5.3.2 Valuation of Forestry Losses

The valuation of expected forestry losses requires estimates of yearly net benefits accrual to logging activities in the storage area with and without the present Tekai dams. Since it was clarified at the discussion with Pahang State officials that there would be adequate time for forest harvesting before reservoir impoundment, the following two cases were assumed for the with condition.

Case 1 : 50 percent of forest resources in the storage area logged
Case 2 : 70 percent of forest resources in the storage area logged

For these two cases, it was further assumed that log harvesting would be carried out for four years - from 1986 to 1990. For the without condition, it was assumed that 50 percent of forest resources in the storage area would be logged within six years and relogged on a 45-year cycle.

The price of logs harvested in the area was estimated at M$144/$m^3$ by using the data obtained from the Forestry Department. Logging costs, including felling, skidding, yarding and hauling cost, were assumed to be M$106/$m^3$, based on the data supplied by Jengka Co. to NEB. Because hauling roads are necessary for both with and without conditions, road construction cost was ignored for the present purpose. These assumptions finally lead to a net benefit of M$38/$m^3$ for one unit of the logging product in the area.

Table 5.3 shows the yearly logging benefits for years up to 2111 for the without and the two with cases of the Project. Two alternative scenarios assuming 1.5 percent and 3 percent of relative escalation in log price per annum are also presented in the Table. Summarized in Table 5.4 are estimates of net present values of forestry losses for these cases and scenarios by applying a 10 percent discount rate.

Table 5.3 Projected Cash Flows for Forest Production (M$ x 10^6)

Year	Without Dams: Constant Log Price (A)	Without Dams: Price Escalation 1.5% (B)	Without Dams: Price Escalation 3.0% (C)	With Dams: Case 1: Constant Price (D)	Increment (D)-(A)	With Dams: Case 1: Escalation 1.5% (E)	Increment (E)-(B)	With Dams: Case 1: Escalation 3.0% (F)	Increment (F)-(C)	With Dams: Case 2: Constant Price (G)	Increment (G)-(A)	With Dams: Case 2: Escalation 1.5% (H)	Increment (H)-(B)	With Dams: Case 2: Escalation 3.0% (I)	Increment (I)-(C)
1986	3.71	3.87	4.05	3.09	-0.62	3.23	-0.64	3.37	-0.68	4.32	0.61	4.52	0.65	4.72	0.67
1987	3.71	3.93	4.17	3.09	-0.62	3.28	-0.65	3.48	-0.69	4.32	0.61	4.59	0.66	4.87	0.70
1988	3.71	3.99	4.30	3.09	-0.62	3.33	-0.66	3.58	-0.72	4.32	0.61	4.66	0.67	5.01	0.71
1989	3.71	4.05	4.42	3.09	-0.62	3.38	-0.67	3.69	-0.73	4.32	0.61	4.73	0.08	5.16	0.74
1990	3.71	4.11	4.56	-	-3.71	-	-4.11	-	-4.56	-	3.71	-	-4.11	-	-4.56
1991	3.71	4.17	4.69	-	-3.71	-	-4.17	-	-4.69	-	3.71	-	-4.17	-	-4.69
2016-21	22.23	37.72	63.56	-	-22.23	-	-37.72	-	-63.56	-	-22.23	-	-37.72	-	-63.56
2049-51	22.23	58.97	754.28	-	-22.23	-	-58.97	-	-154.28	-	-22.23	-	-58.97	-	-154.28
2076-81	22.23	92.17	374.47	-	-22.23	-	-92.17	-	-374.47	-	-22.23	-	-92.17		-374.47
2106-11	22.23	144.06	908.04	-	-22.23	-	-144.06	-	-908.04	-	-22.23	-	-144.06		-908.04

Notes: The figures shown in 'Increment' columns are forestry losses attributable to the Project.
Cash flow figures after 2112 are omitted.

Table 5.4 NPV of Forestry Losses (M$ x 10^6)

	Log Price		
	Constant Price	1.5% of Escalation per annum	3% of Escalation per annum
Case 1: 50% logged	8.06	9.59	11.83
Case 2: 70% logged	3.76	4.99 (most likely)	6.93

Note: A 10% discount rate is applied for 300 years of cash flow streams.

5.4 Flood Mitigation

5.4.1 Flood Damages in the Past

Major flood damages coincide with the north-east monsoon seasons. Judging from the isohyet pattern, high intensity rainfall occurs along the Tekai and the Tembeling. As a result, a such a rather narrow river as the Tekai rises very rapidly in the monsoon season. Although there is no substantial flood record on the Tekai, most of the tributaries of the Pahang are subject to the overflowing of their banks every wet season. The Pahang River system has an extremely high intensity of rainfall once or twice during the monsoon season inundating the area beyond its banks for a week or more.

Three serious floods in the past were recorded in 1926, 1971 and 1972. The 1926 flood was the biggest for the twentieth century in terms of rainfall intensity. Nevertheless, their flood damages were not very serious because the Basin was not adequately developed at that time. In contrast, many development schemes, both urban and rural, were carried out during the 1960s and 70s in the lower areas along the Pahang. As a result, the 1971 flood in January caused serious damages with 24 deaths and 153 thousand refugees. It was considered to be the biggest damage in this century despite the fact that the rainfall intensity was less than that of the 1926 flood. In the case of the 1972 flood, the rainfall was largely restricted to the eastern half of the Pahang.

5.4.2 Flood Mitigation Effects of Tekai Dams

Using the recorded hydrograph of December 1972, flood mitigation effects, in terms of flood water level, were calculated at Kg. Merting and Kg. Temerloh. The economic effects due to the cutting of water levels, however, will be too small to calculate at the moment due to the comparatively small size of the Project's catchment area. It must be mentioned, however, that when the storm rainfall is concentrated in the northern part of the Pahang Basin the flood mitigation effects of the Project on

water levels at the downstream of the Tekai will be much greater than the above mentioned. Also, it must be emphasized that the positively tangible effects of the present Project will become more prominent with the implementation of comprehensive flood control measures as recommended in the following.

5.4.3 Comprehensive Flood Control Measures for the Pahang Basin

In general, flood control measures include river channel improvements and construction of new flood-channels to increase flood discharge capacity; and the construction of retarding basins, regulating reservoirs and dams to regulate flood discharge itself. A decision as to which of these measures or which combination of these measures is to be chosen depends largely on characteristics of the pattern of floods and the present as well as future land uses of the river basin area concerned.

The flood patterns of the Pahang are characterized by a relatively flat hydrograph with long lasting rainfalls. Extensive swamps and barrens in the middle to lower reaches of the river suggest that land use constraints are few. In addition, power development potentials are found in the upper reaches. Considering these characteristics of the Pahang Basin area, the following flood control measures are recommended.

(1) From Temerloh to the River-Mouth

Little physical constraints suggest that channel improvements together with flood-channels and/or retarding basins may be advantageous.

(2) From Yap to Temerloh

As the wilds are found extensively in the left bank, flood-plains in that area may be used for retardings in order to reduce flood flows and to alleviate implementation costs in the lower reaches. Opportunities to plant floating rice varieties can be expected as a side benefit of these retarding basins.

(3) Upper Reaches eg. Sg. Tembeling, Sg. Jelai, etc.

Because of the high potential for power development in the area, multi-purpose dam constructions may be promoted with careful co-ordination with other water resources development. In the branches, however, channel improvements may also be required.

5.5 Agriculture and Irrigation

Careful investigations were carried out on the existing and potential agricultural activities in the State of Pahang, concentrating particularly on the possible impact of the Project on the rice culture in the region. The study included both the positive and negative effects foreseen by the operation of the Project on the production of rice and other major crops, as well as the water transportation activities in the State. However, in considering the relatively minor impact of the Project on the agricultural activities in the region, only a brief summary of the investigation results will be presented in this section of the report.

The State of Pahang is comprised mainly of seven districts: Jerantut, Temerloh, Pekan, Lipis, Raub, Bentong and Kuantan. The ratios of rice area to the total land area of all these districts have been low, ranging from 2 to 13 percent in 1974, and tended to decline.

The remaining land area consists mostly of forest and swamp, and to a certain extent by perenial crops. The two extensive areas of forest -- Teman Negara in the northern Pahang and the Klau Game Reserve in the southwest -- occupy a total land area of 3,130 square kilometers. Swamps are found extensively in the coastal plain and in the Tesek Bera region in the southwest. Along the coast are fishing

villages; single-cropping padi using a rainfed system is also found. The banks and levees of the Pahang River, and the interior valleys are dominated by a mixed-cropping system in which farmers cultivate at the same time coconuts, fruit trees, bananas, cassava, vegetables and a few rubber trees; padi-fields are found only in the inundated valley floors. The inland region of Pahang State, especially in its western and south-western parts, is planted mainly in rubber, and to a lesser extent in oil palm.

The rice production in Pahang State is presently carried out under the following three types of water supply: irrigation system, pump system, and rain-fed system. The average ratios of land area under these three systems in the region's total rice area are 25.5 percent, 36.9 percent, and 37.6 percent respectively. While the rice fields of those districts with small rice areas -- such as Lipis, Bentong and Raub -- are almost totally irrigated, the rice cultivation in the Temerloh District which occupies more than 60 percent of the total rice area of Pahang State is almost entirely under the rain-fed system. The results of a previous study "Pahang Tua Irrigation System" showed that the average yield of rice cultivated in irrigated land was about 80 percent larger compared to the yield of rice under the rain-fed system in the region. Thus, investments in irrigation proved to have more return than the rain-fed system and possible effects of the Project on the water availability for irrigation in the future must be the major factor for consideration.

The present Dam Project which is proposed to utilize the water flow in the Tekai River will principally affect the water flow of the lower stream of the Pahang River in the following manner: (1) The proposed Dam will store water in its reservoir and thus reduce the water flow in the lower stream of the Pahang River during rainy seasons; (2) the proposed Dam will release water and thus increase the water flow in the lower stream of the Pahang River during dry seasons. Therefore, the possible positive and/or negative impacts of the proposed projects can be identified by investigating possible effects of these changes in

water availability to agricultural production. Following are the major findings of the present study.

(a) The project has no negative effects on agricultural production, as the water flow of the Pahang River in rainy seasons is far more than enough to supply water for irrigation in the foreseeable future.

(b) Instead, the proposed project may contribute to increasing rice production, as the Project will increase the water availability in dry seasons. It is estimated that the proposed Dam will work in increasing about 30 percent of the minimum water flow at Temerloh, the district with the largest rice area and the lowest irrigation ratio.

(c) The project will, to some extent, reduce the maximum water flow in the lower stream of the Pahang River and, thus, will function in mitigating crop damages brought about by flood.

(d) As the Project will increase the water flow in the lower stream of the Pahang River in dry seasons, it will contribute to improving water transportation which is presently an important transportation network in the area.

5.6 Tourism

The number of foreign tourists visiting Peninsular Malaysia doubled in the last decade, from 869,599 in 1973 to 2,093,121 in 1982. Foreign exchange earnings by the tourist industry also increased rapidly from M$132 million in 1970 to M$545 million in 1980. The amount of the earnings was ranked seventh in 1979 after rubber, crude petroleum, tin, sawn logs, palm oil and sawn timber.

According to the Fourth Malaysia Plan (1981-1985), programmes to promote the development of the tourist industry will be further expanded. The Tourist Development Cooperation (TDC) will reinforce promotion activities through tourism sales missions to explore new tourist markets. Foreign exchange earnings from tourism are expected to amount to M$877 million at the end of 1985. Thus, tourism will remain one of the major foreign exchange earners which generate a considerable number of employment opportunities.

There are two possible routes for tourists to get to the site of Tekai Power Station, one waterway and one overland route from the town of Jerantut, which is connected with major big cities by road and railway networks. Taman Negara, adjacent to the Project area, however, is accessible only by boat from Kuala Tembeling near Jerantut.

For the future of the area, two proposals of transport facilities by the government must be mentioned. First, a new railway is envisaged to be constructed along the eastern coast of the Peninsula where the tourist industry will be developed. And second, a highway construction is proposed to the north of Taman Negara. Once these facilities are constructed, a circular transport network will be established around the Project area. Not only Tekai Dams but also Taman Negara will be enclosed within this circular network. Eventually, the access to both Tekai Dams and Taman Negara will become much more convenient compared with the present situation. Thus, Tekai Dams and Taman Negara can be considered as a set of the tropical tourist industry. These benefit accruing to the possible tourism development in the Project area, though possibly large, cannot be evaluated in terms of conventional cost-benefit analysis.

5.7 Other Aspects

5.7.1 Environmental Implications

The area surrounding the proposed site is, in general, endowed with a variety of natural resources rather than a base for economic and industrial activities. The environmental implications here focus on factors concerning the biota, and preservation of the natural environment.

The survey indicates that the biota around the proposed site is characterized by lowland dipterocarps forest in a primitive state and diversified fauna. Lowland dipterocarp is tropical rain forests characterized by high productivity and widely varying biota, which is relatively sensitive to development. The current trend is for this type of forest to decrease. Also notable is that, parallel with this trend, the population of several species of animals living in this kind of forest is decreasing.

Since a portion of this forest will be occupied by this project, the animals living there may lose a part of their natural environment. However, it is difficult to estimate the degree of effect on the biota solely from the result of the survey on this limited area. Positioning of the forest concerned and a survey on the ecology of those animals whose number is decreasing must be made on a wider scale.

5.7.2 Innundation of Settlement

Several households of a mountain minority race are living in the proposed flooding area and in the area surrounding the dam lake. Apart from this, there is no other long-established community on related facilities. This mountain minority race is engaged in the slash-and-burn method of agriculture. They also live by hunting, gathering of fruit, etc. The exact population, however, could not be ascertained.

The projected effect of dam construction on these inhabitants includes sumbersion of a part of their living place and fruit-gathering area beneath the dam lake. In addition to this direct effect, there is the indirect effect of the temporary influx of a large number of laborers at the construction stage. This will have a considerable influence on the living environment of the minority race living in the area.

The decision should be made to carry out a survey on the actual condition of these people before implementation of this project. In addition, an anthropological study should be made on how they will be able to adapt themselves to the new environment and to establish flexible and effective countermeasures to minimize the effect of the development project this community.

5.7.3 Mineral Resources

There is no previous record of any mineral findings or investigations within the Tekai area. Recently, however, the Malaysia Geological Survey Department has done research in this area.

