4	76.8	61.6	50.7	48.6	50.2	48.0	40.6	825.8
1951	48.8	38.1	58.9	85.5	102.6	69.0	56.3	50.2	48.4	49.1	47.2	56.1	710.0
1952	53.9	86.0	131.9	176.5	136.3	88.4	68.9	59.4	50.5	50.2	54.1	71.8	1,028.0
1953	85.7	120.2	97.3	194.4	200.7	130.4	82.4	68.3	59.3	54.2	50.0	50.2	1,193.1
1954	50.2	58.4	135.0	169.4	155.4	78.7	62.2	54.6	48.6	50.2	52.2	112.0	1,026.9
1955	103.6	75.3	86.1	85.2	94.0	72.2	61.2	51.1	48.6	50.1	47.8	49.1	824.1
1956	49.1	73.5	76.5	106.0	86.6	63.9	55.3	51.3	48.6	50.2	48.3	49.6	758.9
1957	49.8	49.5	120.3	62.2	69.9	51.8	53.5	52.3	49.7	51.1	51.3	134.4	795.8
1958	199.8	130.5	200.9	112.9	80.1	57.3	57.3	50.2	48.6	50.2	48.6	50.1	1,086.4
1959	106.0	82.2	96.1	110.1	78.4	60.8	57.5	54.1	51.0	52.3	49.9	58.1	856.5
1960	89.5	67.3	129.6	80.2	88.9	63.6	53.1	50.2	48.6	49.3	40.5	44.9	805.9
1961	48.6	52.2	72.6	96.9	77.6	51.9	53.7	50.2	48.6	50.2	47.8	81.6	732.0
1962	68.8	96.1	161.1	116.2	120.8	81.2	65.6	54.5	49.4	50.2	48.6	118.2	1,030.7
1963	95.3	137.0	127.2	135.5	157.3	126.5	86.1	72.3	65.6	61.5	55.5	54.6	1,174.4
1964	50.2	52.1	78.6	64.3	71.3	64.2	58.5	53.4	48.6	50.2	51.1	72.3	714.8
1965	75.3	86.3	146.3	159.1	125.7	107.6	86.2	75.1	67.8	64.5	59.3	72.2	1,125.5
1966	193.8	108.8	122.0	127.2	120.7	99.5	83.9	75.4	65.0	60.8	72.2	129.9	1,259.2
1967	99.7	69.2	129.5	132.2	153.6	106.3	87.6	79.2	72.2	68.6	93.8	87.0	1,178.9
1968	109.0	105.8	196.1	126.9	128.6	102.4	84.7	77.5	73.8	69.9	100.9	129.7	1,305.2
1969	127.6	100.5	200.9	191.2	200.9	120.7	98.0	89.7	82.0	77.9	73.7	104.6	1,467.7
1970	92.9	98.8	122.8	104.7	94.8	74.9	70.6	62.4	56.1	59.3	70.0	69.1	976.5
1971	63.4	58.4	93.3	128.4	98.1	77.5	68.2	58.0	51.0	51.1	48.6	55.4	851.2
1972	50.2	47.0	77.1	106.2	110.2	82.5	74.1	64.8	57.7	57.5	51.1	50.2	828.5
1973	49.9	44.6	57.8	76.9	72.7	60.3	52.3	50.2	48.4	42.7	39.8	42.3	637.8
1974	33.9	37.4	75.7	67.9	67.1	54.6	50.2	49.9	39.2	48.9	47.0	55.5	627.4
1975	59.7	53.1	110.4	178.9	156.6	92.9	79.6	69.9	60.5	57.5	54.0	57.4	1,030.6
1976	68.6	65.4	96.4	129.8	107.6	82.5	71.5	63.6	63.9	66.8	71.3	100.4	987.8
1977	75.5	106.5	121.6	135.3	130.2	89.1	77.5	68.0	62.8	61.7	55.7	58.4	1,042.2
1978	97.2	114.5	123.5	131.4	109.0	85.4	75.5	65.9	59.3	64.1	58.1	82.8	1,066.5
1979	105.6	89.5	84.4	88.5	86.0	79.3	71.3	62.6	58.0	58.8	73.9	104.1	962.1
1980	122.4	107.1	189.6	171.4	111.5	97.0	78.7	71.9	65.8	63.1	63.0	74.4	1,215.9
1981	165.2	147.8	188.8	126.5	114.9	101.7	95.8	77.9	66.7	70.9	67.0	138.7	1,361.9
1982	94.9	54.8	82.5	95.3	75.4	60.9	68.5	64.7	58.2	58.7	53.4	57.8	824.8
TOTAL	3,494.2	3,446.9	5,102.0	5,646.3	5,141.9	3,606.4	2,991,3	2,643.7	2,402.9	2,393.5	2,519.3	3,172.3	42,560.7
AVERAGE	81.3	80.2	118.7	131.3	119.6	83.9	69.6	61.5	55.9	55.7	58.6	73.8	989.8

Table 9-16 Monthly Peak Power of Goktas Power Plant (Stage I)

(Unit: MW)

Year \ Month	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	AVERAGE
1940	270.0	270.0	270.0	270.0	269.8	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1941	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1942	270.0	270.0	270.0	270.0	269.9	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1943	270.0	270.0	270.0	270.0	269.8	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1944	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1945	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1946	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1947	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	269.9	269.8	270.0	270.0
1948	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1949	269.9	270.0	269.8	270.0	270.0	270.0	270.0	270.0	270.0	269.9	269.9	269.9	270.0
1950	269.8	269.9	269.9	270.0	270.0	270.0	270.0	270.0	270.0	270.0	269.9	269.9	270.0
1951	270.0	269.9	269.9	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1952	270.0	270.0	270.0	270.0	269.9	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1953	270.0	270.0	270.0	270.0	269.9	270.0	270.0	270.0	270.0	270.0	270.0	269.8	270.0
1954	269.8	270.0	270.0	270.0	269.9	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1955	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	269.9	269.9	270.0	270.0
1956	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	269.9	269.9	270.0	270.0	270.0
1957	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1958	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1959	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1960	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1961	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	269.8	270.0	269.1	269.9	269.8
1962	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	269.8	269.8	270.0
1963	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1964	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1965	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1966	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1967	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1968	270.0	270.0	270.0	270.0	269.9	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1969	270.0	270.0	270.0	269.9	270.0	269.8	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1970	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1971	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1972	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1973	270.0	270.0	270.0	270.0	270.0	270.0	270.0	269.8	269.9	268.1	265.2	263.9	268.9
1974	262.7	262.7	269.4	270.0	270.0	270.0	269.9	269.9	266.0	263.9	265.1	269.9	267.5
1975	270.0	270.0	270.0	270.0	269.9	269.9	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1976	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1977	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1978	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1979	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1980	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1981	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1982	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
AVERAGE	269.8	269.8	270.0	270.0	270.0	270.0	270.0	270.0	269.9	269.8	269.7	269.8	269.9
MINIMUM	262.7	262.7	269.4	269.9	269.8	269.8	269.9	269.8	266.0	263.9	265.1	263.9	267.5

Table 9-17 Monthly Peak Power of Goktas Power Plant (Stage II)

(Unit: MW)

Year \ Month	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	AVERAGE
1940	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1941	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1942	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1943	270.0	270.0	270.0	270.0	269.9	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1944	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1945	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1946	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1947	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1948	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1949	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1950	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1951	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1952	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1953	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1954	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1955	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1956	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1957	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1958	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1959	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1960	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1961	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1962	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1963	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1964	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1965	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1966	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1967	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1968	270.0	270.0	270.0	269.9	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1969	270.0	270.0	270.0	269.8	270.0	269.9	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1970	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1971	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1972	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1973	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1974	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1975	270.0	270.0	270.0	270.0	269.9	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1976	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1977	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1978	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1979	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1980	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1981	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1982	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
AVERAGE	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
MINIMUM	270.0	270.0	270.0	269.8	269.9	269.9	270.0	270.0	270.0	270.0	270.0	270.0	270.0

Table 9-18 Monthly Peak Power of Goktas Power Plant (Stage III)

(Unit: MW)

Year \ Month	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	AVERAGE
1940	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1941	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1942	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1943	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1944	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1945	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	269.8	269.8	265.2	265.1	269.2
1946	266.1	268.3	269.8	270.0	270.0	270.0	270.0	270.0	270.0	269.9	270.0	269.9	269.5
1947	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	268.6	227.3	269.9	270.0	261.3
1948	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	269.9	270.0	266.7	269.7
1949	206.3	220.3	268.8	270.0	270.0	270.0	270.0	270.0	268.2	223.7	226.6	236.1	250.0
1950	207.2	229.6	269.9	270.0	270.0	270.0	270.0	270.0	269.9	269.9	266.5	218.5	256.8
1951	262.3	226.9	268.0	270.0	270.0	270.0	270.0	269.8	268.8	263.7	262.0	268.6	264.2
1952	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	269.9	269.9	270.0	270.0
1953	270.0	270.0	270.0	270.0	269.8	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1954	269.9	269.9	270.0	270.0	270.0	270.0	270.0	270.0	269.9	270.0	269.9	270.0	270.0
1955	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	269.8	269.1	265.8	263.8	269.0
1956	264.0	269.9	270.0	270.0	270.0	270.0	270.0	270.0	269.8	270.0	268.1	266.7	269.0
1957	267.6	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	269.8
1958	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	269.9	269.9	269.9	269.4	269.9
1959	269.9	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1960	270.0	270.0	270.0	270.0	270.0	270.0	270.0	269.8	269.9	265.3	225.3	241.6	263.5
1961	261.5	267.8	270.0	270.0	270.0	270.0	270.0	270.0	270.0	269.9	265.6	269.1	268.7
1962	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	269.9	269.9	270.0	270.0
1963	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1964	269.9	269.9	270.0	270.0	270.0	270.0	270.0	270.0	270.0	269.9	269.9	270.0	270.0
1965	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1966	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1967	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1968	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1969	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1970	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1971	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	269.9	269.8	270.0
1972	269.9	269.9	269.8	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	269.8	270.0
1973	268.0	265.6	269.9	270.0	270.0	270.0	270.0	269.8	269.1	229.4	220.9	227.5	258.4
1974	182.2	222.4	269.9	270.0	270.0	270.0	269.8	268.5	217.8	263.2	261.1	267.9	252.7
1975	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1976	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1977	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1978	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1979	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1980	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1981	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
1982	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0	270.0
AVERAGE	264.3	265.6	269.9	270.0	270.0	270.0	270.0	269.9	268.6	266.5	266.0	265.8	268.1
MINIMUM	182.2	220.3	268.0	270.0	269.8	270.0	269.8	268.5	217.8	223.7	220.9	218.5	250.0

Fig. 9-14 Monthly Energy Generation (Stage I)

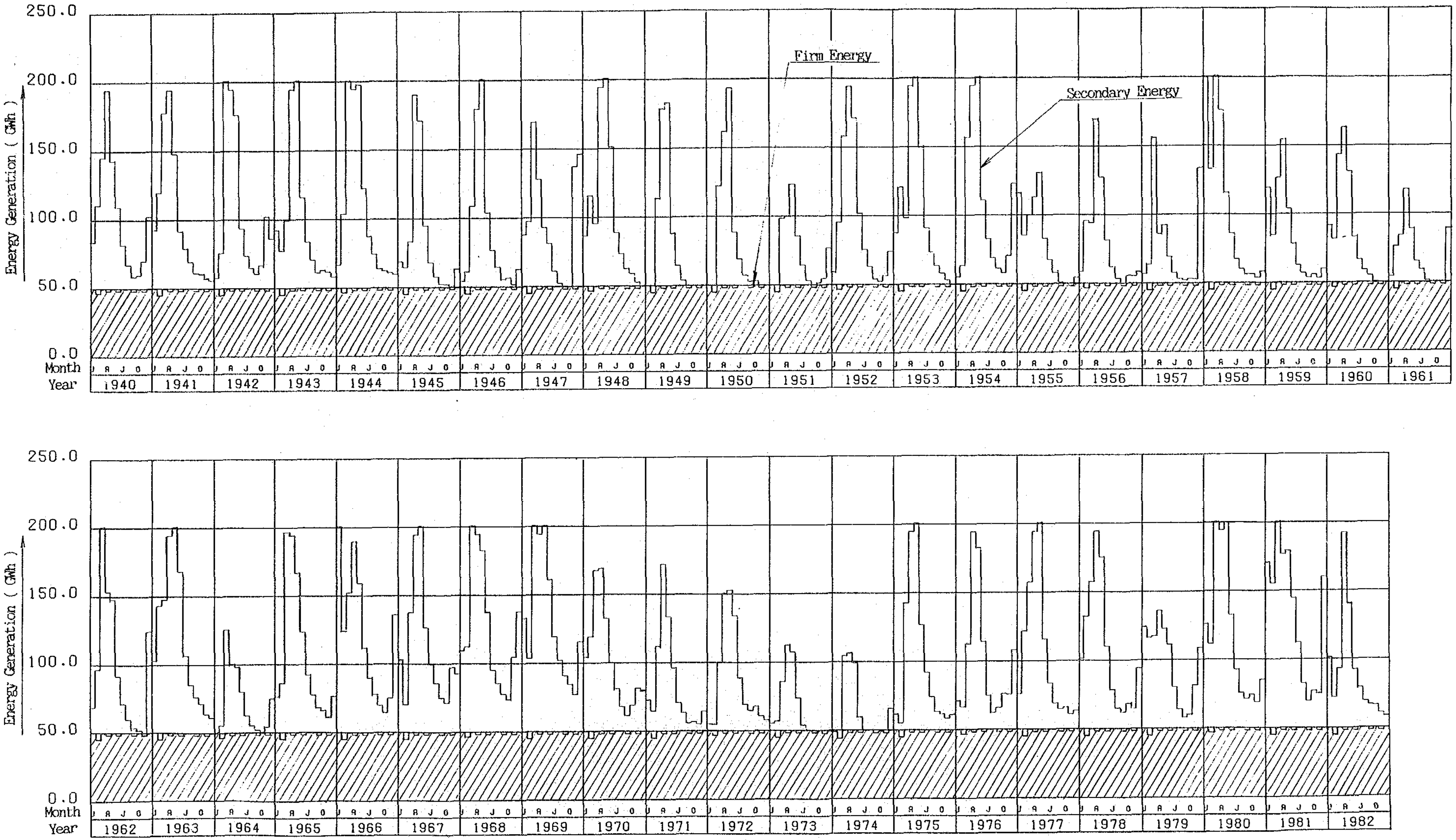
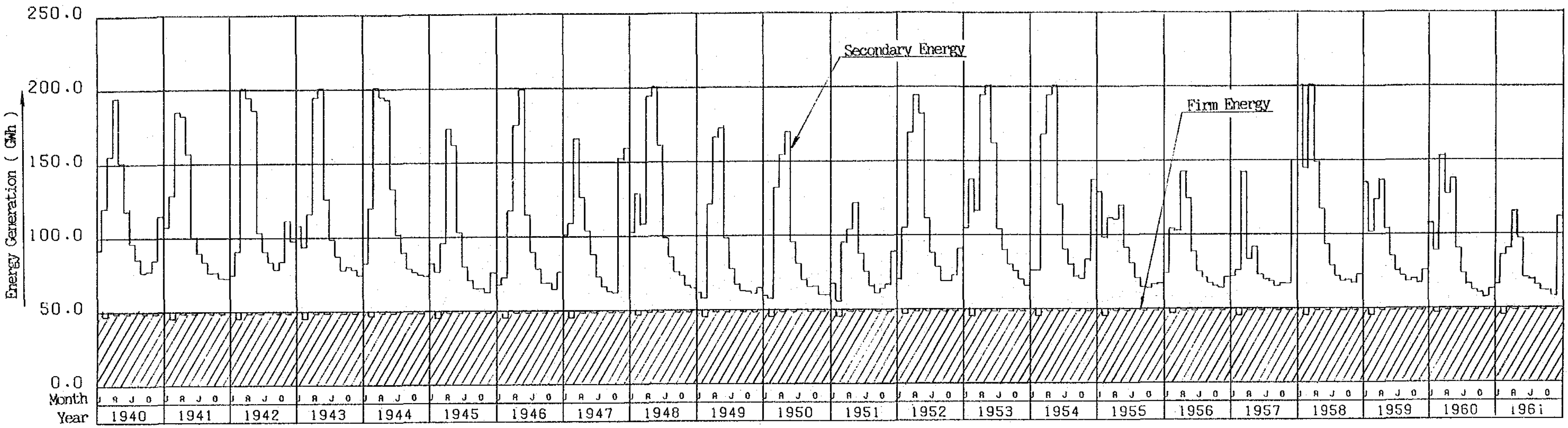


Fig. 9-15 Monthly Energy Generation (Stage II)



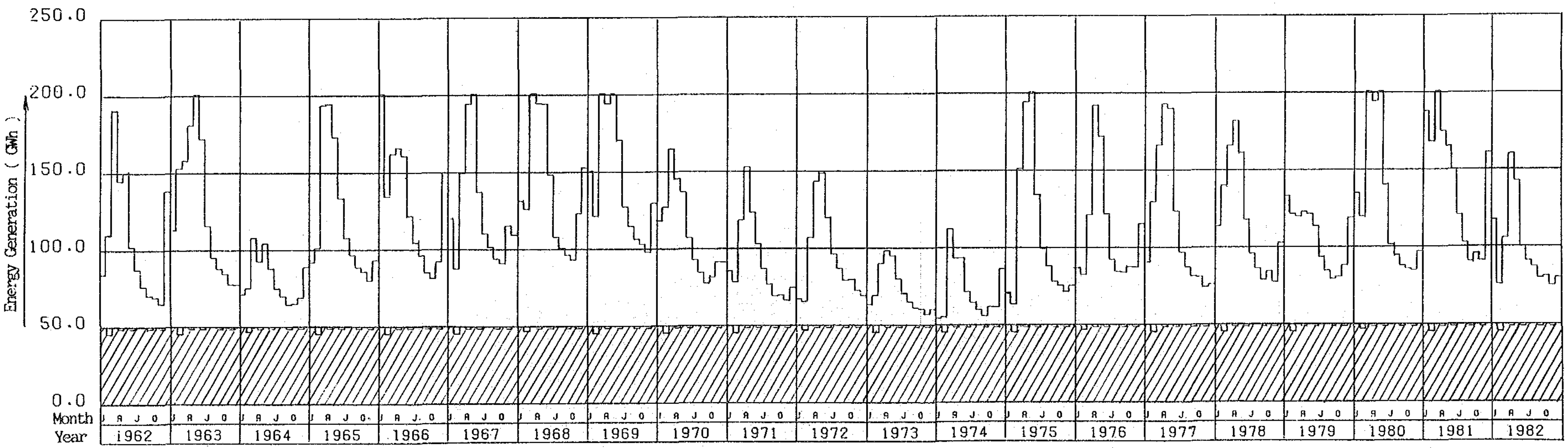


Fig. 9-16 Monthly Energy Generation (Stage III)

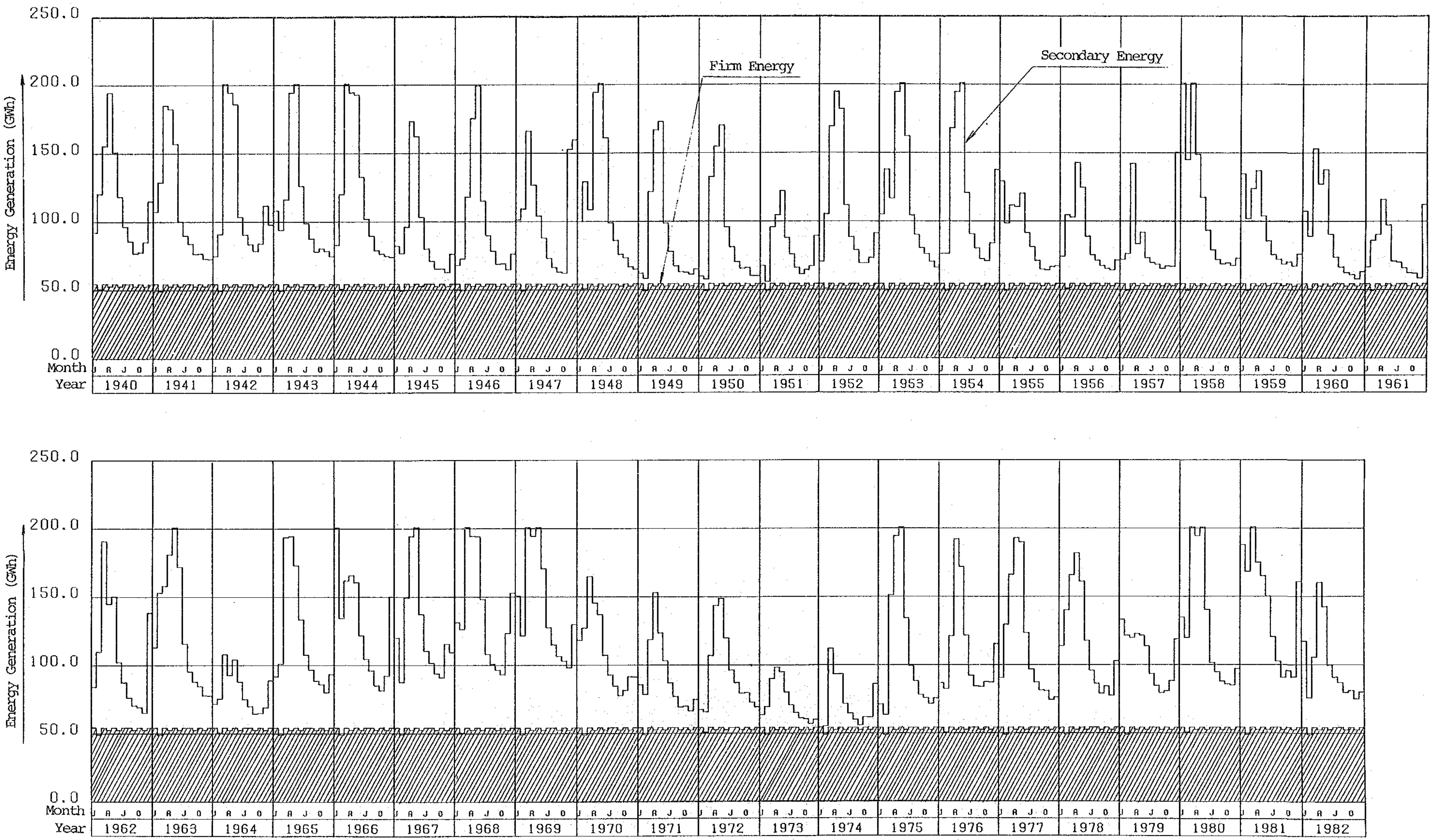


Table 9-19 Economic Condition at Each Stage

Item	Unit	Stage I	Stage II	Stage III
High Water Level	m		630.0	
Low Water Level	m		620.0	
Available Drawdown	m		10.0	
Grass Storage Capacity	10^6 m^3		109.3	
Effective Storage Capacity	10^6 m^3		24.7	
Tunnel Length	m		15,600	
Tunnel Diameter	m		6.8	
Tunnel Type			Pressure	
Maximum Discharge	m^3/s		108	
Gross Head	m		304.9	
Effective Head	m		284.4	
Installed Capacity	MW		270.0	
Annual Inflow	10^6 m^3	1,744.4	1,896.0	1,450.1
Annual Power Discharge	10^6 m^3	1,688.7	1,851.7	1,442.6
Firm Peak Power	MW	267.5	270.0	250.0
Annual Energy Production	GWh	1,159.7	1,272.1	989.8
Plant Factor	%	49.0	53.8	41.8
Investment Cost	10^6 TL		523,030	
Annual Cost (C)	10^6 TL		54,395	
Annual Benefit (B)	10^6 TL	89,836	93,147	81,686
Benefit Cost Ratio (B/C)		1.65	1.71	1.50
Surplus Benefit (B-C)	10^6 TL	35,451	38,758	27,291
Unit Cost of Energy	TL/kWh	47.7	43.5	55.9

CHAPTER 10. TRANSMISSION PROGRAM AND POWER SYSTEM ANALYSIS

CHAPTER 10. TRANSMISSION PROGRAM AND POWER SYSTEM ANALYSIS

CONTENTS

List of Figures

List of Tables

CHAPTER 10. TRANSMISSION PROGRAM AND POWER SYSTEM ANALYSIS

10.1 Outline of Transmission System

10.1.1 Transmission System of TEK

Since 1974, when a 380-kV transmission line was commissioned for the first time, the 380-kV system of Turkey has grown from the early radial system into a grid system. As of 1988, the total length of 380-kV transmission lines have reached 8,000 km to comprise the trunk system of Turkey (Fig. 10-1). As a secondary system, 154-kV transmission lines are being used and the system of nearly all of Turkey are interconnected and are being operated uniformly.

Other than the above, a 220-kV transmission line is being used for a part of the interconnecting line with the U.S.S.R.

Whereas the major load centers of Turkey such as Istanbul, Ankara and Izmir are located in the western part of the country, major power sources such as the large-capacity hydroelectric power plants Karakaya and Keban, and Elbistan Thermal Power Plant are concentrated in the east, consequently electric power normally flows from east to west.

The load flow diagram of the 380-kV system in May 1988 is shown in Fig. 10-2. As this figure shows, in order to maintain the stability of the huge power system stretching over 2,000 km east-west, the main 380-kV transmission lines connecting east and west have series capacitors.

Regarding upgrade of the system in the Adana district, TEK plans to newly construct a 380-kV substation in the northern part of Adana for meeting future demand of this district with electric power supplied from the Seyhan River and the coal-fired thermal plant of Yumurtalik. And, when the electric demand of Adana is small, surplus electric power would be transmitted from here to load centers of the west.

10.1.2 Power Transmission System of Cukurova Electric Power Company (CEAS)

The power demand of the three provinces around Adana is supplied with the transmission line of a private power company called Cukurova Electric Power Co. (CEAS) (Fig. 10-3).

The demand in the service area of Cukurova Electric Power Co. was approximately 3,400 GWh (peak power is 571 MW) in 1987, making up 7 percent of the power demand of entire Turkey. On the other hand, the supply capability was approximately 40 percent of the energy demand, and only about 50 percent in terms of installed capacity (298 MW), with the shortage filled by purchases from TEK. The 154-kV line which is the trunk transmission line of Cukurova Electric Power Co. has a total length of approximately 760 km.

The major interconnection points of the Cukurova System and TEK are Erzin Substation at the east and Toroslar Substation at the north-west, and watt-hour meters are installed at the entrances of the respective interconnecting lines for measurements of electric energy.

As described above, the Cukurova System comprises a loop with the large TEK system and the electric power of TEK passes through from Erzin in the east to Bor in the west.

10.2 Transmission Line Route Investigation

According to the Upper Seyhan Master Plan, the scheme is for the electric power of the various power plants headed by Goktas Hydroelectric Power Plant and plants on the tributary Zamanti and Goksu rivers to be transmitted toward Adana passing the vicinity of Kozan.

In order to coordinate Goktas Power Plant with development of Kavsak Power Plant and Kopru Power Plant in the surroundings, an investigation was made of the transmission line route through a section of approximately 80 km from Adana to the Goktas Power Plant site.

The route map of the investigation is shown in Fig. 10-4.

The section of 60 km from Adana to Akdam via Imamoglu, other than crossing a single-circuit 380-kV transmission line of TEK on the way, is a plain or gently undulating hill area and there is nothing to constitute an obstacle to the transmission line route. Over the 10 km from Akdam to Comluk, there is a continuous low mountainland of elevations 500 to 700 m, but there will be no problem in particular about building 2 or 3 circuits, 154-kV transmission line.

Between Comluk and the power plant site there is a steep mountain of about EL 1,000 m, and the transmission line from Goktas Hydroelectric Power Plant will detour around the foot of this mounatin. It is noted that there is a 34-kv distribution line from Akdam to Baladan Village, near the power plant site, but because of its small capacity it will be necessary for a power line for power plant construction to be built separately from Kozan.

10.3 Switchyard Site Investigation

The site of Goktas Power Plant is planned to be at the right-bank side of the Zamanti River approximately 4 km upstream from the confluence of the Zamanti river and Goksu river.

