of farmhouse economy. First, the average area of farmed land is calculated from the figures in Table 2-5-37. The total area per household is 0.5 ha, as shown below.

Per household:	Irrigated field	0.28 ha
	Upland field	0.19 ha
	Rain-fed field	0.04 ha
	Total	0.51 ha

If the crops of 40 cavans is assumed as the yield per ha, then the production is 20 cavans (1 cavan = 44 kg) from 0.5 ha That is, 880 kg in the husk and 440 kg in terms of polished rice (with a yield rate of polishing of 50% assumed). Supposing each person eats 120 kg in a year, then this amount of rice can feed only 3.6 of the household members. In a typical 7-member family with many children, rice is considered to be substituted by corn, camote (sweet potato), beans and such like. Since the price ex-farmhouse of seedrice is ₱1.1 per kg, the annual revenue would be ₱968. The above description relates only to rice. If the other products, such as corn, camote, beans and some fruit are included, the income from selling the farm products would amount to ₱1,500. However, these are all for domestic consumption, and cash comes in only from the sale of hogs and chickens. The gross annual income is estimated to range from around ₱1,800 to ₱2,500. per households.

Table 2-5-31 Area of Crop Land in Nueva Vizcaya and Isabela P.V.s., 1971

(units : 10^3ha)

	Nueva Vizcaya and Quirino	Isabela
Palay	35.40	129.60
Corn	3.19	51.53
Tobacco	1.70	29.24
Coconut	0.70	0.95
Others	7.24	8.22
Total	48.23	219.54

Source : 1971 Census of Agriculture (Isabela) : NEDA
: 1971 Census of Agriculture (Nueva Vizcaya) : NEDA

Table 2-5-32 **Production of Palay per 1 ha**
(Average in 1960 ∿ 1972)

(unit : cavan)

Crop Land	Palay per 1 ha
Irrigated palay field	50
Non-irrigated palay field in rainy season	26
Irrigated palay field in dray season	48
Upland	17
Average	39

Source : Hearing at the Bureau of Agro-Economy, Bayombong

Table 2-5-33 **Area of Farms Classified by Land Use in Nueva Vizcaya & Isabela P.V.s., 1971**

(units : ha, %)

	Nueva Vizcaya and Quirino		Isabela	
	Hectarage	%	Hectarage	%
1. Planted to Temporary Crops	34,060.2	57.8	164,219.5	69.8
2. Lying Idle	4,218.0	7.2	22,835.2	9.7
3. Land Planted to Permanent Crops	4,183.3	7.1	8,003.8	3.4
4. Land under Permanent Meadows and Pastures	11,498.1	19.5	23,026.5	9.8
5. Land Covered with Forest Growth	2,792.1	4.7	9,006.4	3.8
6. All other land	2,162.0	3.7	8,264.7	3.5
Total	58,913.7	100.0	235,356.0	100.0

Source: 1971 Census of Agriculture (Isabela) : NEDA
: 1971 Census of Agriculture (Nueva Vizcaya) : NEDA

Table 2-5-34 **Farms Classified by Cultivated Size in Nueva Vizcaya & Isabela P.V.s, 1971**

(unit : %)

	Nueva Vizcaya and Quirino	Isabela
under 1 ha	13.8 %	5.6 %
1 ha ∿ 3 ha	56.9	53.8
3 ha ∿ 5 ha	20.7	27.2
over 5 ha	7.6	13.4

Source : 1971 Census of Agriculture (Nueva Vizcaya)
1971 Census of Agriculture (Isabela)

Table 2-5-35 Planted Area in Nueva Vizcaya & Isabela P.V.s, 1971

(units : ha, farm)

	Nueva Vizcaya and Quirino	Isabela
Planted Area	25.30 ha (17,592 farms)	103,092 ha (49,123 farms)
Irrigated palay field	15,503 ha (10,283 ")	53,965 ha (20,071 ")
Non-irrigated palay field	9,800 ha (7,309 ")	49,127 ha (29,052 ")

Source : 1971 Census of Agriculture (Nueva Vizcaya)
1971 Census of Agriculture (Isabela)

Table 2-5-36 **Farms - Number and Area in Kasibu M.P., 1975**

(Unit : Household)

Name of Barrio	Number of Households	(Bulaue of Agr. Economy)Household
Poblacion (Alloy)	127	99
Bua	78	75
Cordon	85	90
Macalong	72	75
Malabing	63	50
Kakiduguen	59	39
Kinalo	101	53
Muta	145	50
Antutot	52	40
Binogawan	68	115
Capisaan	55	120
Didipio	122	80
Catarawan	41	115
Nantawacan	102	130
Pao	78	80
Siguem	75	80
Tukod	107	75
Alimit	72	115
Belet	43	50
Biyoy	105	103
Camamasi	26	100
Dine	92	225
Lupa	68	66
Papaya	69	60
Pudi	99	110
Tadji	60	75
Wangal	53	90
Watwat	79	90
Total	2,219	2,510

Source: 1975 Integrated Census of the Population and Its Economics Activities (Population Nueva Vizcaya)

Table 2-5-37 Farms and Area Classified by Land Use (Kasibu M.P.), 1971

Planted to Temporary Crops		Land Planted to Permanent Crops		Permanent Meadows and Pastures		Land Covered with Forest Growth	
Farms	Area of all arable land	Farms	Area	Farms	Area	Frams	Area
1044	ha 2108	699	ha 391	416	ha 566	422	ha 605

Note: 1) Farms are those reported.
2) Farms include those laying idle (431 ha)

Source: 1971 Census of Agriculture: NEDA

Table 2-5-38 Farms and Area Classified by Size (Kasibu M.P.), 1971

(units : ha, farms)

	Total Area of Farms	under 1 ha	1 ~ 3 ha	3 ~ 5 ha	5 ~ 10 ha	10 ~ 25 ha
Area	4,025.2 ha	8.5	643	1,276	1,302	774
Number of Farms	1,064	25	405	365	212	57

Source : 1971 Census of Agriculture
(Nueva Vizcaya : NEDA)

Table 2-5-39 Farms by Types of Tenure (Kasibu M.P.), 1971

Number of Farm Reporting	Full-Owner	Part-Owner	Tenant			Others
			share of product	Free	Total	
1,064	958	25	66	10	76	5

Source : 1971 Census of Agriculture (Nueva Vizcaya): NEDA

Table 2-5-40 **Products Per Farm, Area and Capita**
(Kasibu M.P., 1971)

Number of Farm Reporting	Effective Crop Area (ha)	Farm Household Population	Value of Crops Producted (1,000 ₱s)	Average Value of Crops Producted (₱)		
				/farm	/ha	/capita
1064	2525	5834	1659	1559	657	284

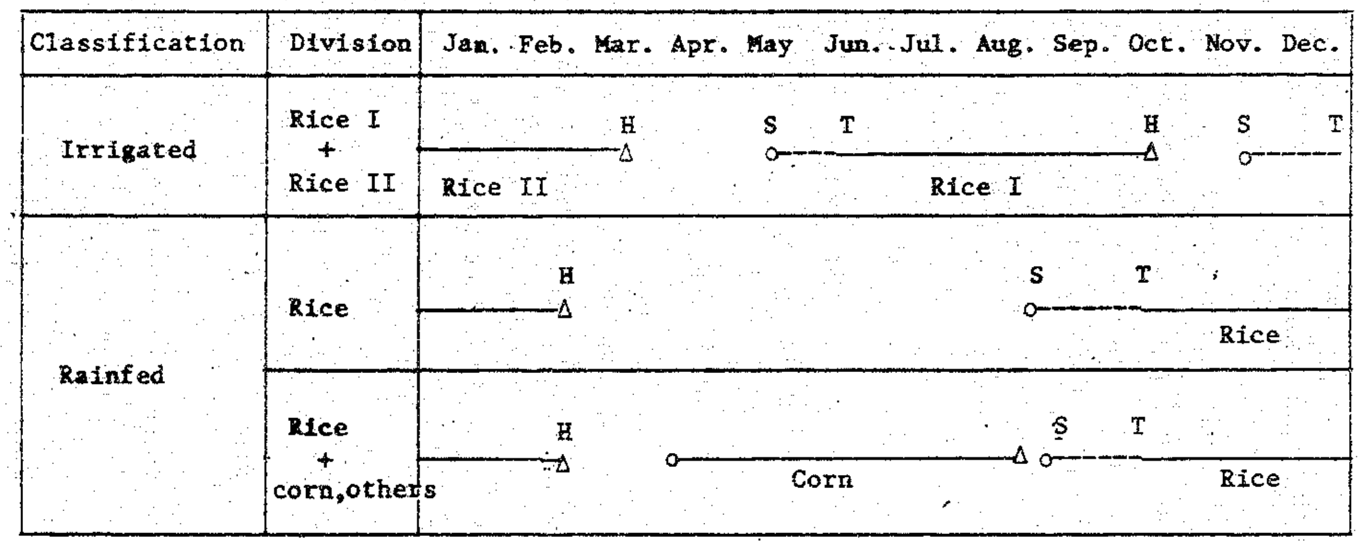
Source: 1971 Census of Agriculture (Nueva Vizcaya) : NEDA

Table 2-5-41 Products Classified by Crop and Livestock

	₱
Palay	839,480
Irrigated field	490,590
(Irrigated Upland and Kaingin)	(37,620)
Non-irrigated field	348,890
(Non-irrigated Upland and Kaingin)	(294,690)
Corn	17,600
Sugarcane	28,815
Camote	146,926
Cassava	6,132
Gabi	3,990
Haliehuplas (beans)	93,460
Tomato	1,645
Coffee	128,697
Banana	143,825
Pineapple	6,300
Carabao	256,675
Cattle	124,133
Hog	301,926
Horse	33,060
Chicken	25,194
Duck	3,135

Source : 1971 Census of Agriculture (Nueva Vizcaya) : NEDA

Fig. 2-5-10 <u>Cropping Pattern</u>



S : Sowing

T : Transplanting

H : Harvesting

Source : Cagayan Total Agricultural Development Feasibility Survey Report

2.6. Power Sector

2.6.1. Brief Comment on the Philippine Economy

The gross national product (GNP) of the Philippines was 131.3 million Pesos (US$17.5 million at an exchange rate of US$1.00 = ₱7.5) according to a NEDA source. Per capita GNP was ₱3,003 (US$404)for the whole population of 432.9 million as of July 1976.