The results of the research indicate that no apparent prospective mineral resources exist in the dam filling area. However, the potential of uranium and mineral phosphate reserves existing should not be completely ruled out for rocks in the Tembeling group. The dam filling area is principally made up of Tembeling group rocks, but the filling area occupies a very small percentage of the entire area including the Tembeling group. As a result, the probability of these mineral resources existing within the filling area is extremely small.

5.8 Economic Evaluation

The principal costs and benefits of the proposed Project are those associated with the electrical power supply. In the preceding sections, however, other associated aspects -- including forestry, flood mitigation, irrigation and agriculture, tourism and some others -- are also dealt with. Among these aspects, forestry losses, innundation of settlements and the environmental impact on flora and fauna can be considered as types of indirect costs of the Project to the region's economy and society. In economic analysis, however, only forestry losses in terms of opportunity cost of land were estimated (M$3.76 million to M$11.83 million depending on assumptions), since other indirect effects are not obvious and not measurable.

With regard to flood mitigation, agriculture and irrigation, and tourism, due to the limited effects of the Project at present and uncertainties involved in the future, only qualitative assessments were made. It must be emphasized, however, that the Project will positively function in the future development of the region and no adverse effects will be brought about in the downstream areas.

The power benefits, in the absence of an established and properly measured methodology, were conventionally evaluated by comparison with alternative gas turbine units, which have the load-follow operation for the peak demand to be met by the Project. Assumptions for the power benefits, or the costs attributable to the alternative gas turbines, are presented in Section 5.2. The economic analysis for power benefits was carried out based on these assumptions. With regard to the fuel cost, however, the analysis included <u>with</u> and <u>without</u> cases of relative fuel price escalation together with cases using natural gas with 70 percent of the fuel oil price or the oil equivalent price. Thus, the analysis was extended to cover the following six cases of different fuel cost streams.

Case 1 : Fuel oil at constant price

Case 2 : Fuel oil with relative price escalation of 1.5 percent per annum

Case 3 : Fuel oil with relative price escalation of 3 percent per annum

Case 4 : Natural gas at constant OEP

Case 5 : Natural gas with relative price escalation of 1.5 percent per annum

Case 6 : Natural gas with relative price escalation of 3 percent per annum

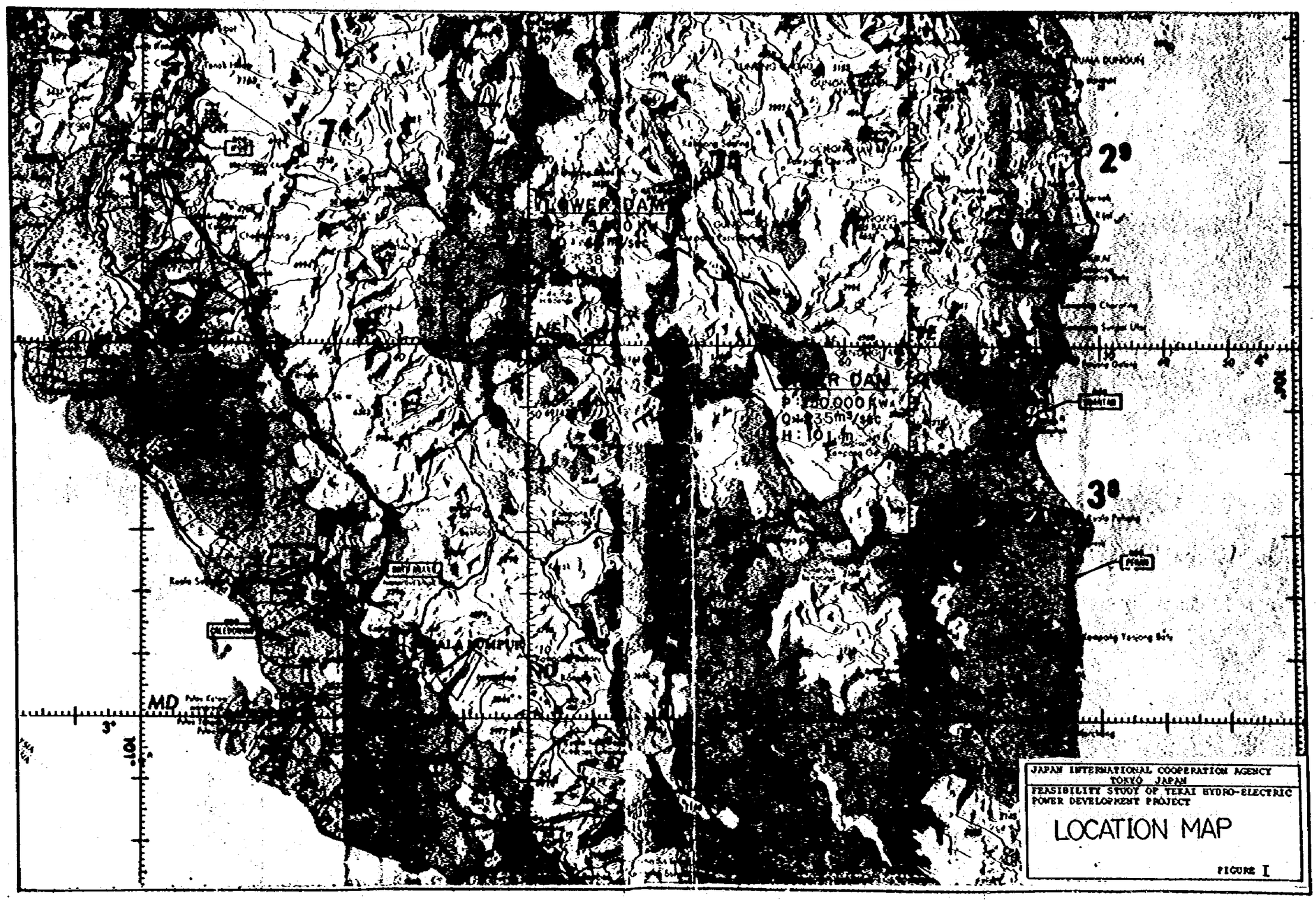
The calculated net present values and IRRs of the Project for the above assumed six cases are summarized in Table 5.5 . 1983 was taken as the base year for the calculation of fuel costs and 1984 for the present values. It must be mentioned, however, that these estimates do not include the cost of land loss or the forestry losses incurred by the Project. If this cost, say M$5 million, is included, the estimated IRRs will decrease by about 0.4 percent.

Table 5.5 Series Development for Upper and Lower Tekai (NPVs and IRRs)

	IRR	NPV ($M\$ \times 10^6$) for Discount Rate			
	%	10%	12%	14%	16%
Case 1	14.78	104.8	46.8	10.2	-13.3
Case 2	17.13	181.8	98.7	46.8	13.4
Case 3	19.60	292.0	170.2	95.7	48.3
Case 4	11.62	33.2	6.6	-30.6	-45.3
Case 5	13.67	87.1	29.8	-5.0	-26.6
Case 6	15.86	164.2	79.8	29.2	-2.2

Figures I to XVI

LOCATION MAP OF PROJECT SITE (S. 1/1,000,000)



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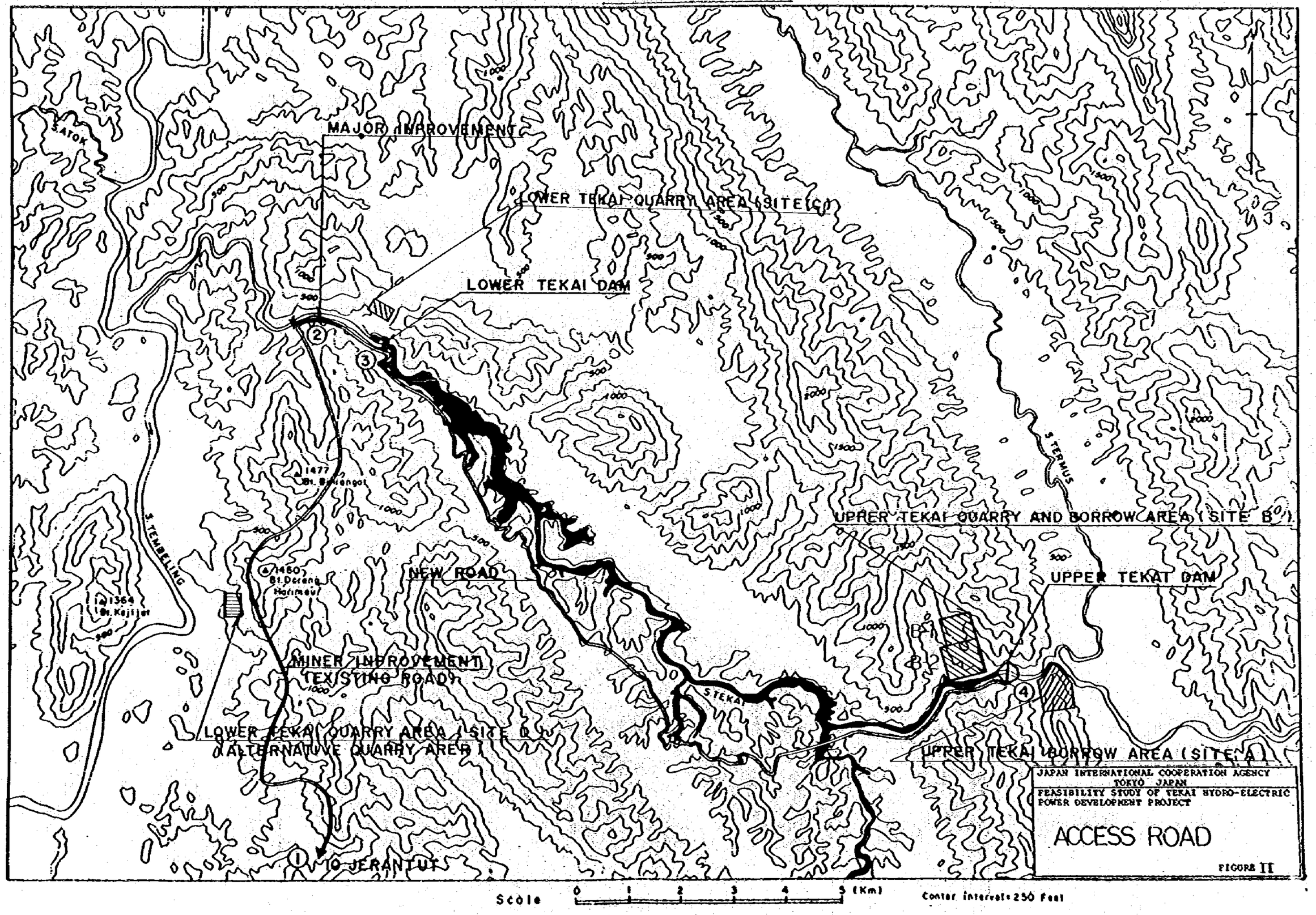
TOKYO JAPAN

FEASIBILITY STUDY OF TERAI HYDRO-ELECTRIC POWER DEVELOPMENT PROJECT

LOCATION MAP

FIGURE I

ACCESS ROAD



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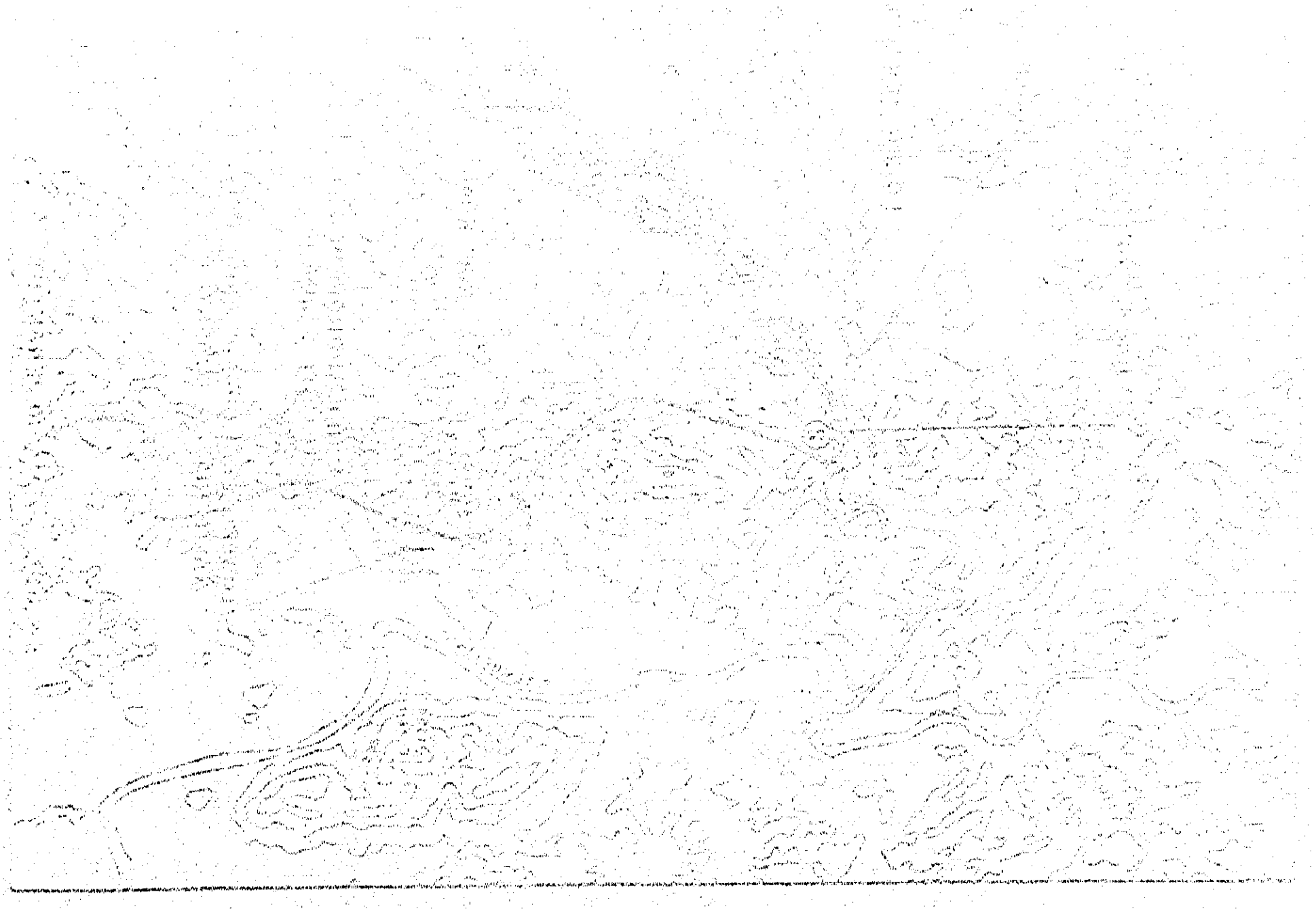
FEASIBILITY STUDY OF TEKAI HYDRO-ELECTRIC POWER DEVELOPMENT PROJECT