The right-bank downstream side of the powerhouse site is a rugged rocky area, and in addition to construction of a transmission line being very difficult, the powerhouse site is of a steeply sloped topography of 40 to 45 deg and there is no space for providing a switchyard. On the other hand, the left-bank side has a topography which is gently sloped compared with the right-bank side, and there are three spots where space for a switchyard (75 x 150 m) can be developed. These candidate sites, SY-1, SY-2, and SY-3, are shown in Fig. 10-5. Of these, SY-3 shows signs of landsliding having occurred. The site SY-2 requires a large volume of excavation to be done and is disadvantageous form the standpoint of cost.

In contrast, SY-1 is advantageous form both the aspects of site development costs and of providing the transmission line going through to Adana because of being situated at the most downstream location.

Consequently, it is thought suitable for SY-1 to be made the site of the switchyard for Goktas Power Plant.

10.4 Power Transmission Scheme of Goktas Hydropower Plant

10.4.1 Preconditions

Planning was done assuming that the electric power of the Seyhan and Goksu river systems, including that of Goktas Power Plant, would be transmitted toward Adana, but the electric power of the Zamanti river system, such as of Camlica Power Plant, would be transmitted toward Kayseri. The reasons for this assumption are as follows;

(1) The Zamanti river System, which includes Camlica Power Plant, is under the autonomous administration of Kayseri Province, with moreover, Camlica Power Plant to be developed 2 to 5 years earlier than Goktas Power Plant, and it is highly possible that this power will be used to meet the demand of the Central Anatolian Plateau Region.

(2) Power plants other than Camlica are located in the Central Anatolian Plateau from the point of view of morphology. The topography to Goktas Power Plant is that of rugged mountains and it is expected there will be difficulty in making interconnections with transmission lines.

Further, in setting up transmission plans of Goktas Power Plant, the basis was that there would be no trouble concerning transmission thermal capacity and stability no matter which single circuit of transmission line or single bank of transformers should be tripped due to fault.

10.4.2 154-kV Scheme

This scheme is for all of the hydroelectric power plants under program in the Goksu River and the midstream basin of the Seyhan River to be connected by 154-kV and transmitted to three different substations of TEK and CEAS. The network at a final stage is shown in Fig. 10-6 (2). Namely, the power of approximately 340 MW generated at Yamanli I, II, and III, and Feke is mainly to be transmitted via Kozan to Ceyhan Substation by a double-circuit 154-kV line, and the power totalling 580 MW of Kopuru, Goktas, and Kavsak is to be transmitted via Yedigoze Power Plant to Adana Substation and Misis Substation both by double circuits. Menge Power Plant situated between these sub-systems is to be interconnected with the respective systems by single-circuit 154-kV lines, the plan being to alleviate overloading of the other transmission lines whenever one circuit of any of the systems is permanently tripped-out due to occurrence of fault.

This scheme gives also a flexible transmission plan since it will be possible to transmit to Ceyhan Substation by one route when Feke and Yamanli power Plants upstream of Kopru Power Plant were to be developed in advance.

The interconnections of Goktas Power Plant in this scheme will be by one circuit each for Kopru, Kavsak, and Yedigoze power plants, a total of three circuits.

The conductor type selected is ACSR 1272 MCM (1b) (Phesant, current capacity 1,000 A) being planned to be adopted newly by TEK.

10.4.3 380-kV Scheme, Pattern 1

This scheme is for transmitting all of the electric power of approximately 1,250 MW of the Seyhan River midstream basin and the Goksu River System mainly by a single route of a 380-kV transmission line to Adana Substation of TEK to be newly constructed.

The system diagram at the final stage is shown in Fig. 10-7 (2). In the Master Plan, Elgenusagi Village (EL. approx. 900 m) at the north side of the confluence of the Goksu and Zamanti rivers is the candidate site for a substation of the 380-kV transmission line scheme, but here, the power transmission plan was formulated judging that the vicinity of Akarca 6 to 7 km southeast of the confluence would be more desirable for the reasons given below.

(1) An existing road of 6-m width runs through Akarca and this is advantageous for transportation of substation equipment.

(2) There is a rocky mountain of 1,000-m class to the south of Elgenusagi Village and this is disadvantageous from the standpoint of the transmission line route and the aspect of frequency of lightning strikes.

(3) Akarca has a more gentle topography and it is easier for substation space to be secured, in addition to which leading in of transmission lines from Kopru Power Plant and Kavsak Power Plant can be done more smoothly.

(4) Akarca is a site along the way of the transmission line going toward Adana.

The conductor types for 380-kV are to be ACSR 1272 MCM (2b) and 1272 MCM (3b).

10.4.4 380-kV Scheme, Pattern 2

This is a scheme which would be the same as pattern 1 at the time of start-up of Goktas Power Plant, but of the two 380-kV circuits from Yedigoze Power Station to Adana Substation, one circuit would be led into Dikili Substation instead of Adana.

By doing so the westward power flow of the 154-kV transmission line from Adana to Dikili via Catalan would be lightened, and reduction in transmission loss and improvement in reliability can be achieved. A condition for this scheme, however, is that the 154-kV substation of Cukurova Electric Power will be stepped up to 380-kV and strengthened. The power transmission system diagram at the final stage is shown in Fig. 10-8.

With regard to the standpoint of thermal capacity, it would suffice for Akarca to Yedigoze to be 380-kV, 954 MCM (26), single circuit, even at the final stage, but double circuit was adopted from the aspect of reliability.

10.4.5 380-kV Scheme, Pattern 3

This plan gives two 380-kV rating main transformers to Goktas Power Plant. Accordingly, the switching yard is designed for 380-kV and 380-kV one circuit transmission line is led into Yedigoze Power Station. At the final stage, 380-kV one circuit line would be constructed between Goktas switchyard and Yedigoze Power Station via Kavsak Power Station, and another one circuit would be led to Feke substation via Kopru Power Station.

The transmission plans upper part of Feke and lower part of Yedigoze substation are the same as that of pattern 2. The system diagram of this scheme is illustrated at Fig. 10-9.

There is no significant difference between transmission pattern 2 and pattern 3., therefore at the next section, "Network Analysis" a case study of pattern 3 is neglected.

Akarca substation can be neglected by this plan, however at the final stage, the land area of Goktas switchyard will be 4 times (200 m x 200 m) bigger than that of 154 kV designed (90 x 120 m) due to three 380-kV feeders required. Furthermore, geographical condition around the site gives difficulty for the 380-kV switchyard sized 200 m x 200 m.

10.5 Network Analysis for Cukurova Power System

Studies were made of thermal capacities, voltages, short circuit capacities, and stabilities for the beforementioned 154-kV and 380-kV transmission schemes. The stages examined were the two of 2001 A.D. when Goktas Power Station will be commissioned and 2006 A.D. and thereafter when it is thought hydroelectric power development in the Goksu River Basin will all have been completed. The demand, however, was calculated corresponding to that in the year 2006.

10.5.1 Voltage-Power Flow Calculations

(1) Conditions for Study

Total demand of Cukurova Power System

2001 A.D.: 1,870 MW
2006 A.D.: 2,500 MW

The interconnecting points with TEK were considered to be the 380-kV substations of Andirin, Ergin, and Adana, ignoring interconnection with 154 kV.

Load power factor: 99% (lagging) at substation end

Generator output : All generators other than Yumurtalk were considered to operate at full capacities with surpluses or shortages adjusted by Yumurtalik.

Voltage target : Range of 95 to 105% at each power station or substation

(2) Results of Study

Power flow diagrams are shown in Fig. AP4-1 (1) - (5). What may be said in common for the various cases is that it will be desirabel for reactive power phase modifying facilities to be installed to maintain voltages at Antakya, Tarsus, and Dikili.

Table 10-1 Leading Reactive Power Capacities Required (MVA)

Case / Substation	2001 Year		2006 Year		
	154 kV	380 kV	154 kV	380 kV	
				Pattern 1	Pattern 2
Antakya 2	40 MVA	40	90	90	90
Tarsus 2	150 MVA	150	150	150	120
Dikili	0 MVA	40	200	270	120
Total	190 MVA	230	440	510	330

The parts where strengthening of downstream power sytems would be necessary according to transmission of the power of the Seyhan River System are as indicated below.

Table 10-2 Number of Circuits of Transmission Lines Requiring Strengthening

Case / Transmission Line	2001 Year		2006 Year		
	154 kV	380 kV	154 kV	380 kV	
				Pattern 1	Pattern 2
Adana - Catalan (20 km)	0	0	0	1	0
Catalan - Dikili (25 km)	1	1*	1	1	0

Note) *: In Pattern 2 of 380-kV transmission it will be advantageous for the transmission line between Calatan and Dikili to be designed for 380-kV and operation to be started at 154 kV.

In case of Pattern 2, the westward power flow of the 154-kV transission line connecting the eastern and western systems of Cukurova Electric power will be reduced, so there will e the merit that transmission loss of the entire system will be the least.)

10.5.2 Short Circuit Capacity

(1) Conditions for Study

Phase : The phase was assumed to correspond to the final stage which will be the severest.

Generator: All units were considered to be connected to the system and Xd' (transient reactance) is used as reactance.

Power inflow from load was ignored, but inflow from the system from TEK was considered. Fig. AP4-2 (1) - (3).

(2) Results of Study

The 3-phase short circuit capacities at principal sites are as shown below.

Table 10-3 Short Circuit Currents in Major Substations (KA)

	154 kV Scheme	380 kV Scheme	
		Pattern 1	Pattern 2
(154 kV system)			
Goktas S/Y	16.4	13.9	13.8
Yedigoze S/Y	21.5	-	-
Catalan S/Y	18.6	14.8	14.1
Dikili S/S	14.2	12.3	17.2
Seyhan S/S	11.2	9.4	11.9
Adana S/S	24.0	19.9	17.4
Misis S/S	17.3	12.7	12.0
Ceyhan S/S	12.9	9.4	9.3
Akarca S/S	-	16.2	16.0
(380 kV system)			
Adana S/S	11.3	13.1	12.7
Erzin S/S	11.0	11.5	11.4
Dikili S/S	-	-	7.9
Akarca S/S	-	10.8	10.4
Yedigoze S/S	-	11.6	11.2

Naturally, the short circuit current of the 154-kV system will be greatest in case of 154-kV transmission, but since it is within the 31.5-kV in IEC standards there will be no problem in particular with regard to a newly-installed substation. There are only a few differences in short circuit currents between Pattern 1 and Pattern 2 of 380-kV transmission.

10.5.3 Stability

(1) Conditions for Study

(Fault Condition)

For the 154-kV scheme, the trouble was considered to be single-circuit, 3-phase short circuiting (3LG) at the 154-kV bus of Goktas Switchyard, with clearing time 6 cycles.

For the 380-kV proposal, the fault was considered to be single-circuit 3LG of the 380-kV bus at Yedigoze Switchyard with the

380-kV transmission line, between Yedigoze and Adana clearing in 5 cycles (100 ms).

(2) Results of Study

Fig. 10-11 shows the output fluctuations P_G of the various power stations on time bases. All cases are stable in both the years 2001 and 2006, although power disturbance is greatest in case of 3LG at Yedigoze in Pattern 2 for 380 kV.

Table 10-4 Results of Stability Calculations

Case / Fault Point	2001 Year		2006 Year		
	154 kV Scheme	380 kV Scheme	154 kV Scheme	380 kV Scheme	
				Pattern 1	Pattern 2
Goktas Bus	Fig. AP4-3 (1) Stable	Fig. AP4-3 (3) Stable	Fig. AP4-3 (4) Stable	Fig. AP4-3 (6) Stable	Fig. AP4-3 (8) Stable
Yedigoze Bus	Fig. AP4-3 (2) Stable	--	Fig. AP4-3 (5) Stable	Fig. AP4-3 (7) Stable	Fig. AP4-3 (9) Stable

10.6 Economic Study

Economic analyses of the power transmission facilities were made for the case of transmitting only the power of Goktas Power Station and Yedigoze Power Station (2001 A.D.) and the case of transmitting the power of all hydroelectric power stations of the Goksu River System (2006 A.D. and thereafter). The results are given in Table 10-5 (1) - (2).

(1) Conditions for Study

Unit cost of transmission loss:

The unit generating costs of the alternative thermal in Chapter 9, "The Development Plan," were employed.

Unit Costs: 242,000 TL/kW

24.7 TL/kWh

Transmission lines considered for transmission loss:

For conformity between the 154-kV and 380-kV proposals, the distribution facilities from Goktas Switchyard to receiving-end substations of Dikili, Adana, Misis, and Ceyhan were considered.

Annual cost of transmission and transformation facilities:

Uniform 11.4 percent

Goksu River System hydroelectric power stations:

Average plant factor, p_f: 40 percent

Transmission loss ratio, L_f: 23 percent*

* Calculated by Buller-Woodrow equation

$$L_f = 0.3 \times p_f + 0.7 \times (p_f)^2$$

(2) Results of Study

As can be comprehended from Table 10-5 (1), (2), the construction cost is lower for the 154-kV proposal at both commissioning of Goktas in 2001 A.D. and at the final stage, but in terms of annual cost including transmission losses, the 380-kV proposal is more advantageous at both stages. Among the 380-kV transmission scheme, the pattern 3 is the least expensive at the initial stage, however at the final stage, the scheme of pattern 2, boosting the voltage from 154-kV to 380-kV at Akarca substation becomes the most economical.

In Table 10-5 the cost of civil engineering works at Goktas switchyard is excluded, because it is common for each transmission scheme of 154-kV, 380-kV pattern 1 and pattern 2.

Same as above, additional civil engineering cost for pattern 3 is also neglected, but essentially this should be taken into account.

10.7 Conclusions

Judging from economic evaluation and space saving aspect of the switchyard at the final stage, transmission pattern 2 (380-kV) is recommended as the method of power transmission of Goktas power plant.

The power transmission and substation facilities of this proposal are as listed below.

(1) Initial Stage

Akarca Substation (new construction):

380 kV/154 kV, 150 MVA transformer, 3 units
154 kV feeder line, 3 cct*
380 kV feeder line, 1 cct * (circuit)

Goktas Switchyard - Akarca Substation:

154 kV, ACSR 1272 MCM, 3 cct, 10 km (of which 1 cct to go by Kopru Power Station to be commissioned in the future)

Akarca - Yedigoze Switchyard:

380 kV, ACSR 954 MCM (2b), 1 cct, 25 km

Yedigoze Switchyard:

Addition of 380 kV, 954 MCM (2b) feeder line, 1 cct

Adana Substation (expansion):

Addition of 150 MVA transformer, 2 units

Further, as strengthening of downstream side power system:

Catalan Power Station - Dikili Substation
Stringing of 380 kV design ACSR 954 MCM (3b), 1 cct, 25 km and operation initially at 154 kV

(2) Final Stage

The principal places south of Akarca Substation where the power system will be strengthened are indicated below.

- Akarca - Yedigoze : Addition of 380-kV, 954 (2b) transmission line, 1 cct

- Yedigoze - Catalan: Stringing of 380-kV, 954 (3b) transmission line, 1 cct

- Dikili 380 kV Substation (new construction): Installation of 150-MVA transformer, 8 units

- Yedigoze - Dikili : Step-up to 380-kV transmission line

The merits and demerits of this transmission pattern are the following:

- Although the initial investment is large, this transmission pattern is the most economical from a long-term point of view.

- The reliability is high since the downstream side 380-kV system is made double circuit.

- Short circuit currents of 154 kV system shall be reduced.

- Voltage drops of substations at receiving end are small.

- On the other hand, there will be problems accompanying the introduction of 380-kV with which Cukurova Electric Power has no experience.

10.8 Power System Analysis of 380-kV Trunk System

10.8.1 Regional Power Demand and Supply Balance

Turkey has 6 local power dispatching areas, connected by 380-kV transmission lines each other as shown in Fig. 10-10. Among the each dispatching system, north-west Anatoria where Istanbul locates, has large power deficit, whereas south-east Anatoria in the upper stream of Euphrates river has much surplus power.

This energy inbalance between demand and supply is expected to increase in future.

Accordingly, reinforcement of the transmission lines, which extend more than 1,000 km from east to west is required, and TEK plans to cope with the situation by construction of series capacitorcompensated 380-kV lines. After this, current 5-transmission lines connecting east and west region are going to be expanded into 15-circuits in the year 2000. (See Fig. 10-11)

Almost all 380-kV tie-lines install series capacitors (compensating rate is 20 - 30%) from voltage and stability points of view.

10.8.2 Results of Analyses

In power system analyses of EHV system, mainly voltage analysis at peak time in 2,001 when Goktas power plant will be commissioned are carried out.

(1) Pre-conditions

(a) Transmission Line

The line conductor which commonly used in TEK are the following four types.

° Rail (2b)	954 MCM	Current Capacity is	2 x 850 A
° Cardinal (2b)	954 MCM	"	2 x 850 A
° Cardinal (3b)	954 MCM	"	3 x 850 A
° Pheasant (3b)	1,272 MCM	"	3 x 1,000 A

(b) Power Factor

Load : 98% (lag)
Generator: 90 - 100% (lag)

Utilization of static condensers is not taken into account.

(2) Results of Load Flow Study

The load flow in 2,001 (total demand is about 28,000 MW) is illustrated in Fig. 10-12. Power flow in each transmission line is less than 1,000 MW so that there is no problem, however, voltage drops in central and western load center become larger.

On the other hand, Fig. 10-13 shows a load flow in the case, when one 380-kV line between Elbistan and Ankara (422 km) is out of service. In this case voltage in the western system decreases to nearly 90%.

Fig. 10-14 shows the voltage drop and deviation of phase angle between Istanbul and Ataturk Power station (vertical axis) versus power demand-increase (holizontal axis) in Istanbul region.

In the graph, the broken lines mean, no solution obtained in this area at load flow calculation and this actually suggests that the system will be unstable and unable to be operated.

(3) Conclusions

It is anticipated, if demand increase steadily at current level, the development project of 380-kV EHV system now undertaken by TEK, will reach the limit of its ability from the route restriction of EHV line, voltage and stability aspects in the beginning of the 21st century.

The following countermeasures are proposed to cope with the situation.

(a) Keeping the balance between demand and supply by developing large scaled power stations near Istanbul region.

(b) Reinforcement of tie-line connecting east and west region by introducing AC 750 kV and/or HVDC system.

Table 10-5 (1) Results of Economic study for each transmission plan. (initial stage)

<table>
<tr><td>Plan</td><td colspan="2">All 154kv Plan</td><td colspan="2">380kv pattern -1</td><td colspan="2">380kv pattern -2</td><td>380kv</td></tr>
<tr><td>Transmission system
(Initial stage)
2001 Year

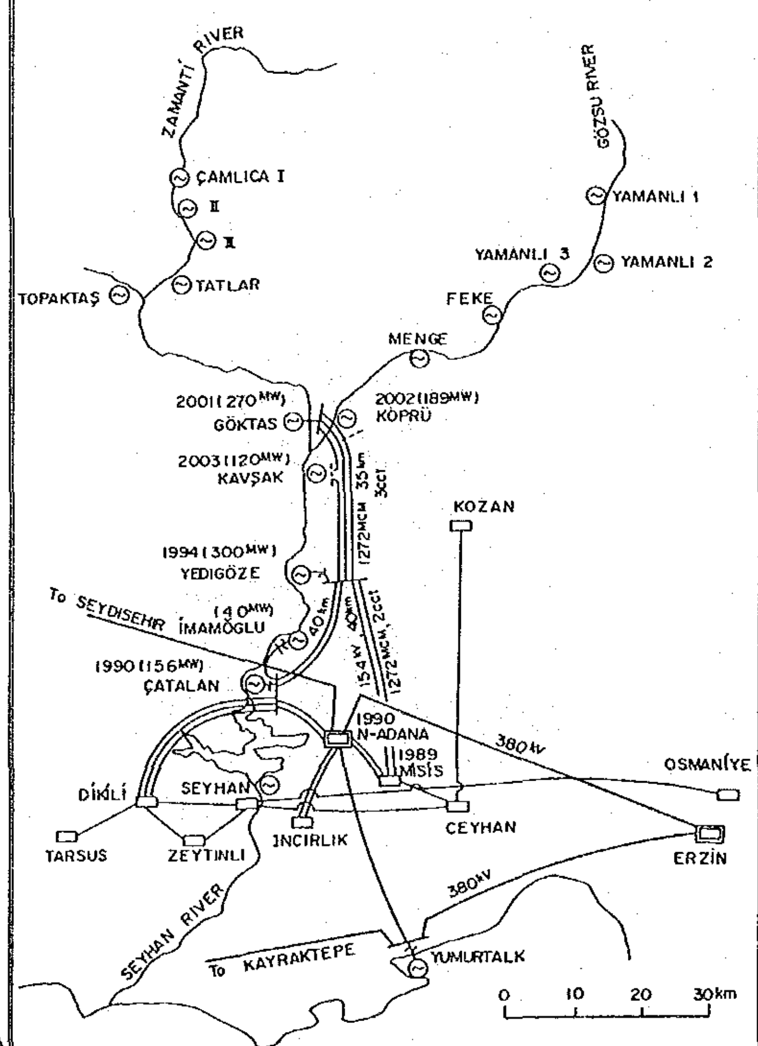
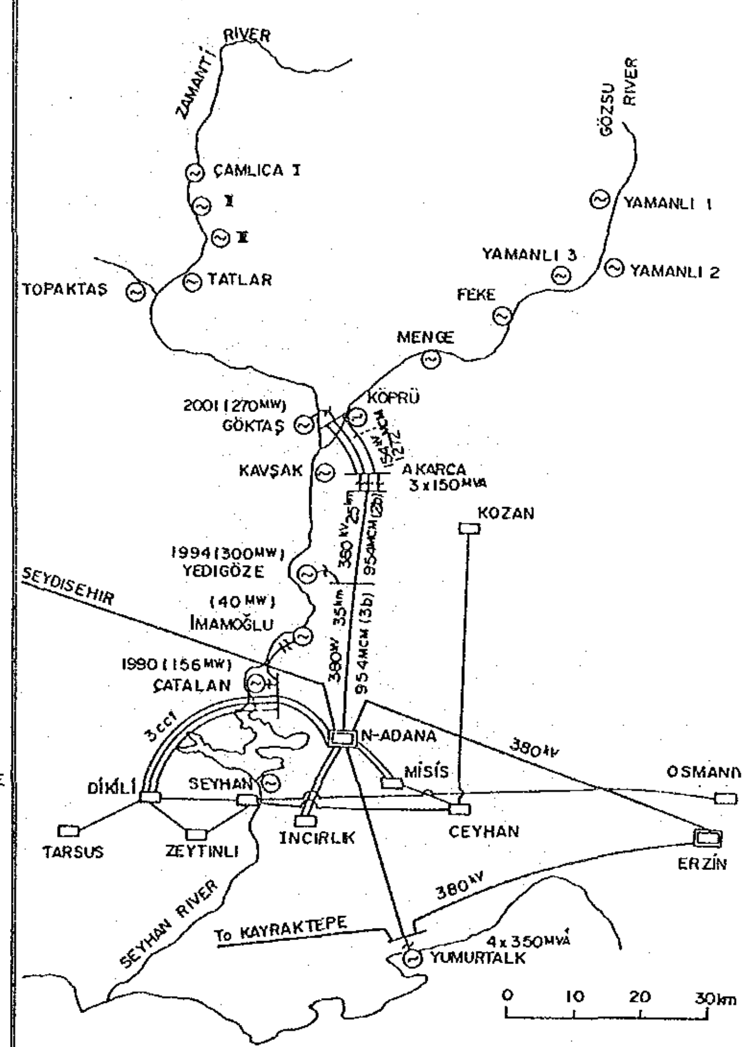
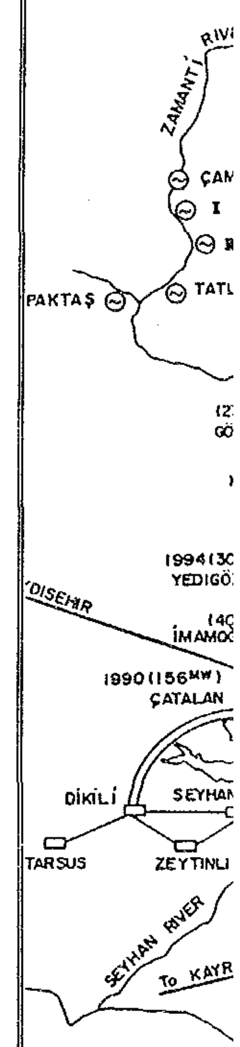
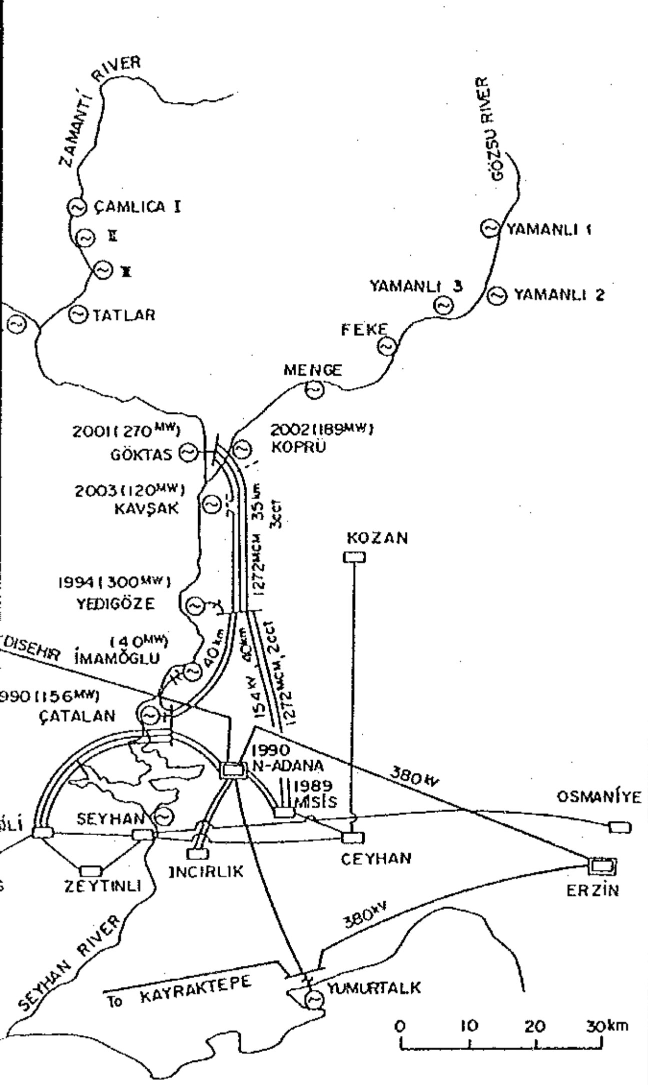
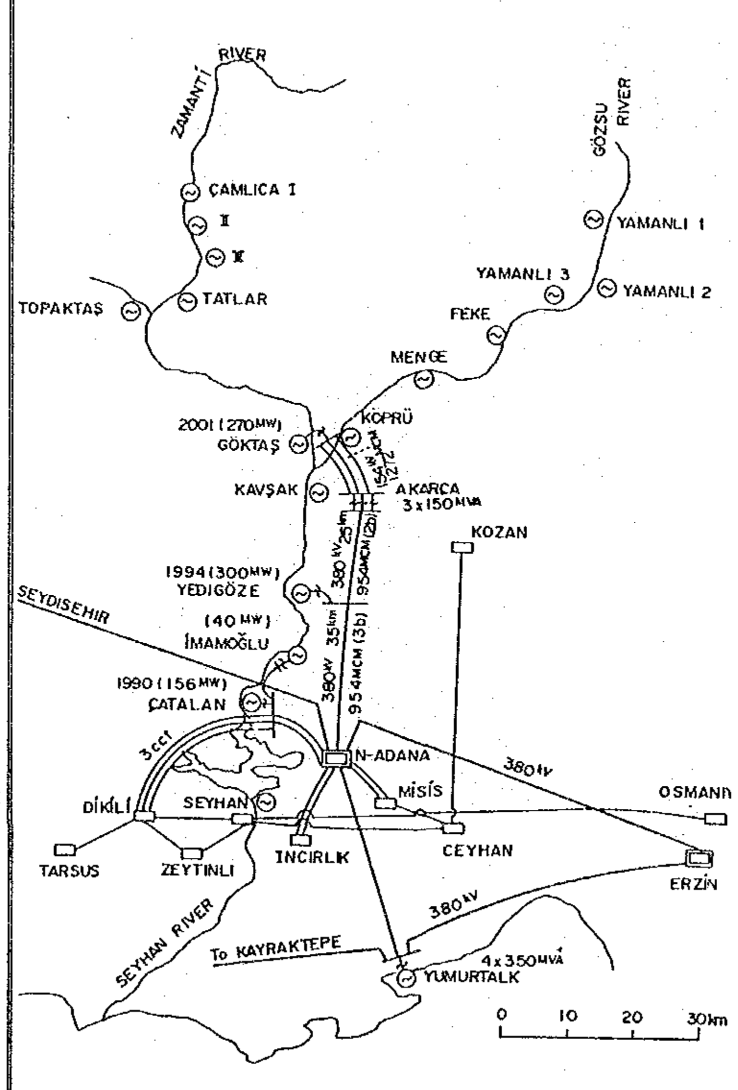
Economic evaluation items(10^6TL)</td><td colspan="2"></td><td colspan="2"></td><td colspan="2">Same as Pattern-1
except for The line
between CATALAN and DIKILI
designed in 500kv</td><td></td></tr>
<tr><td>Total constraction cost</td><td colspan="2">9, 222</td><td colspan="2">15, 438</td><td colspan="2">16, 319</td><td></td></tr>
<tr><td>Annual cost annual factor=11.4%</td><td colspan="2">(1) 1, 051</td><td colspan="2">1, 760</td><td colspan="2">1, 860</td><td></td></tr>
<tr><td rowspan="2">Total transmission losses</td><td>peak power loss(MW)</td><td>energy loss(GWH)</td><td>peak power loss(MW)</td><td>energy loss(GWH)</td><td>peak power loss(MW)</td><td>energy loss(GWH)</td><td>peak power l</td></tr>
<tr><td>MW 13. 5</td><td>GWH 27. 2</td><td>MW 10. 0</td><td>GWH 20. 1</td><td>MW 10. 0</td><td>GWH 20. 1</td><td>9. 8</td></tr>
<tr><td>Loss cost</td><td>(2) 3, 267</td><td>(3) 672</td><td>2, 420</td><td>496</td><td>2, 420</td><td>496</td><td>2, 3</td></tr>
<tr><td>Total annual cost</td><td colspan="2">(1)+(2)+(3) 4, 990</td><td colspan="2">4, 676</td><td colspan="2">4, 776</td><td></td></tr>
</table>