According to a census made by the Japan Economy Planning Agency in 1978, per capita national income in the Philippines was US$333 (based on I.F.S. statics). This figure is, as compared with those of other Asian counties, slightly bigger than that of Thailand (US$323), and about 1.7 times that of Indonesia (US$200), while that in Japan was US$3,188.

The net GNP growth has been 5 - 6.5% per annum since 1967. It is noticeable that in the Philippines the net GNP growth was maintained high at a rate of 6% for 1973 - 74 and 5.9% for 1974 - 75 even after the oil crises in 1973 and the succeeding economic recessions, while in other developed countries it dropped greatly in 1974 - 1975. It is explained that the Philippine economy was supported during these years by construction booms, rich crop harvests of main foods, prosperity in tourism, sound growth of traffic industries and so on.

The share by industries of net GNP as of 1976 is 30.9% for agrofishery, the annual growth of industry is 9 - 11%, noticeably higher than that of agro-fishery, causing a bigger yearly share of the industry sphere.

The labour population of 15 years of age and over is distributed 50% in agro-fishery, 15% in industry and 35% in the service sphere.

Labour productivity per capita as of 1977 is estimated at ₱2,559 in agro-fishery. ₱8,286 in industry and ₱4,761 in the service sphere, all at the 1972 price level, or assuming that of industry at 100, the service sphere will be 57 and agro-fishery 31. The target of Government Programs (5-year program for 1978 - 1982 and 10-year program for 1978 - 1987) is to raise the GNP growth to 7.5 - 8 % during the first five years and maintain it at 8 % during the successive five years. (see Table 2-6-1). The programs aim at raising national per capita income from ₱3,376 in 1977 to ₱5,912 in 1982 and to ₱10,580 in 1987 on the assumption that population will grow at a rate of 2.9 - 3 % annually and that the expected growth rate of per capita GNP will be 3.9 - 5 % during the first five yeras and maintained at 5 % during the successive five years.

In Fig. 2-6-1 is presented the correlation of per capita electricity consumption and GNP in several countries of the world, decuced from U.S. Statics for 1975.

2.6.2. Energy Situation in the Philippines

According to the Philippine 5-year Program (1978 - 1982) gross energy consumption in the Philippines was estimated at 83.4 M.M.B. (million metric barrels of oil equivalent) in 1977. Energy consumption was shared at 36.3 % for transportation, 41.6 % for industry, 8.1 % for commerce and 14.0 % for home use and others.

Energy sources relied 5.3 % upon hydro, 0.6 % upon coal and 94.1 % upon oil (see Table 2-6-2).

Energy consumption increased at 9 % annually for the 1965 - 73 period. As the GNP growth rate was 6 % annually during the some period energy consumption increased at 1.5 times GNP growth.

The 1973 world oil crisis did not fail to have a great impact on the Philippne economy. The impact was critically shown in the trade balance, compelling the Philippines to import US$1,800 million of crude oil and oil products, amounting to 21 % of all imports. This was the principal cause of the US$4,200 million deficit in the Philippine international trade balance suffered in 1974, which was US$2,700 million in the black the previous year.

In 1974 the Philippine Government announced the introduction of a new Energy Development Plan in order to improve the pressing situation. In this plan is shown that energy consumption of 83.4 M.M.B. (11 M.M.T.) in 1977 will reach 127.1 M.M.B. (17 M.M.T.) in 1982 and 190 M.M.B. (25 M.M.T.) in 1987 and that the growth rate will be 8.8 % and 8.4 % annually for 1977 - 1982 and 1983 - 1987, respectively (see Table 2-6-3). The plan aims at reducing Philippine reliance upon oil from 94.1 % in 1977 to 80 % and 70 % or less in 1982 and 1987, respectively (see also Table 2-6-2).

To attain this aim, the Government decided to develop more actively indigeneous natural resources such as hydro and geothermal as well as nuclear power (see Table 2-6-3).

The monetary funds needed for total energy development were estimated at ₱66.1 billion or US$8.8 billion (at 1977 prices), of which 50 % was expected from foreign loans.

The final funds will be devided as follows:-

for construction of power stations and transmission lines

₱30.1 billion for 1978 - 1982

₱17.5 billion for 1983 - 1987

for electrification programs

₱2.6 billion for 1978 - 1982

₱2.8 billion for 1983 - 1987

The total used for power reserouces development reaches ₱53 billion, or 80 % of all plan funds.

(1) Power system in general

Electric power generation in the Philippines is now being made by the following organizations:

National Power Corporation (NAPOCOR or NPC)

National Eelctrification Administration (NEA)

Manila Electric Company (MERLCO)

Privately-owned Public Utilities and Cooperatives

By Presidential Decree No.1206 dated 6 October, 1977, the Ministry of energy was created, udner which NPC has become the solely responsible organization for power generation, and NEA has been made responsible for reorganizing the distribution sector in the country.

Total installed capacity in the Philippines is around 3,600 MW in 1979 (NPC Plants plus MERALCO Plants).

About 3,000 MW of the installed capacity (83 %) is located in Luzon grid, while 135 MW (4 %) is in the Visayas grid and 473 MW (13 %) in the Mindanao grid. Following NPC's acquisition of MERALCO steam power plants with installed capacity of about 1,700 MW in 1978 - 1979, about 85 % of the total generating facilities are now owned by NPC.

Total length of transmission lines is 9,800 circuit km. (circuit km = Nos. of circuit x route length in km) throughout the country, which includes:

1,525 km of 230 kV
824 km of 138 kV
1,087 km of 115 kV, and
6,363 km of 69 kV and below.

About 82 % of the transmission line is located in the Luzon grid, while around 13 % is in the Mindanao grid and only 5% in the Visayas grid.

Total electric power generation and consumption in the coutnry amounted to 12,488 GWh and 10,887 GWh, respectively, 1978. Per capita consumption of electric power in the Philippines was 235 kWh in 1978.

The electrification ratio is still at a low level of 32 % for the whole country, but on Luzon Island it is considerably higher at 47 % (See Table 2-6-4).

The load curves for the Luzon Grid are shown in Fig. 2-6-2, 2-6-3, and 2-6-4.

(2) Power demand and power facilities in the Luzon Grid

As seen from what has been explained, power demand in the Philippines is concentrated mainly in the Luzon Grid, the present feasibility study also aims at determinnig the position of the Diduyon project in the Luzon Grid. Therefore, hereunder will be given a description of this grid.

Total net power generation in Luzon attained 11,239 GWh in 1978, which consisted of 3,641 GWh produced by NPC, 7,145 GWh produced by MERALCO and 453 GWh by self-generating cooperatives and industries. About 80 % of the total power generation, or 9,041 GWh, was from thermal power which is mainly oil-fired and steam power plants, while 16 % or 1,745 GWh was from hydropower plants and 4 % or 453 GWh from self-generation. These figures indicate that the power sector in Luzon depends highly on imported oil.

Net power generation has increased considerably at a growth rate of 10.4 % annually over the past 18 years (1960 - 1978). From 1960 - 1969, it expanded at the highest growth rate of

13.5 % per annum. The high rate of growth slowed after 1969, however. Relatively mild growth rate continued from 1969 to 1973 with an average annual increase rate of 8.2 %. The growth of power generation was stopped in 1973 - 1974 due to the oil crisis and the following economic disturbances. However, it began to increase again from 1974 to 1978 at an average annual growth of 8.1 %. The growth rate from 1979 on is now under investigation, as will be described later.

By sector, the industrial sector consumed the largest portion of energy with a 39 % share, followed by residential use with 34 %. The commercial sector consumed 23 % while miscellaneous required 4 % (NPC plus MERALCO energy consumption).

The load factor of generating facilities has gradually been increasing since the early 1960s and attained 63 % in 1978. System loss has been decreased from the early 1960s and was estimated at 10 % in 1978.

Total sales revenues of NPC were ₱921.6 million including fuel cost adjustment in 1978. About 80 % or ₱738.7 million of total sales revenues of NPC was raised in Luzon. The average revenue per kWh in luzon was ₱0.2 in 1978, which was slightly higher than that of the whole country.

Existing power generating facilities in the Luzon Grid as of 1979 are presented in Table 2-6-5. The power projects under construction in 1980 are as follows:

Magat Hydro (540 MW); PNPP No. 1 Nuclear (620 MW);
Kalayaan Pumped Storage Hydro (300 MW);
Tiwi Geothermal No.3 & No.4 (110 MW);
Mac-Ban Geothermal No. 3 & No.4 (110 MW) - 1,680 MW
in total.

Existing electric power plants as of 1979, amounting 2,991 MW or approximately 3 GW, in the Luzon Grid are 75 % thermal (oil-fired), 18 % hydro, and 7 % geothermal.

Table 2-6-1 GROSS NATIONAL PRODUCT, POPULATION, AND PER CAPITA GNP 1977-82 AND 1987

	Value (In Million Pesos)							Annual Growth Rates (In Per Cent)					
	1977[e]	1978	1979	1980	1981	1982	1987	1977 1978	1978 1979	1979 1980	1980 1981	1981 1982	1982 1987
Gross National Product (In Million Pesos at Constant Prices of 1972)	77,804	83,250	89,494	96,206	103,902	112,214	164,879	7.0	7.5	7.5	8.0	8.0	8.0
Gross National Product (In Million Pesos at Current Prices)	152,029	174,076	200,198	230,317	266,093	307,578	633,795	14.5	15.0	15.0	15.5	15.6	15.6
Total Population[1] (In Thousands, Medium Assumption)	45,028	46,350	47,719	49,137	50,557	52,026	59,903	2.9	3.0	3.0	2.9	2.9	2.9
Per Capita GNP (In Pesos at Constant Prices of 1972)	1,728	1,796	1,875	1,958	2,056	2,157	2,752	3.9	4.4	4.4	5.0	5.0	5.0
Per Capita GNP (In Pesos at Current Prices)	3,376	3,756	4,195	4,687	5,263	5,912	10,580	11.3	11.7	11.7	12.3	12.3	12.3

e. Estimated
1. Although the medium assumption is used, the target population level uses the low assumption.