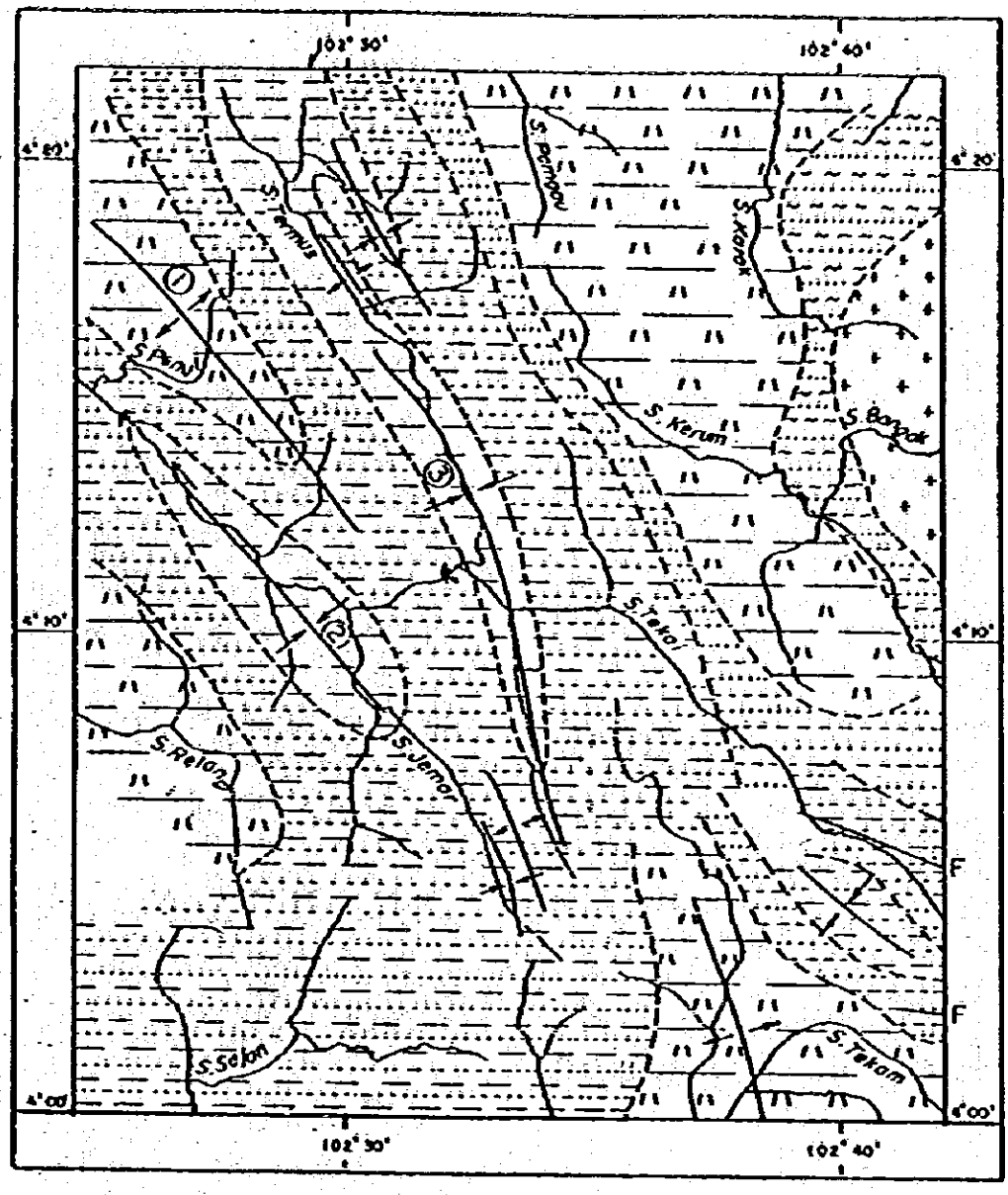
ACCESS ROAD

FIGURE II



OUTLINE OF GEOLOGY IN THE SUNGAI TEKAI AREA

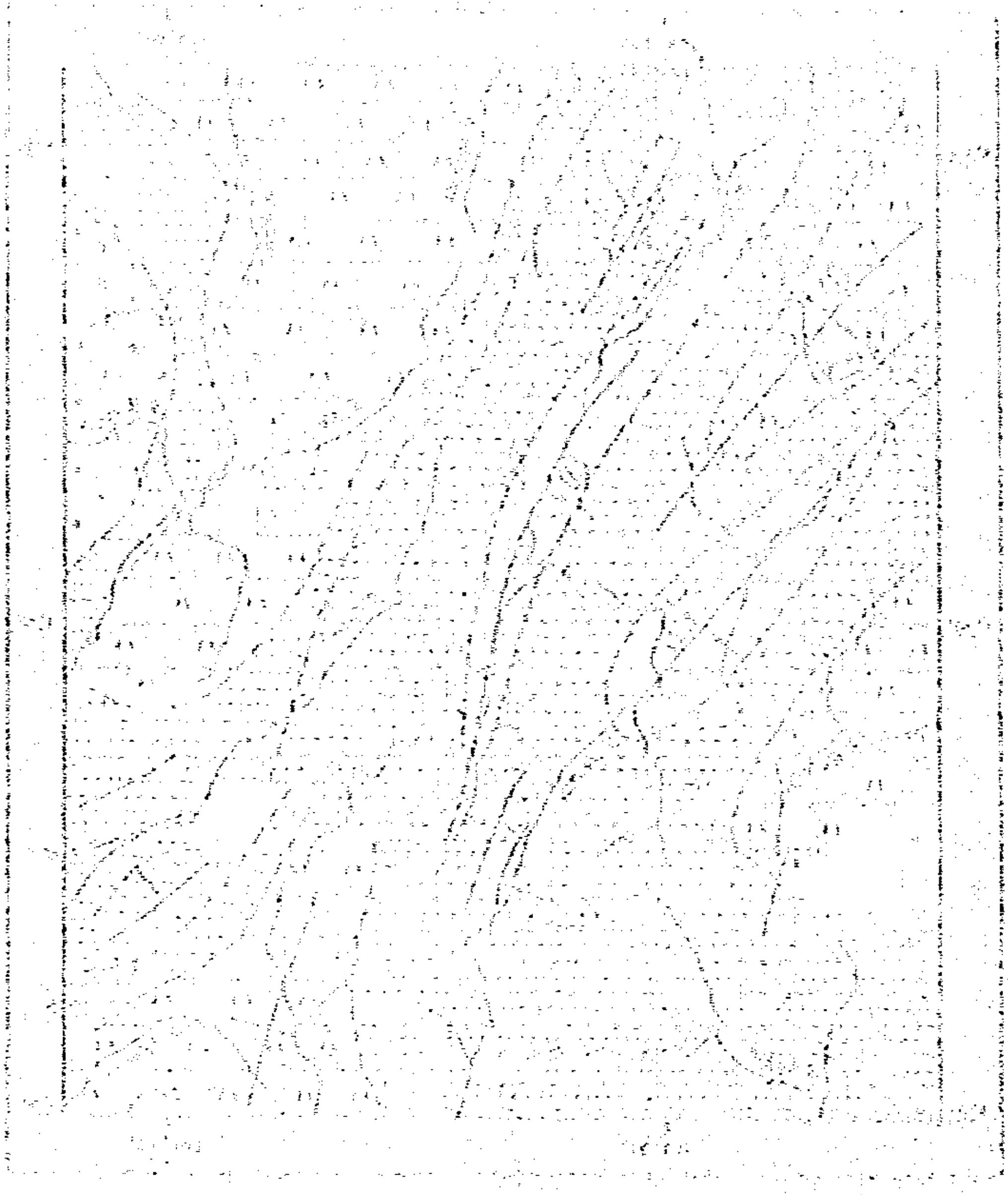
(after KHOO HAN PENG, 1977, page 93, Annual report of the geological surveyof Malaysia)

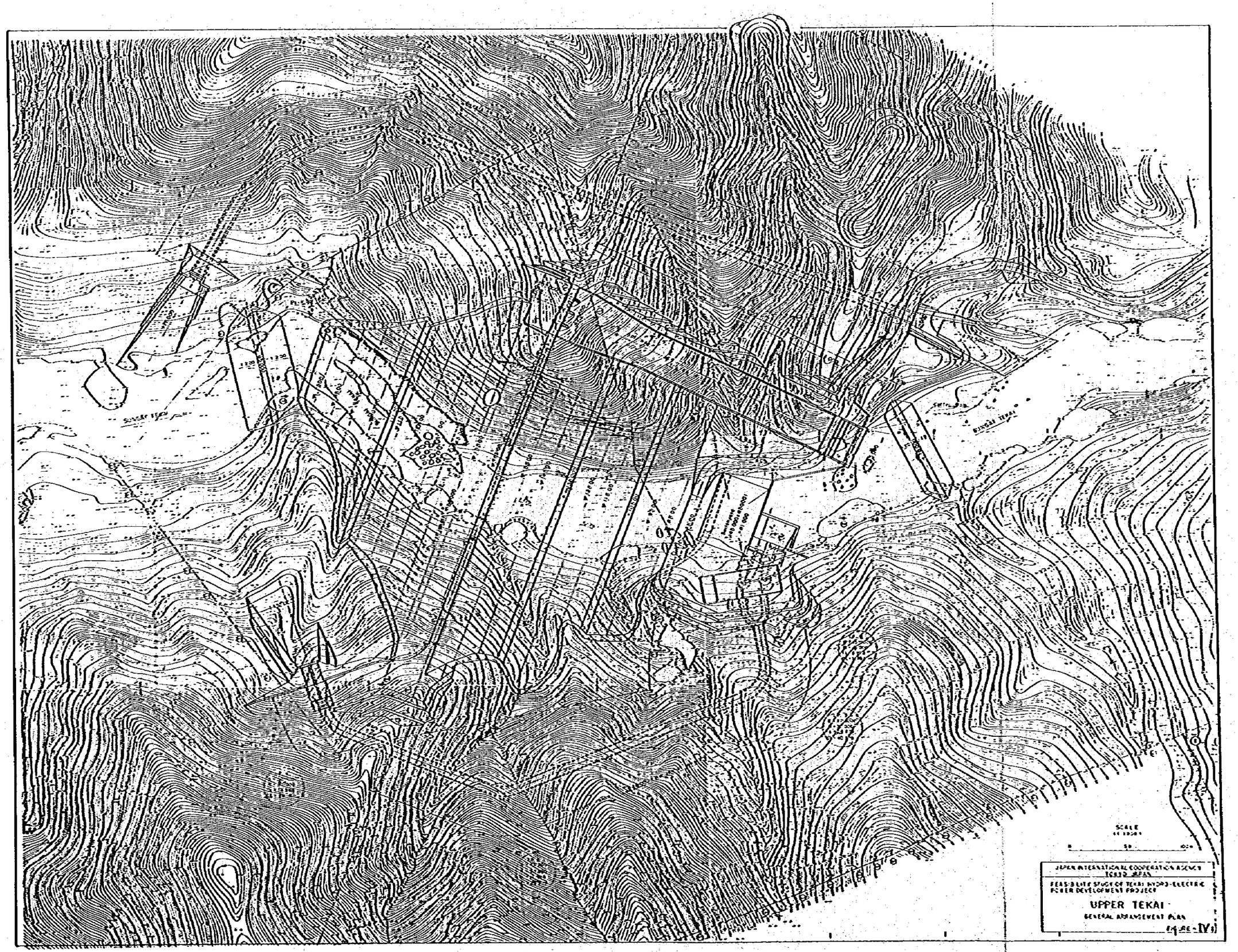


0 5 10 20km

Scale

Termus Redbeds	Mangking Sandstone	Lanis Conglomerate
Kerum Formation	Adamellite (Granitic rocks)	Bongak Metasediments
Anticline	Syncline	F Fault
① Penut anticline	② Tekal syncline	③ Termus syncline
Upper dam. site and lower dam site		




SCALE
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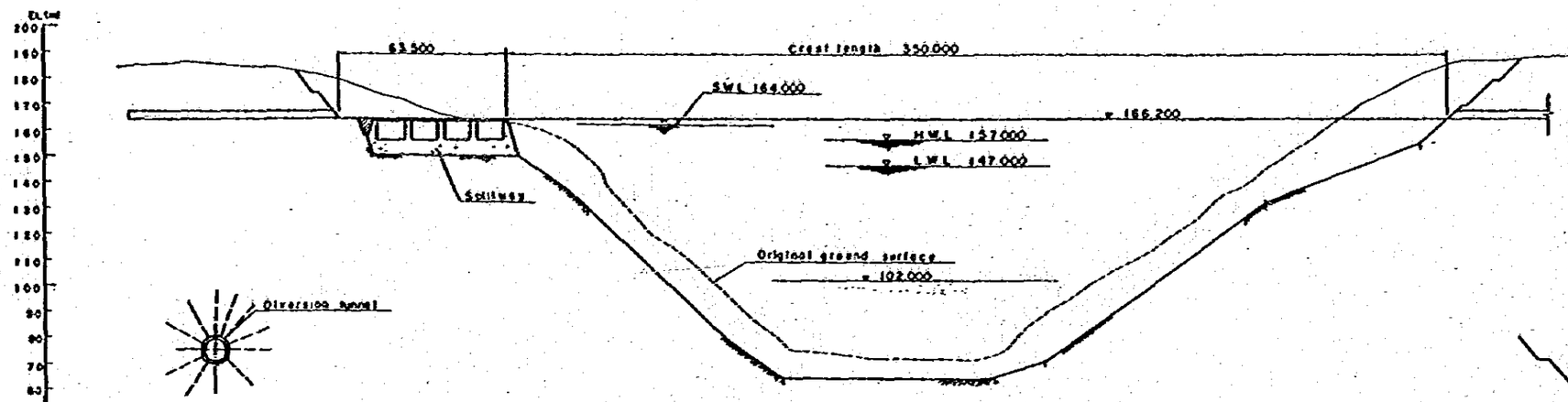
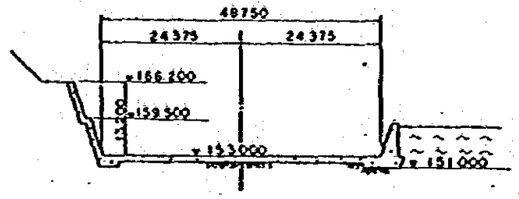
FEASIBILITY STUDY OF TEKAI HYDRO-ELECTRIC POWER DEVELOPMENT PROJECT
UPPER TEKAI
GENERAL ARRANGEMENT PLAN
FIG. E-IV