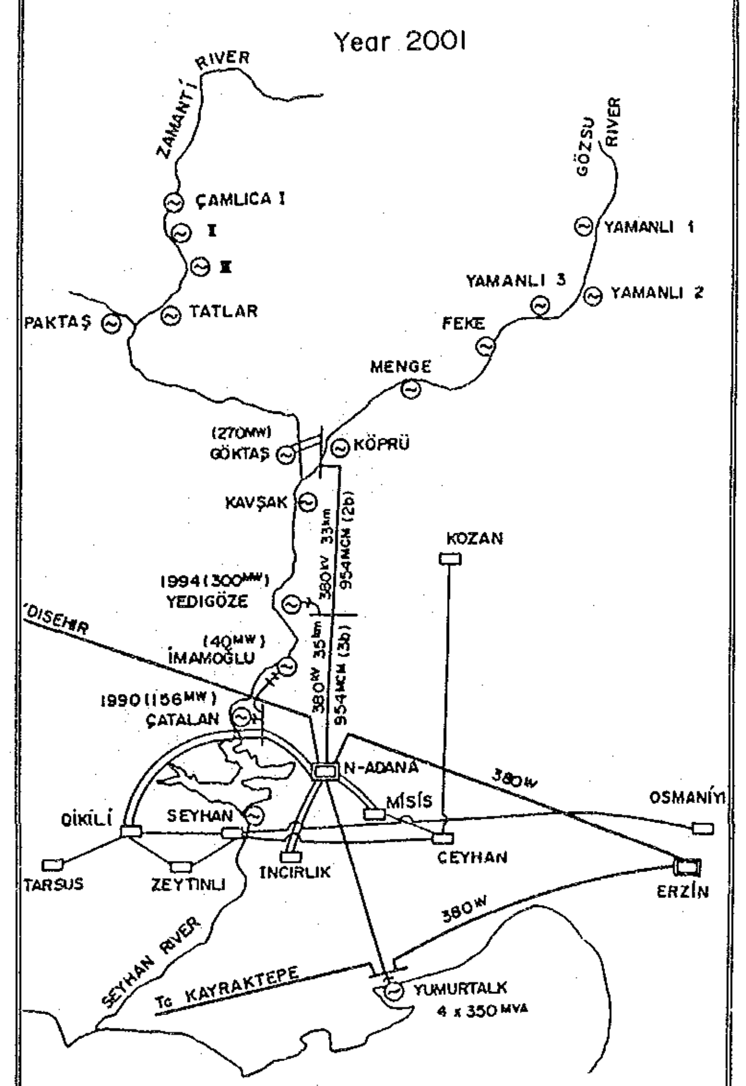
Table 10-5 (1) Results of Economic study for each transmission plan. (initial stage)

All 154kv Plan		380kv pattern -1		380kv pattern -2		380kv pattern -3	





Same as Pattern-1
except for The line
between CATALAN and DIKILI
designed in 500kv



9,222		15,438		16,319		12,147	
1,051		1,760		1,860		1,385	
power loss(MW)	energy loss(GWH)	peak power loss(MW)	energy loss(GWH)	peak power loss(MW)	energy loss(GWH)	peak power loss(MW)	energy loss(GWH)
MW 13.5	GWH 27.2	MW 10.0	GWH 20.1	MW 10.0	GWH 20.1	MW 9.8	GWH 19.7
3,267	(3) 672	2,420	496	2,420	496	2,372	487
2)+(3) 4,990		4,676		4,776		4,244	

Table 10-5 (2) Results of Economic study for each transmission plan, (final stage)

<table>
<tr><td>Plan</td><td colspan="2">All 154kv Plan</td><td colspan="2">380kv pattern -1</td><td colspan="2">380kv pattern -2</td><td colspan="2">380kv</td></tr>
<tr><td>Transmission system
(final stage)

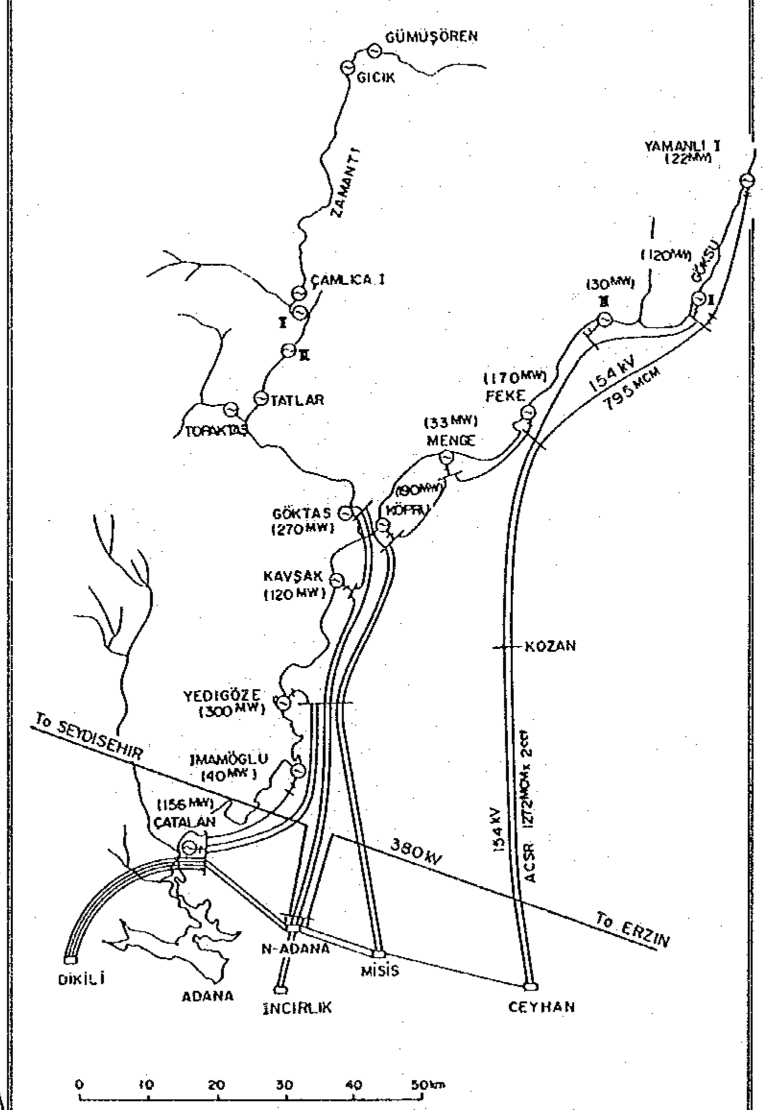
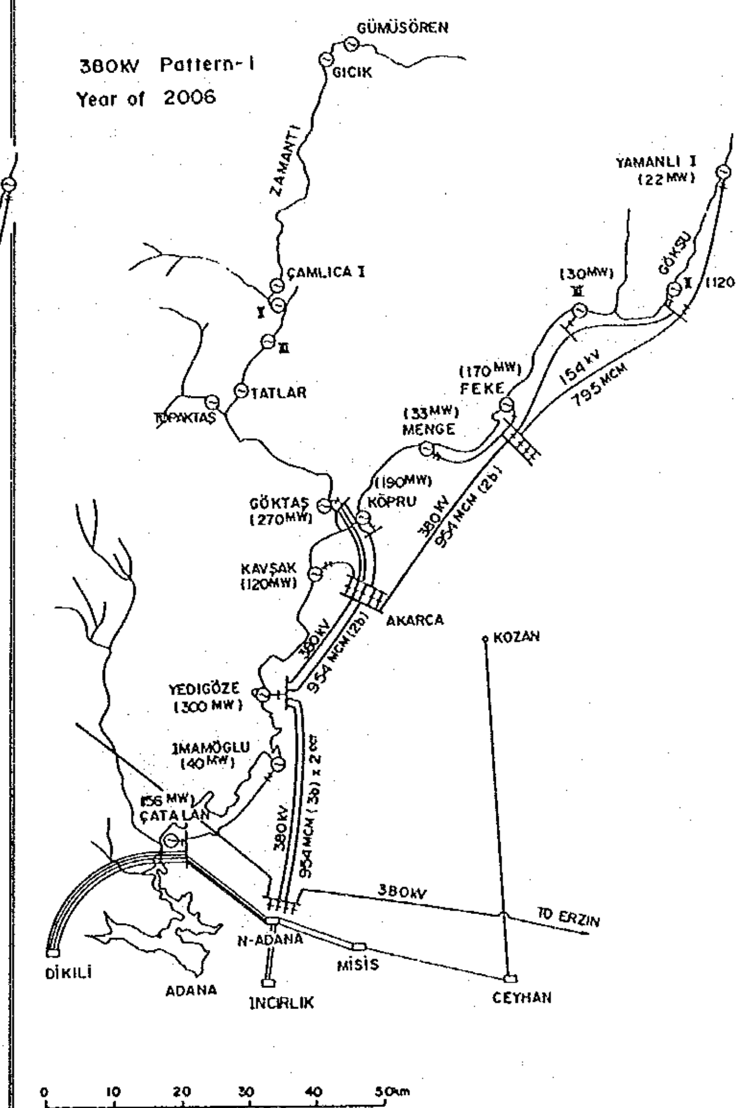
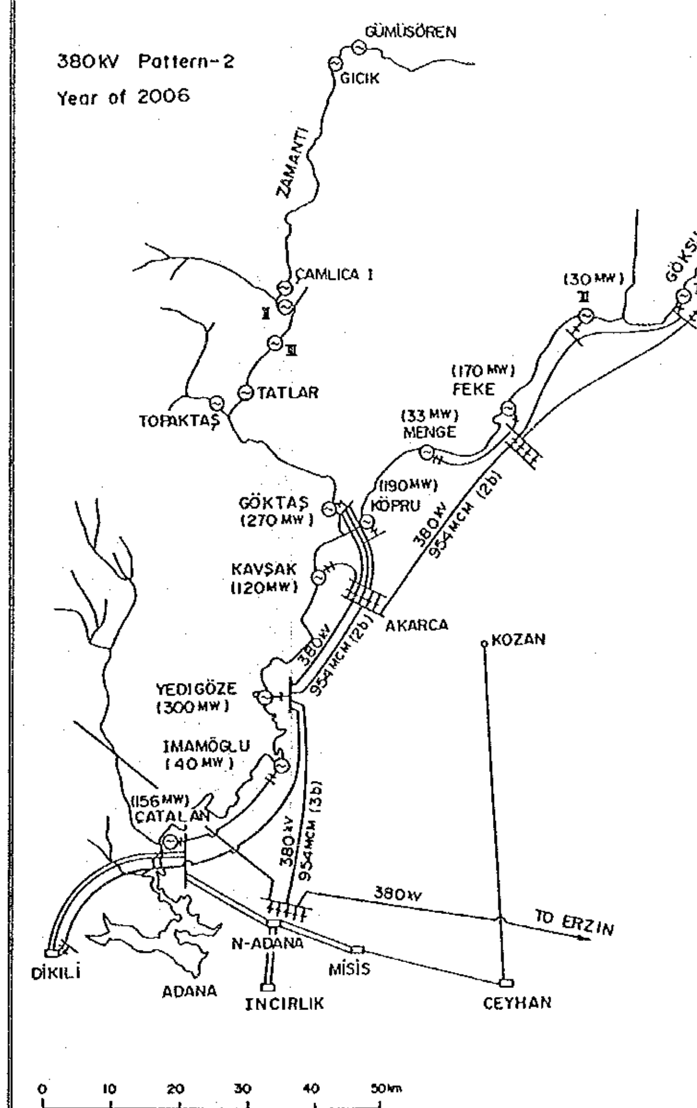
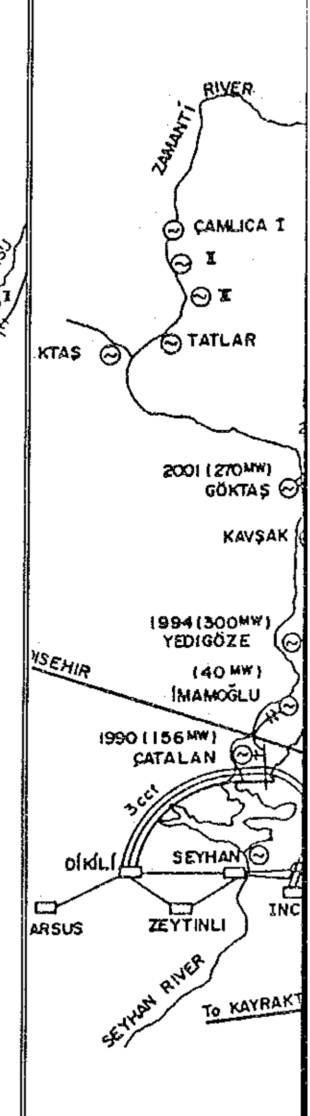
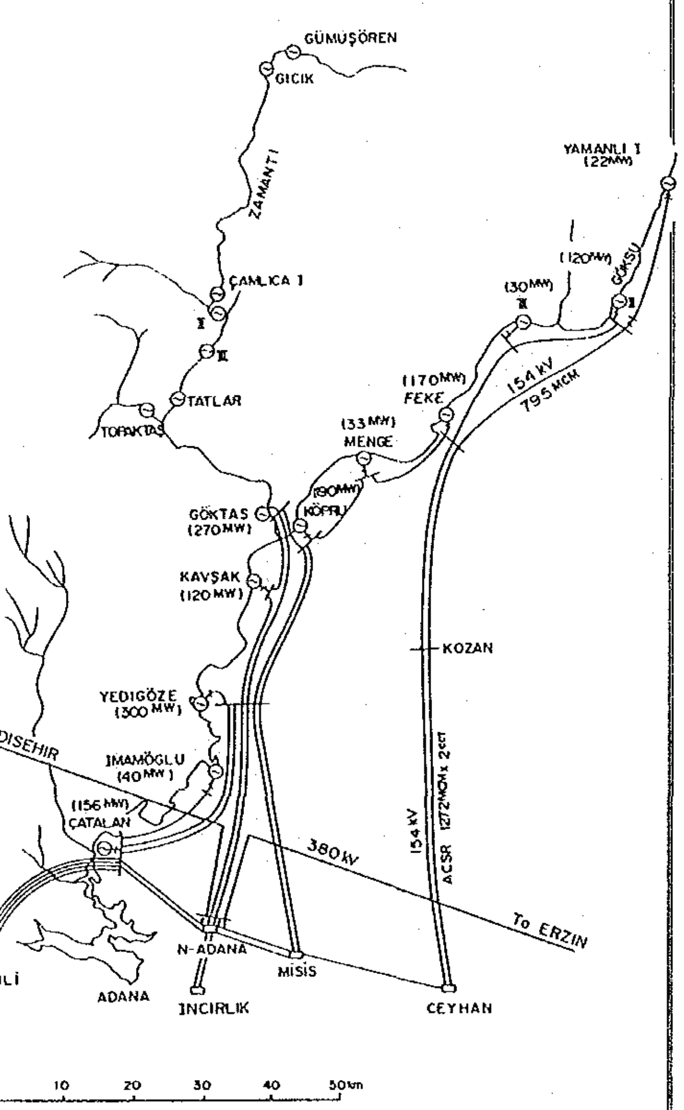
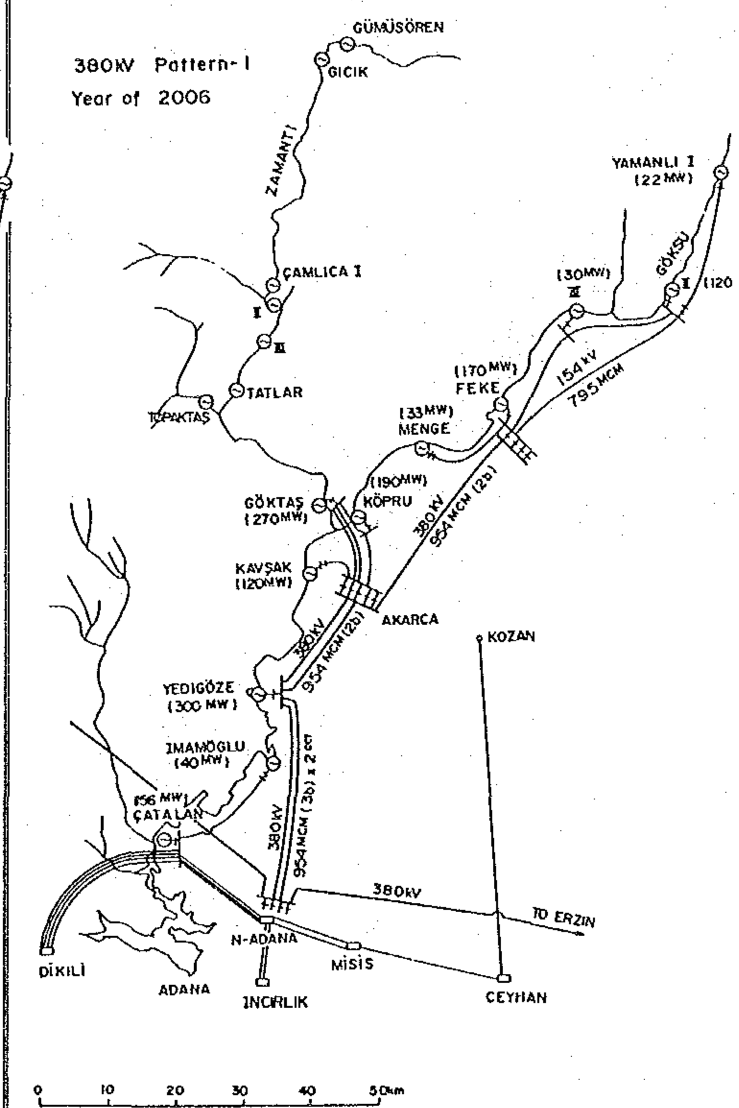
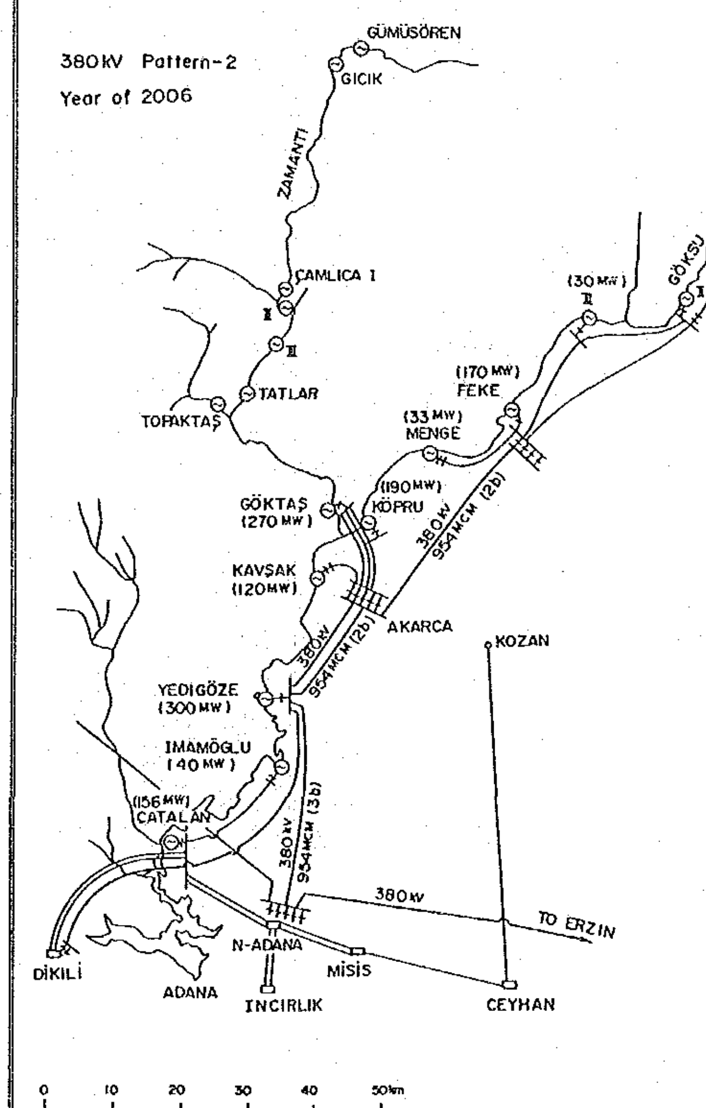
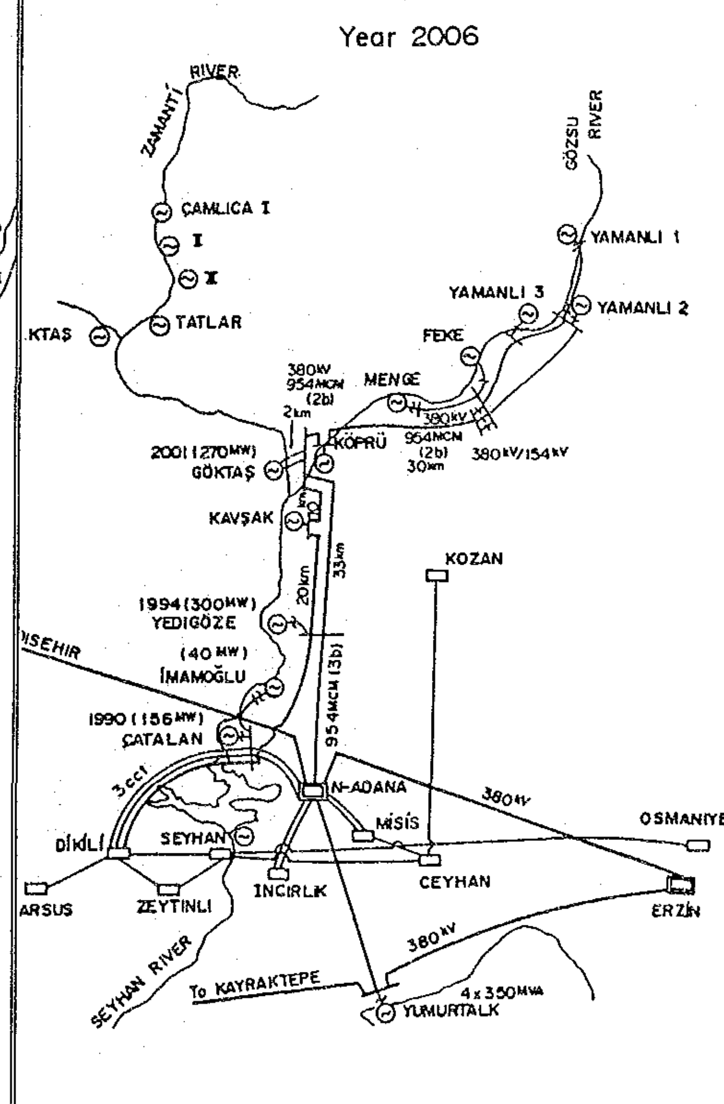
Economic evaluation items(10⁶TL)</td><td colspan="2">
</td><td colspan="2">
</td><td colspan="2">
</td><td colspan="2">
</td></tr>
<tr><td>Total constraction cost</td><td colspan="2">20,734</td><td colspan="2">35,177</td><td colspan="2">37,880</td><td colspan="2">(Incremental (</td></tr>
<tr><td>Annual cost annual factor=11.4%</td><td colspan="2">(1) 2,364</td><td colspan="2">4,010</td><td colspan="2">4,318</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Total transmission losses</td><td>peak power loss(MW)</td><td>energy loss(GWH)</td><td>peak power loss(MW)</td><td>energy loss(GWH)</td><td>peak power loss(MW)</td><td>energy loss(GWH)</td><td>peak power loss(M</td><td></td></tr>
<tr><td>MW
34.0</td><td>GWH
68.5</td><td>MW
25.7</td><td>GWH
51.8</td><td>MW
12.5</td><td>GWH
25.2</td><td>MW
12.3</td><td></td></tr>
<tr><td>Loss cost</td><td>(2)
8,228</td><td>(3)
1,692</td><td>6,219</td><td>1,279</td><td>3,025</td><td>622</td><td>2,977</td><td></td></tr>
<tr><td>Total annual cost</td><td colspan="2">(1)+(2)+(3)
12,284</td><td colspan="2">11,508</td><td colspan="2">7,965</td><td colspan="2"></td></tr>
</table>

Table 10-5 (2) Results of Economic study for each transmission plan. (final stage)

All 154kv Plan		380kv pattern -1		380kv pattern -2		380kv pattern -3	
							
20,734		35,177		37,880		(Incremental cost from the year 2001) 43,520	
2,364		4,010		4,318		4,961	
k power loss(MW)	energy loss(GWH)	peak power loss(MW)	energy loss(GWH)	peak power loss(MW)	energy loss(GWH)	peak power loss(MW)	energy loss(GWH)
MW 34.0	GWH 68.5	MW 25.7	GWH 51.8	MW 12.5	GWH 25.2	MW 12.3	GWH 24.8
8,228	(3) 1,692	6,219	1,279	3,025	622	2,977	613
(2)+(3) 12,284		11,508		7,965		8,551	