Source : EPRS-NEDA

Table 2-6-2

SOURCE MIX, 1977, 1982 AND 1987

(In MBO/MMBOE)

	1977		1982		1987	
	MMB	% Dist'n.	MMB	% Dist'n.	MMB	% Dist'n.
TOTAL ENERGY	83.40		127.10		190.00	
A. ELECTRIC GENERATION	22.98	27.5	49.40	39.0	66.16	34.8
Hydro	4.42	5.3	9.76	7.7	20.79	10.9
Oil	18.55	22.2	29.33	23.1	21.55	11.4
Coal	0.01	0.0	2.00	1.6	3.90	2.1
Geothermal	-	-	4.80	3.8	10.62	5.6
Nuclear	-	-	2.51	2.0	6.00	3.1
Non-Conventional[1]	-	-	1.00	0.8	3.30	1.7
B. NON-ELECTRIC GENERATION	60.43	72.5	77.70	61.1	123.84	65.2
Oil	59.93	71.9	72.00	56.6	107.64	56.7
Coal	0.50	0.6	4.20	3.3	10.00	5.3
Non-Conventional[1]	-	-	1.50	1.1	6.70	3.2
Oil Share	94.1		79.8		68.1	

1. Includes only usage of non-conventional energy sources attributable to usage proliferation program for non-conventional energy.

Sources: EDB and EPRS-NEDA.

Table 2-6-3 **PLANNED ENERGY CONSUMPTION, 1977, 1982 AND 1987**
(In million metric barrels of oil/equivalent)

Sector	1977		1982		1978-82 Growth	1987		1983-87 Growth	1978-87 Growth
	MMBOE	% Dist'n	MMBOE	% Dist'n	Rate	MMBOE	% Dist'n	Rate	Rate
Total	83.4	100.0	127.1	100.0	8.8	190.0	100.0	8.4	8.6
Transportation	30.3	36.3	40.5	31.9	6.0	59.5	31.3	8.0	7.0
Industry	34.7	41.6	54.1	42.5	9.3	84.2	44.3	9.3	9.3
Commercial	6.8	8.1	12.4	9.7	12.8	17.8	9.4	7,5	10.1
Residential & Others	11.6	14.0	20.1	15.9	11.6	28.5	15.0	7.2	9.4

Sources : EDB and EPRS-NEDA

Table 2-6-4 Status of National Electrification in the Philippines

TOWNS
As of December 31, 1978

Region	Potential	Co-op	Non-Co-op	Total	Per cent-Electrified
I	175	113	25	138	79
II	113	23	12	35	31 Luzon
III	120	91	25	116	97 Grid
IV	234	70	95	165	71 71%
V	115	76	9	85	74
VI	130	71	24	95	73
VII	131	32	42	74	56
VIII	138	37	35	72	52
IX	86	24	16	40	47
X	119	38	18	56	47
XI	90	30	26	56	62
XII	85	46	6	52	61
Total	1,536	651	333	984	64

HOUSE CONNECTIONS
As of December 31, 1978

Region	Potential	Co-op	Non-Co-op	Total	Per cent-Electrified
I	506,300	142,264	44,175	186,439	37
II	295,200	22,396	4,304	26,700	9 Luzon
III	651,700	232,368	174,793	407,161	63 Grid
IV	1,573,500	123,248	833,346	956,594	61 47%
V	497,100	81,181	1,507	82,688	17
VI	596,900	76,908	30,921	107,829	18
VII	514,900	17,191	73,466	90,657	18
VIII	386,700	33,673	7,653	41,326	11
IX	340,900	29,644	3,793	33,437	10
X	370,600	31,034	19,720	50,754	14
XI	485,700	29,169	43,565	72,734	15
XII	324,200	26,061	22,867	48,928	15
Total	6,543,700	845,137	1,260,110	2,105,247	32

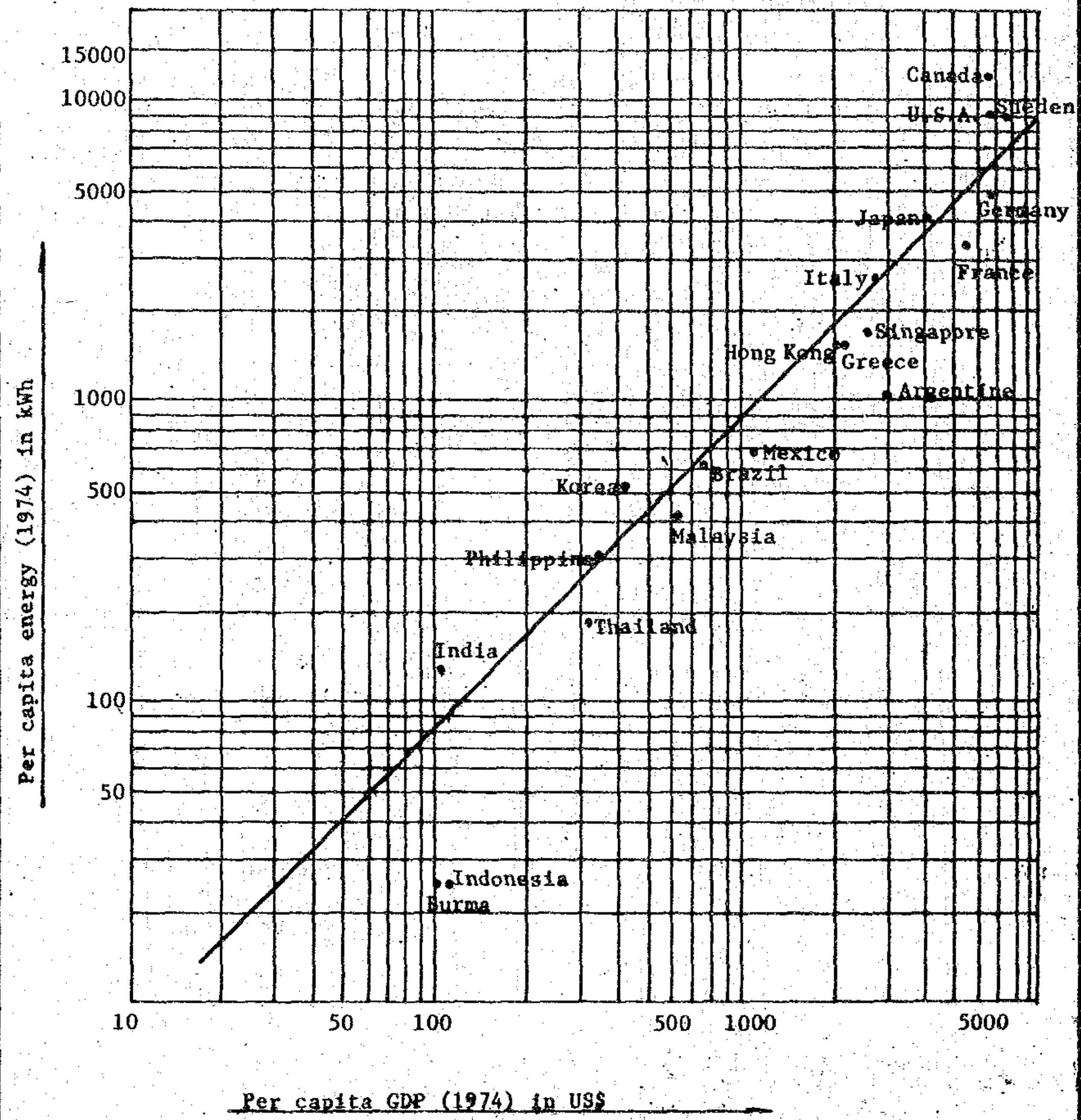
Table 2-6-5 Existing Power Plants In Luzon Grid

(as of end of 1979)