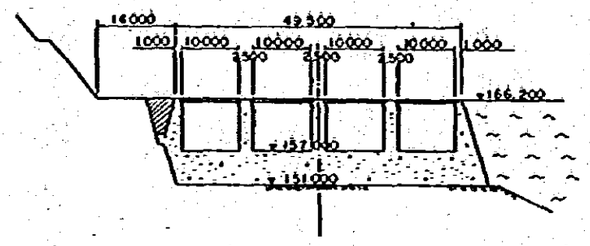
PROFILE OF DAM



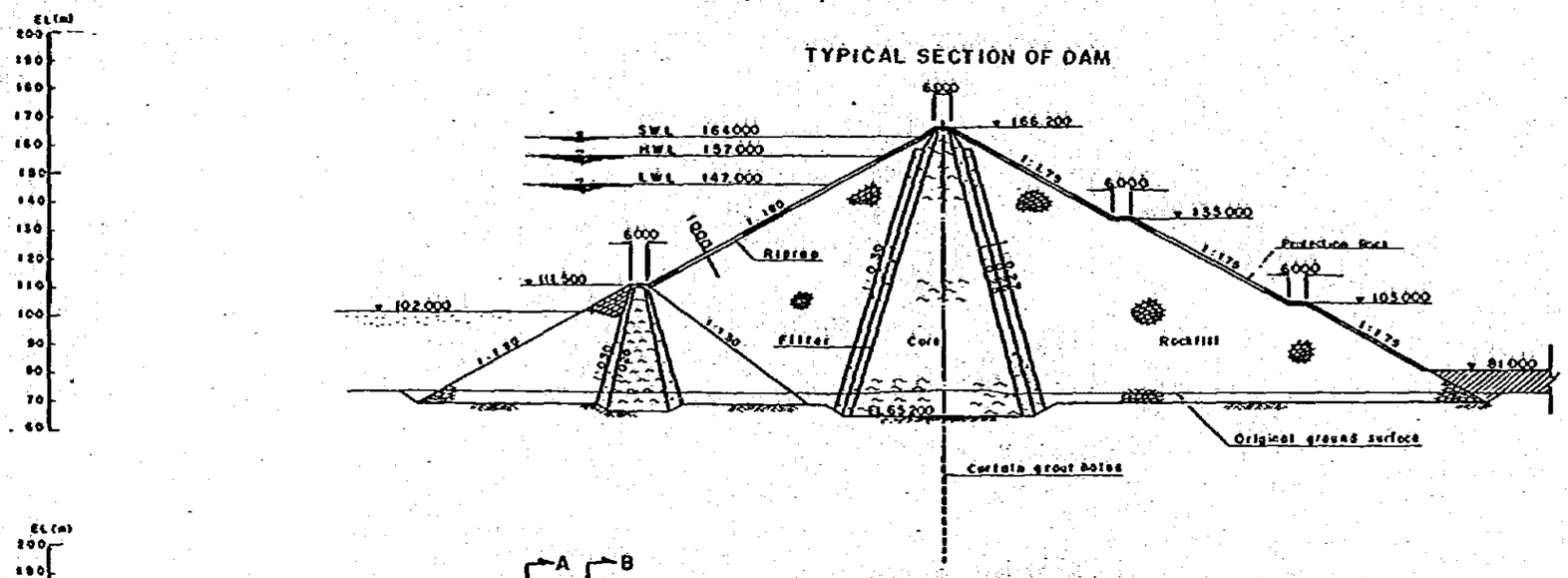
SECTION A-A



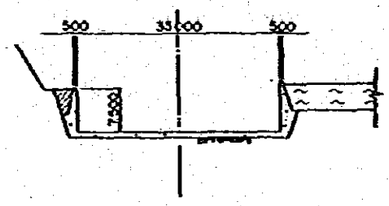
SECTION B-B



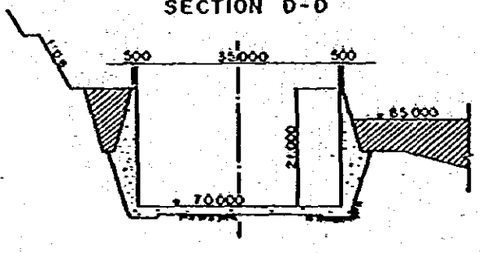
TYPICAL SECTION OF DAM



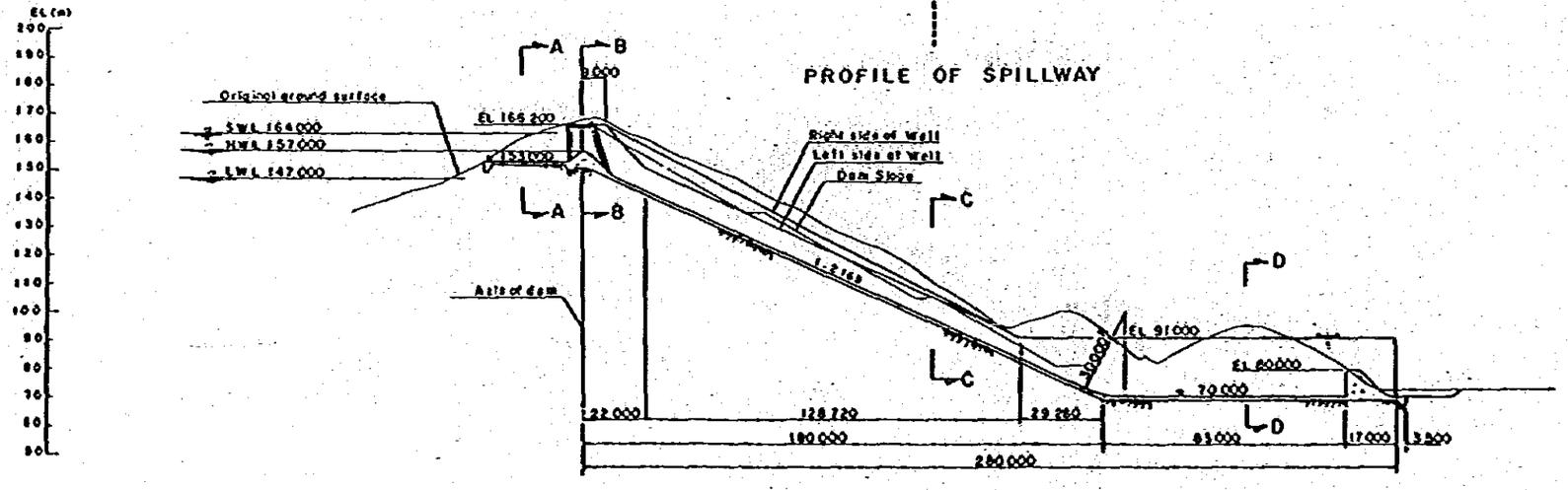
SECTION C-C



SECTION D-D



PROFILE OF SPILLWAY



SCALE
(1:1.000)

0 50 100m

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FEASIBILITY STUDY OF TEKAI HYDRO-ELECTRIC POWER DEVELOPMENT PROJECT

UPPER TEKAI

SPILLWAY AND SECTIONS

FIGURE - IV$_2$

PLAN

SECTIONS

NO. 1

NO. 2

NO. 3

NO. 4

NO. 5

NO. 6

NO. 7

NO. 8

NO. 9

PROFILE OF SPILLWAY

Original ground surface(m/s)
(Center)
(Right)
SWL 164.000
HWL 157.000
LWL 147.000
EL. 166.200
EL. 155.000
Right side of Wall
Left side of Wall
Dam Slope
1:2.160
Axis of dam
EL 91.000
EL 80.000
EL 70.000
22.000
128.720
29.280
180.000
83.000
12.000
280.000
3.500

SCALE
(1:1000)

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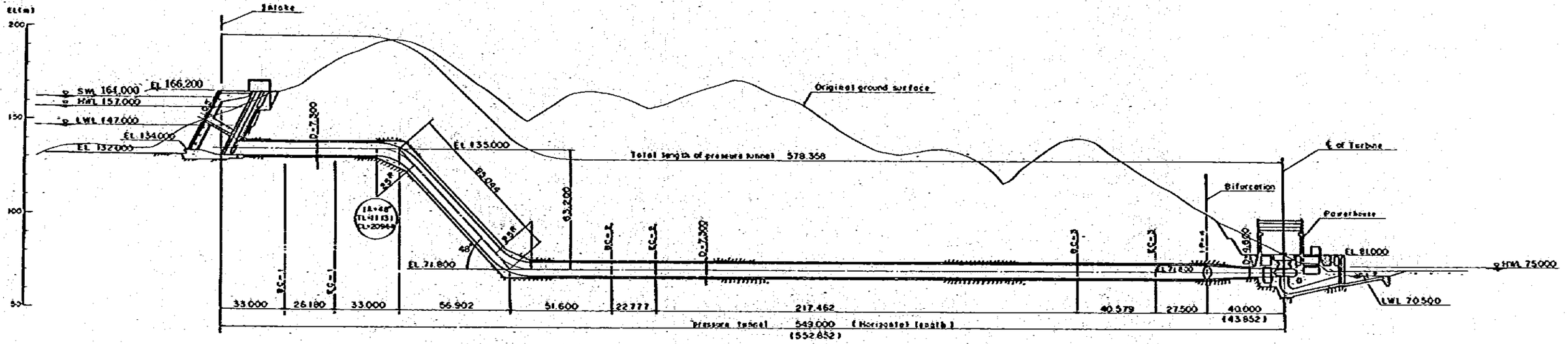
FEASIBILITY STUDY OF TEKAI HYDRO-ELECTRIC POWER DEVELOPMENT PROJECT

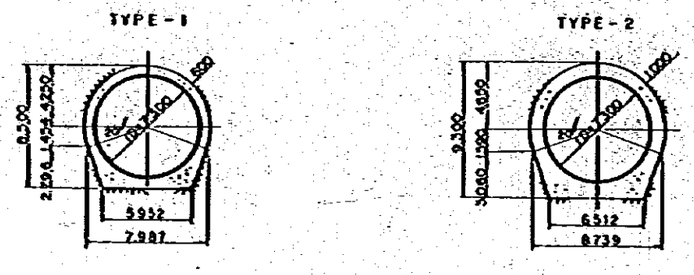
UPPER TEKAI
SPILLWAY

FIGURE-V

PROFILE OF TUNNEL



SECTION OF PRESSURE TUNNEL



SCALE
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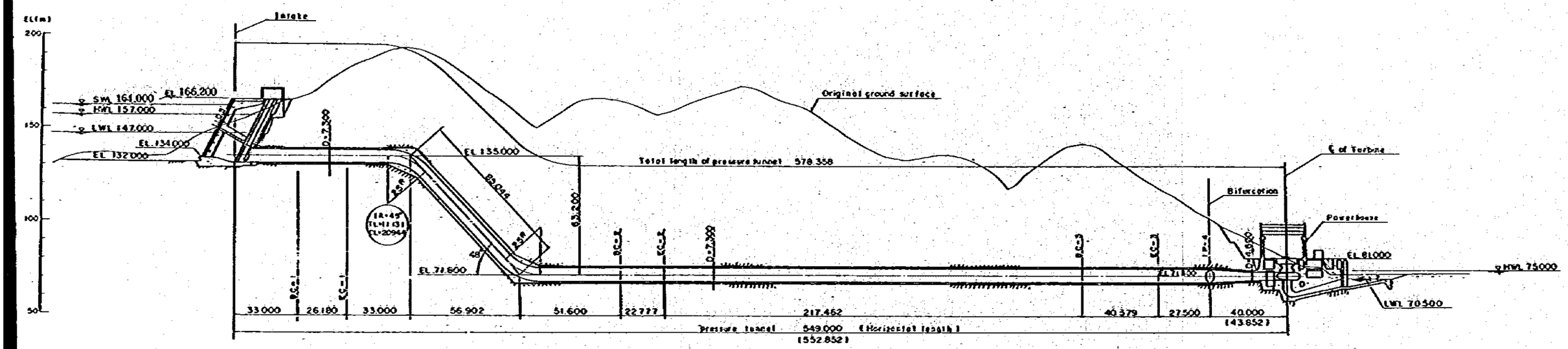
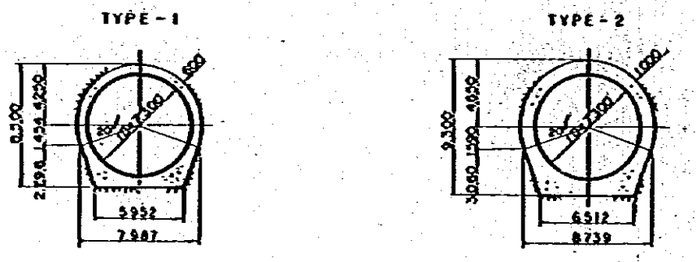
JAPAN INTERNATIONAL COOPERATION AGEI TOKYO JAPAN
FEASIBILITY STUDY OF TEKAI HYDRO-ELEC POWER DEVELOPMENT PROJECT
UPPER TEKAI
PRESSURE TUNNEL
FIGURE

PROFILE OF TUNNEL



SECTION OF PRESSURE TUNNEL



SCALE
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JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO JAPAN