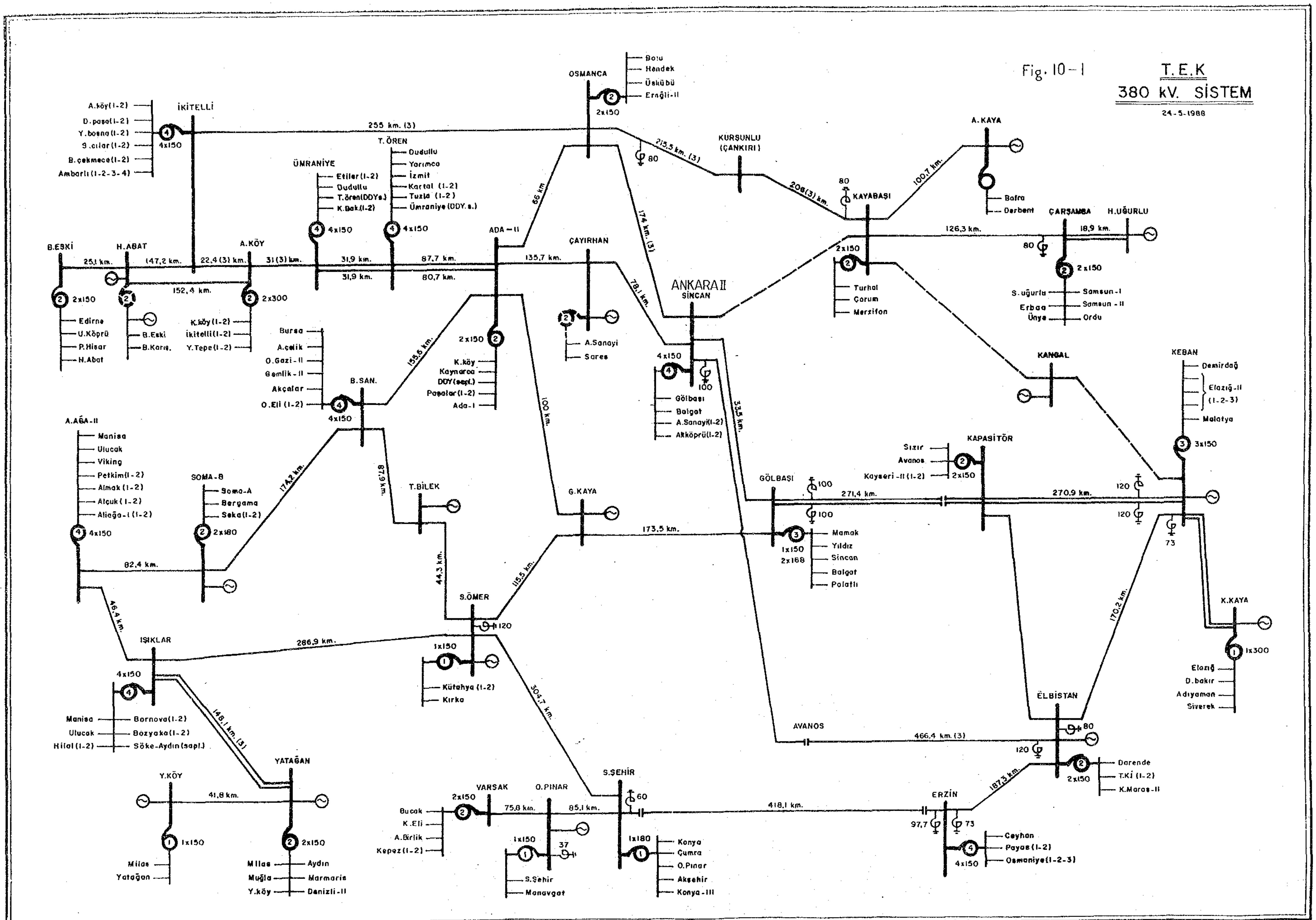
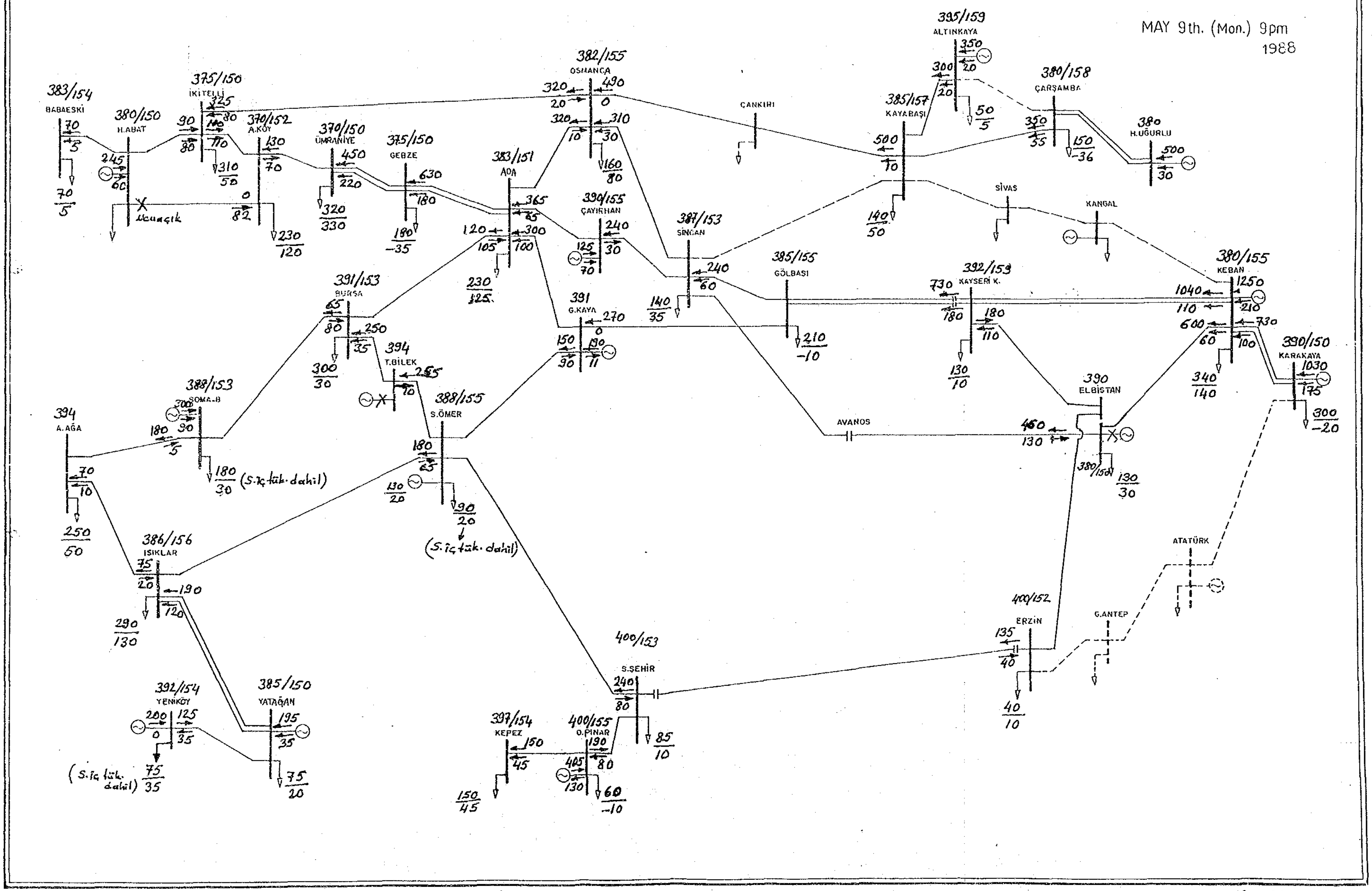


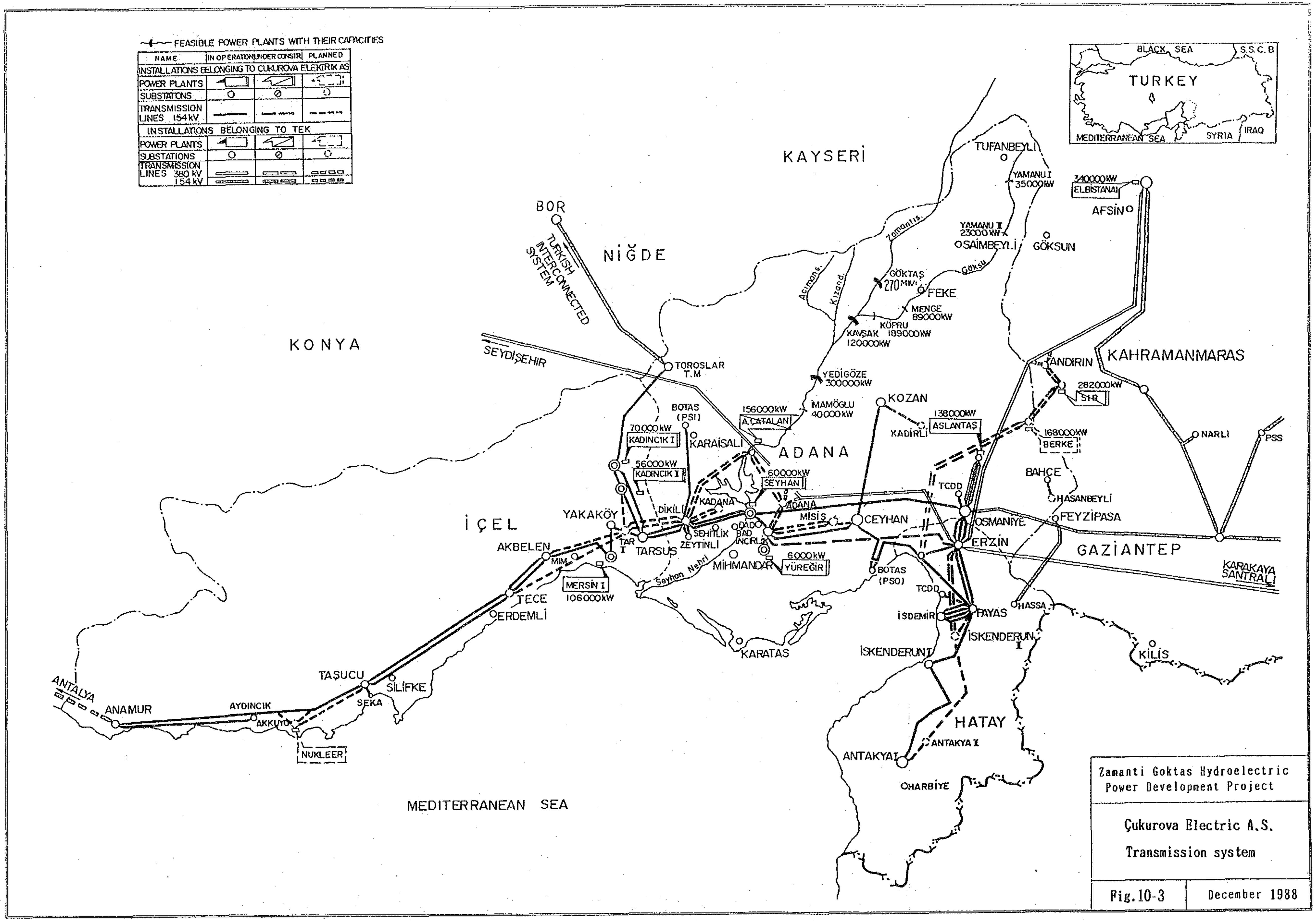
Fig. 10-1

T.E.K
380 kV. SİSTEM
24-5-1988

Fig. 10 – 2 LOAD FLOW of 380 KV SYSTEM

MAY 9th. (Mon.) 9pm 1988





Zamanti Goktas Hydroelectric Power Development Project

Çukurova Electric A.S.

Transmission system

Fig.10-3 December 1988

Fig. 10-4 Route map from Adana to Goktas P/S

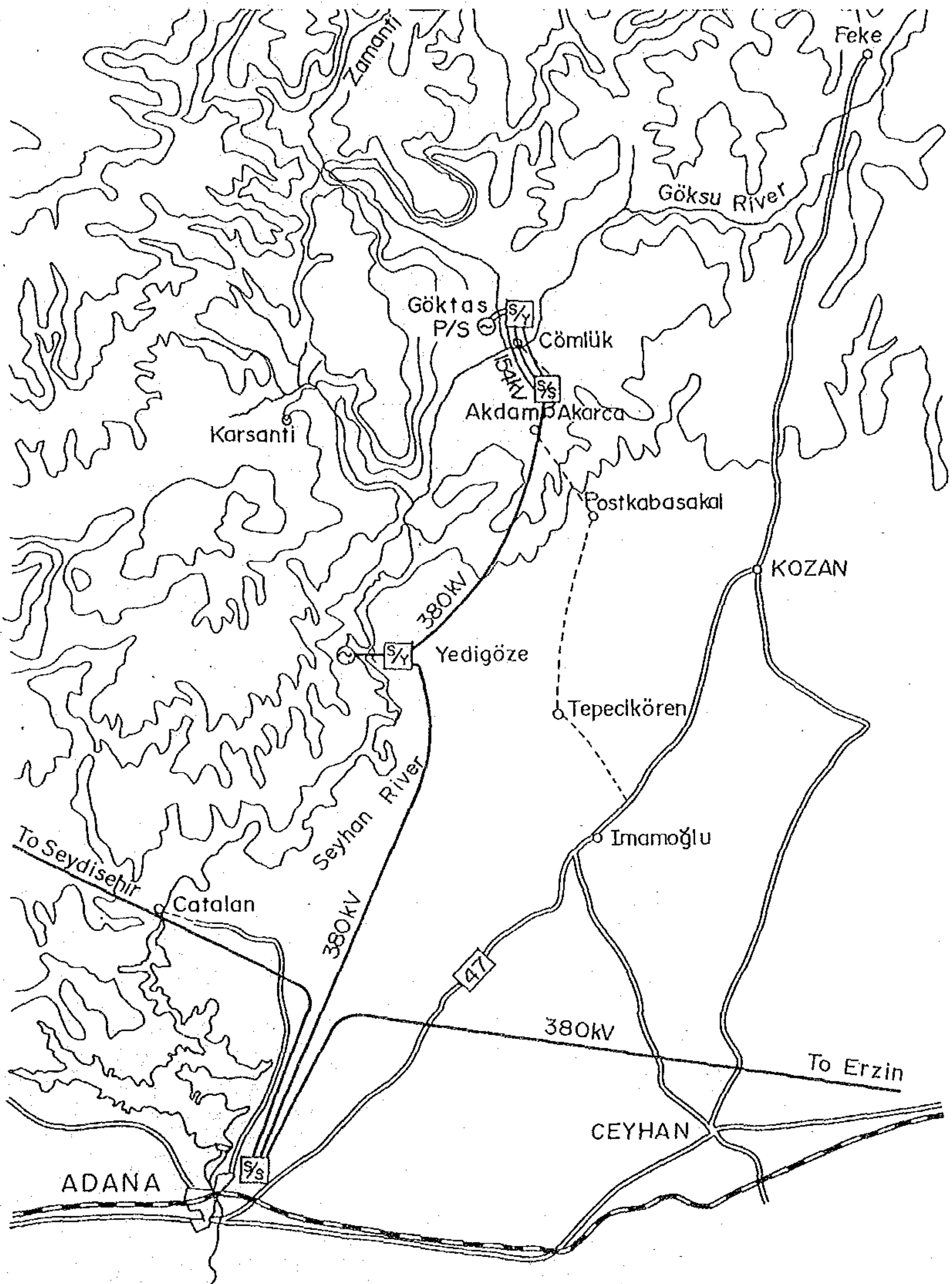
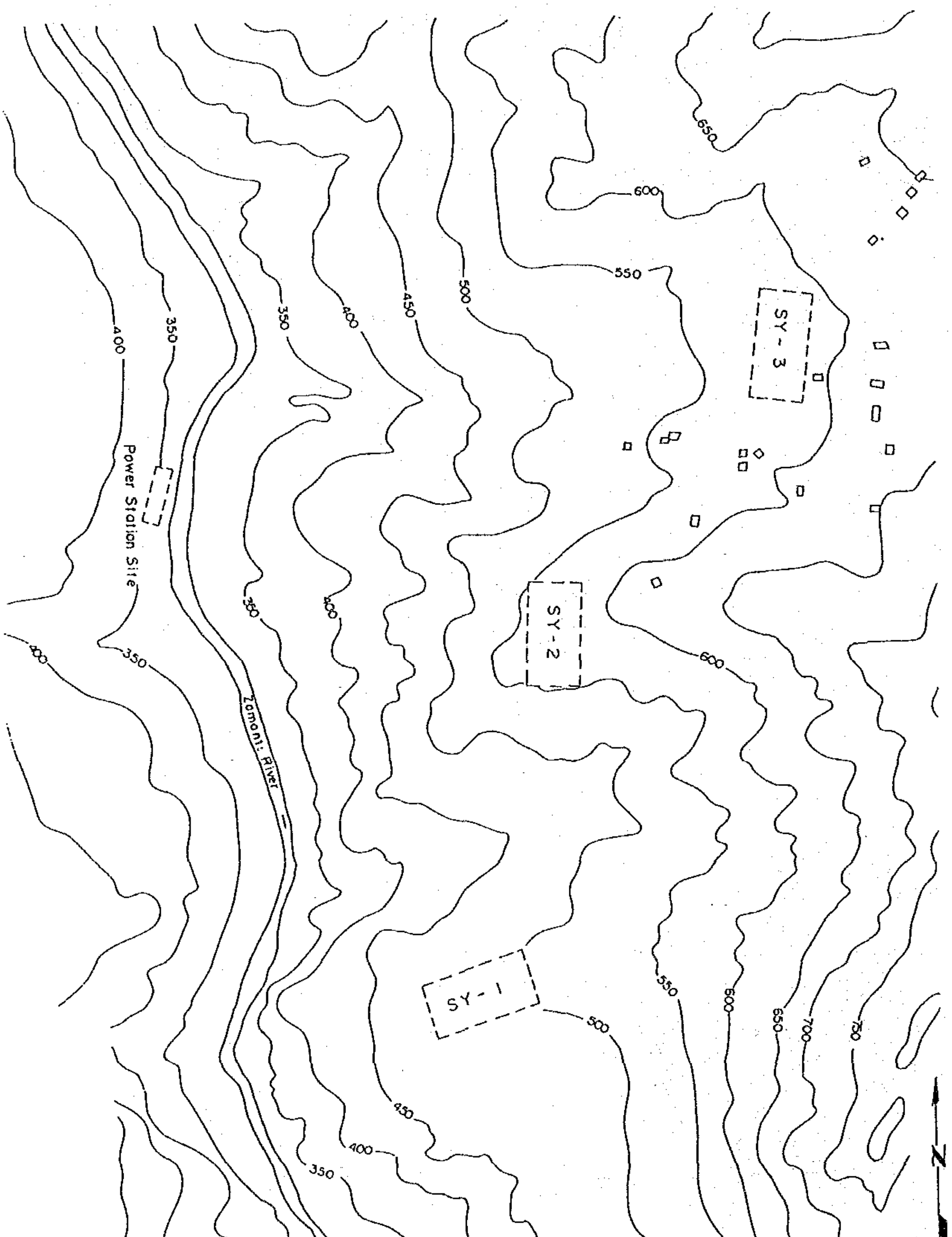
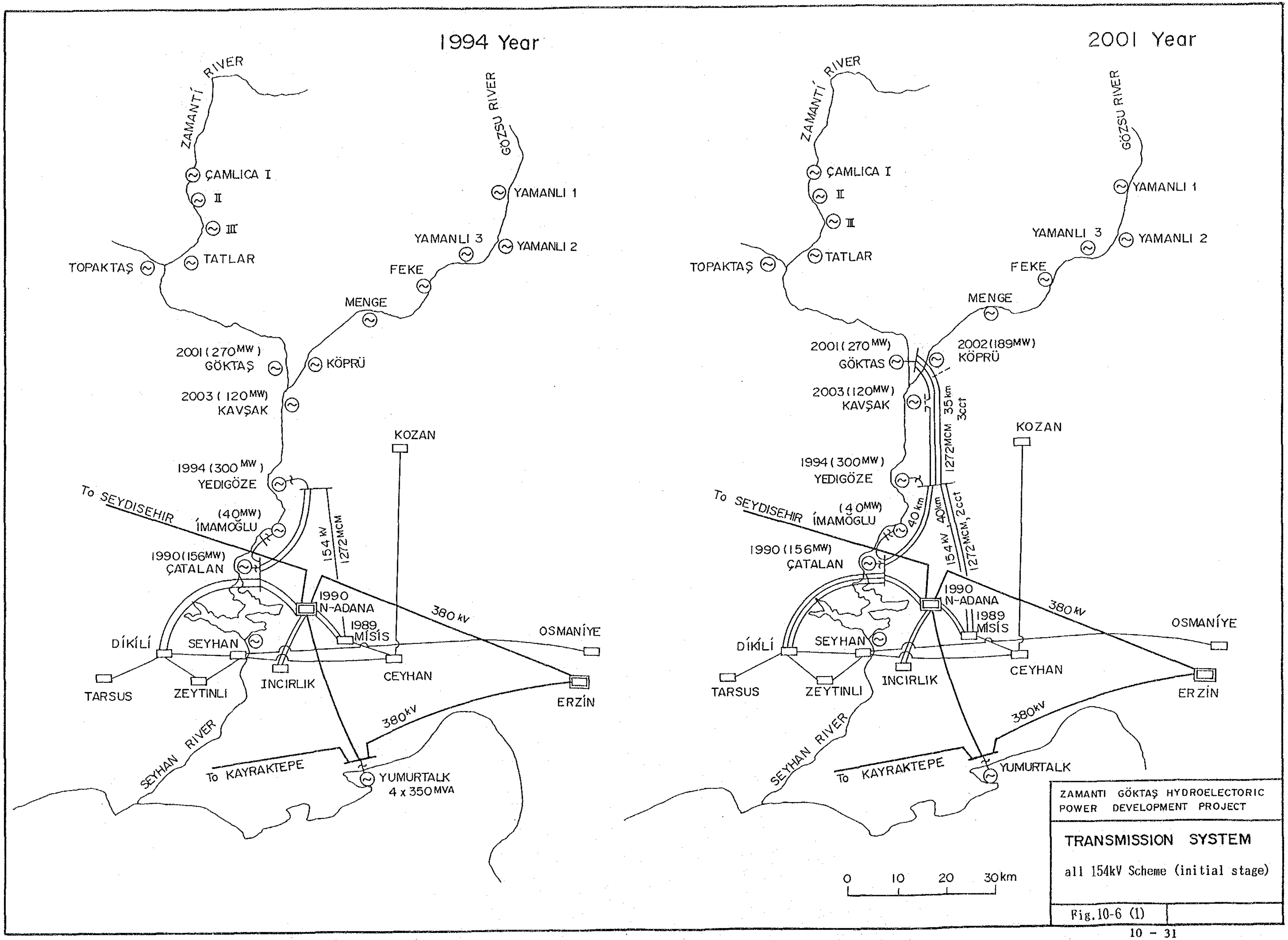


Fig. 10.5 Location map of Switchyard





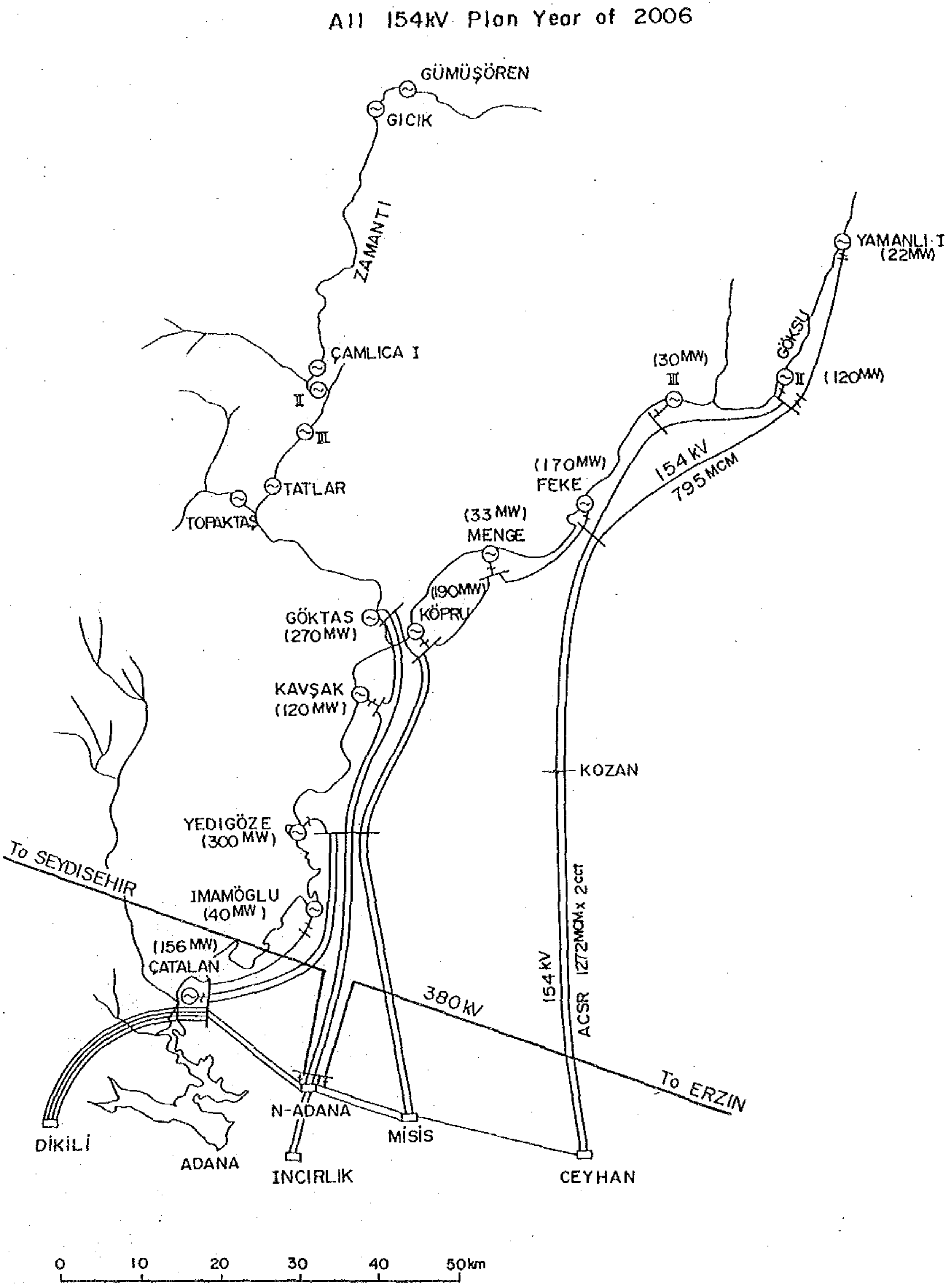
ZAMANTI GÖKTAŞ HYDROELECTORIC POWER DEVELOPMENT PROJECT

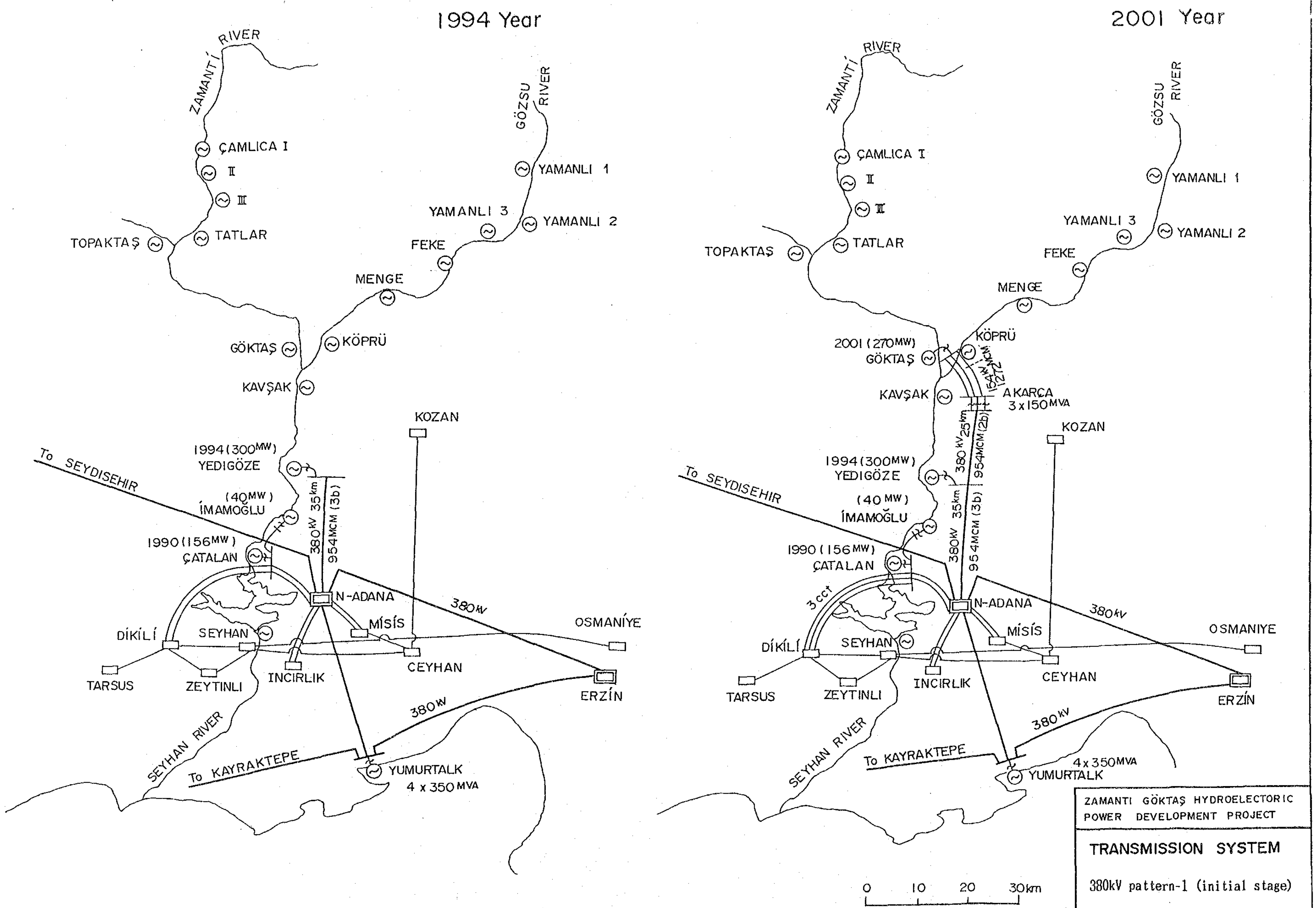
TRANSMISSION SYSTEM

all 154kV Scheme (initial stage)