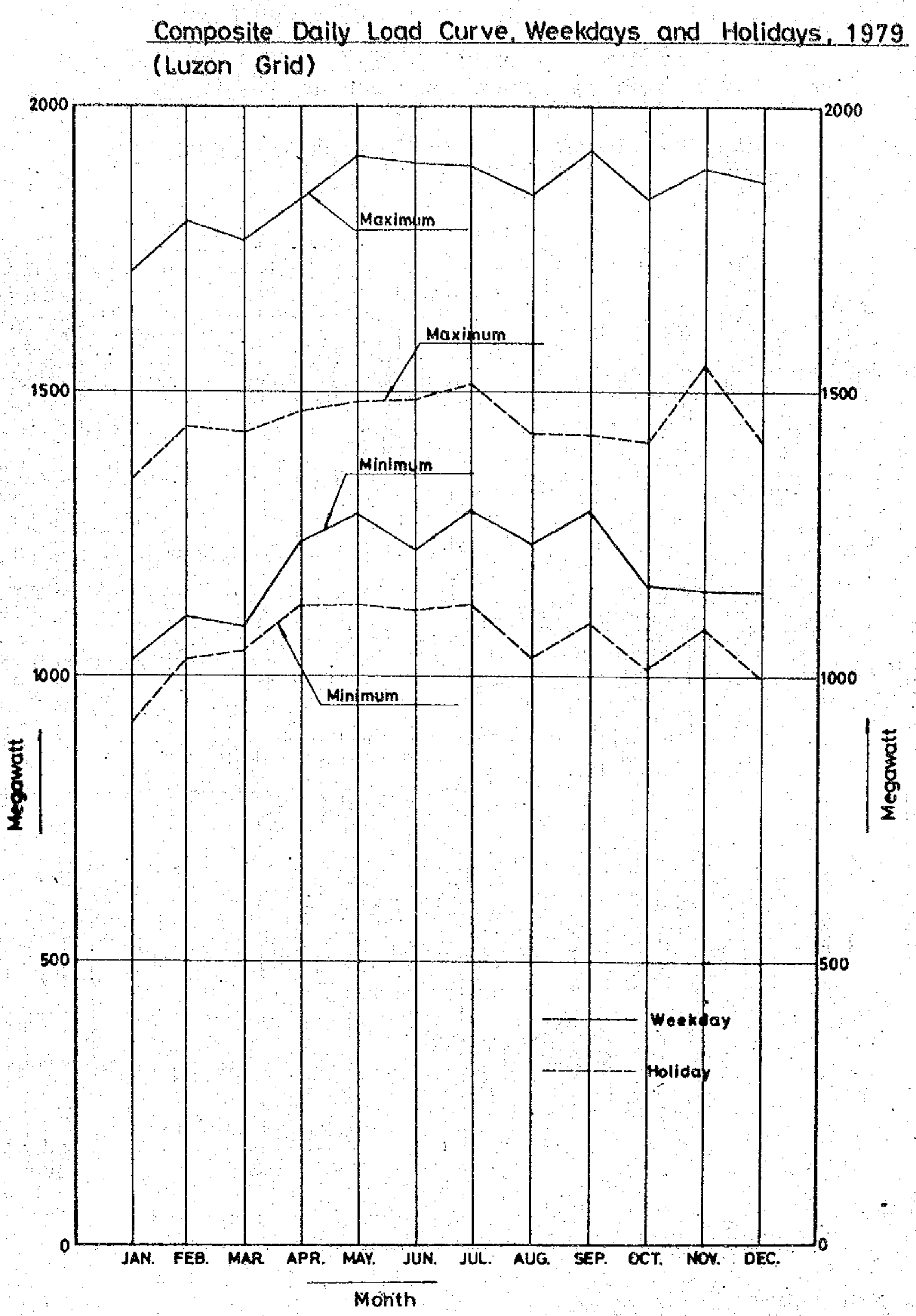
Type	Name		Commision Year	Installed Capacity (MW)
Hydro	Botocan		1928	16
	Caliraya		1945/50	32 (8 x 4)
	Ambuklao		1956	75 (25 x 3)
	Binga		1959	100 (25 x 4)
	Angat		1963	218 (50 x 4 & 6 x 3)
	Pantabangan		1978	100 (50 x 2)
	Hydro Total			541 (18%)
Thermal	Rockwell	1-5	1955	125 (25 x 5)
		6-8	1963	180 (60 x 3)
	Tegan	1-2	1965	200 (100 x 2)
	Cardner	1	1968	150
	Gardner	2	1970	200
	Snyder	1	1971	200
	Snyder	2	1972	300
	Bataan	1	1972	75
	Bataan	2	1978	150
	Malaya	1	1975	300
	Malaya	2	1979	350
	Thermal Total			2,230 (75%)
Geothermal	Tiwi	1-2	1979	110
	Mak-Ban	1-2	1979	110
	Geothermal Total			220 (7%)
	Grand Total			2,991 (100%)

Correlation between Electricity Consumption and GDP, per capita, as seen in the World

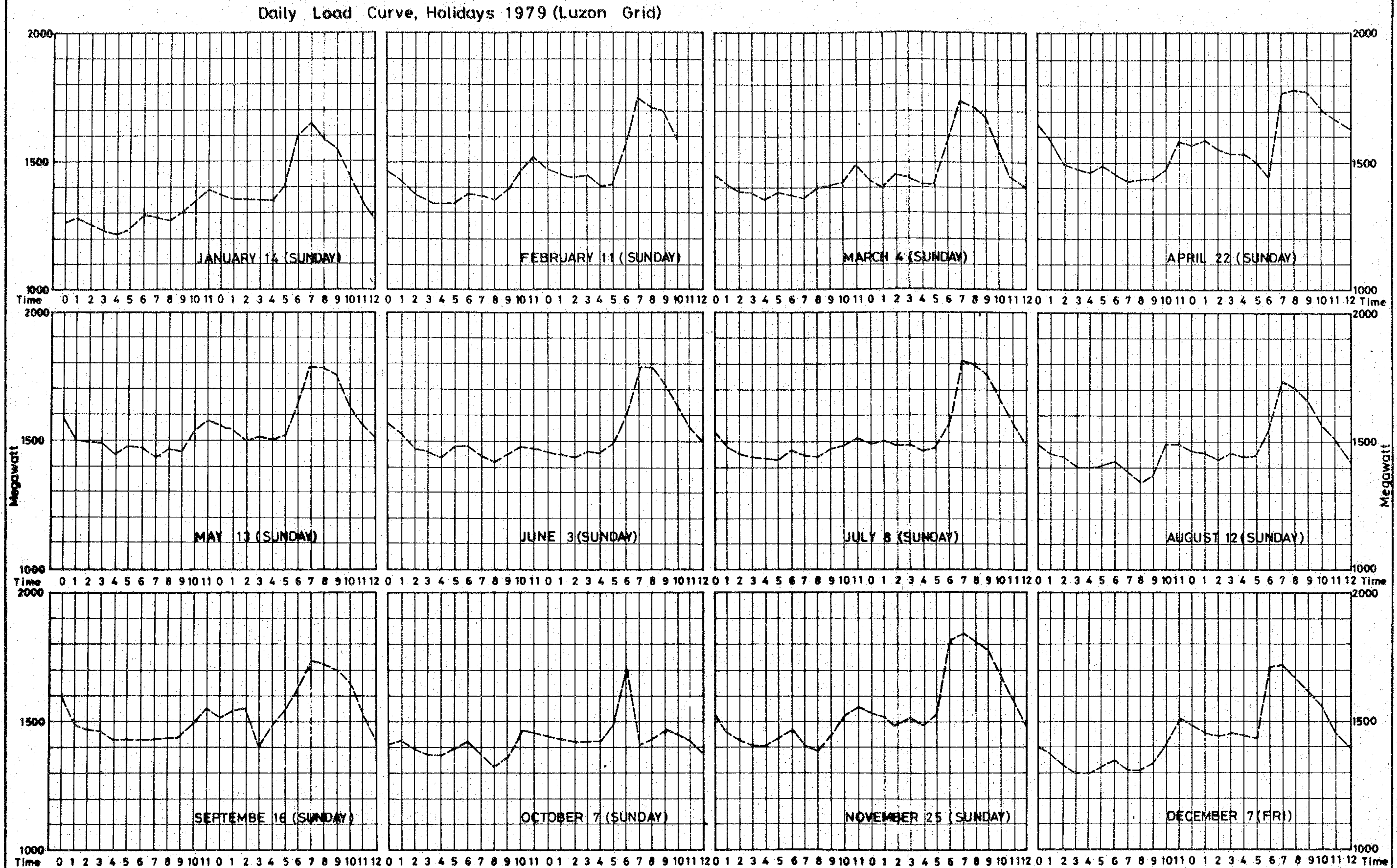
Source: Statistical Year Book, U.N., 1975



Diduyon Hydroelectric Project Upper Cagayan River Republic of the Philippines	
Japan International Cooperation Agency	
Correlation between Electricity Consumption and GDP	
October 1980	Fig. 2-6-1



Diduyon Hydroelectric Project Upper Cagayan River Republic of the Philippines	
Japan International Cooperation Agency	
Composite Daily Load Curve, Weekdays and Holidays, 1979 (Luzon Grid)	
October 1980	Fig. 2-6-2



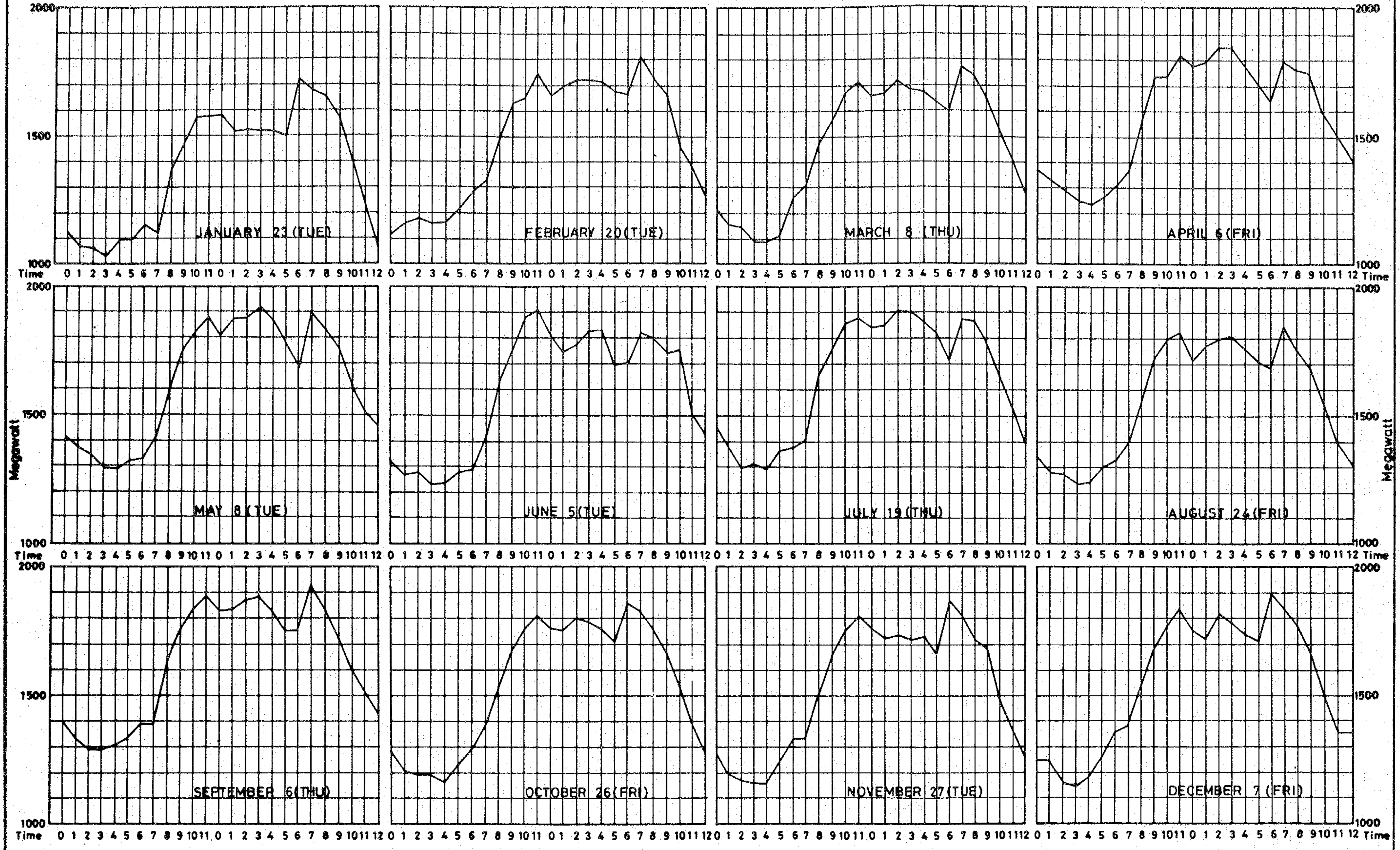
Diduyon Hydroelectric Project
Upper Cagayan River
Republic of the Philippines