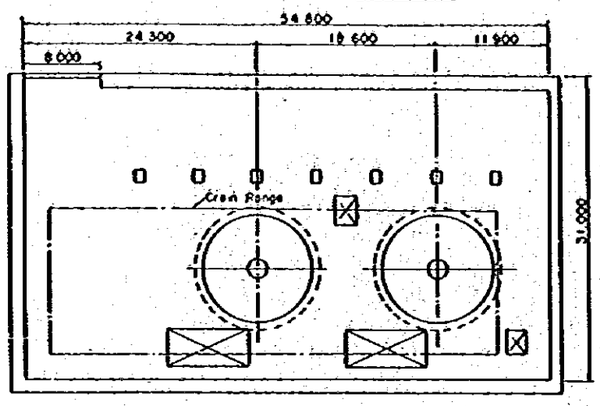
FEASIBILITY STUDY OF TEKAI HYDRO-ELECTRIC POWER DEVELOPMENT PROJECT

UPPER TEKAI

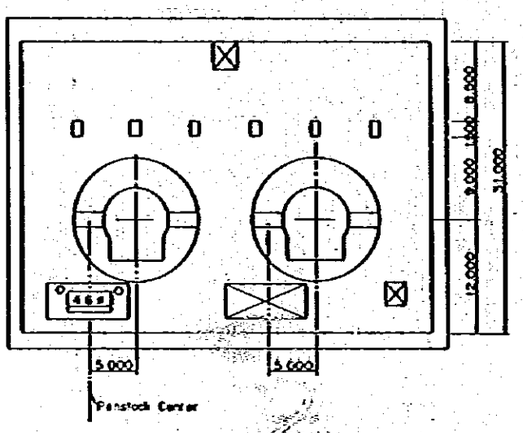
PRESSURE TUNNEL

FIGURE-VI

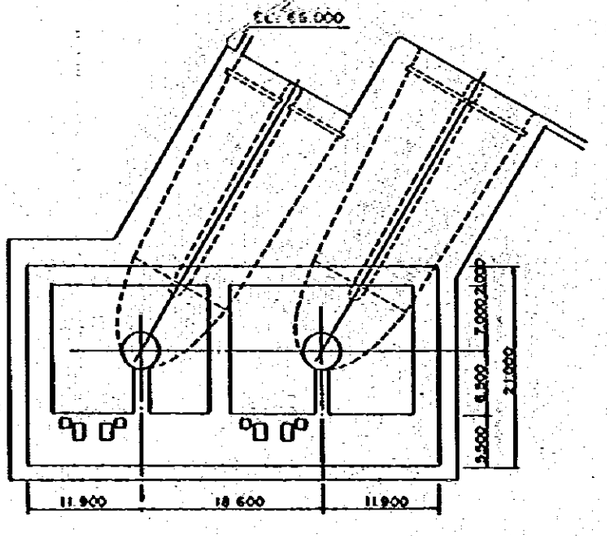
EL 81000



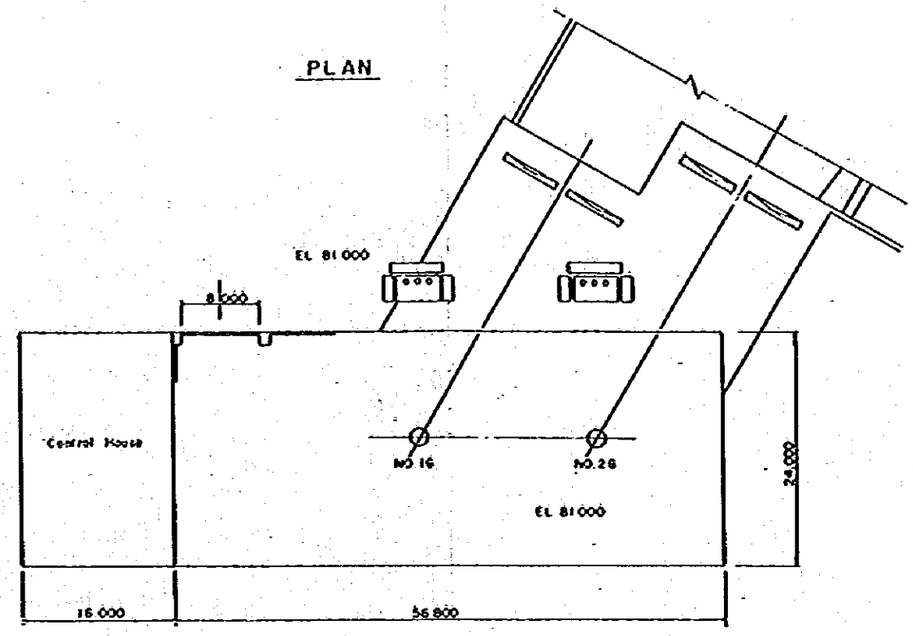
EL. 76.000



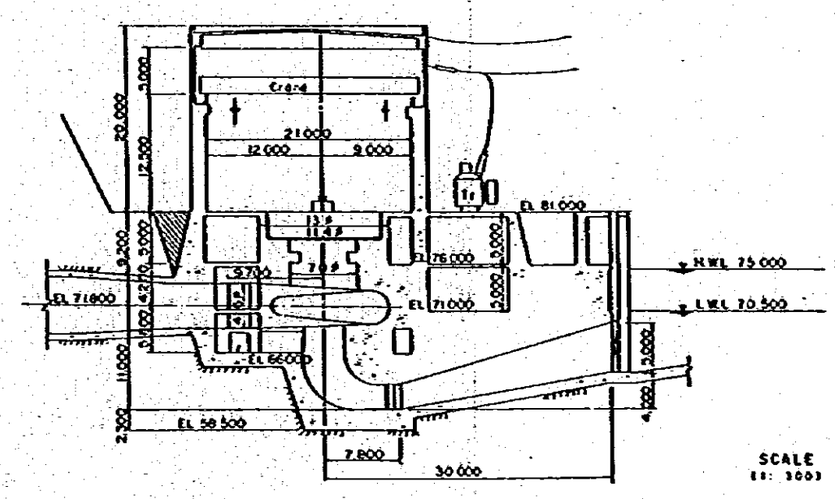
EL. 65.000



PLAN



SECTION



SCALE
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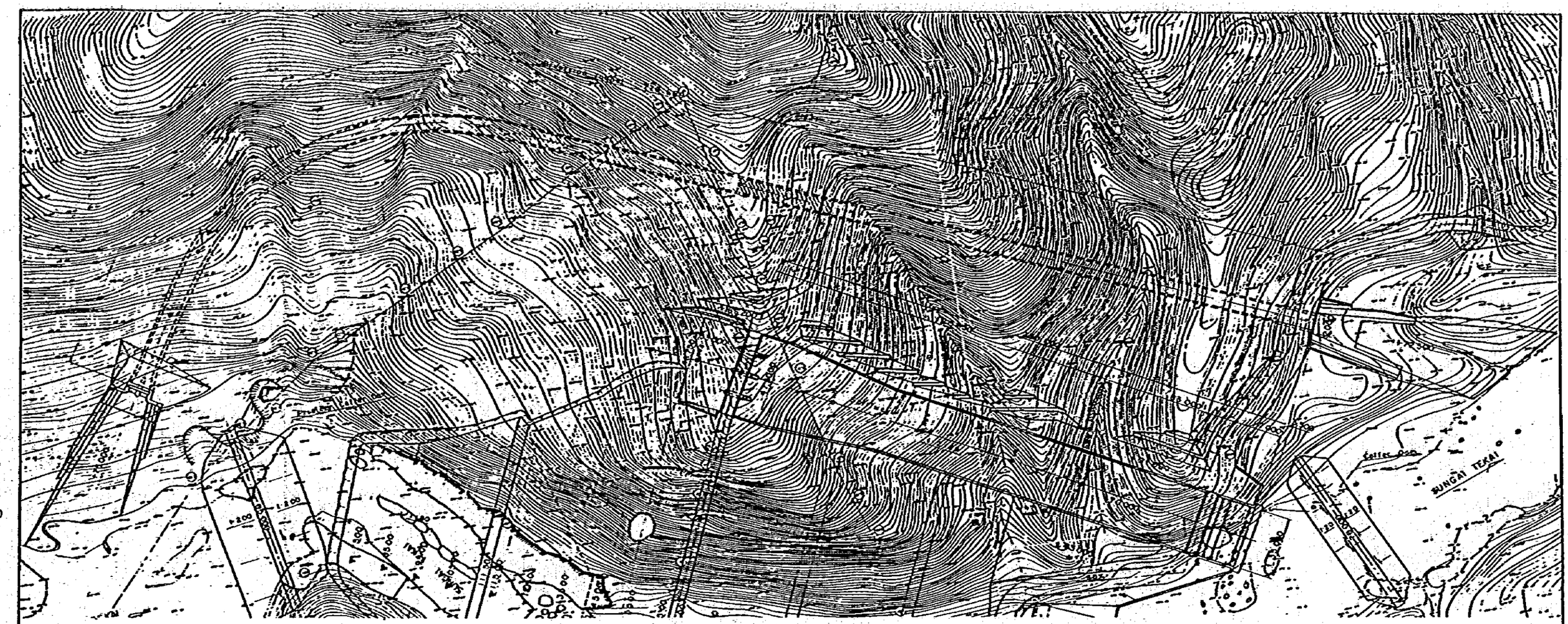
JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO JAPAN

FEASIBILITY STUDY OF TEKAI HYDRO-ELECTRIC POWER DEVELOPMENT PROJECT

UPPER TEKAI
POWER STATION

FIGURE-VII



PROFILE OF DIVERSION TUNNEL

SCALE
(1:1000)

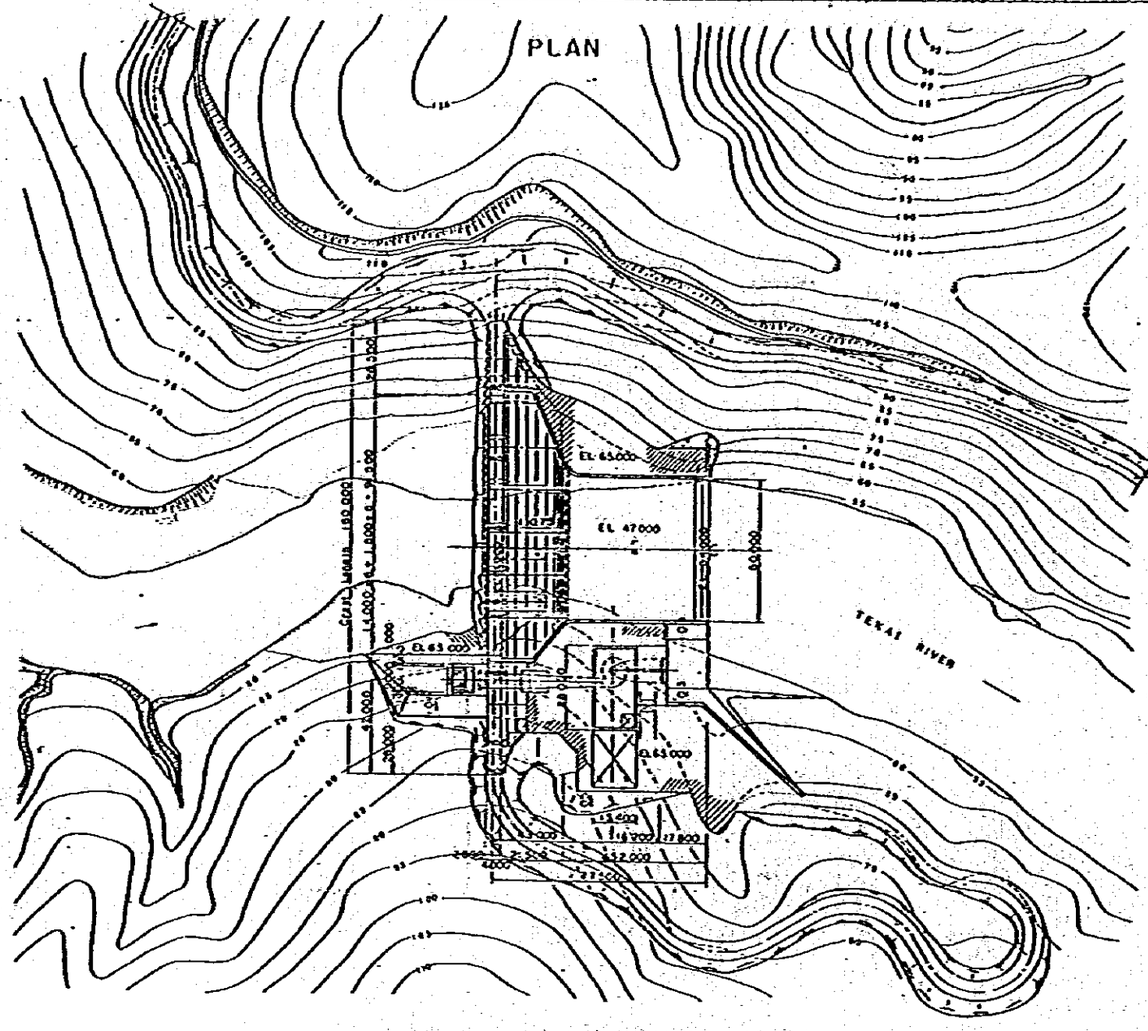
JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO JAPAN