Fig. 10-6 (1)

Fig. 10-6 (2) Transmission plan all 154kV Scheme (final stage)





ZAMANTI GÖKTAŞ HYDROELECTORIC POWER DEVELOPMENT PROJECT

TRANSMISSION SYSTEM

380kV pattern-1 (initial stage)

Fig.10-7 (1)

Fig. 10-7 (2) Transmission plan 380kV pattern-1 (final stage)

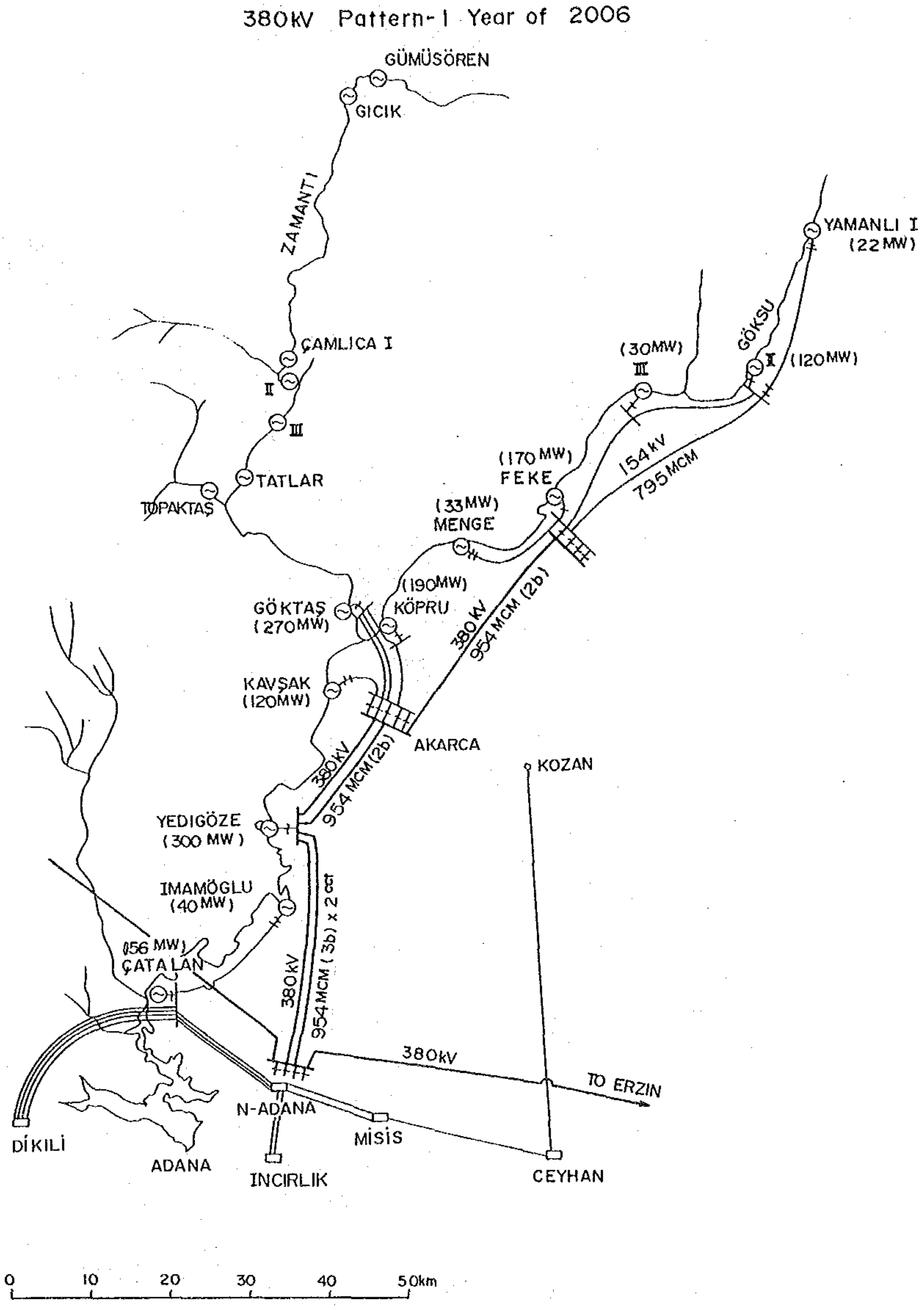
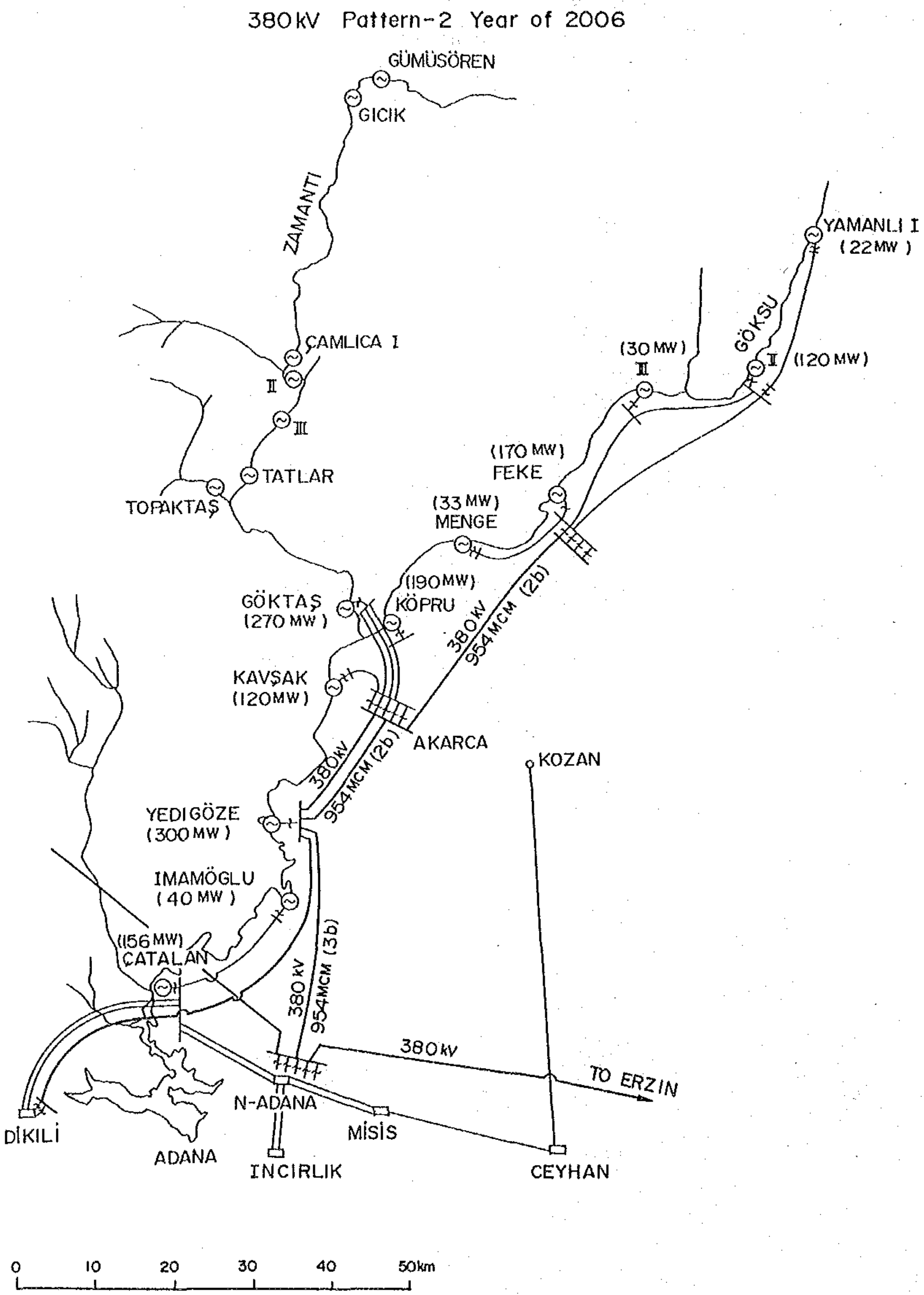
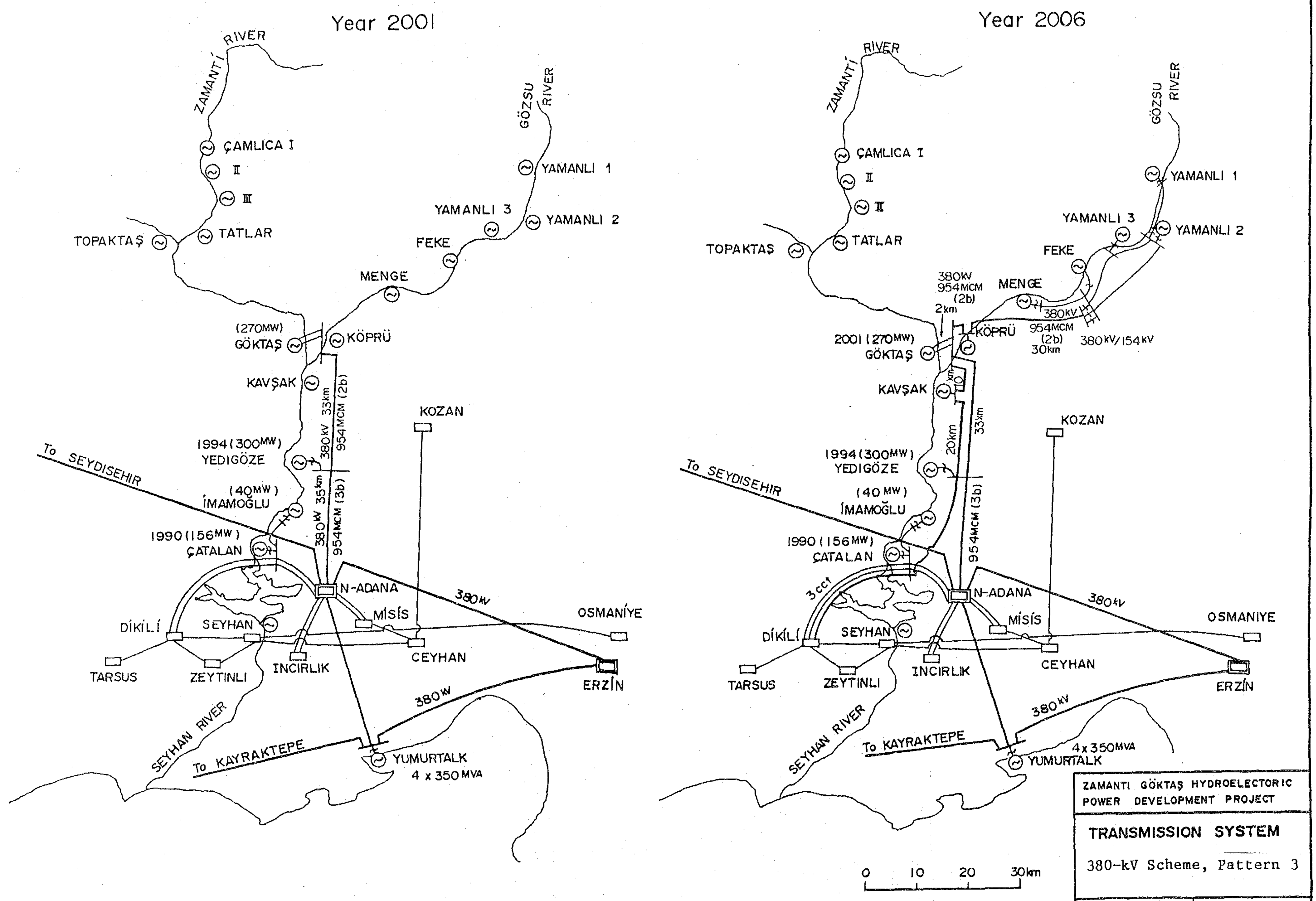


Fig. 10-8 Transmission plan 380kV pattern-2 (final stage)





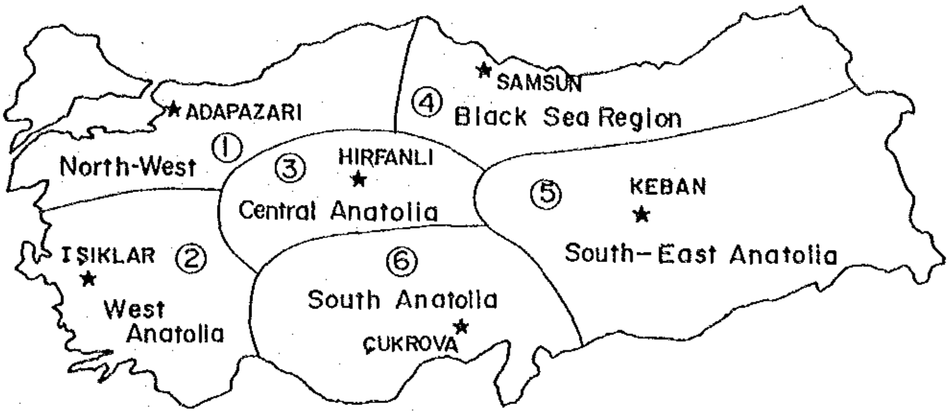
ZAMANTI GÖKTAŞ HYDROELECTORIC POWER DEVELOPMENT PROJECT

TRANSMISSION SYSTEM

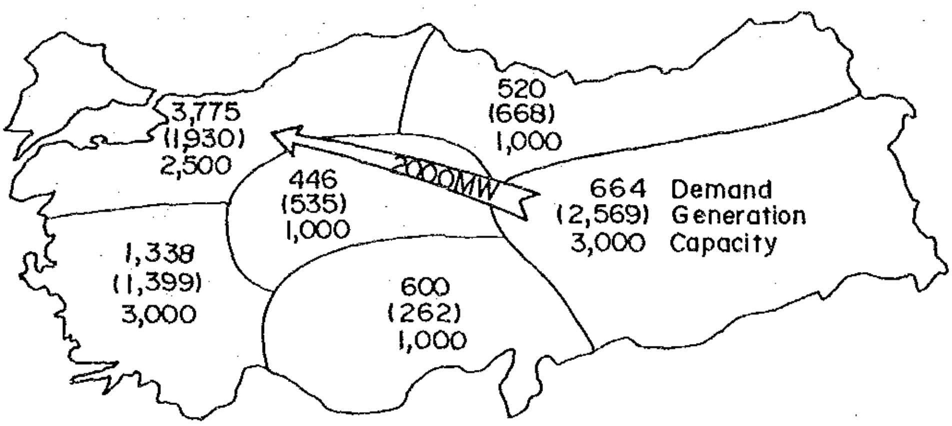
380-kV Scheme, Pattern 3

Fig. 10-9

Fig.10-10 Regional Power Demand & Supply in Turkey

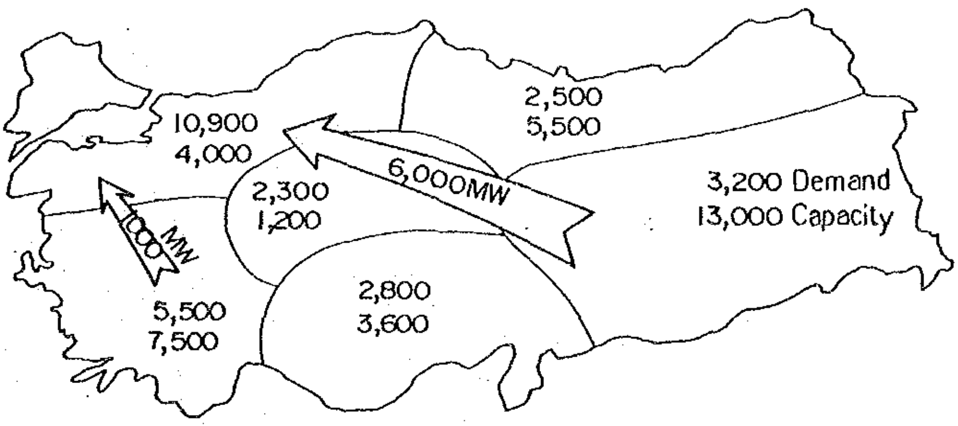


Dec. Peak In the Year 1987

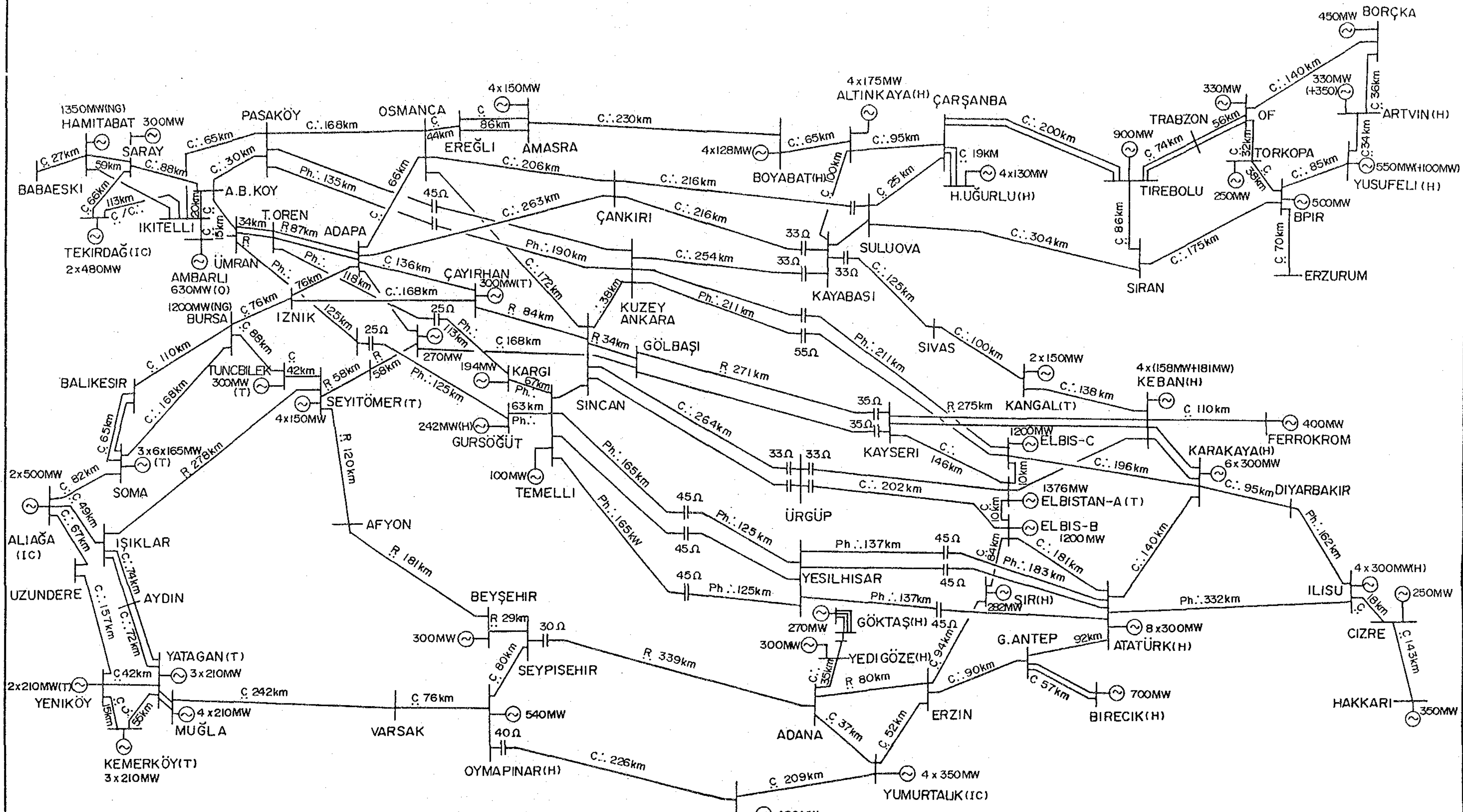


Total Demand = 7,343MW
Total Installed Capacity = 11,500MW

Peak Time in the Year 2,000



Total Demand = 27, 200MW
Total Installed Capacity= 34,800MW



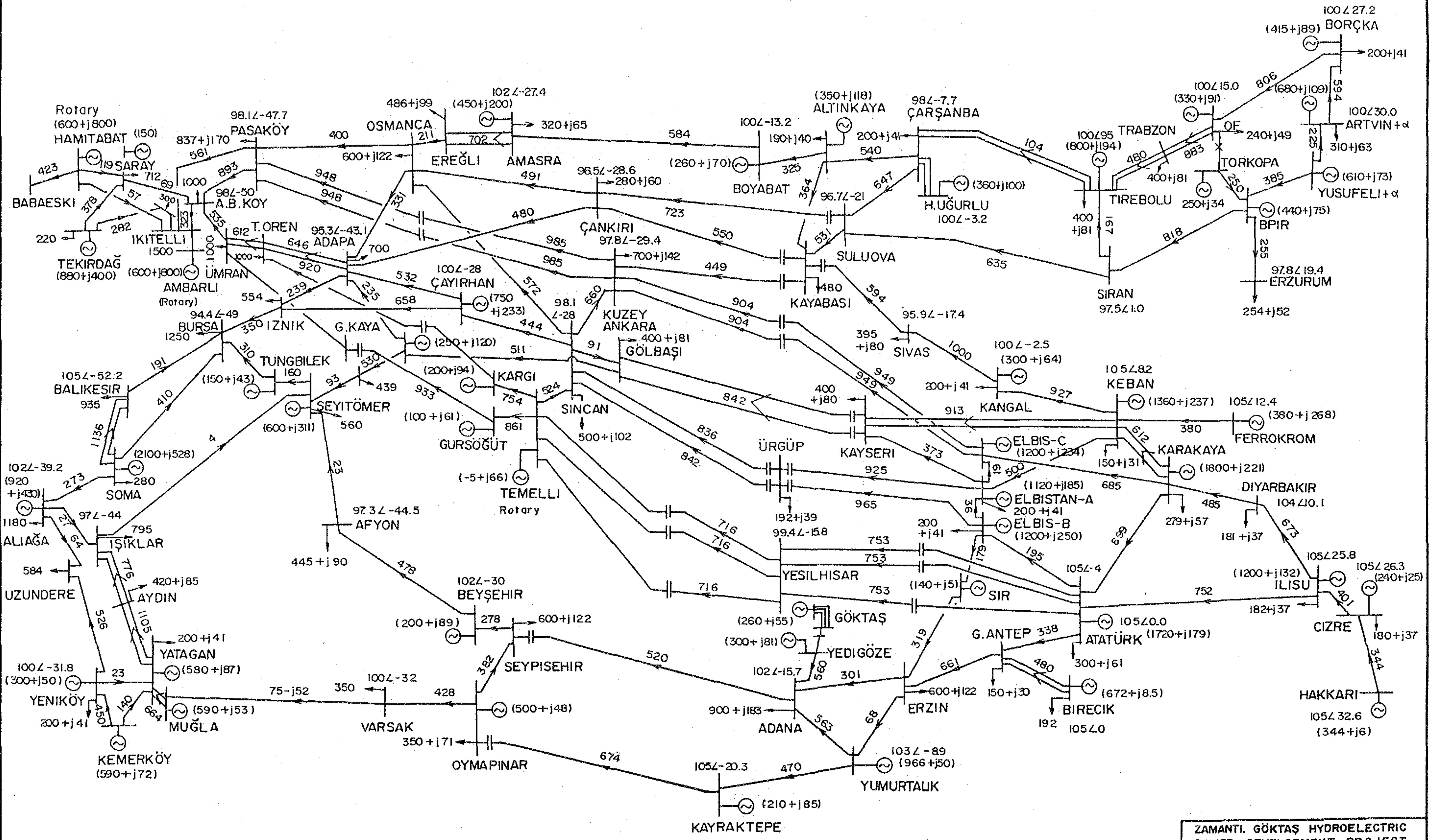
—||— : Series Capacitor
|—⊙ : Generator with Capacity in MW
(T) : Lignite-fired P. Plant
(O) : Oil-fired 〃
(IC) : Imported Coal 〃
(NG) : Natural gas 〃
(H) : Hydro 〃