Japan International Cooperation Agency

Daily Load Curve, Holiday
(Luzon Grid)

October 1980 Fig. 2-6-3

Daily Load Curve, Weekdays 1979 (Luzon Grid)



Diduyon Hydroelectric Project Upper Cagayan River Republic of the Philippines
Japan International Cooperation Agency
Daily Load Curve, Weekdays 1979 (Luzon Grid)
October 1980 Fig. 2-6-4

2.7. Transportation

2.7.1. Outline

As a part of the investigation of the upper Cagayan River Diduyon Hydroelectric Power Plant Project, this chapter will study the problems of transportation of materials and equipments, i.e., major components of the power plant such as generators, transformers, etc. Studies on the access roads for transportation of materials and equipment up to the powerhouse site and damsite and local procurement of these items were made. Based on the results of the said studies, discussions to determine the basic route for transportation of heavy items are also presented in this chapter.

The outline of field investigations is as follows:

(i) Period of investigation :

July 6, 1978 - August 19, 1978.

(ii) Investigation of ports:

Manila, San Fernando and Casambalangan.

(iii) Investigation of existing roads and bridges:

Manila - Bambang - Cordon,
San Fernando - Rosario - Bambang - Cordon,
San Fernando - Baguio - Bambang - Cordon, and
Casambalangan - Cordon - Bambang.

(iv) Field survey of access road

(a) Access roads

(1) Existing road - damsite (via Bambang), and

(2) Existing road - powerhouse site (via Cordon).

(b) Communication roads (damsite - powerhouse site)

(1) Right bank route,

(2) Left bank route, and

(3) Didipio route.

2.7.2. Port facilities

(1) Selection of ports to be investigated

The maximum unit weight of the generators, transformers, etc., for the Diduyon Hydroelectric Power Plant is assumed to be approximately 37 - 40 tons. Thus, selection of the port facility will be based upon factors such as mooring facilities (pier), water depth, landing facilities for the electric equipment, customs, quarantine, etc., studied on the occasion of field investigations. When selecting the ports to be investigated, the fact that the project area of the Diduyon Hydro electric power plant is located at the center of Luzon island, upstream on the Cagayan River, with the Maddela mountain Range to the east was taken into consideration. It will be necessary to cross the Moddela Range if transporting materials from the ports located on the east side. Taking into consideration these aspects, the ports of Manila, San Fernando, Casambalangan and Aparri, among the international ports existing presently or being planned for construction, located close to the project area,were studied. The locations of the various ports are shown in the map of Figure 2-7-1. and outlines of the facilities available at each port are summarized in Table 2-7-1.

(2) Characteristics of ports

1) Manila

Manila is the largest port of the Republic of Philippines, and is equipped with all facilities required for international trade, such as customs, quarantine, etc. Manila port is divided into 2 parts; South Port (international port) and North Port (domestic port).

2) San Fernando

This is an international port equipped with facilities such as customs, quarantine, etc., required for international trade, and it is reported that transformers of the 90 ton class have been landed here. It is, therefore, expected that this port will present no problem for handling of the equipment of this project.

3) Casambalangan and Aparri

Aparri is equipped with customs, quarantine, etc., facilities required for international trade, but since it is a quasi-international port, it is not equipped with piers, and is expected to be closed after completion of the Casambalangan port. Presently, the port of Casambalangan is equipped with a pier (15 m width, 144 m length, 12 m water depth), with plans for further extension. One petroleum tank and one sugar storage warehouse are presently under construction in that port, and the construction of warehouses, sheds and temporary storage yards is possible, but these are not complete yet.

4) The net tonnage of the ship (W), the berth length (ℓ m) and the berth water depth (dm) are related as follows:

$$W = \left(\frac{\ell}{6.5}\right)^{2.94}, \quad \text{or } W = \left(\frac{d}{0.52}\right)^{3.33}$$

Thus, we have :

when ℓ = 150 m we have a net tonnage W ≒ 10,000 t, and
when d = 9 m, we have net tonnage W ≒ 13,000 t.
It is assumed that the anchoring of cargo ships of 10,000 t net tonnage or more is possible in the ports of Manila, San Fernando and Casambalangan.

2.7.3. Existing roads and bridges

(1) Existing roads (see Fig. 2-7-2)

We carried out investigations on the present condition of main roads and bridges located on the transportation route for heavy items. The roads were investigated with reference to such aspects as radius of curvature, width, gradient, etc., by assuming traffic trailers carrying heavy cargo.

In the Philippines the road network is composed of trunk roads for connection of areas, semitrunk roads for connection of main locations within the area, and daily life roads for connection between villages, and between villages and regional centers used for the daily life of the local peoples.

Trunk roads taken into consideration here refer to the trunk roads mentioned above.

(2) Total extension of existing roads and total number of existing bridges.

1) Starting from Manila:

a) Manila - Bambang

L = 272 km, and No. of bridges - 85.

b) Manila - Cordon

L = 343 km, and No. of bridges - 105.

2) Starting from Casambalangan :

a) Casambalangan - Cordon

L = 329 km, and No. of bridges - 128.

b) Casambalangan - Bambang

L = 400km, and No. of Bridges - 149.

3) Starting from San Fernando :

a) San Fernando - via Route 3 - Bambang

L = 272 km, and No. of bridges - 108.

b) San Fernando - via Route 3 - Cordon

L = 343 km, and No. of bridges - 129.

c) San Fernando - via Route 9 (Baguio) - Bambang

L = 217 km, and No. of bridges - 37.

d) San Fernando - via Route 9 (Baguio) - Cordon

L = 288 km, and No. of bridges - 58.

(3) Existing roads and bridges

1) Route from the port of Manila to Cordon or Bambang (Route 5).

The route for communication between Manila and Bambung is Route 5 (road in relatively good condition), which is a concrete paved road of 8 m width, and does not practically present problems. However, the traffic congestion in Manila and road obstructions in the mountainous area around Dalton Pass during the rain season may present some problems. In addition, due to the excessive load resulting from transportation of heavy component, more than 10 bridges on the existing road will require reinforcement.

2) Route from the Port of Casambalangan to Cordon or Bambang

Communication between the Port of Casambalangan and Diduyon at the intersection with Route 5, is by means of a gravel road of 7 - 10 m width with some 12 m wide sections. This road is constructed on hard soil and is trafficable except the rainy season when it is inundated, however, in such cases the recovery is quick. The existing bridges are either wooden (14) or Pony bridges (6), 3.5 - 4 m in width and with wooden floor slabs. Since the maximum load limit of these bridges is approximately 10 tons, it will be necessary to either replace them or construct temporary bridges. The section between Diduyon and Cordon or Bambang is interconnected by means of Route 5 (road with relatively good traffic conditions), with a width of 6 - 8 m and concrete paving.

As for existing bridges, there are 2 places with Pony bridges and 1 traffic lane (4 m width). Since the floor plate of these bridges is made of wood, it will be necessary to either replace the floor plate or to construct temporary bridges. Bridges requiring protection of the floor number approximately 20, and 2 of them are actually under construction.

3) Route between the Port of San Fernando and Rosario, Sanjose, Bambang or Cordon, vir Route 3, 8 and 5.

Route 3 is a concrete paved road of 8 m width. As for existing bridges, reinforcement will be required at 10 places (especially floor plates, etc.,) in case of transportation of heavy cargo, because the load restriction is approximately 20 tons.

Route 8 is a gravel road of approximately 8 m width. As for the bridges, replacement or construction of temporary bridges will be required at approximately 13 places, where mainly wooden floor palte bridges exists. Route 5 is the Japan-Philippines friendship road, of more than 8 m width and concrete paved, and does not practically present problems with regard to traffic. However, some problems may be expected in the neighbourhood of Dalton Pass, as mentioend before. As for the existing bridges, protection of the floor plate is required at more than 5 places.

4) Route from the Port of San Fernando to Baguio, Aritao, Bambang or Cordon, via Route 9

The section of Route 3 between the Port of San Fernando and Bambang is concrete paved road of 8 m width, and does not present any problems at all. Bridges also are secure. The section between Bauan and Baguio is an asphalt paved road of 5 - 8 m width. In case of transportation of heavy cargo, trafficability will be low, in view of the existence of slopes of 8 - 10 % in the road. There are many places requiring cutting of the mountain side slope, because the radii of curvature are too small. As for bridges, there are at least 2 places requiring reinforcement, especially in the floor palte.

The section between Baguio and Aritao is composed of gravel road of 3.5 - 4.5 m width, and there are many points with 8 - 12 % slope. The dadli of curvature of this road are small, requiring cutting of the mountain side slope in many places, in addition to landslide occuring at many points. As for the bridges, there are pony bridges at approximately 20 places, and almost all of them require either replacement of the wooden floor slabs or construction of temporary bridges. The section between Aritao and Cordon is a concrete paved road of 8 m width. There are 5 bridges in this section, and reinforcement of the floor plate is not required.