FEASIBILITY STUDY OF TEKAI HYDRO-ELECTRIC POWER DEVELOPMENT PROJECT

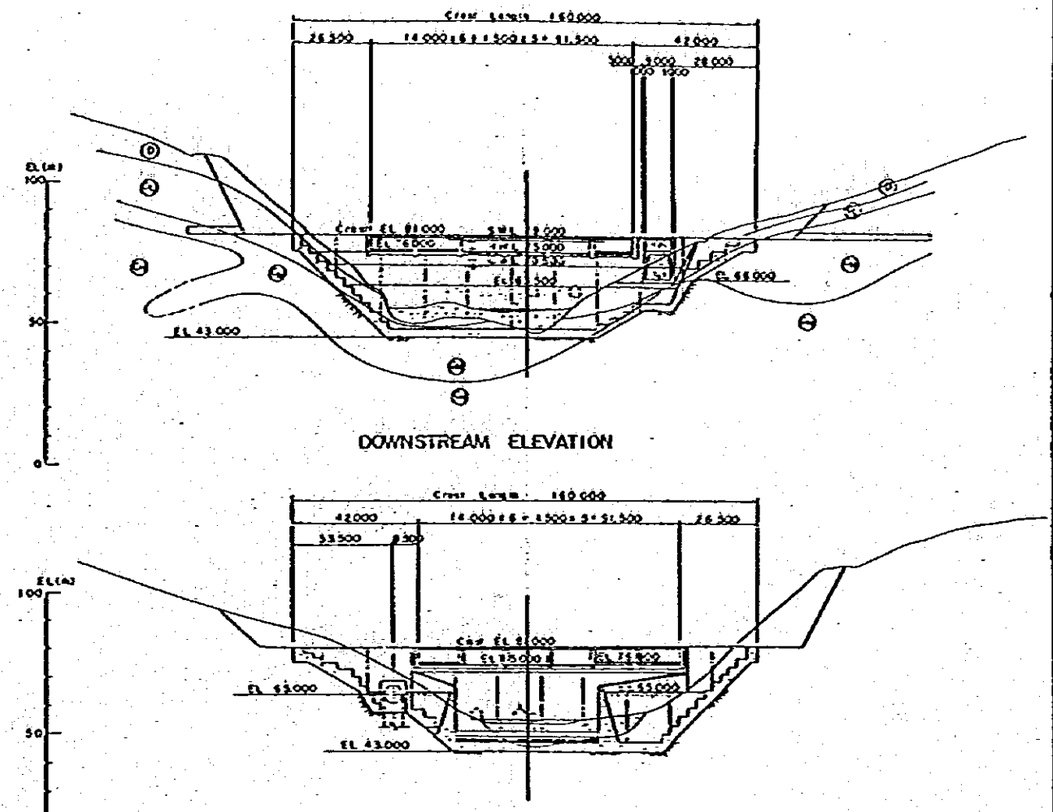
UPPER TEKAI
DIVERSION

FIGURE - VIII

PLAN

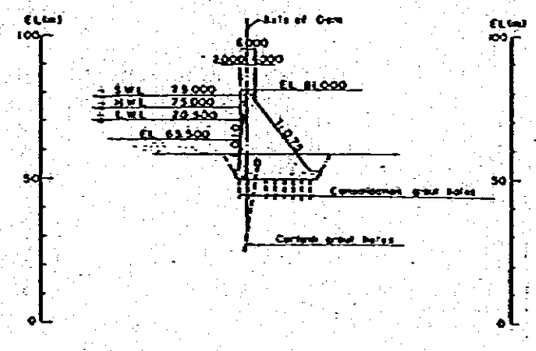


UPSTREAM ELEVATION

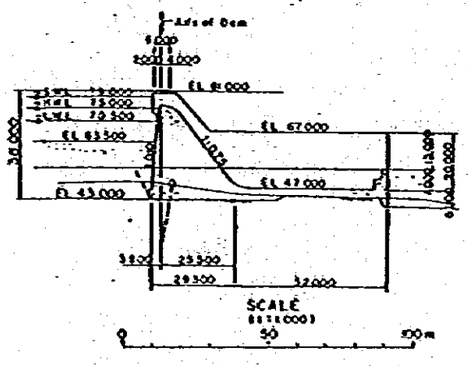


DOWNSTREAM ELEVATION

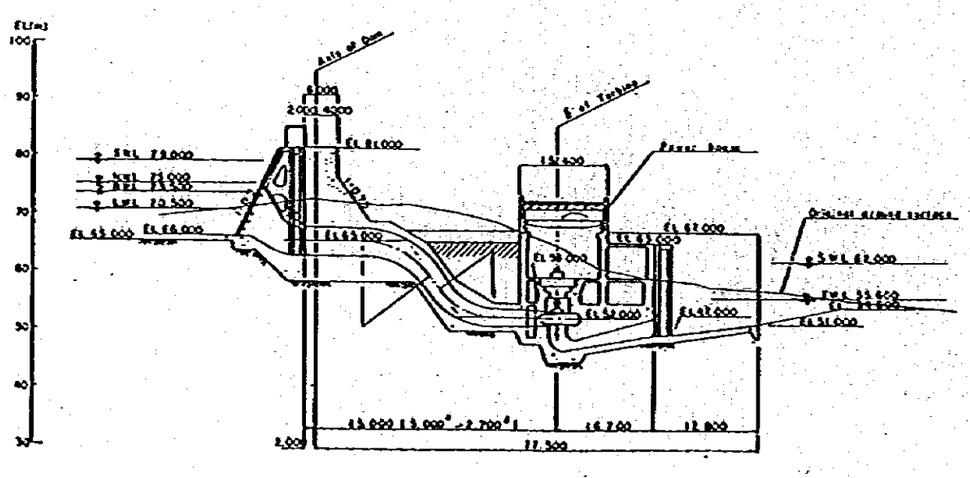
NON OVERFLOW SECTION



OVERFLOW SECTION



LONGITUDINAL SECTION PRESSURE PIPELINE



SCALE
0 50 100m

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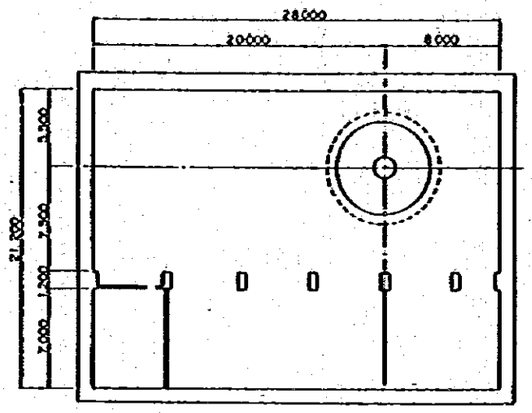
FEASIBILITY STUDY OF TEKAI HYDRO-ELECTRIC POWER DEVELOPMENT PROJECT

LOWER TEKAI

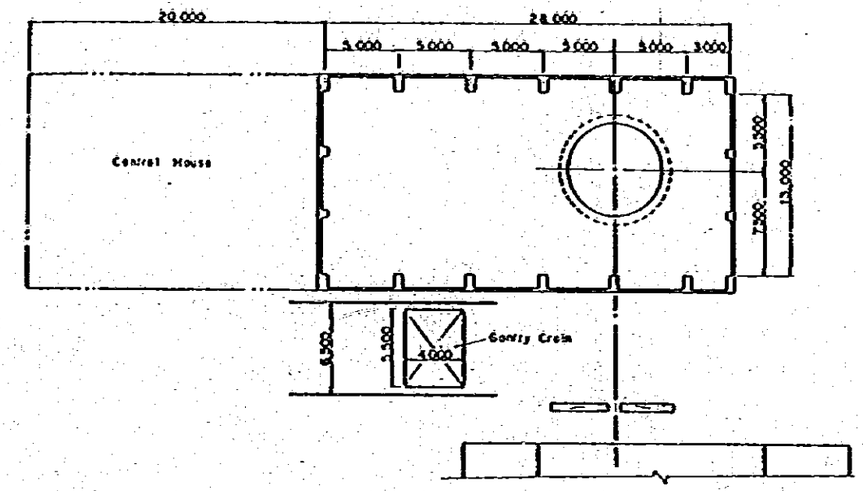
GENERAL ARRANGEMENT-PLAN, POWER STATION AND SECTIONS

FIGURE- IX

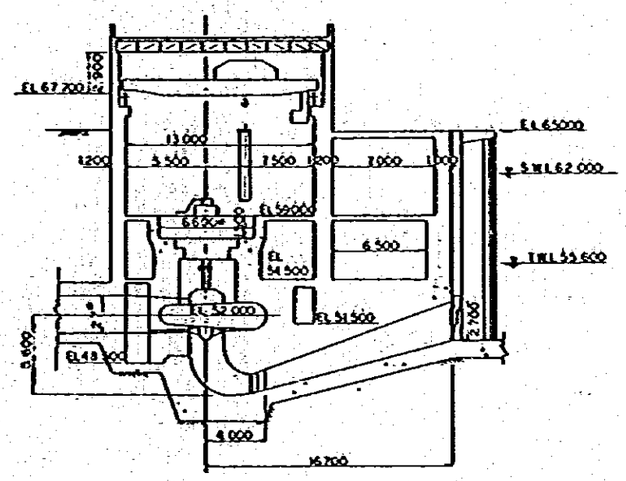
EL 59.000



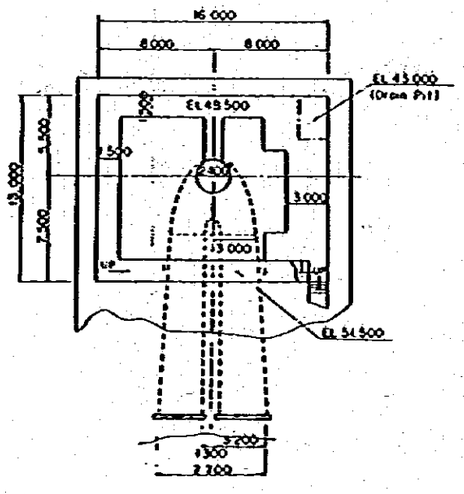
PLAN (EL 65.000)



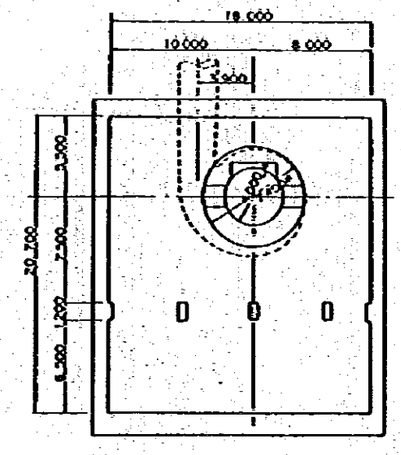
SECTION



EL 49.500



EL 54.500



SCALE
(1/200)

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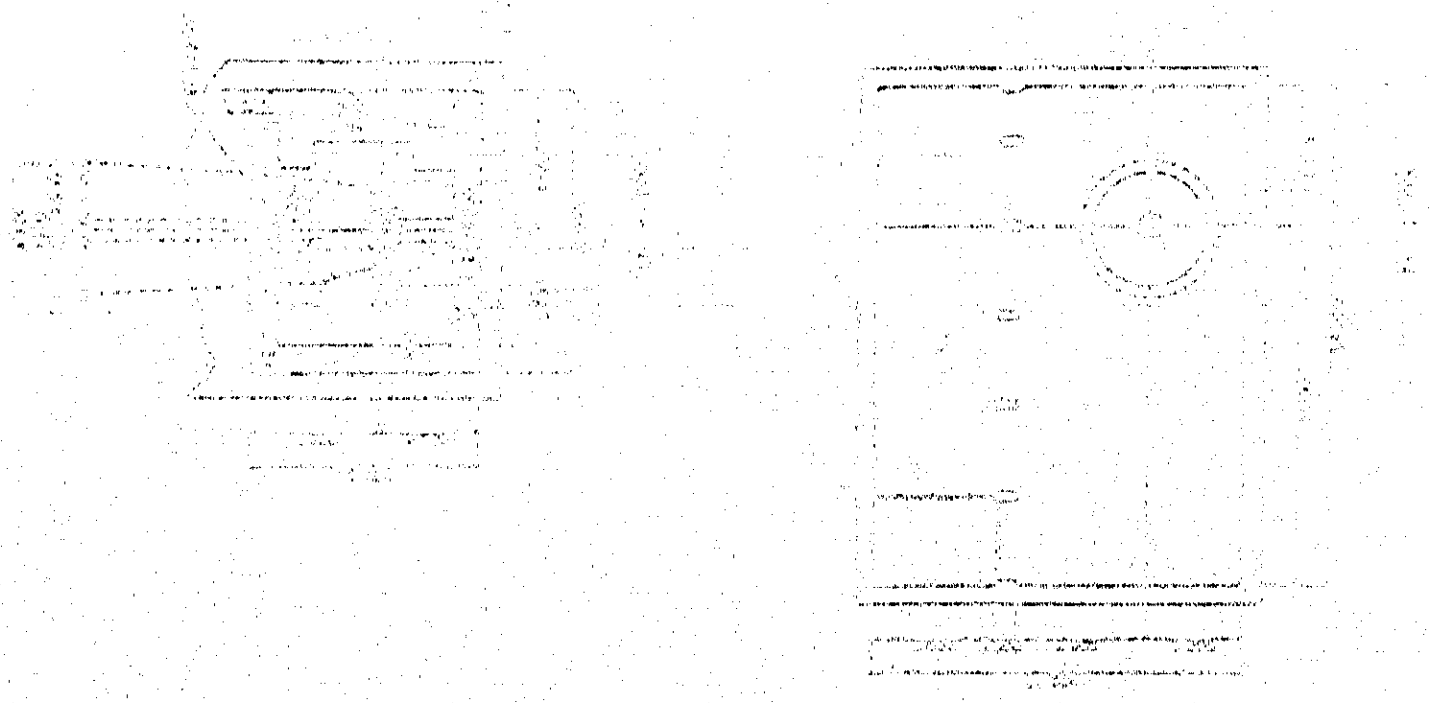
FEASIBILITY STUDY OF TEKAI HYDRO-ELECTRIC POWER DEVELOPMENT PROJECT