LINE CONDUCTOR
- R RAIL(2b) ACSR 954MCM
- C CARDINAL(2b) 〃 〃
- C∴ CARDINAL(3b) 〃 〃
- Ph∴ PHEASANT(3b) 〃 1272MCM

ZAMANTI, GÖKTAŞ HYDROELECTRIC POWER DEVELOPMENT PROJECT

The 380kV Turkish System in the year 2001

Fig. 10-11



Total Demand ≒ 28,000MW

Total Ploss ≒ 974MW

Total Q loss ≒ 1,551MVAR

$(P_G^{MW} + jQ_G^{MVAR})$

$V_B\% \angle \theta_{deg}$

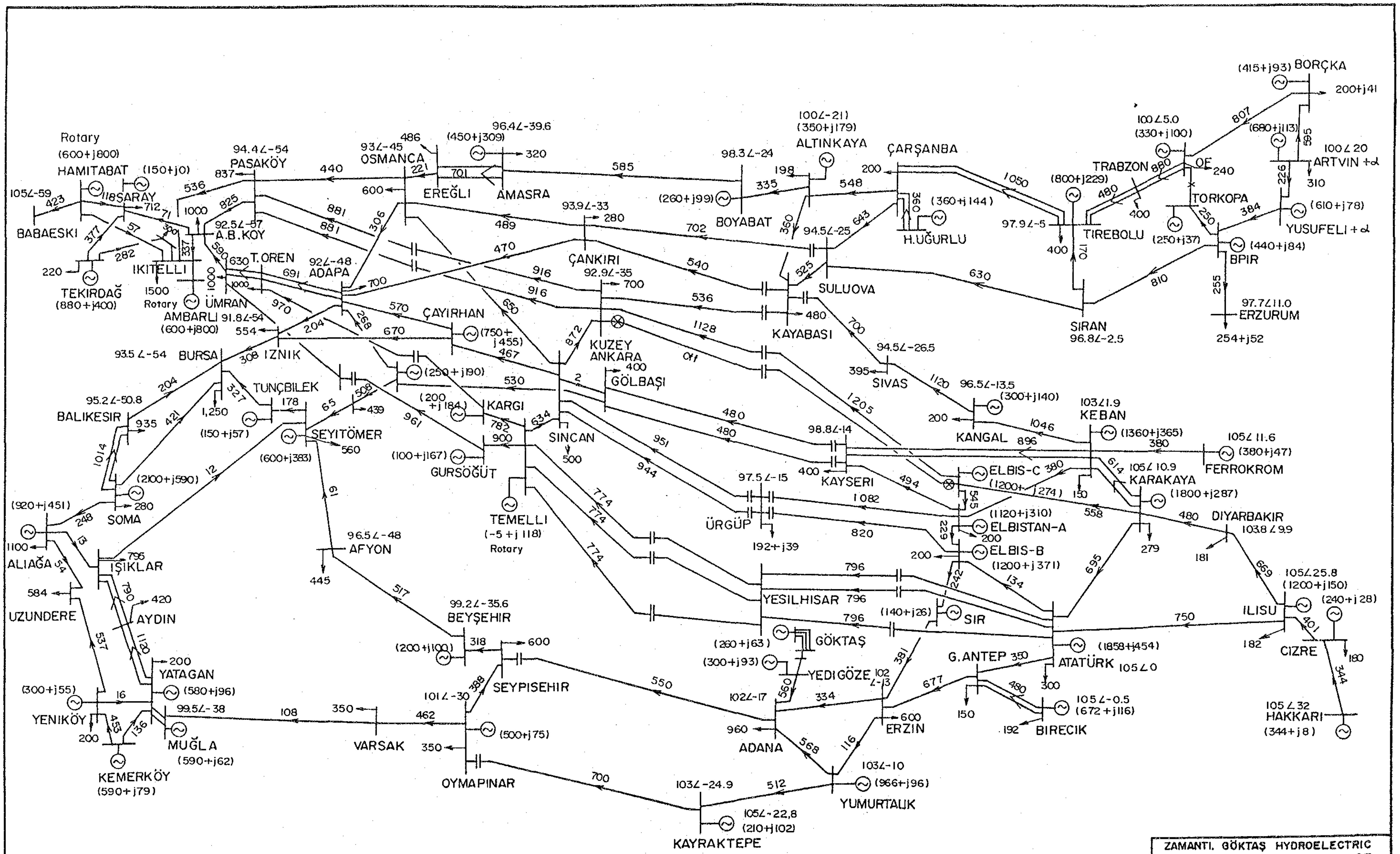
→ Pline^MW

⊢→ Pload^MW

ZAMANTI. GÖKTAŞ HYDROELECTRIC POWER DEVELOPMENT PROJECT

Load Flow in 2,001
All 380kV Lines are in service

Fig. 10-12



Total Demand ≒ 28,000MW

Total Ploss ≒ 1,098MW

Total Qloss ≒ 3,305MVAR

$(P_G^{MW} + jQ_G^{MVAR})$

$V_B\% \angle \theta deg$

→ P_{line}^{MW}

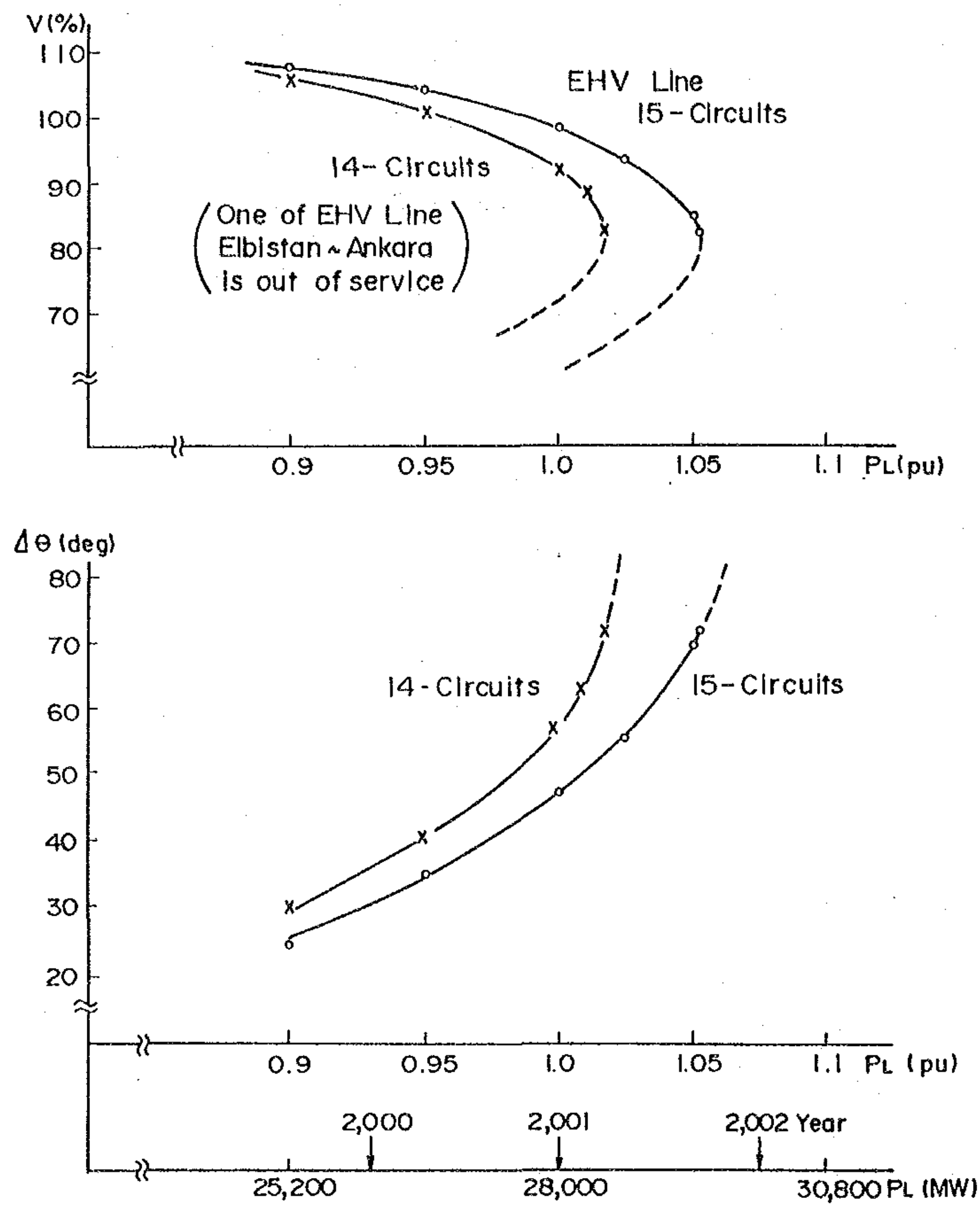
⊢→ P_{load}^{MW}

ZAMANTI, GÖKTAŞ HYDROELECTRIC POWER DEVELOPMENT PROJECT

Load Flow in 2,001 One 380kV Line (ELBISTAN-KUZEY) is out of service

Fig. 10-13

Fig. 10 - 14 Voltage Drop Versus Demand Increasment



V ; 380kV Bus Voltage (%) at Alibeyköy S/S (Istanbul)

Δθ ; Phase angle between Alibeyköy and Atatürk 380kV Bus

PL ; Total demand in pu
1 pu is 28,000 MW, corresponding to the demand in the year 2001

CHAPTER 11. FEASIBILITY DESIGN

CHAPTER 11. FEASIBILITY DESIGN

CONTENTS

List of Figures

List of Tables

List of Drawings

CHAPTER 11. FEASIBILITY DESIGN

11.1 Outline

The feasibility designs of permanent civil structures, hydraulic equipment, electrical equipment, and the transmission line, along with temporary structures, are discussed in this chapter. The cofferdams and the diversion tunnel are included in the category of temporary structures. The dam, spillway, power intake, headrace tunnel, surge tank, penstock, powerhouse, switchyard, appurtenant, hydraulic equipment and electrical equipment are classified as permanent structures.

The access road from the powerhouse site to the dam site will be discussed in Chapter 12.

11.2 Dam and Appurtenant Structures

11.2.1 Goktas Dam

(1) Location and Outline

The projected dam site is located approximately 22 km upstream from the confluence of the Goksu River and the Zamanti River, and approximately 20 km upstream from the projected powerhouse site.

The topography in the vicinity of the dam site, as stated in 7.5.1, is that of a V-shaped valley with a continuation of steep slopes partially close to vertical, and other than at slope wash, bedrock is outcropped at the ground surface. The river bed is at an elevation of 510 m with a width of 40 m. The estimated maximum thickness of alluvial deposits obtained in boring investigations is approximately 23 m.

The geology of the vicinity of the dam, as described in 7.5.2, is composed of hard peridotite. Small-scale faults exist at the surface layer, while joints are also developed, and serpentinization is seen at joint surfaces at parts, but these are all discontinuous and do not extend to great depths.

(2) Selection of Dam Type

It is conceivable for the dam to be either one of two types, a fill type or a concrete type according to the materials. The major points in design of the dam is that not only the dam body but the foundation will be safe and the construction cost economical.

Firstly, with respect to a fill dam, an inner core type requiring a large volume of core material is conceivable, but such material cannot be found in the surroundings of the dam site. Core material does exist in a pine forest at Dogan Cay near Karsanti on the other side of a pass of EL. 1,500 m from the dam site. The transport distance in this case would be as long as 20 km. In addition, since the dam site is of rugged topography and the valley width is small, large scale of excavation would be necessary for a large-capacity spillway to be provided at the side of the mountain or by big tunnels. Trafficability in embankment work would also be poor and the economics will not be good.

A rockfill dam with concrete facing would be the same as an inner core type with regard to poor trafficability in embankment work, but besides that, the topography at the dam site in one of numerous gullies with large and small cutting into both the right and left banks so that it cannot be said with full confidence that an impermeability can be secured at the abutment.

In contrast, as stated in 7.5 and 7.7, from the standpoint of mechanical and hydraulic stability of the foundation rock, there would be no objection to a concrete dam, in addition to which concrete aggregates can be obtained in ample quantity in the neighborhood so that a concrete type is thought will be suitable for Goktas Dam.

However, there are joints lined with fine-grained serpentine, in addition to which the topography is that of a deeply and complicatedly cut valley where there would be problems about adopting a thin arch dam. Therefore, a comparison will be made here of gravity type and arch gravity type dams with the economics.

The drawings for gravity type and arch gravity type dams are shown in Dwgs. 11-3 and 11-4, 5 respectively.

As a result of making the comparisons shown in Table 11-1, it was recommended to adopt the arch gravity type which is superior in economics for Goktas Dam.

Table 11-1 Comparison of Dam Type

Item	Gravity Type	Arch Gravity Type
Stability	Good	Good
Layout	Good	Good
Slope	1 : 0.8	1 : 0.6
Concrete Volume	1.1×10^6 m^3	0.8×10^6 m^3
Excavation Volume	4.4×10^5 m^3	2.9×10^5 m^3
Ratio of Construction Cost	1.28	1.00

The layouts of the cofferdams and the diversion tunnel were the same at the both dam types as shown in Dwgs. 11-3 and 11-4, 5, because layouts of the cofferdams were determined on account of topography as well as space needed for dam construction works, so that volume of the cofferdams should be small at narrow portion of the valley (see 11.2.3). Therefore, construction cost of the dams was simply considered at the comparisons in Table 11-1, neglecting that of care of river works.

(3) Selection of Dam Configuration

The dam crest elevation, as stated in 11.2.2, was selected to be at EL. 635 m taking into consideration PMF discharge level and freeboard. Consequently, the dam height from the foundation rock at EL. 487 m to the crest will be a maximum of 148 m.

There is no especially unsuitable spot from the standpoint of geology for a dam foundation in the neighborhood of the projected dam site so that for the location of the dam the topography was studied in detail, and various alternatives were examined avoiding gullies and depressions as much as possible in order that the dam volume would be minimum and that the mechanical stabilities of the abutments for the horizontal arch shapes would be the best in view of the topography.

Also, on considering the seismic forces studied in Chapter 8, the downstream slope gradient and arch radius of the dam were selected to be 1:0.6 and R = 220 m, respectively, in regard to the recommended configuration for the arch gravity type dam.

11.2.2 Spillway

The spillway would be located at approximately the middle of the dam body with its direction roughly coinciding with the direction of the downstream thalweg. With regard to the dimensions and number of gates, three radial gates each 14.0 m in width and 13.0 m in design head were selected taking into consideration gate fabrication performances in Turkey so that there would be the capacity to discharge the PMF flow of 3,900 m^3/s at high water level of 630.00 m as stated in 6.6.

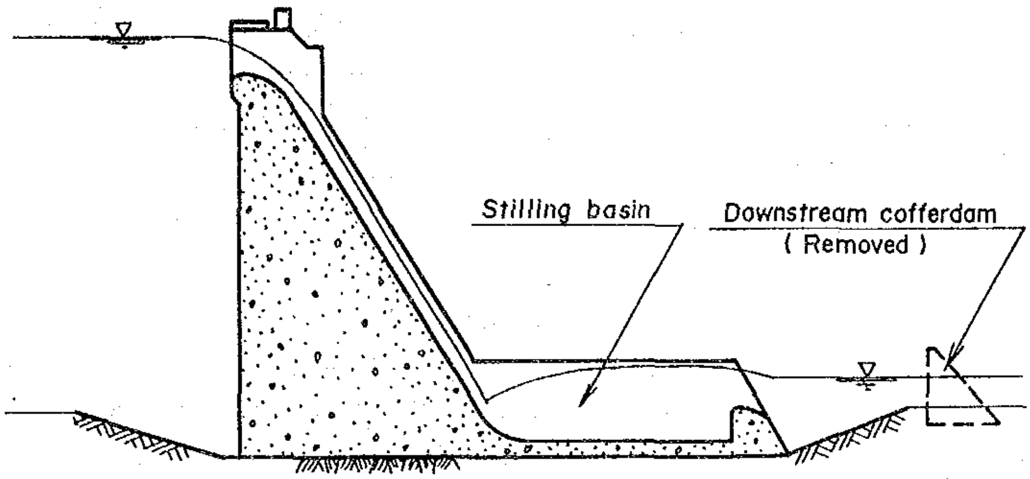
The dam crest elevation was selected so that the dam would not be overtopped even when one gate is out of order at time of PMF. That is, since the wave height adding freeboard of 0.80 m to the PMF water level elevation when there is trouble with one gate is EL. 634.70 m, the dam crest elevation was made 635.00 m.

Further, the convenience during repairing a spillway gate were considered and a set of stoplogs are to be provided in front of the gates.

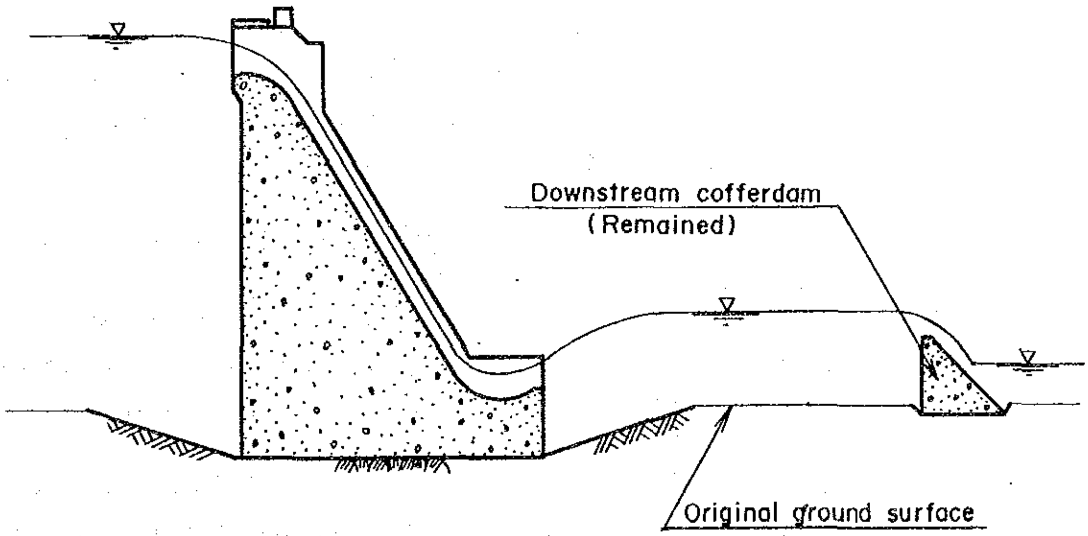
Two methods are conceivable for energy dissipation of the spillway as shown in Fig. 11-1. Since important structures and houses do not exist between the dam and powerhouse sites, complete energy dissipation does not have to be aimed for, while with Alternative A for a concrete stilling basin, it is clear that the quantity of work will be increased, and a system such as that of Alternative B of converting temporary structures into permanent works for economy, a setup where the downstream cofferdam would be left in place to form a pool at the river bed between it and the dam for energy dissipation of the spillway flow to an extent was selected.

Fig.11-1 Comparison of Stilling Basin Type

Alternative - A



Alternative - B



11.2.3 Care of River

(1) General

The discharge considered for care of river during construction is taken as the 10-year return period flood of 530 m^3/s in view of the fact that this will be a concrete dam (see 6.5). When the conditions are that the river width is narrow and the depth of foundation excavation is great to some extent, construction of the dam would be difficult with the diversion canal method. Therefore, it was decided to adopt the diversion tunnel method with which a large construction space can be secured and dewatering work performed with relative ease. The design drawing of care of river is shown in Dwg. 11-2.

(2) Cofferdams

Primary and secondary cofferdams are to be adopted for both the upstream and downstream sides. The primary cofferdams are for the purpose of temporarily diverting the river flow to the diversion tunnel in order to construct the secondary cofferdams.

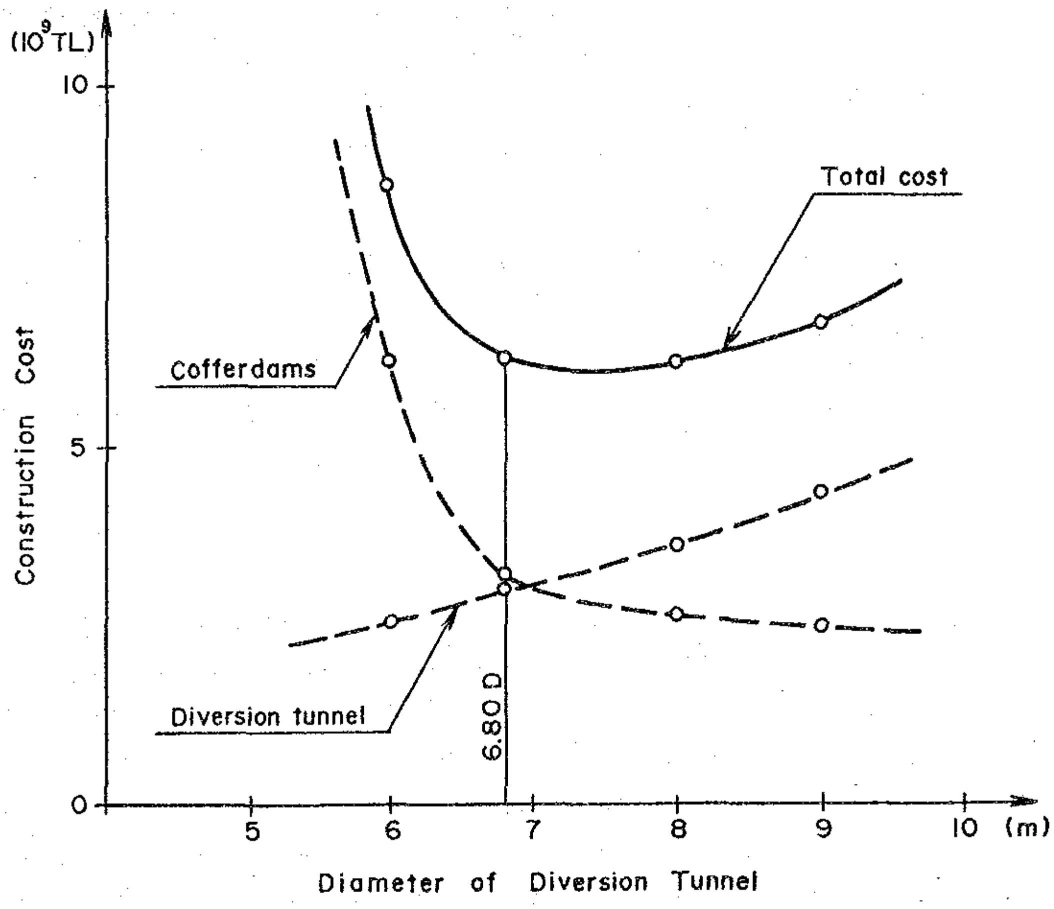
The locations of the secondary cofferdams were selected so that space for carrying out dam construction work could be secured, and moreover, where the width of the river would be narrow so that the lengths of the cofferdams could be made short. Fill and concrete types are conceivable for the secondary cofferdams, but concrete type was selected for the reasons given below.

- o Core material cannot be obtained in the neighborhood.
- o With a fill type the area occupied by the cofferdam would be large, and to secure the same work space it will be necessary for the diversion tunnel to be made that much longer.
- o In case of a concrete type it will be possible for the downstream cofferdam to serve as an auxiliary dam for the spillway.

Alluvial deposits are distributed thickly at the dam-site river bed so that the cofferdams would be floating types with the alluvial deposits grouted to reduce hydraulic gradients.

As mentioned in 11.2.1 (2), layout of the cofferdams was common to the alternative gravity dam, because that was not determined merely on account of construction space of the dam works but also topographical fitness of the cofferdams and enough function of the stilling basin taking advantage of the downstream cofferdam.

Fig. 11-2 Estimation of Optimum Diameter of Diversion Tunnel



(3) Diversion Tunnel

The alignment of the diversion tunnel is that of the section between the cofferdams selected according to the preceding clause connected by a single tunnel of the shortest distance while having a cover of 30 m or more. Fig. 11-2 shows a study of the optimum diameter of the diversion tunnel on comparisons of total construction costs of tunnels of various diameters. According to this, the optimum diameter from an economic standpoint is about 7.50 D. However, judging by the facts that it would be advantageous in execution of work to have the same section configuration as the headrace tunnel because the same forms can be utilized, while there would be not much difference in economic comparisons between D = 6.80 m and the optimum diameter according to Fig. 11-2, the inner configuration of tunnel is to be a circular cross section of 6.80 D, the same as the headrace tunnel.

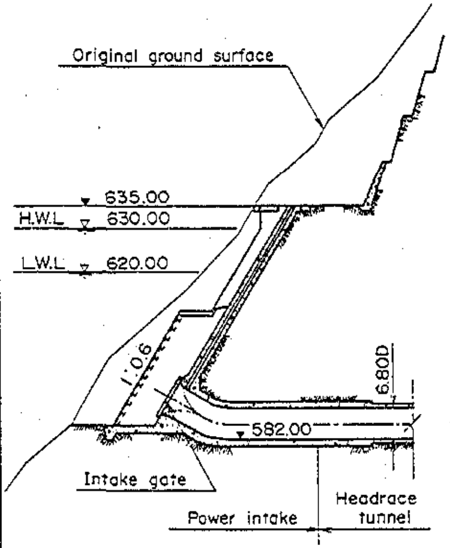
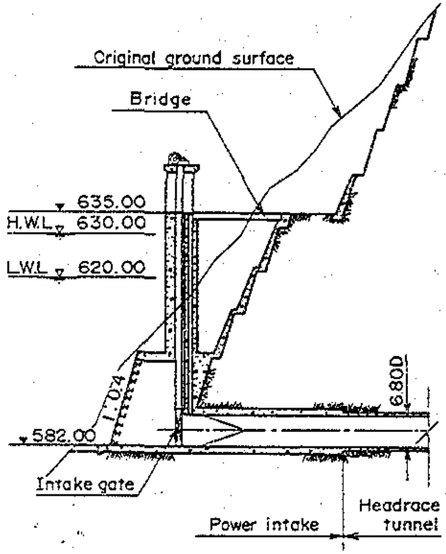
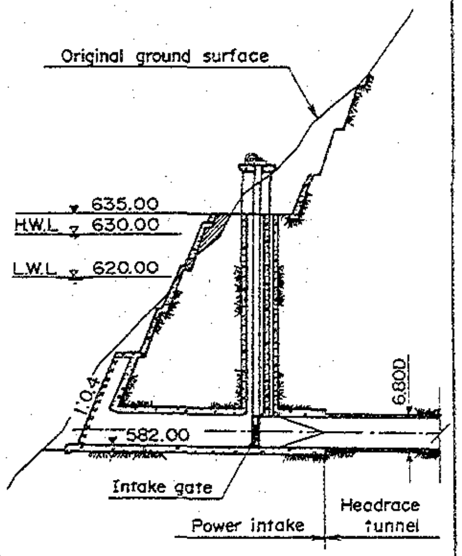
11.3 Waterway and Powerhouse

11.3.1 Power Intake

The power intake is to be provided at a right-bank gully approximately 100 m upstream from the dam.

The topography and geology of this site are as described in 7.6.1. There is no special problem geologically as the foundation for the power intake structure. However, since the topography in that of a steep slope of gradient approximately 65 deg, if surface excavation of the power intake structure were to be excessive, it is thought it would be disadvantageous from the aspects of the economics and slope stability during construction. Regarding the structural form of the power intake, as a result of the comparisons and studies of the three kinds shown in Table 11-2, it was judged that a gate shaft type would be the best from the aspects of the economics and construction execution.

Table 11-2 Comparison of Power Intake Type

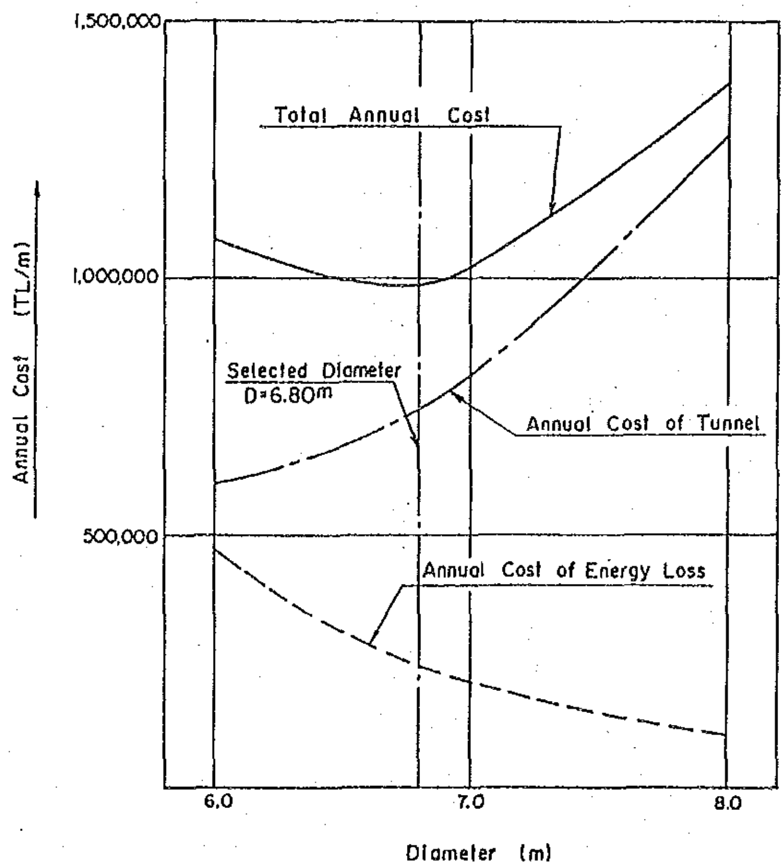
Item	Inclined Type	Intake Tower	Gate Shaft
Typical Section			
Excavation Volume	Open 9.2×10^4 m^3 Tunnel 0.4 Total 9.6×10^4 m^3	Open 6.3×10^4 m^3 Tunnel 0.4 Total 6.7×10^4 m^3	Open 3.2×10^4 m^3 Tunnel 0.6 Shaft 0.4 Total 4.2×10^4 m^3
Concrete Volume	1.1×10^4 m^3	1.3×10^4 m^3	0.9×10^4 m^3
Construction	Fair	Good	Good
Cost of Construction Cost	1.23	1.18	1.00

11.3.2 Headrace Tunnel

Regarding the topography and geology of the headrace tunnel route, as stated in 7.6.2, it is not expected that a serious problem will occur both during construction and after completion. The design maximum internal pressure of the tunnel is approximately 90 tf/m^2. The alignment of the tunnel was selected to connect the power intake site and the surge tank site by the shortest distance while giving consideration to a range of amply safe rock cover against this maximum internal pressure and to easy connection of construction adits.