5) The standard width of the actually existing road is shown in Fig. 2-7-3.

2.7.4. Access Roads

(1) Planned route

The following routes can be taken into consideration when planning the access roads between the presently existing main roads and the damsite and powerhouse site.

1) Route between existing roads and damsite.

(i) Bambang - Kasibu - Siguem - damsite

(ii) Bambang - Malashiu - Siguem - damsite

2) Route from existing roads to the power plant site

Route from Cordon to the power plant site, via Luna, Debibie and the left bank of the Diduyon River.

The various routes surveyed are shwon in Fig. 2-7-4.

(2) Routes from the presently existing roads to the damsite

1) Route from Bambang to the damsite, via Kasibu and Siguem

a) Bambang - Kasibu

i) Surveyed route and extension

(Refer to Fig. 2-7-4.)

Indication of maximum distance calculated by methods such as,

- Calculation of the distance : the longest distance among those measured by odometer of automobile, step counter, scale-up from the topographical maps, extension from 8% slope of elevation difference.

- Elevation : Estimated by means of altimeter (barometer and topographical map).

- Total extension of roads : L = 35 m.

ii) Actual road situation

The presently existing roads have a width of 4 - 5 m, there are rocks and stones scattered everywhere along the road, the subbase course is not in good condition, and practically the whole extension of the road is composed of gravel without paving.

There are sections of the road with altitudes exceeding 900 m in the mountainous districts, where the slopes are quite steep, of the order of 8 - 12%.

In addition, due to the small radii of curvature, there are sections where cutting of the mountain side slope, changes of route, etc., will be needed. It is expected that improvements such as widening of the road, improvement of the subbase course, improvement of the slope, etc., will also required. As for the bridges, there are 13 wooden bridges and 3 Bailey bridges, totalling 16 bridges. Since all bridges have 3.6 m width, they require replacement or the construction of temporary bridges. Among the presently existing bridges, the San Fernando bridge was destroyed by innundation, and requires construction of a new bridge of more than 50 m or the construction of a temporary bridge.

iii) Topographical and geological conditions

The section between Bambang and the town of San Fernando is a gravel road of 8 - 10 m width, and does not require improvment. In the neighbourhood of Dalton Pass the road width narrows, and topographically there are places with steep slopes, but from the geological point of view the ground is hard, and can be considered satisfactory.

Next, in the Kongkong Valley, the topography becomes easy, because the required cut will be small. However, since the soil is soft (large quantities of sand and clay, with small quantities of gravel), it will be necessary to add gravel and other materials to the subbase course in order to attain sufficient bearing capacity.

iv) Problems

Since the Bambang - Kasibu ection is a semi-trunk line, measures to cope with the transportation of daily necessities and emergencies will be required in case of prolonged interruption of traffic due to the improvement works.

b) Kasibu - Damsite

i) Surveyed route and extension

Kasibu - Siguem - Damsite :

L = 27 km

ii) Actual state of the road

Actually there is a logging road in this section which can be used for transportation of construction materials. During the dry season it is possible to transport materials of considerable weight using special vehicles. However, its plan, maximum slope, state of maintenance of road surface, etc., are just able to fulfill the minimum indispensable conditions. Consequenly, in order to make possible the traffic of ordinary vehicles, it will be required to carry out overall road repairs and construction of new bridges. In addition, since these roads are located within the area expected to be inundated by the storage reservoir, it will be necessary to study carefully the problems of construction indemnification of the existing roads and construction of relocated roads.

As for the actual situation of the logging road, there are many landslide places due to soft ground condtions. Road buried under debris, erosion of the road due to imperfect drainage facilities (culverts, etc.) intended to cope with water coming from mountain streams, formation of quagmires, etc. are observed everywhere. Steep slopes of the order of 8 - 12% and small radii of curvature are also observed, it therefore being required to cut the mountain side of the slope at various places along the road. As for bridges, the construction of a temporary bridge will be required at the Biyoy River, and in addition, there are more than 3 places where the road will cross mountain streams, requiring the construction of either culverts or temporary bridges.

iii) Topographical and geological characteristics

At the section between Kasibu and the damsite, the topography is not steep, and the work is expected to be easy, with the exception of some places requiring slightly larger cuttings. However, in view of the soft soil (composed mostly of sand and clay, with small quantities of pebble), reinforcing of the subbase course with gravel and other materials will be required in order to ensure sufficient bearing capacity.

In general, burying of the road due to landslides and erosion and formation of mud due to water from mountain streams is very pronounced, and careful studies to cope with these problems will be required from the planning stage.

2) Section between Bambang and the damsite, via Malashiu, Manga and Siguem

a) Section between Bambang, and Malashiu, and Manga

i) Surveyed route and extension

Bambang - Malashiu - Manga : L = 20 km

ii) Actual stage of the road

The section between Bambang and Malashiu passes through Route 5. There are no any problem at all for traffic. From Route 5 the road branches immediately to Route 30, and the road becomes a gravel double lane road, which is perfectly trafficable. However, there are 2 places with wooden bed plate bridges which should be replaced. At the section between Malashiu and Manga the road is gravel but has 2 lanes, and is perfectly trafficable. However, there are 2 places with Pony bridges approximately 10 m long, with wooden bed plate requiring replacement. This section does not present any special problem, with the exception of the bridges.

b) Section between Manga and Siguem and the damsite

i) Surveyed road and extension

Manga - Siguem - Damsite : L = 38 km

ii) Actual state of the road

This logging road enters into the basin of the Diduyon River at Manga and since it climbs a difference of altitude of 600 m, starting from the initial EL 400 m up to EL 1,000 m at the Pass, the slope of logging road is very steep. As a logging road it disploys no problems because cut logs are transported from the Diduyon river basin in the downhill direction on this road. In case of the hydroelectric power plant development project, however, the required materials and equipment will be transported uphill. Thus, this section should be improved or alternative routes constructed.

At the section between Siguem and the pass, both topography and slope are very easy, and the road has sufficient width. From the geological point of view, however, there are many parts with soft subbase course, so construction of drainage facilities and the application of gravel to cope with the rainy season will be necessary. In this section there are also 2 precipices requiring relocation of the road. The road crosses the river at 2 points, each of which require the construction of long bridges

As for the section between Siguem and the damsite, the road shows the same characteristics as prevailing in the section between Kasibu and the damsite described previously.

3) Section between Cordon and the powerhouse site via Luna and Dibibie

i) Surveyed route and extension

Cordon - Luna - Dibibie - Powerhouse site	:	L = 48 km

ii) Actual state of the road

The section between Cordon and Luna is a gravel road of approximately 8 m width, and no problem is expected with regard to traffic. In the section between Luna and Dibibie the surface of the road is in very bad condition, so paving with gravel or asphalt will be required. As for the bridges, there are wooden bridges (3 places, 4 m width) and Pony bridge (1 place, 4 m width), but in case of transportation of heavy cargo, either replacement or construction of temporary bridges will be required. In this section there is also a place with a synthetic (composite) beam bridge ($\ell \fallingdotseq 50$ m), which will require reinforcement.

At the section between Dibibie and the powerhouse site, there is a logging road for transportation of logs, constructed up to the halfway point, of 4 - 5 m width and with 8 - 12 % slope at various points. Generally speaking, the soil is soft, and burying of the road due to landslides and formation of mud due to the mountain streams observed at approximately 15 places.

iii) Topography and geology

Since the section between Cordon and Luna and Dibibie is a plain area, the road does not present special problems except enlargement and improvement at the section between Luna and Dibibie. Since at the section between Dibibie and the powerhouse site the soil is soft (composed mostly of sand and clay, with small quantities of pebble), gravel and other materials should be applied on the subbed course in order to ensure sufficient bearing capacity. Generally speaking, burying of the road and erosion due to mountain streams formation of mud are observed, so care will be required from the planning stage.

2.7.5. Communication roads

(1) Planned routes

There are 3 possible routes for the communication road between the damsite and the powerhouse site, as listed below:

i) Route utilizing the presently existing logging road

ii) Route newly constructed along the headrace tunnel

iii) Route branching from the access road

The routes mentioned above are shown in Fig. 2-7-5.

① Communication road starting from the powerhouse site, coming back to Dibibie, and then probressing from Didipio to the damsite

The road between Dibibie and the log storage yard located halfway to Didipio is a gravel road of 4 - 6 m width and 8 - 12 % slope, and requires improvements. There are wooden bridges at 2 places, requiring either replacement or construction of temporary bridges.

The section between the log storage yard and the damsite via Didipio,is also a road of 4 - 5 m width and a maximum slope of approximately 12 %, and there are more than 5 places with radii of curvature requiring cutting of the mountain side slope. As for the subbase course, the same improvements described above will be required.

② Route of the roads located in the waterway section for construction and maintenance purposes

In view of the geological and topographical conditions prevailing in the area, the work itself seems to be easy. Howevery, improvements to cope with the soft subbase course and drainage facilities will be also be required in this case.

③ Route branching from the access road

This road has the same characteristics of route as the waterway section mentioned above, with the exception of the location of the route. There are 5 - 7 valleys requiring construction of either bridges or culverts.

2.7.6. Summary of Results of Investigation on Transportation Routes

The results of the present investigations can be summarized as follows:

(1) Taking into consideration factors such as available port facilities, actual situation of the roads, transportation time, location of shops dealing with automobile parts and

repair garages, the occurrence of landslides and the consequent road traffic trouble which occurs frequently during the rainy season, etc., it is recommended that the Manila - Bambang transportation route to the project site located in Diduyon be adopted.

The other routes can be used as alternatives when transportation via Manila becomes impossible.

The Magat construction project was also taken into consideration as a reference before deciding on the Manila - Bambang route. The Magat project site is located far to the north of Manila compared with Diduyon, but the main machinery and construction materials were transported from Manila.

(2) The transportation of materials, equipment and heavy items will be done using the Port of Manila as the starting point.

Both San Fernando and Casambalangan allow anchoring of ships with net tonnage of the 10,000 ton class, and the mooring facilities are sufficient, but the port of Manila has the most desirable characteristics, in view of its most favourable pier facilities. The ports of San Fernando and Casambalangan present problems of transportation route up to the site.