LOWER TEKAI
POWER STATION

FIGURE - X



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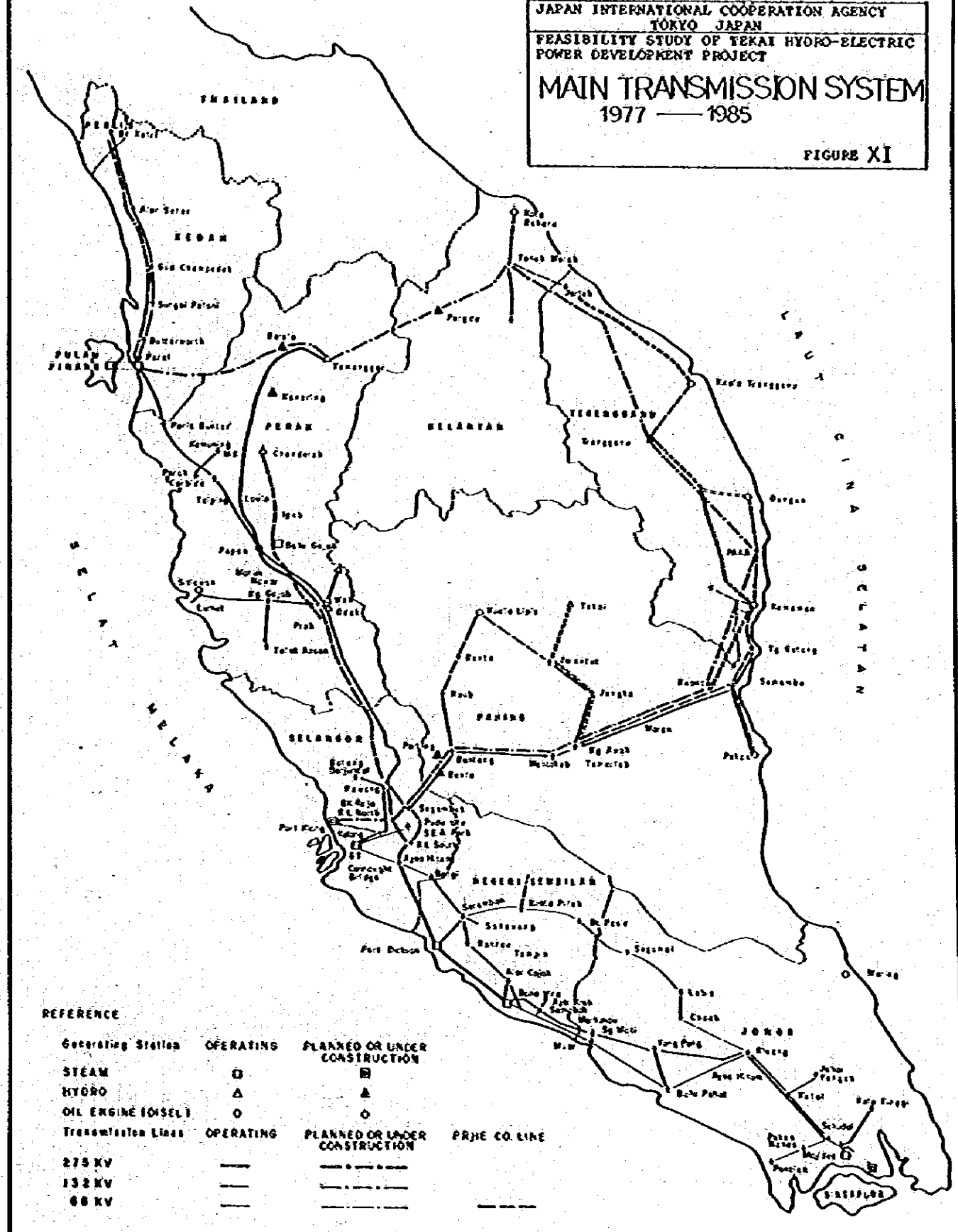
FEASIBILITY STUDY OF TEKAI HYDRO-ELECTRIC POWER DEVELOPMENT PROJECT

MAIN TRANSMISSION SYSTEM
1977 —— 1985

FIGURE XI



DRG No 1, CCE/529

Construction Schedule, Tekai Hydro-electric Power Development Project

Description of Works		Unit	Quantity
(Upper Tekai)			
Preparation	Access Road	L.S	1
	Temporary-Facilities	L.S	1
Diversion	Excavation	m^3	57.700
	Tunnel Excavation	m^3	56.000
	Lining Concrete	m^3	16.600
	Coffer Dam	m^3	357.900
	Others	L.S	1
Dam	Excavation	m^3	442000
	Embankment	m^3	2795.000
	Grouting	L.S	1
	Others	L.S	1
Spillway	Excavation	m^3	283.000
	Concrete	m^3	48450
	Others	L.S	1
Other Structures	Intake	L.S	1
	Penstock	L.S	1
	Power House, Switch Yard	L.S	1
	Others	L.S	1
Generating Equipment		L.S	1
(Lower Tekai)			
Preparation	Access Road	L.S	1
	Temporary Facilities	L.S	1
Sluice Diversion	(1st)	L.S	1
	(2nd)	L.S	1
	Others	L.S	1
Dam	Excavation	m^3	42.300
	Concrete	m^3	56.900
	Grouting	L.S	1
	Others	L.S	1
Other Structures	Intake	L.S	1
	Penstock	L.S	1
	Power House, Switch Yard	L.S	1
	Others	L.S	1
Generating Equipment		L.S	1

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FEASIBILITY STUDY OF TEKAI HYDRO-ELECTRIC POWER DEVELOPMENT PROJECT

CONSTRUCTION SCHEDULE

FIGURE XII

UPPER TEKAI

1983 | 1984 | 1985

1 2 3 4 5 6 7 8 9 10 11 12 | 1 2 3 4 5 6 7 8 9 10 11 12 | 1 2 3 4 5 6 7 8 9 10 11 12 | 1 2 3 4

CIVIL CONTRCT

PRE QUALIFICATION 1,1, 85

CALL TENDERS 1,6,85

CLOSE TENDERS 1,9, 85

AWARD CONTRACT 1,1,86

Formal

Pre design stage

Complete site investigation , general planning , basic design detail design & tender document
18

Tendering period
3

Tender evaluation
4

2

Mobilisati
5

Inst
batc

Prepare brochure
1

Registration period
1

Select tenders
1

Pre tendering period
2

Negotiate construction finance
16

Access Road

Survery & design
4

Tendering period
1

Tender evalution
1

Construction for access road
21

CALL TENDERS 1,4,84

AWARD CONTRCT 1,6,84

CLOSE TENDERS 1,5,84

ELECTRICAL & MECHANIC PLANT CONTRACTS

CALL TENDERS 1,2,86

Prepare contract document
26

Tendering period
4

1 2 3 4 5 6 7 8 9 10 11 12 | 1 2 3 4 5 6 7 8 9 10 11 12 | 1 2 3 4 5 6 7 8 9 10 11 12 | 1 2 3 4

1983 | 1984 | 1985

10 | 11 | 12 | 1986: 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1987: 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1988: 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1989: 1 | 2 | 3 | 4 | 5 | 6 | 7

AWARD CONTRACT 1,1,86

DIVERT RIVER THROUGH DIVERSION TUNNEL 1,10,87

Formal agreement

ender aluation 4

Mobilisation 5

2

Open excavation 3

2

Excavate diversion tunnel outlet site $6\frac{1}{2}$

Excavate spillway 6

Continue excavate spillway 9

Concrete in spillway 24

Install aggegate & concrete batcher plant 7

Concrete tunnel linning 11

Excavate dam foundation 7

Main embankment to EL. 1300m 16

Construct coffer dam 6

Grouting 23

Excavate intake 1

Continue excavate intake 2

Concrete in intake 9

Install trashracs & gate 6

Excavate acces tunnel 2

Excavate pressure tunnel $4\frac{1}{2}$

Continue excavate pressure tunnel 7

Install penstock 20

Concrete in pressure tun 20

NTRACTS

CALL TENDERS 1,2,86

CLOSE TENDERS 1,6,86

AWARD CONTRACT 1,4,87

Excavate power station 5

Commence in concrete in power station substructure 8

Install & embed draftube liners 4

Tendering period 4

Tender evaluation 10

Turbine model test 6

Manufacture & deliver draft tube liners 18

Manufacture & deliver spiralcasings 25

Manufacture & deliver turbine & generator 30

10 | 11 | 12 | 1986: 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1987: 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1988: 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1989: 1 | 2 | 3 | 4 | 5 | 6 | 7

11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
		1989												1990												1991											

COMMENCE STORAGE 1,11,89

CLOSE DIVERSION 1,2,90

UNIT 1,2 IN SERVICE 1,7,91

crete in spillway
24

Concrete in tunnel plug
3

Main embankment to EL. 1300m
16

Store water to minimum operating level
20

Grouting
23

Complete embankment
11

e
Install trashracs & gate
6

Install penstock
20

Concrete in pressure tunnel
20

Grouting
5

Plug of ocess tunnel
$2\frac{1}{2}$

e in concrete in
otion substructure
8

Install & embed draftube liners
4

Install station crane
2

Install & embed spiral casings & complete station concrete
6

Install turbine & generator unit 1
12

Complete adjuct test
1

Operation test
2

rs

Install turbine & generator unit 2
11

otor

Comple power station civil works & move out
15

11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
		1989												1990												1991											

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO JAPAN

FEASIBILITY STUDY OF TEKAI HYDRO-ELECTRIC POWER DEVELOPMENT PROJECT

DESIGN AND CONSTRUCTION PROGRAM FOR UPPER TEKAI

FIGURE XIII

1983												1984												1985															
1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4

LOWER TEKAI

1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
1983												1984												1985															

8 9 10 11 12 | 1986: 1 2 3 4 5 6 7 8 9 10 11 12 | 1987: 1 2 3 4 5 6 7 8 9 10 11 12 | 1988: 1 2 3 4 5 6 7 8 9 10 11 12 | 1 2 3 4 5

CIVIL CONTRACT

PRE QUALIFICATION 1,1,88 | CALL TENDERS 1,6,88 | CLOSE TENDERS 1,8,88 | AWARD CONTRACT 1,11,88

Pre design stage

Complete site investigation, general planning, basic design, detail design & tender document — 12

Prepare brochure — 1

Registration period — 1

Select tenders — 1

Negotiate construction finance — 10

Pre tendering period — 2

Tendering period — 2

Tender evaluation — 3

Mobilisation — 2

Formal agreement

Install concrete batcher plant — 5

Sluice

ELECTRICAL & MECHANIC PLANT CONTRACTS

CALL TENDERS 1,7,88 | CLOSE TENDERS 1,10,88 | AWARD CONTRACT 1,3,89

Prepare contract documents — 13

Tendering period — 4

Tender evaluation — 5

Turbine model test — 2

8 9 10 11 12 | 1986: 1 2 3 4 5 6 7 8 9 10 11 12 | 1987: 1 2 3 4 5 6 7 8 9 10 11 12 | 1988: 1 2 3 4 5 6 7 8 9 10 11 12 | 1 2 3 4 5

1988 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
1989 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
1990 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
1991 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |

PRE QUALI-FICATION 1,1,88

CALL TENDERS 1,6,88

CLOSE TENDERS 1,8,88

AWARD CONTRACT 1,11,88

Diversion (1st) 1,8,89

Diversion (2nd) 1;8,90

UNIT 1, 2 IN SERVICE 1,7,91

Formal agreement

...on, general planning, basic tender document — 12

Prepare brochure — 1

Registration period — 1

Select tenders — 1

Pre tendering period — 2

Tendering period — 2

Tender evaluation — 3

Mobilisation — 2

Install concrete batcher plant — 5

Sluice diversion (1st) — 4

Excavation dam foundation — 4

Sluice diversion (2nd) — 2

Excavation — 2

Concrete — 16

Grouting — 17

Removing sluice diversion (Sheet piles) — 2

Complete concrete & plug of d... in the dam — 1½

Excavate spillway — 4

Concrete in spillway — 17

Excavate intake — 4

Concrete in intake structure — 15

Install trashracs & gates — 3½

Store wate... operating l...

Concrete in pressure tunnel — 9

Install penstock — 9

...L & MECHANIC PLANT CONTRACTS

CALL TENDERS 1,7,88

CLOSE TENDERS 1,10,88

AWARD CONTRACT 1,3,89

Prepare contract documents — 13

Tendering period — 4

Tender evaluation — 5

Turbine model test — 2

Excavate power station — 5

Commence concrete in power station substructure — 2

Install & embed draft tube liners — 2

Manufacture & deliver draft tube liners — 10

Install & embed spiral casing & complete power station concreot — 6

Install station crane — 1½

Install turbine & generator unit 1 & unit 2 — 6

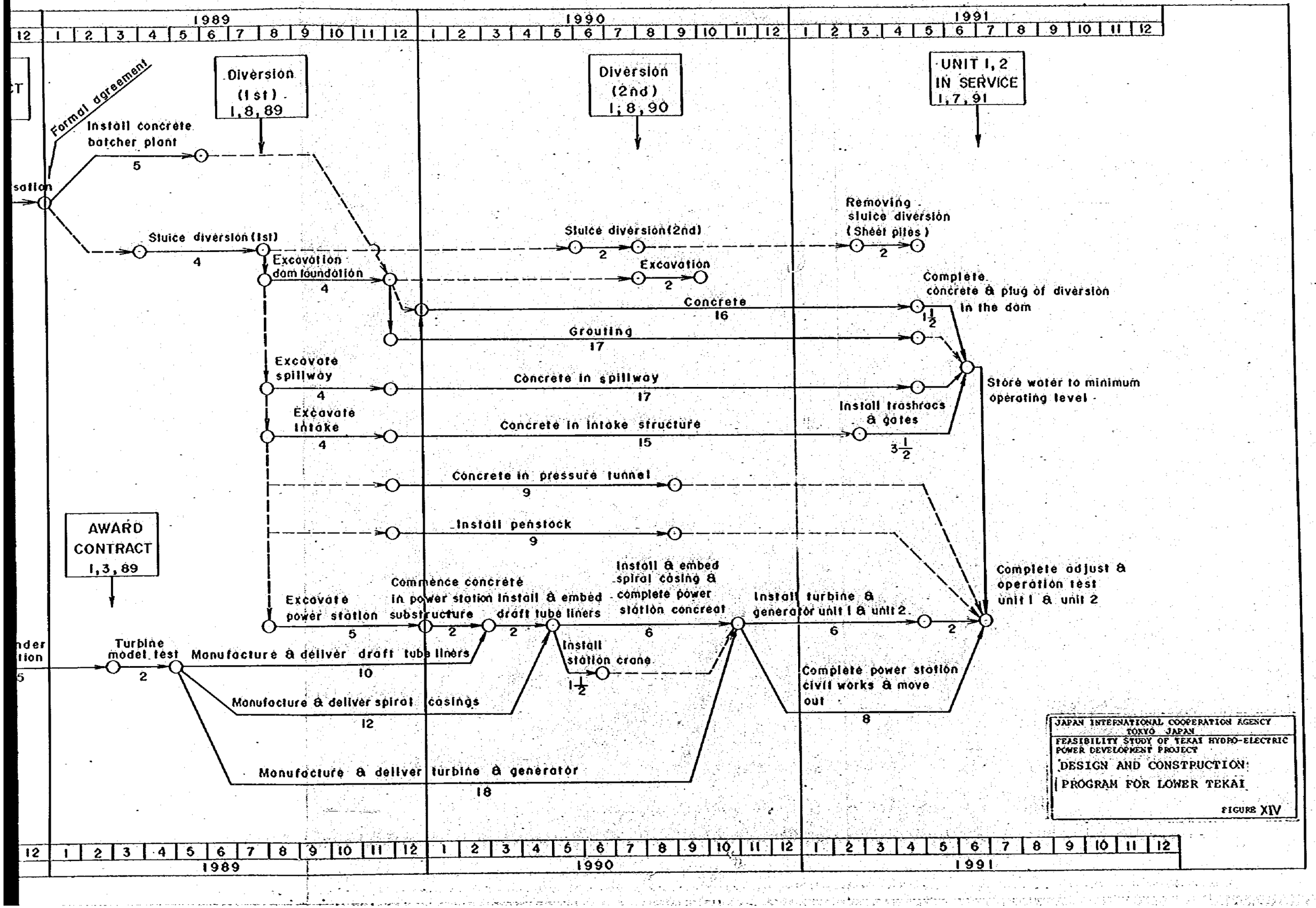
Complete ... operation ... unit 1 & ...