Inner diameter of tunnel is determined 6.80 m because it gives economical optimization as shown in Fig. 11-3. When the fact that the geological condition of the tunnel route is generally favorable is considered, it should be amply safe against the anticipated external and internal pressures with lining thickness of 0.70 m.

Fig. 11-3 Estimation of Optimum Diameter of Headrace Tunnel



11.3.3 Surge Tank

(1) Topography and Geology

The surge tank is to be provided at the upper part of the right bank approximately 2 km upstream from the confluence of the Zamanti River and the Goksu River. As mentioned in 7.6.3, the topography is slightly scraggy-looking sandwiched by gullies on both upstream and downstream sides, but surface deposits is not very thick, and the slope is gentle. There are no special problems to be pointed out geologically, either. Consequently, the location of the surge tank was selected taking also the arrangement of penstocks and powerhouse into consideration.

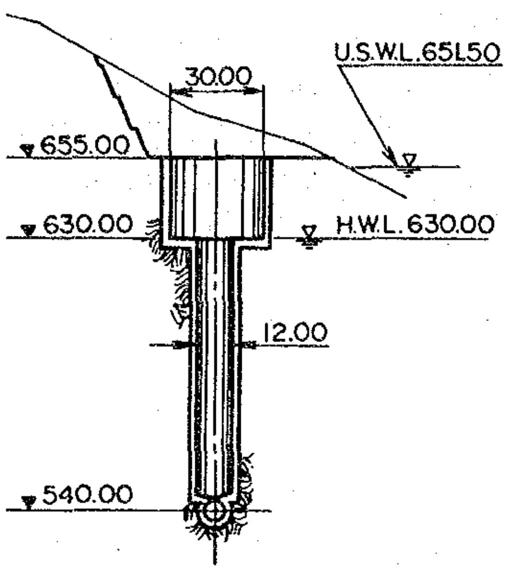
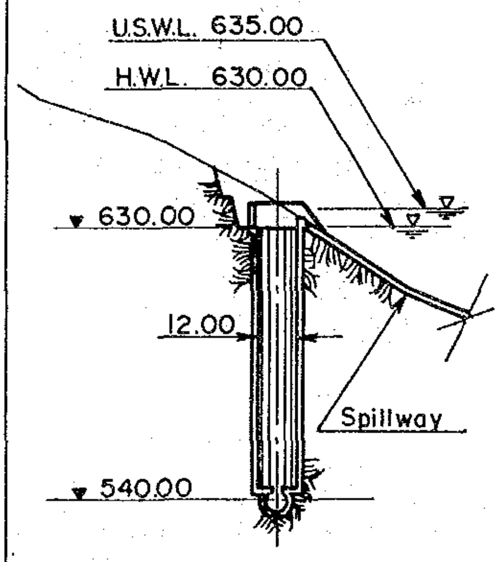
(2) Hydraulic Characteristics

With regard to the hydraulic characteristic of surging, because of the length of the headrace tunnel of as much as 15.7 km, both up-surging and down-surging with load variations of the turbines being extremely large, and surging being of long periods of more than 7 minutes, are the two features that can be pointed out. In order to reduce range of surging, and also to hasten attenuation of surging, it will be extremely effective to provide resistance with an orifice at the base of the surge tank.

(3) Selection of Type and Configuration

The two types shown in Table 11-3 were compared and studied for the surge tank. As a result, it was learned that an overflow type would be better economically than an upper chamber type. The overflow type is that in which the up-surging is not contained in an upper chamber, but is made to overflow to a gully immediately downstream taking advantage of the topography. With this type, there will be a sudden rise in the downstream water level of the Zamanti River from sudden occurrences of overflow, but considerating the fact that important structures do not exist immediately downstream, while it is planned for a downstream dam to be constructed in the future, it is thought that the effects on the downstream area will be minor. A surge tank of overflow type was selected based on overall consideration of the abovementioned conditions.

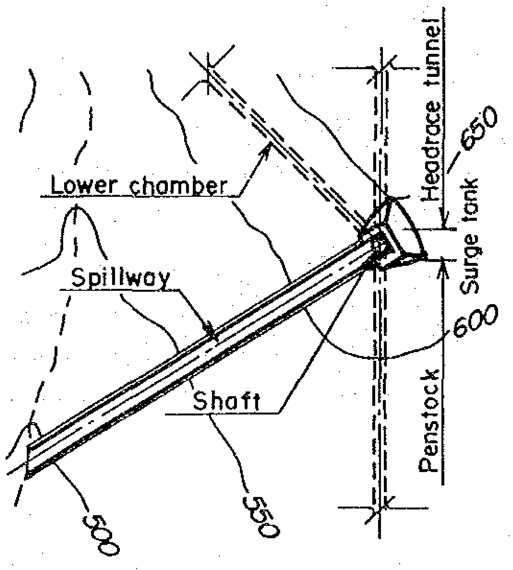
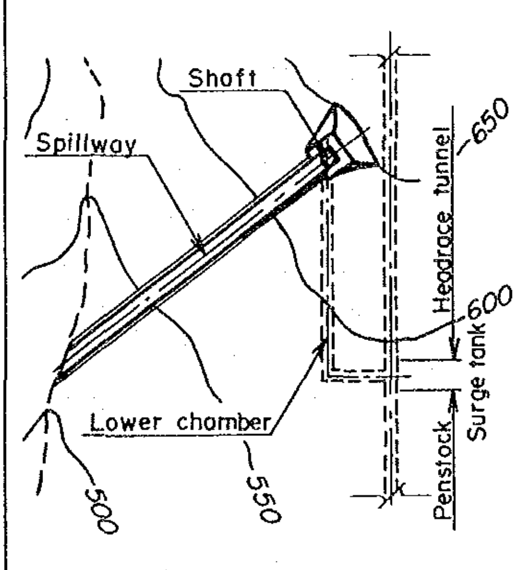
Table 11-3 Comparison of Up-Surging Handling

	Upper Chamber Type		Overflow Type	
Section				
Excavation Volume	Open	10.5 x 10^4 m^3	Open	1.9 x 10^4 m^3
	Shaft	4.4	Shaft	1.5
	Total	14.9 x 10^4 m^3	Total	3.4 x 10^4 m^3
Concrete Volume		1.3 x 10^4 m^3		0.6 x 10^4 m^3
Ratio of Construction Cost		2.74		1.00

The inner diameter of the lower chamber is to be the same 6.80 m as the headrace tunnel in consideration of convenience in construction. In order to absorb down-surging at time of sudden load increase of the turbines, the length required for a lower chamber with a cross section of this inner diameter will be 180 m.

The diameter of the vertical shaft was selected to be 12.00 m from the conditions for static and dynamic stability of the water surface. The vertical shaft will not be provided immediately above the headrace tunnel, but moved close to a gully on the upstream side taking advantage of the lower chamber of 180 m as shown in Table 11-4 for a layout making it easier for overflow to occur and at the same time reduce the length of the penstock.

Table 11-4 Comparison of Shaft Layout

	Immediately above Headrace Tunnel	Moved close to Gully
Plan		
Length of Spillway	300 m	250 m
Length of Penstock	700 m	600 m

11.3.4 Penstock

(1) Selection of Type

The penstock would be located at roughly the middle of the ridge and will have a plan alignment in a straight line from the surge tank to the powerhouse. The topography and geology at this site are favorable as described in 7.6.3, and there is no problematic point recognizable that would be a serious obstacle regardless of whether an exposed type or an embedded type is adopted.

Regarding the profile alignment of the penstock, the three forms given in Table 11-5 were compared and studied. As a result, the partially exposed type proposal which excelled in both the economics and hydraulic characteristics was selected.

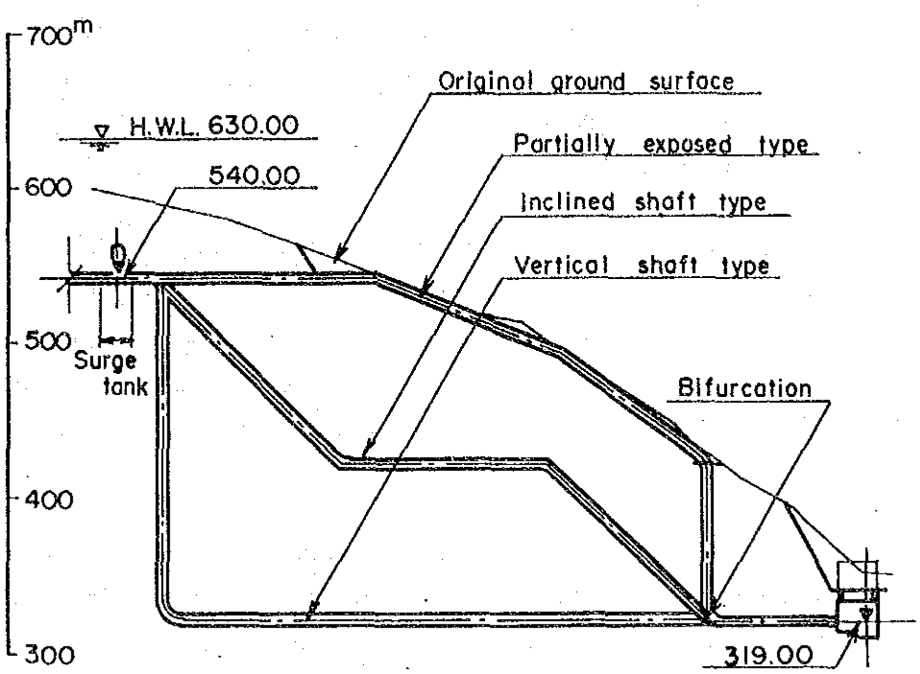
(2) Steel Penstock

The steel penstock would be a large-scale, high-pressure facility 600 m in length and having a maximum static head of 310 m. In addition, it is necessary for the design to be made thoroughly taking into consideration the present engineering level and performance record in Turkey so that all steel penstock including bifurcation can be procured domestically.

The diameter of the steel penstock at the upper bend would be 5.20 m, a fairly large size for an exposed penstock and there would be concern about buckling from external pressure. Therefore, the elevation of the center was studied and made 539 m so that negative pressure would not be produced at the upper bend even when there is variation of load on the turbine on lowering of the reservoir water level. Further, in making the detailed design, it would be recommended that the safety of the steel penstock be increased by providing stiffeners as necessary.

Because of topographical factors, it will be unavoidable to adopt an embedded type instead of exposed type below EL. 420 m, but this will be a great advantage from the standpoint of the penstock structure. In effect, the bedrock can be expected to share some of the load at the end portion of the penstock where design head will become large and at the bifurcation where loads will be complex.

Table 11-5 Comparison of Penstock Layout

	Vertical Shaft Type	Inclined Shaft Type	Partially Exposed Type
Profile			
Length of Penstock	Shaft 220 m Tunnel 460 Total 680 m	Shaft 240 m Tunnel 320 Total 560 m	Shaft 100 m Tunnel 210 Exposed 290 Total 600 m
Ratio of Construction Cost	1.32	1.09	1.00
Construction	Fair	Fair	Good

11.3.5 Powerhouse

(1) Natural Conditions

The powerhouse would be located at the right bank of the Zamanti River approximately 2 km upstream from its confluence with the Goksu River.

The topography and the geology at this site are as have been described in 7.6.3. Below EL. 520 m are steep slopes averaging 40 deg, and especially below around 340 m, there are rock masses of sandstone and shale in block form outcropped to comprise cliffs at the edges of the river. It is thought river deposits are fairly thick since the cross-sectional topography of the river is that of a V-shaped valley. With regard to geology, although the surface layer has development of cracks, and weathering and discoloration have occurred, deeper parts are sound and it is thought there will be no special problem as the foundation for the powerhouse.

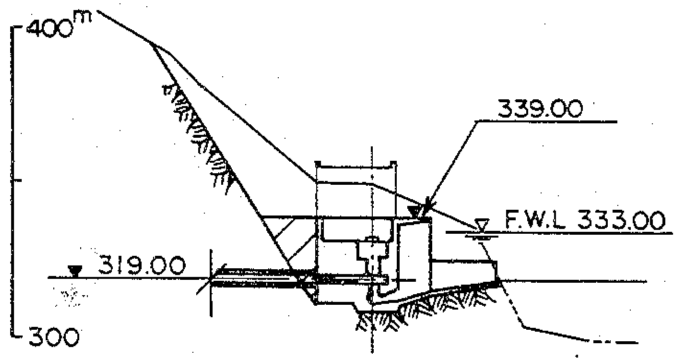
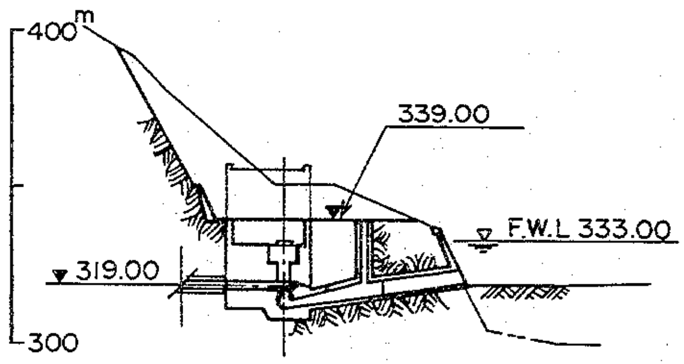
The Zamanti River in the vicinity of the powerhouse site meanders gently from south-southwest to south-southeast, but there are rapid flows upstream and downstream of the powerhouse site. That bank erosion and sand bars can be seen at both banks of the river speaks of the severity of erosion and transportation actions during flood condition.

The design of the Goktas powerhouse was made to be optimum from the standpoints of economy, constructability and maintainability giving thorough consideration to the natural conditions mentioned above.

(2) Selection of Powerhouse Type

The three types of exposed, semi-underground, and underground are conceivable for the powerhouse. In consideration of the fact that static draft head of this powerhouse will suffice to be small, and otherwise, in view of the natural conditions of the site, there is no reason discernible requiring an underground type which is inferior to the other two types in its economics to be selected. Consequently, as shown in Table 11-6, a comparison study was made of exposed and semi-underground types. As a result, it was found that rather than an exposed type, which would require an enormous amount of open excavation, a semi-underground type would be superior not only in the economics, but also in the aspects of care of river and safety during floods.

Table 11-6 Comparison of Powerhouse Type

	Exposed Type	Semi-underground Type
Section		
Excavation Volume	Open 468,000 m^3 Total 468,000 m^3	Open 176,000 m^3 Shaft 29,800 Tunnel 7,200 Total 213,000 m^3
Concrete Volume	33,900 m^3	30,700 m^3
Ratio of Construction Cost	1.12	1.00
Care of River	Fair	Good
Safety during Floods	Fair	Good

The powerhouse would be of a structure having two units consisting of a shaft of inside diameter 22 m and depth 31 m, and with tailrace tunnels and draft gate shafts. Although there will be congestion of tunnels and shafts in the vicinity, it is judged that construction would be amply feasible considering the geological conditions and construction technology available. The excavation height of the surface portion will be a maximum of 70 m, and it may be said there is no possibility that the landslide will occur considered from the geological conditions.

The elevation of the powerhouse at the ground level is required to be 339 m because of the layout of machinery. On the other hand, the PMF discharge at the powerhouse site is computed to be 4,400 m^3/s as indicated in 6.6, and the water level in this case would be EL. 333 m. Therefore, it may be said this powerhouse would have a reasonable freeboard even against PMF, and there would be no possibility of inundation.

(3) Tailrace

With the powerhouse a semi-underground type, the tailraces would be tunnels. The plan alignments of the tailraces were made to be diverted from the turbine centers towards the thalweg on the downstream side in a manner that the downstream river regime would not become adverse, or that the outputs of the two generators would not differ because of vortex.

The outlets would correspond to impinging points of flood flows. Accordingly, although a merit would be that there would be little possibility of sediment burying the tailraces, it will be necessary for revetment work to be provided at the outlets for protection against impact from flood flows.

Furthermore, submerged weirs would be constructed upstream of the powerhouse to restrict bed load sediment flowing into the outlets along with dissipating the energy of flood flow as a measure for utmost safety against actions of the river.

(4) Care of River

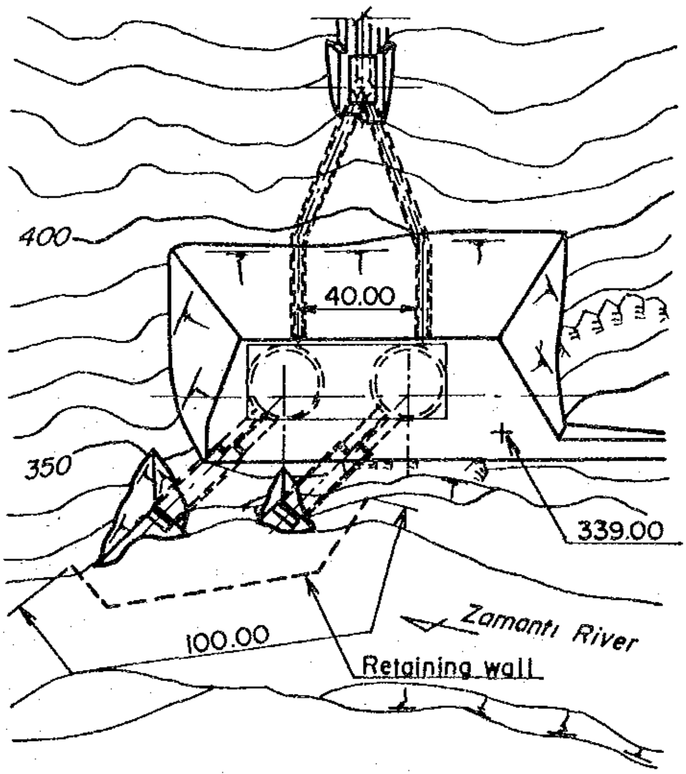
It would be necessary for cofferdamming of the river to be done while constructing the tailraces.

In determining design discharge of care of river, it will be necessary to consider the construction schedule and the degree of importance of the structure. In view of the importance of the structures in this case, a 10-year return period flood the same as for the dam is to be considered. According to 6.5, the flood discharge to be considered in care of river would be 590 m^3/s.

Furthermore, in order to prevent inundation if the powerhouse during construction due to an unexpected flood, draft gates for two units are to be installed.

As the type of cofferdam a concrete retaining wall of appropriate scale is to be constructed on river deposits in the same manner as that for the main dam, with grouting of the river deposits performed to reduce the hydraulic gradient.
The care of river scheme is shown in Fig. 11-4.

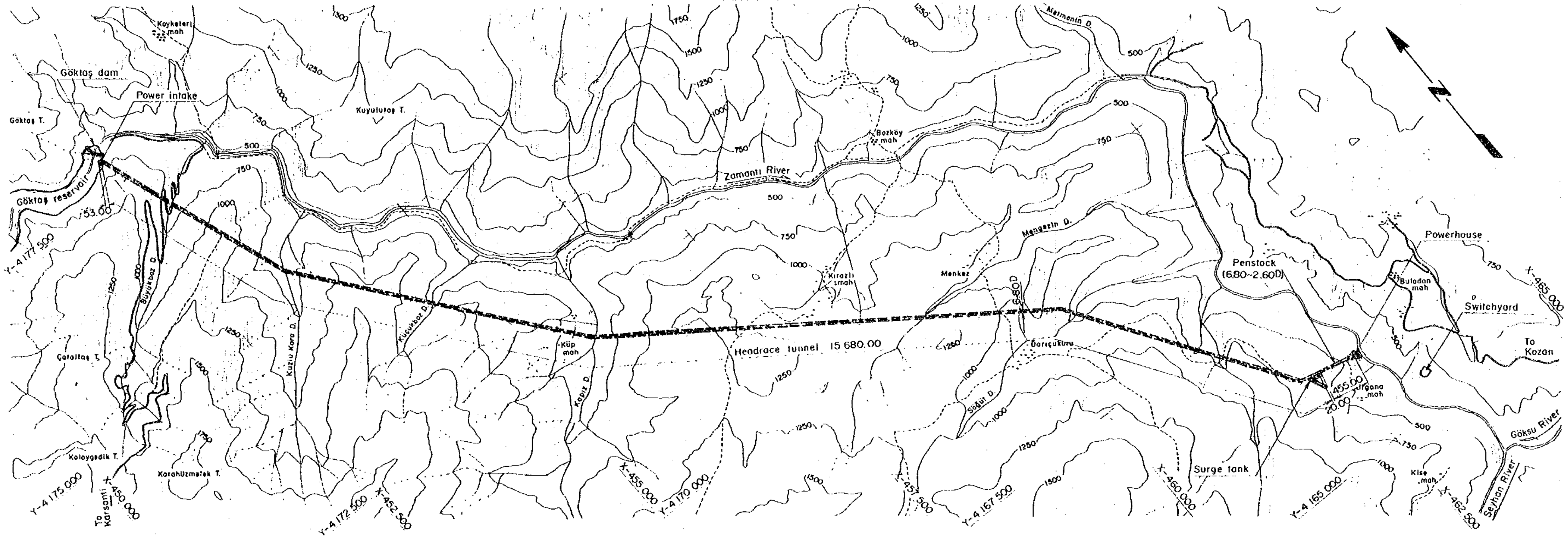
Fig. 11-4 Care of River Scheme



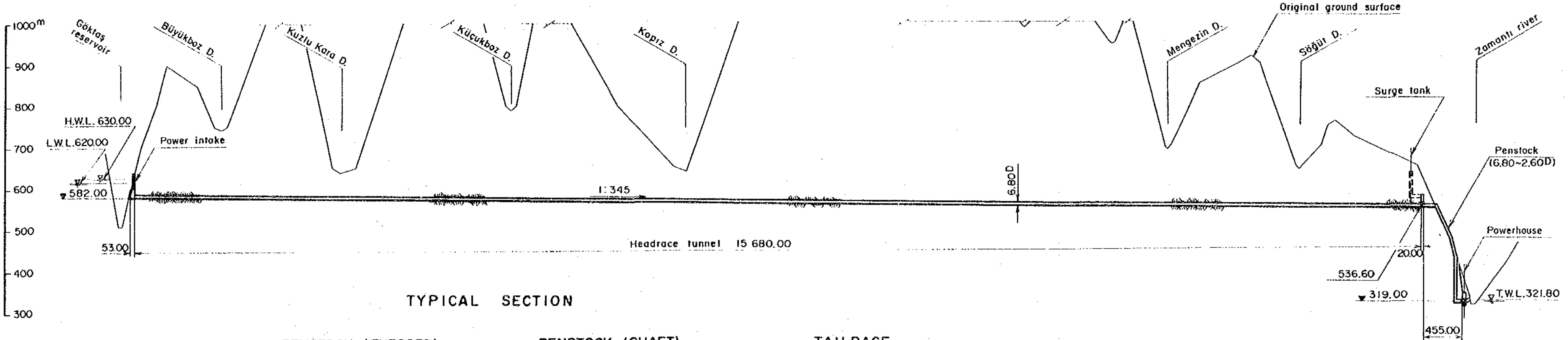
11.3.6 Switchyard

As stated in Chapter 10, the switchyard would be provided at a terrace on the opposite bank to the powerhouse. In order to secure the required space of 90 m x 120 m, excavation and banking would be performed, and since there are no signs that landsliding would occur at the site, no special problem is expected to be encountered in construction.

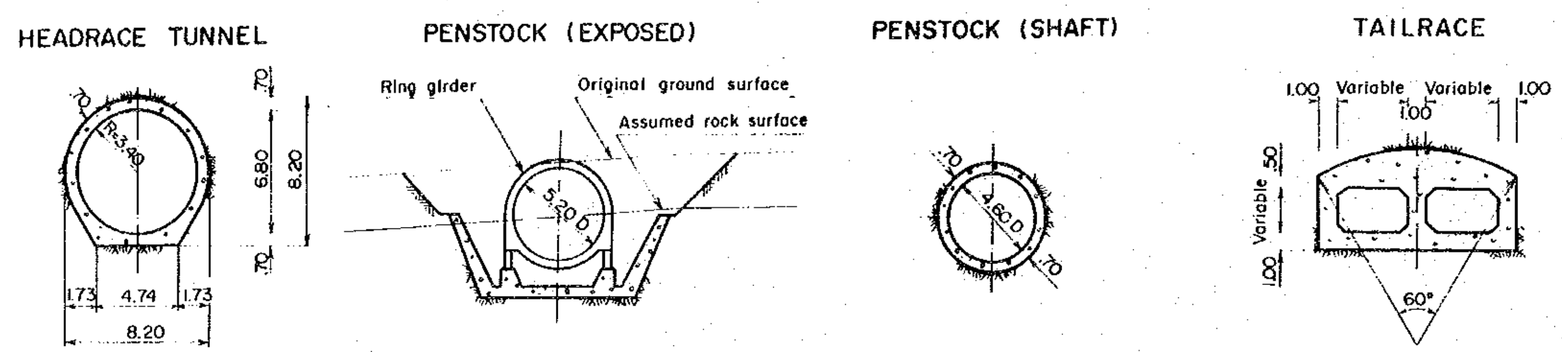
GENERAL PLAN

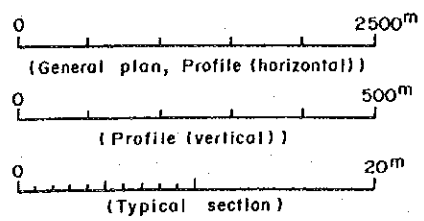


PROFILE



TYPICAL SECTION



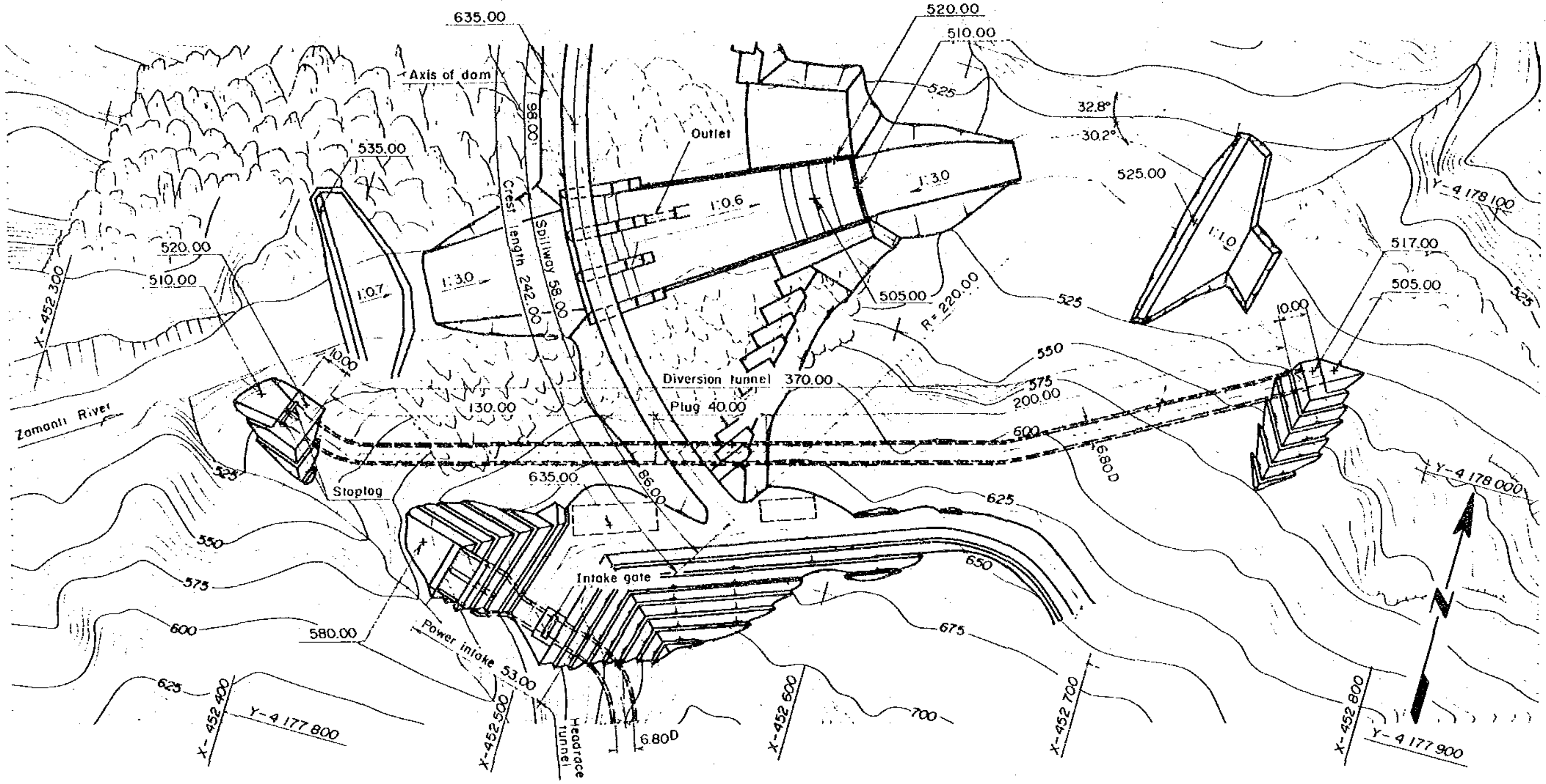


ZAMANTI GÖKTAŞ HYDROELECTRIC POWER DEVELOPMENT PROJECT

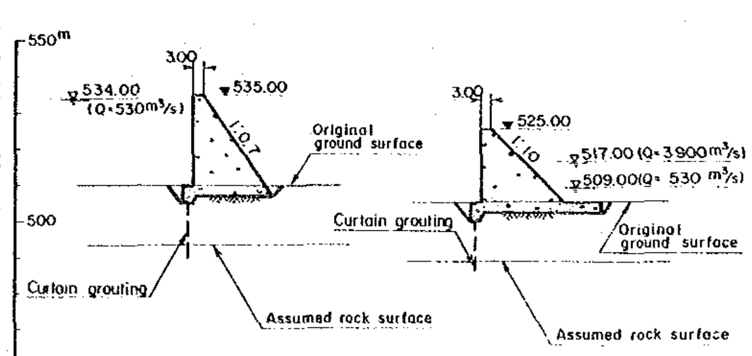
GENERAL PLAN, PROFILE AND TYPICAL SECTION