(3) The Manila-Bambang route is recommended for transporting materials from the port of Manila. This route doesnot exhibit any practical problems referring to the existing roads, and the bridges requring reinforcement are approximately 19, a considerably smaller quantity than with other routes as follows:

L = 272 km and No. of bridges - 84.

(4) As for the access road between the extremity of the main road up to the damsite, there are two possible alternatives, i.e., the route Bambang-Kasibu-Damsite, with improvements to the existing logging road, and the Bambang-Malashiu-Campote route, with improvements to the actually existing logging road. The selection of either alternative will depend upon future investigations and studies.

(5) For the access road to the powerhouse site, the Cordon-Luna-Dibibie-left bank road-powerhouse site seems to be best.

(6) The communication road between the damsite and powerhouse depends upon future investigations, but the route damsite-left bank mountanous districts-Didipio adit sites-Surge tank seems to be best. Another access road to the surge tank and the power plant will be required; and on this case a roundabout route of considerable length will be necessary in view of the very large difference in altitude.

2.8. Construction Materials

2.8.1. Concrete Aggregate

The concrete aggregate required for construction of the dam, waterway, surge tank, powerhouse and other structures will be excavated from riverbed sediments and quarries in the neighbourhood of the damsite.

The locations of possible places for excavation of aggregate determined as a consequence of the present studies are shown in Fig. 2-7-6. As a results of the present atudies, the deposited materials found at Aglipay in the Addalam River and at Bambang in the Magat River seem best suited for utilization as concrete aggregate. The site for exploration of a quarry initially selected, located on the right bank of the river, downstream of the damsite does not seem to be adequate, in view of negative factors such as the excessive thickness of the overburdens, inadequate quality and insufficient quantity of rock.

However, in the present project the dam will require 1.2 million m^3 of concrete, and if the other structures are taken into consideration, the required quantity of concrete will be 1.6 million m^3. The corresponding quantity of aggregate will be approximately 2 million m^3, and to secure a source of supply of aggregate in the neighbourhood of the project site is a fact which will acquire special importance.

Thus, at the next stage of the study it will be necessary to carry out detailed investigations in order to locate an adequate quarry or a place on the river bed for procuring aggregates for concrete.

Generally speaking, both the production of fine aggregates from a quarry and the transportation of river-deposited materials from a distant point will mean a considerable increase in cost. Thus, detailed studies are required with regard to the costs for production and transportation of aggregates.

In addition, sicne artificial aggregate obtained by crushing rocks excavated from quarries results in some cases in alkaline reactions, it is necessary to carry out tests regerring to this aspect.

2.8.2. Cement

Presently, the supply of cement in the Philippines is sufficient to meet domestic demand.

However, both at the present and in future, large scale cosntruction projects will be carried out around the country. Especially on Luzon Island,the Gened Project, including the construction of a concrete arch dam of 175 m height 2 million m^3 of concrete, is scheduled for construciton before the present Diduyon project.

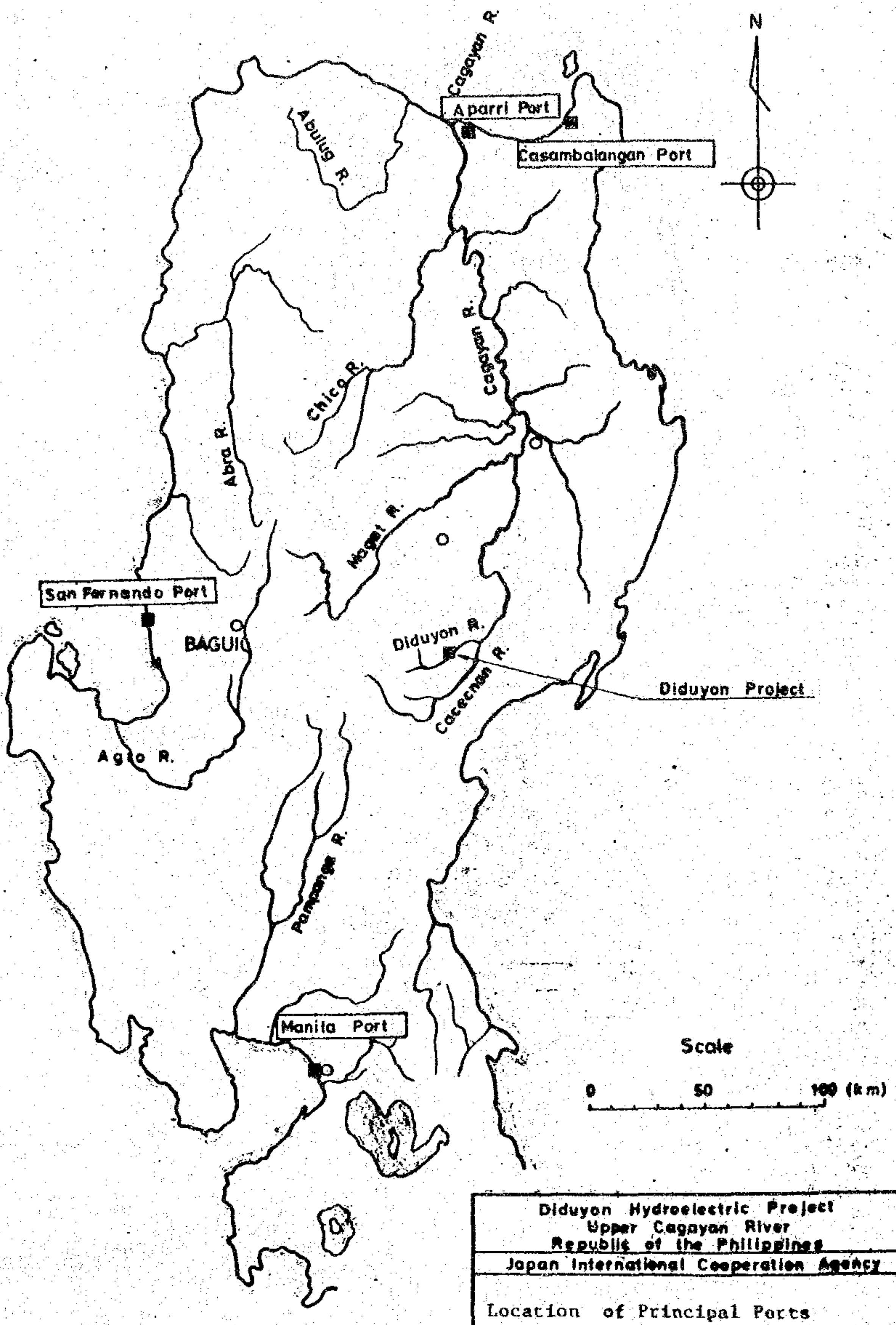
In the Philippines, it is possible to expect an increase in cement supply capacity in the future, and for construction of the Diduyon project it will be possible to utilize the cement supply facilities used in the otehr peojcts mentioned above.

Besides the quantitative aspect of cement supply, it will be necessary to carefully study the qualitatibe aspect, in order to reflect the obtained results in the design.

Table 2-7-1 Existing Port Facilities

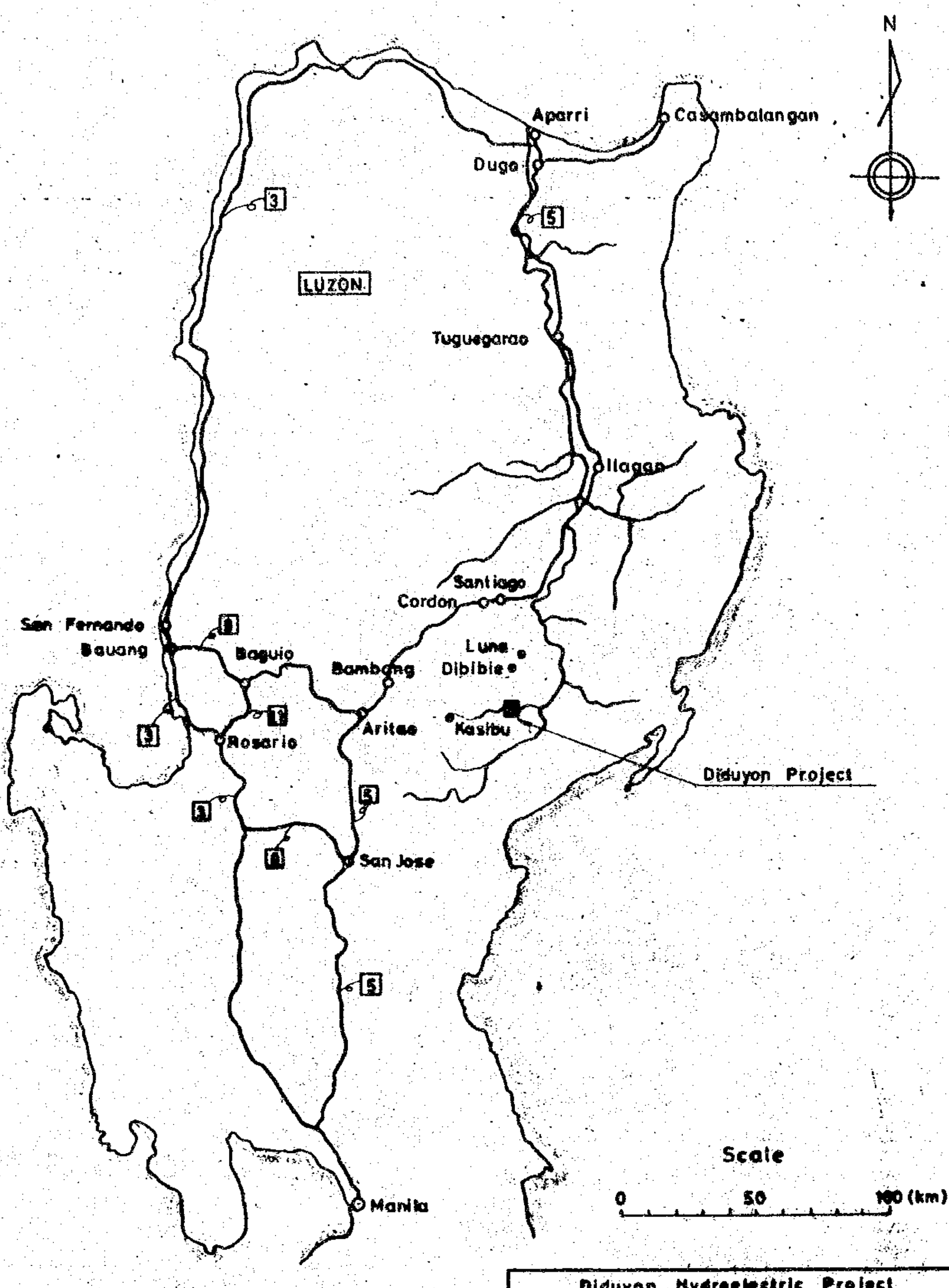
Port (Facilities)		Berthing facilities: Pier			Berthing facilities: Wharf		Storage facilities: Transit shed		Storage facilities: Ware house		Storage facilities: Open storage	Control depths	Open port facilities: Port area	Open port facilities: Causeway	Open port facilities: Other port	Open port facilities: Unlooding facilities
		Number of berths	Length in meters	Width in meters	Number of berths	Length in meters	Number	Area in square meters	Number	Area in square meters	Area in square meters	Depth in meters	Area in square meters	Length in meters	Structure	
Manila	Foreign (South Harbor)					1,012			2	30,470	26,247		579,103		Bulkhead	
	Pier 3	4	385	103											Jetty	
	Pier 5	4	360	103			4	12,195							Slip	
	Pier 9	4	361	101			3	10,461							- do -	
	Pier 13	4	433	82			4	12,035							- do -	
	Pier 15															
	Domestic (North Harbor)												17,850		Break water	
	Pier 2	3	221	84											Slip	
	Pier 4	6	214	82			3	2,232							- do -	
	Pier 6	6	221	80			2	1,488							- do -	
	Pier 8	6	221	81			2	1,488							- do -	
	Pier 10	6	221	80			4	2,976							- do -	
	Pier 12		221	81			4	10,080							- do -	
	Pier 14		221	84			2	3,200							- do -	
San Fernando	Foreign	2	200	19								9	19,600	85		
	Domestic	2	264	26								9		85		
Casambalangan			144	15								12				
Aparri	Foreign and Domestic				5	385						15	118		Jetty	