Manufacture & deliver spiral casings — 12

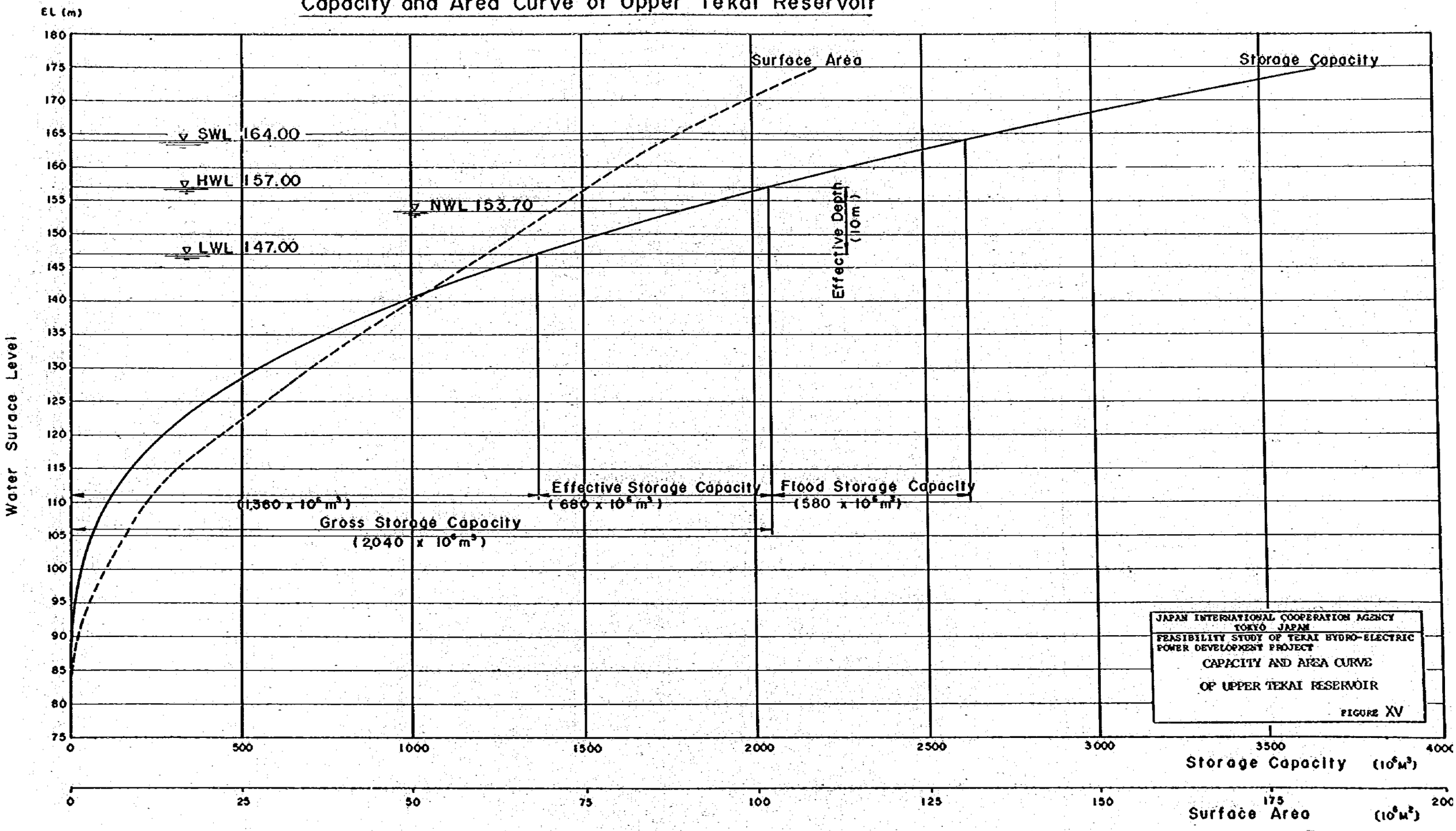
Complete power station civil works & move out — 8

Manufacture & deliver turbine & generator — 18

1988 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
1989 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
1990 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
1991 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |


1989
1990
1991
12 1 2 3 4 5 6 7 8 9 10 11 12
Diversion (1st) 1,8,89
Diversion (2nd) 1,8,90
UNIT 1,2 IN SERVICE 1,7,91
Formal agreement
Install concrete batcher plant
5
sation
Sluice diversion(1st)
4
Excavation dam foundation
4
Sluice diversion(2nd)
2
Excavation
2
Removing sluice diversion (Sheet piles)
2
Concrete
16
Grouting
17
Complete concrete & plug of diversion in the dam
1 1/2
Excavate spillway
4
Concrete in spillway
17
Excavate intake
4
Concrete in intake structure
15
Install trashracs & gates
3 1/2
Store water to minimum operating level
Concrete in pressure tunnel
9
Install penstock
9
AWARD CONTRACT 1,3,89
Excavate power station
5
Commence concrete in power station substructure
2
Install & embed draft tube liners
2
Install & embed spiral casing & complete power station concreat
6
Install turbine & generator unit 1 & unit 2.
6
2
Complete adjust & operation test unit 1 & unit 2
nder tion
5
Turbine model test
2
Manufacture & deliver draft tube liners
10
Install station crane
1 1/2
Complete power station civil works & move out
8
Manufacture & deliver spirol casings
12
Manufacture & deliver turbine & generator
18
JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO JAPAN
FEASIBILITY STUDY OF TEKAI HYDRO-ELECTRIC POWER DEVELOPMENT PROJECT
DESIGN AND CONSTRUCTION PROGRAM FOR LOWER TEKAI
FIGURE XIV

Capacity and Area Curve of Upper Tekai Reservoir



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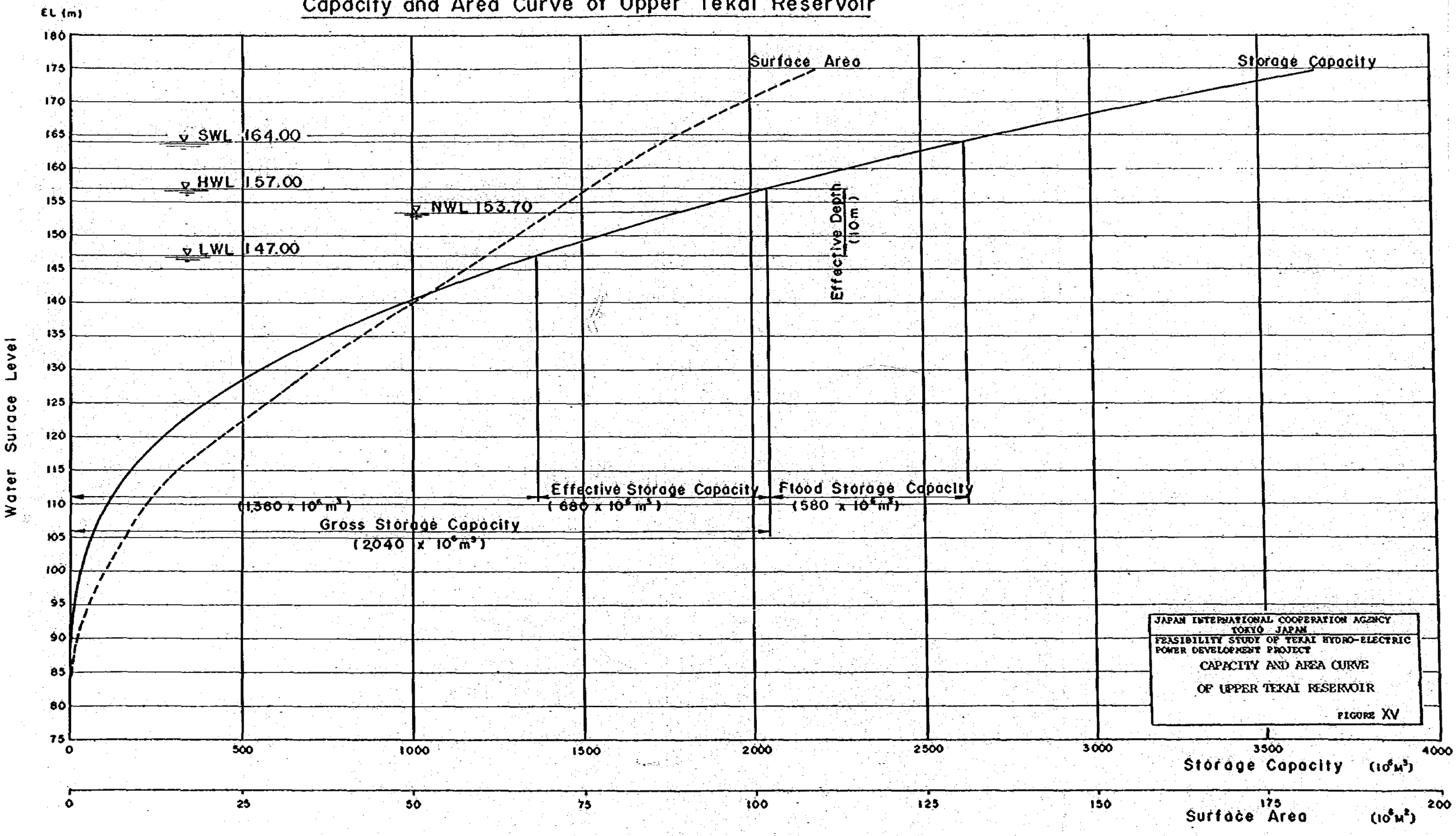
FEASIBILITY STUDY OF TEKAI HYDRO-ELECTRIC POWER DEVELOPMENT PROJECT

CAPACITY AND AREA CURVE OF UPPER TEKAI RESERVOIR

FIGURE XV

Capacity and Area Curve of Upper Tekai Reservoir



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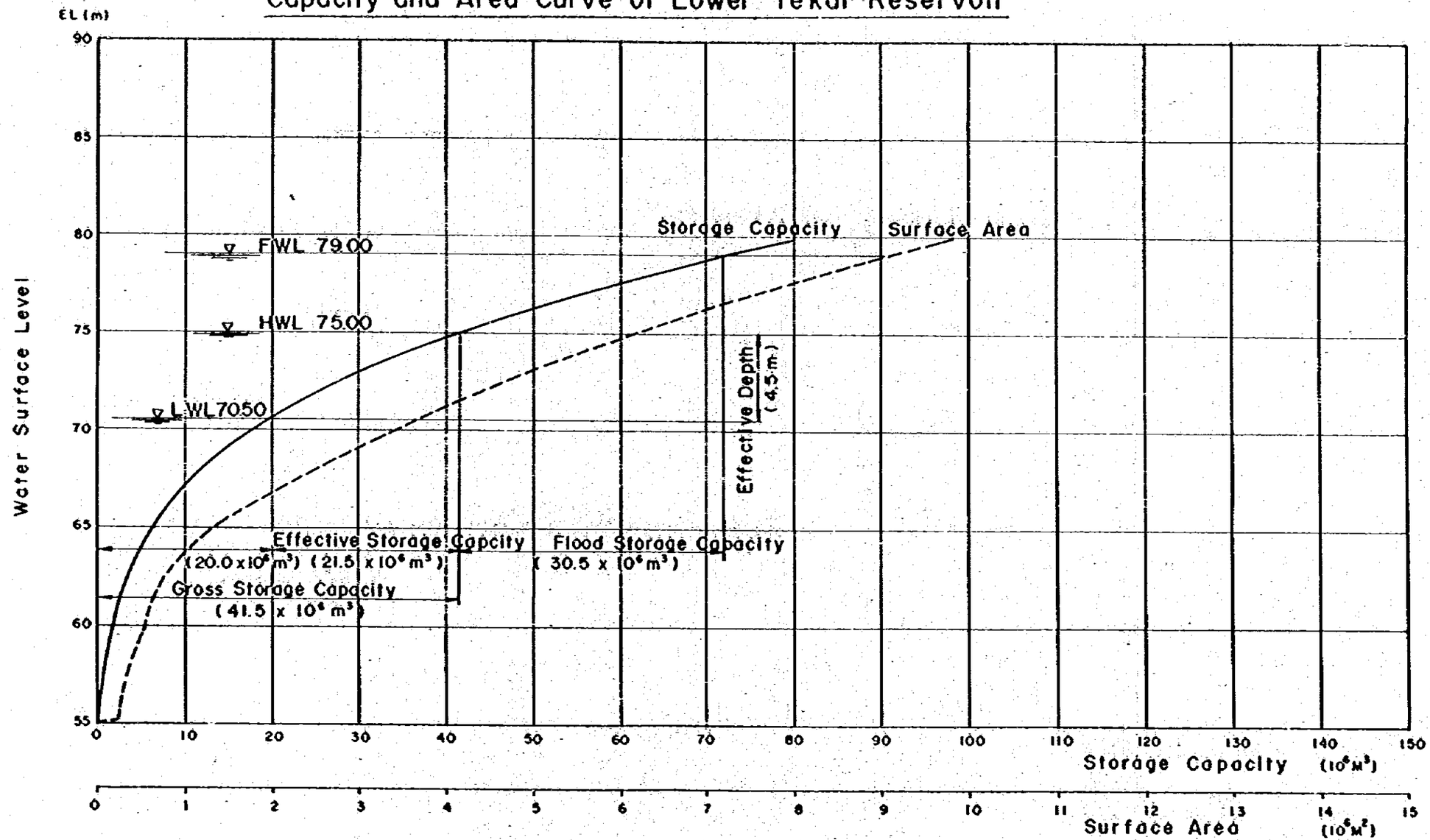
FEASIBILITY STUDY OF TEKAI HYDRO-ELECTRIC POWER DEVELOPMENT PROJECT

CAPACITY AND AREA CURVE
OF UPPER TEKAI RESERVOIR

FIGURE XV

Capacity and Area Curve of Lower Tekai Reservoir



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FEASIBILITY STUDY OF TEKAI HYDRO-ELECTRIC POWER DEVELOPMENT PROJECT

CAPACITY AND AREA CURVE OF LOWER TEKAI RESERVOIR

FIGURE XVI

JICA