DWG. II-1

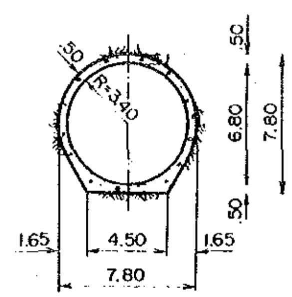
PLAN



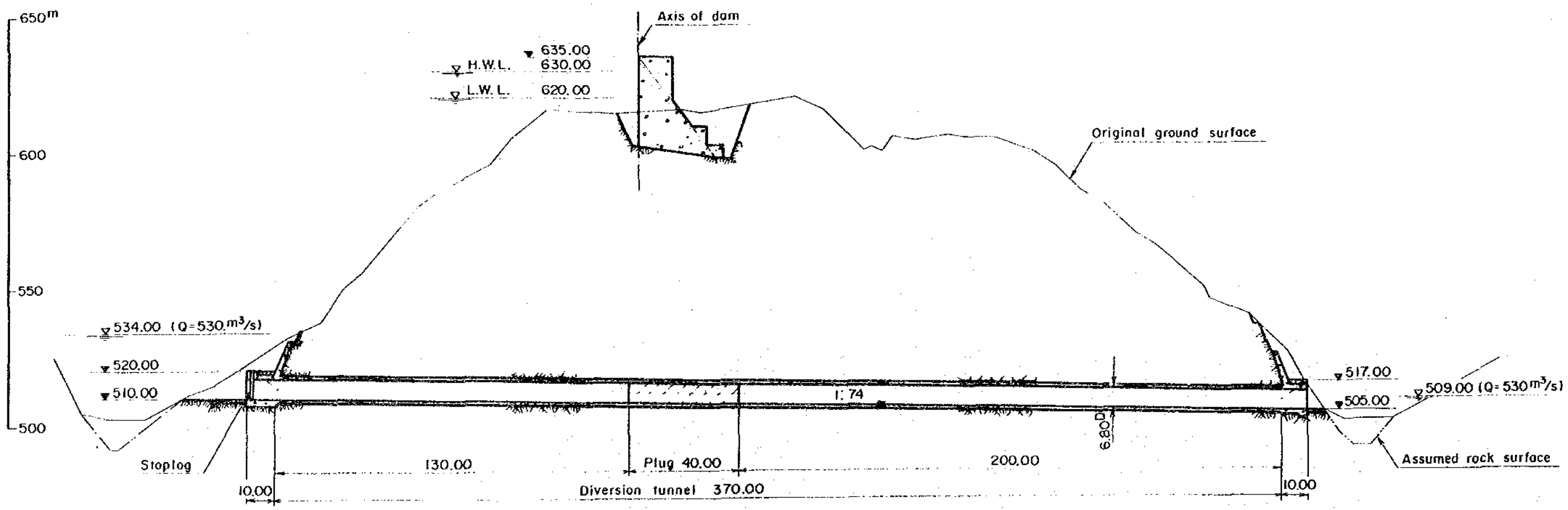
TYPICAL SECTION



DIVERSION TUNNEL



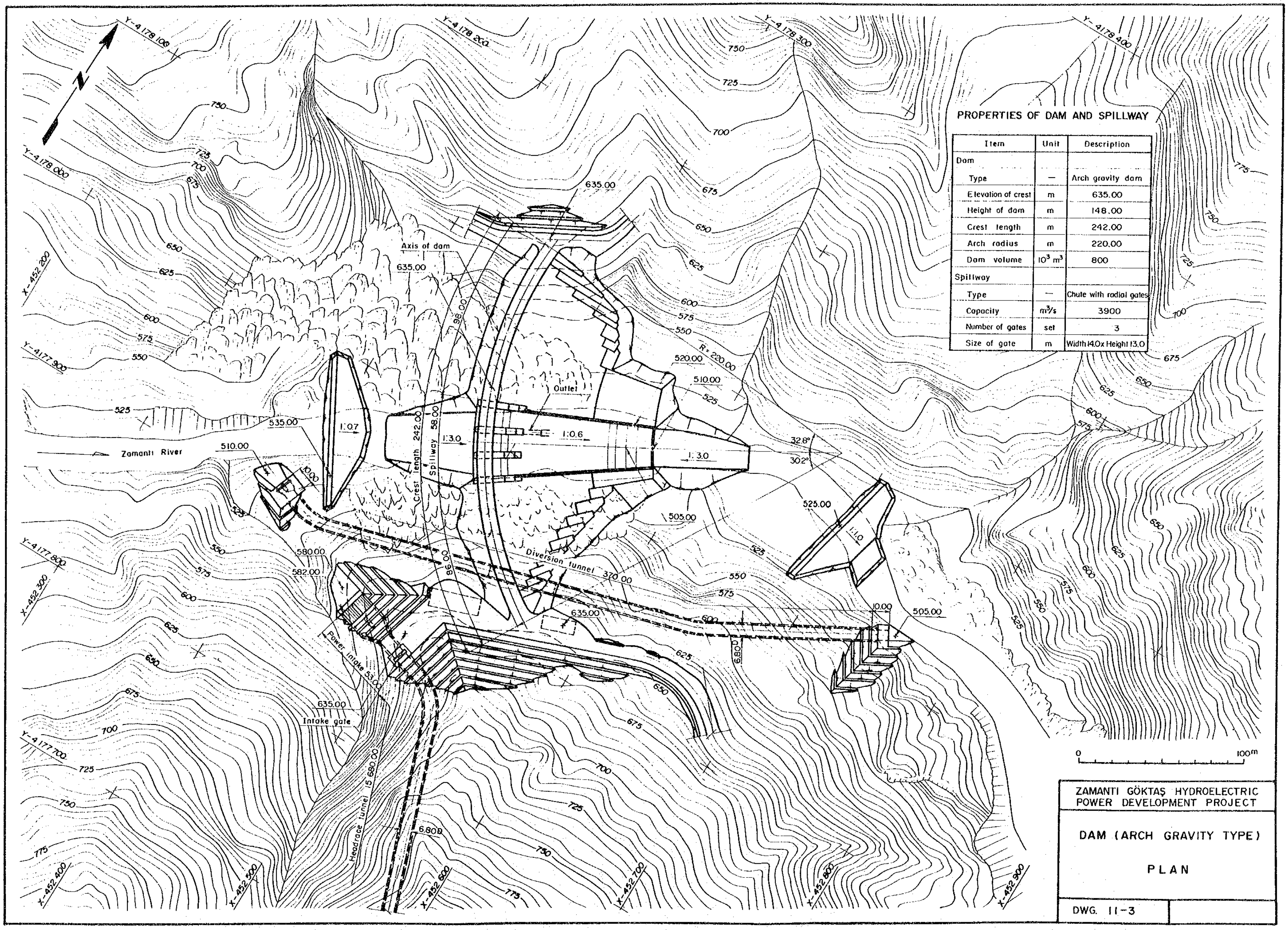
PROFILE OF DIVERSION TUNNEL



0 — 100m (Plan, Profile, Typical section (Cofferdam))

0 — 20m (Typical section (Diversion tunnel))

ZAMANTI GÖKTAŞ HYDROELECTRIC POWER DEVELOPMENT PROJECT
CARE OF RIVER
COFFERDAM AND DIVERSION TUNNEL
DWG. 11-2



PROPERTIES OF DAM AND SPILLWAY

Item	Unit	Description
Dam		
Type	—	Arch gravity dam
Elevation of crest	m	635.00
Height of dam	m	148.00
Crest length	m	242.00
Arch radius	m	220.00
Dam volume	10^3 m^3	800
Spillway		
Type	—	Chute with radial gates
Capacity	m^3/s	3900
Number of gates	set	3
Size of gate	m	Width 14.0 x Height 13.0

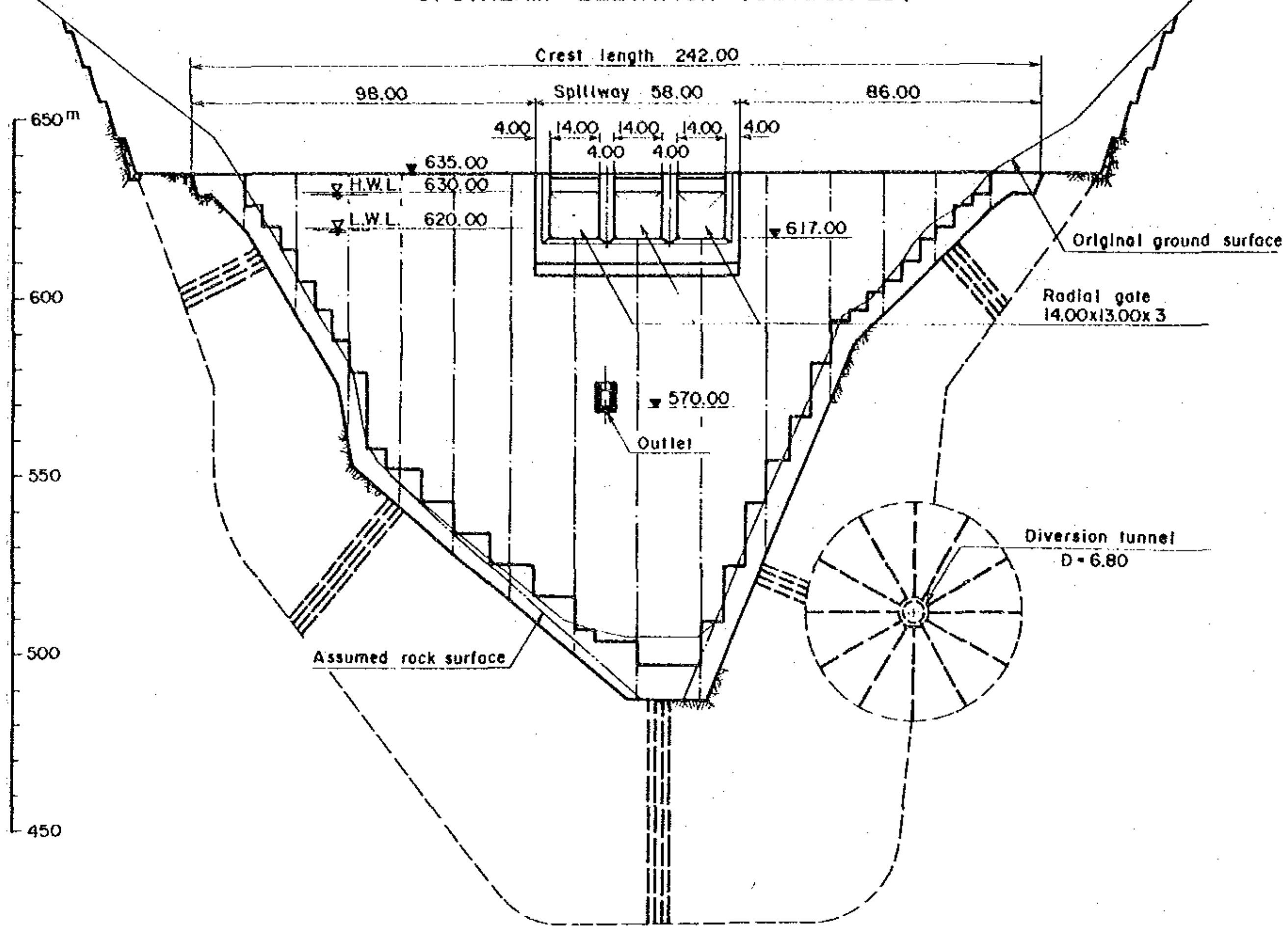
ZAMANTI GÖKTAŞ HYDROELECTRIC POWER DEVELOPMENT PROJECT

DAM (ARCH GRAVITY TYPE)

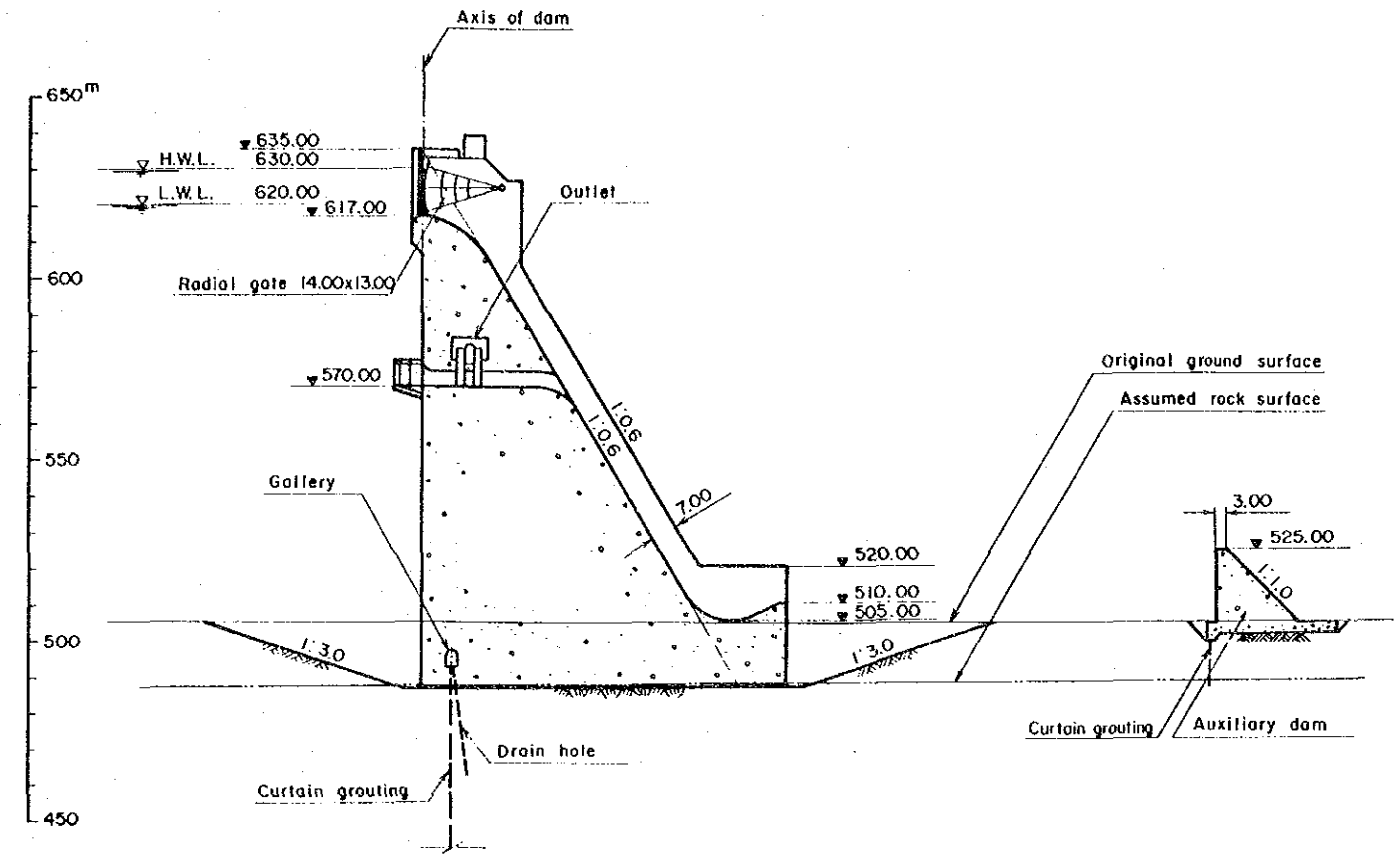
PLAN

DWG. 11-3

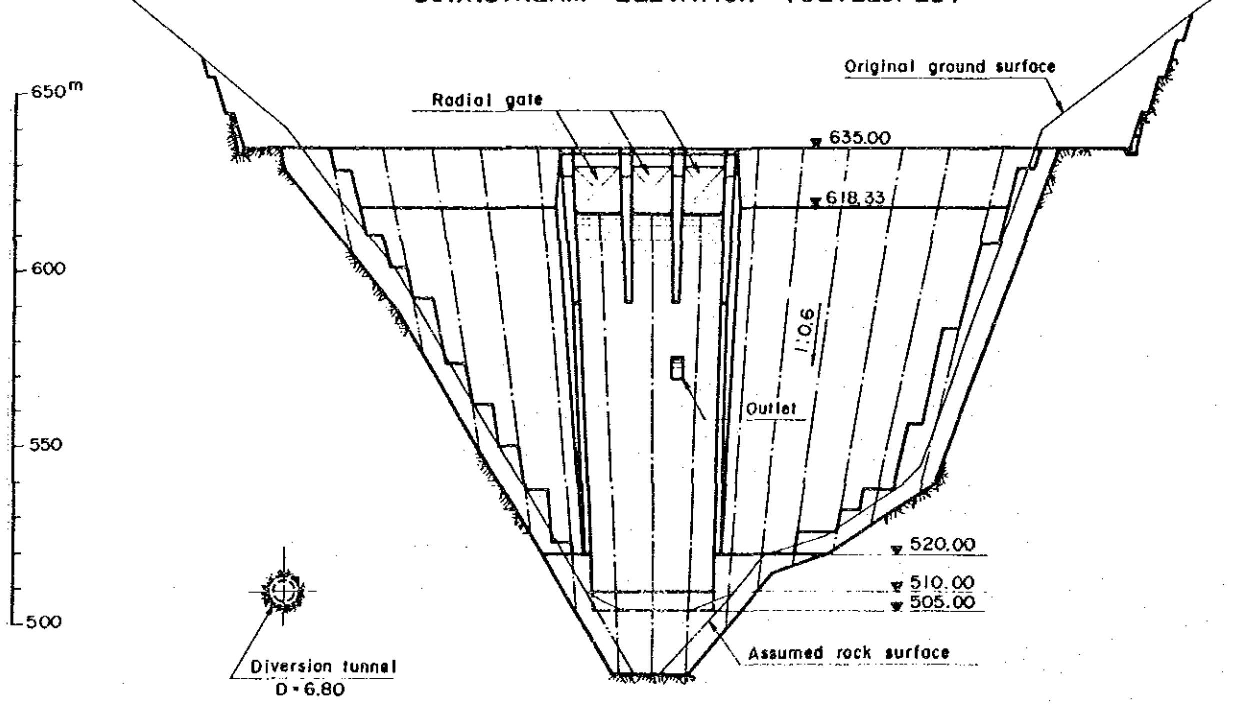
UPSTREAM ELEVATION (DEVELOPED)



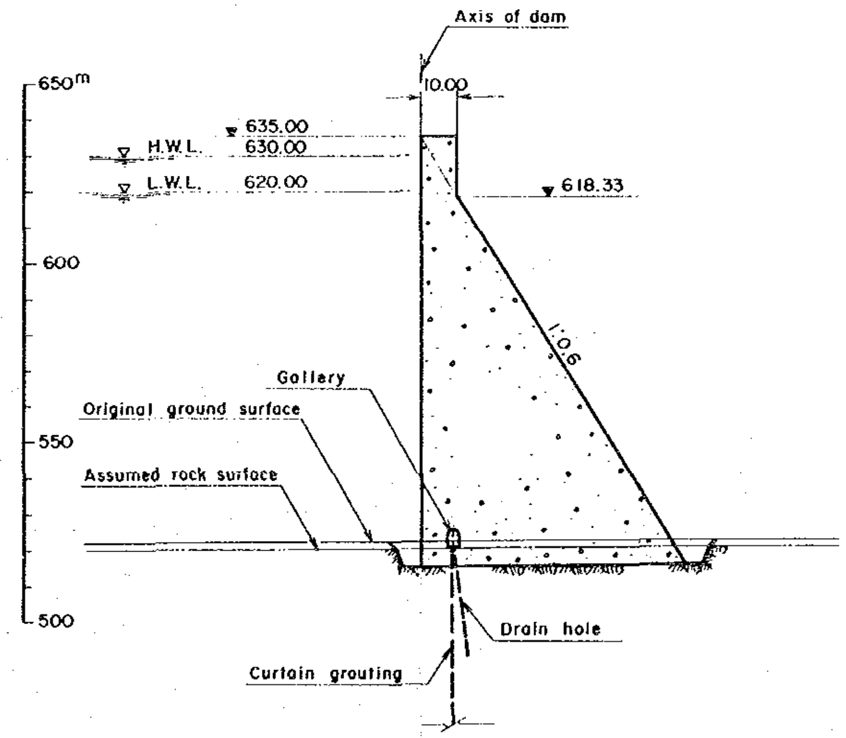
OVERFLOW SECTION



DOWNSTREAM ELEVATION (DEVELOPED)



NON-OVERFLOW SECTION



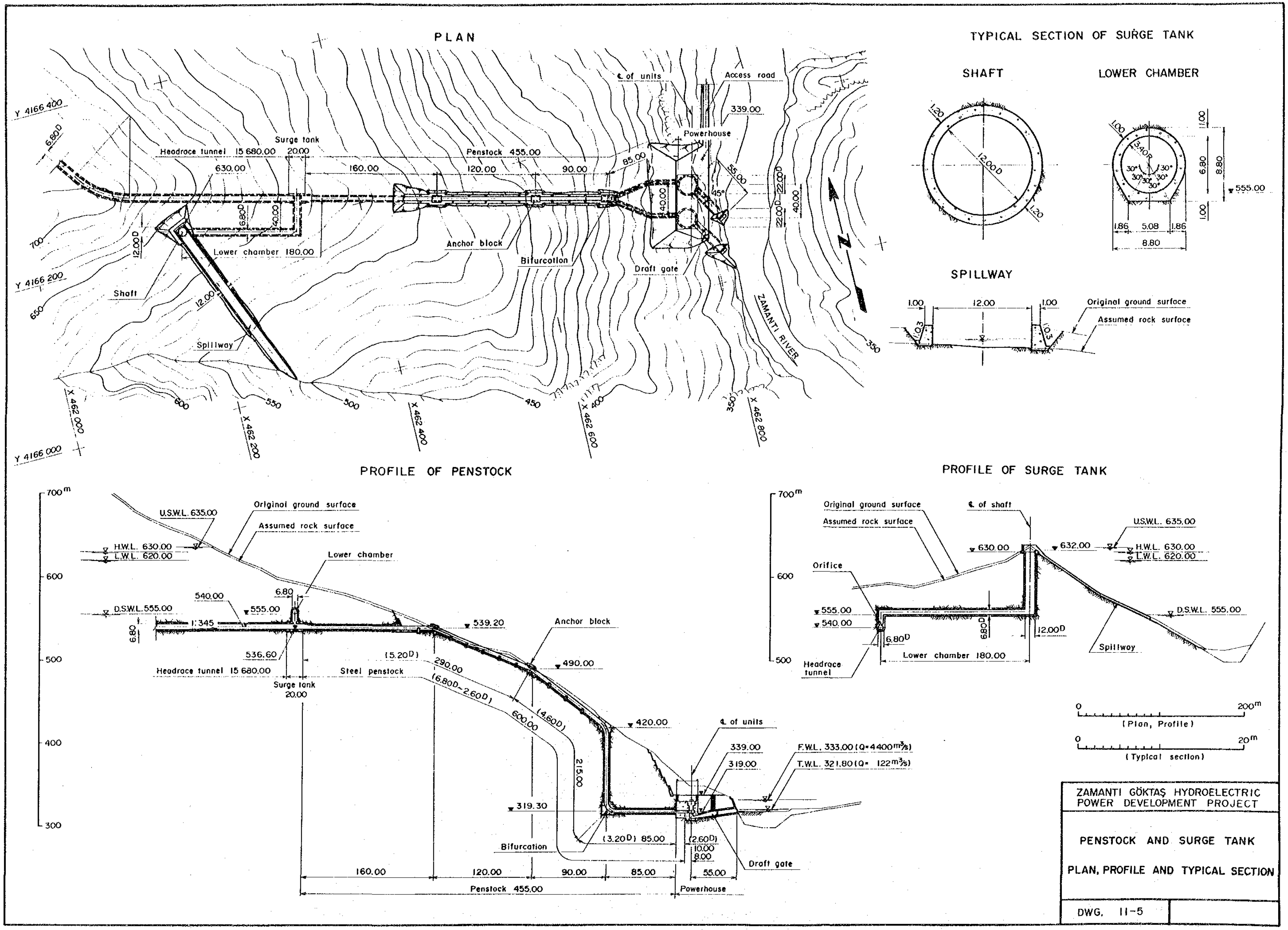
0 100m

ZAMANTI GÖKTAŞ HYDROELECTRIC POWER DEVELOPMENT PROJECT

DAM (ARCH GRAVITY TYPE)

ELEVATION AND SECTION

DWG. 11-4



PLAN
TYPICAL SECTION OF SURGE TANK
SHAFT
LOWER CHAMBER
SPILLWAY
PROFILE OF PENSTOCK
PROFILE OF SURGE TANK
Headrace tunnel 15 680.00
Surge tank 20.00
Penstock 455.00
160.00
120.00
90.00
85.00
630.00
Lower chamber 180.00
Shaft
Spillway
Anchor block
Bifurcation
Draft gate
Powerhouse
Access road
℄ of units
339.00
ZAMANTI RIVER
Y 4166 400
Y 4166 200
Y 4166 000
X 462 000
X 462 200
X 462 400
X 462 600
X 462 800
Original ground surface
Assumed rock surface
U.S.W.L. 635.00
H.W.L. 630.00
L.W.L. 620.00
D.S.W.L. 555.00
Steel penstock
(6.80D~2.60D)
Orifice
Headrace tunnel
℄ of shaft
F.W.L. 333.00 (Q=4400 m³/s)
T.W.L. 321.80 (Q= 122 m³/s)
(Plan, Profile)
(Typical section)
ZAMANTI GÖKTAŞ HYDROELECTRIC POWER DEVELOPMENT PROJECT
PENSTOCK AND SURGE TANK
PLAN, PROFILE AND TYPICAL SECTION
DWG. 11-5