Location of Principal Ports



Diduyon Hydroelectric Project Upper Cagayan River Republic of the Philippines	
Japan International Cooperation Agency	
Location of Principal Ports	
October 1980	Fig. 2-7-1

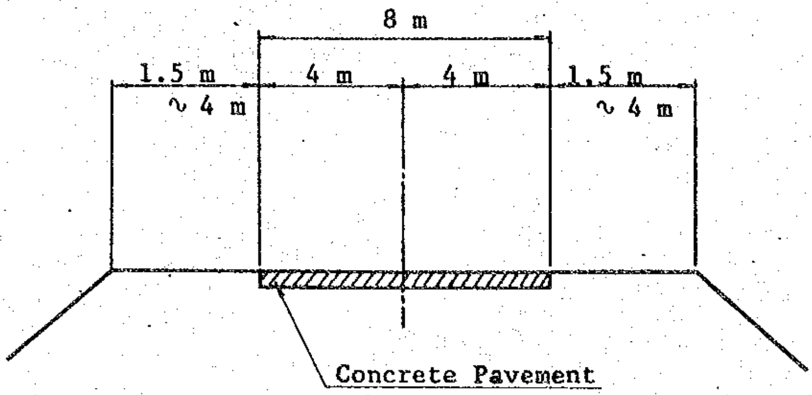
Existing Road Map



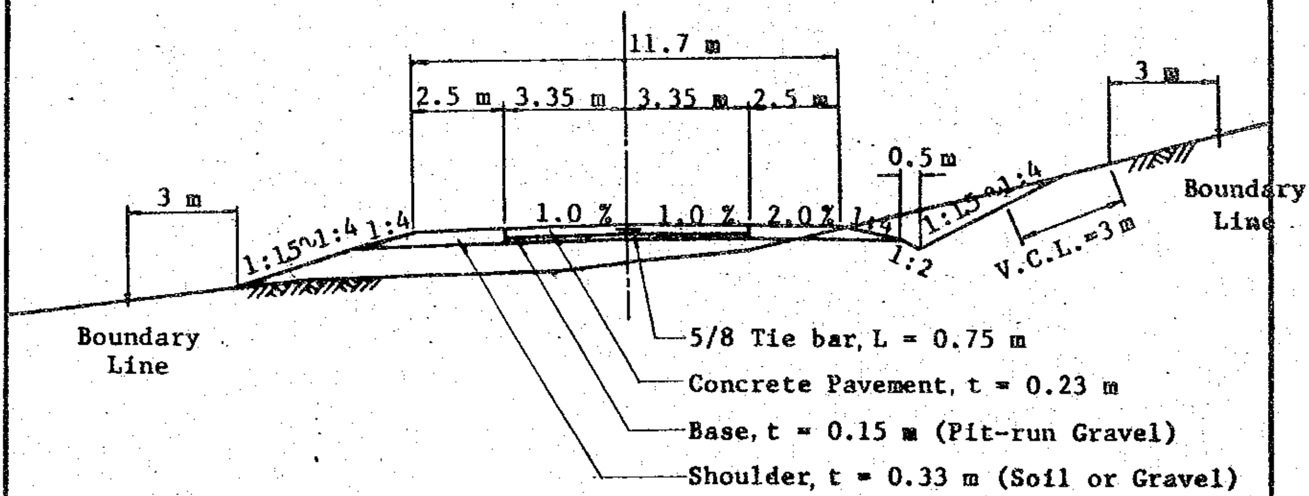
Diduyon Hydroelectric Project Upper Cagayan River Republic of the Philippines
Japan International Cooperation Agency
Existing Road Map
October 1980 Fig. 2-7-2

Standard Section of Existing Road

a) National Road



b) Japan-Philippine Friendship Highway

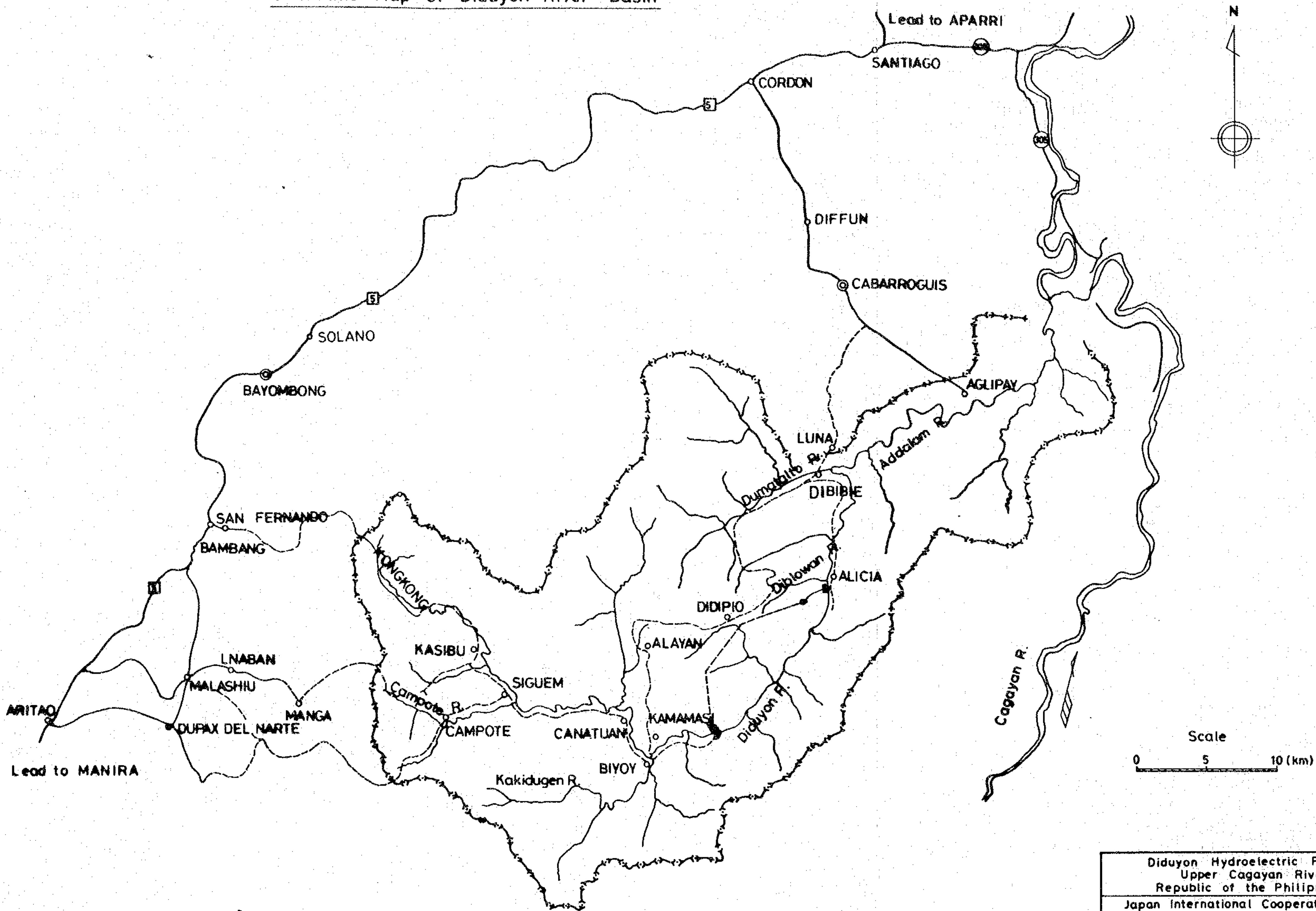


Design Criteria

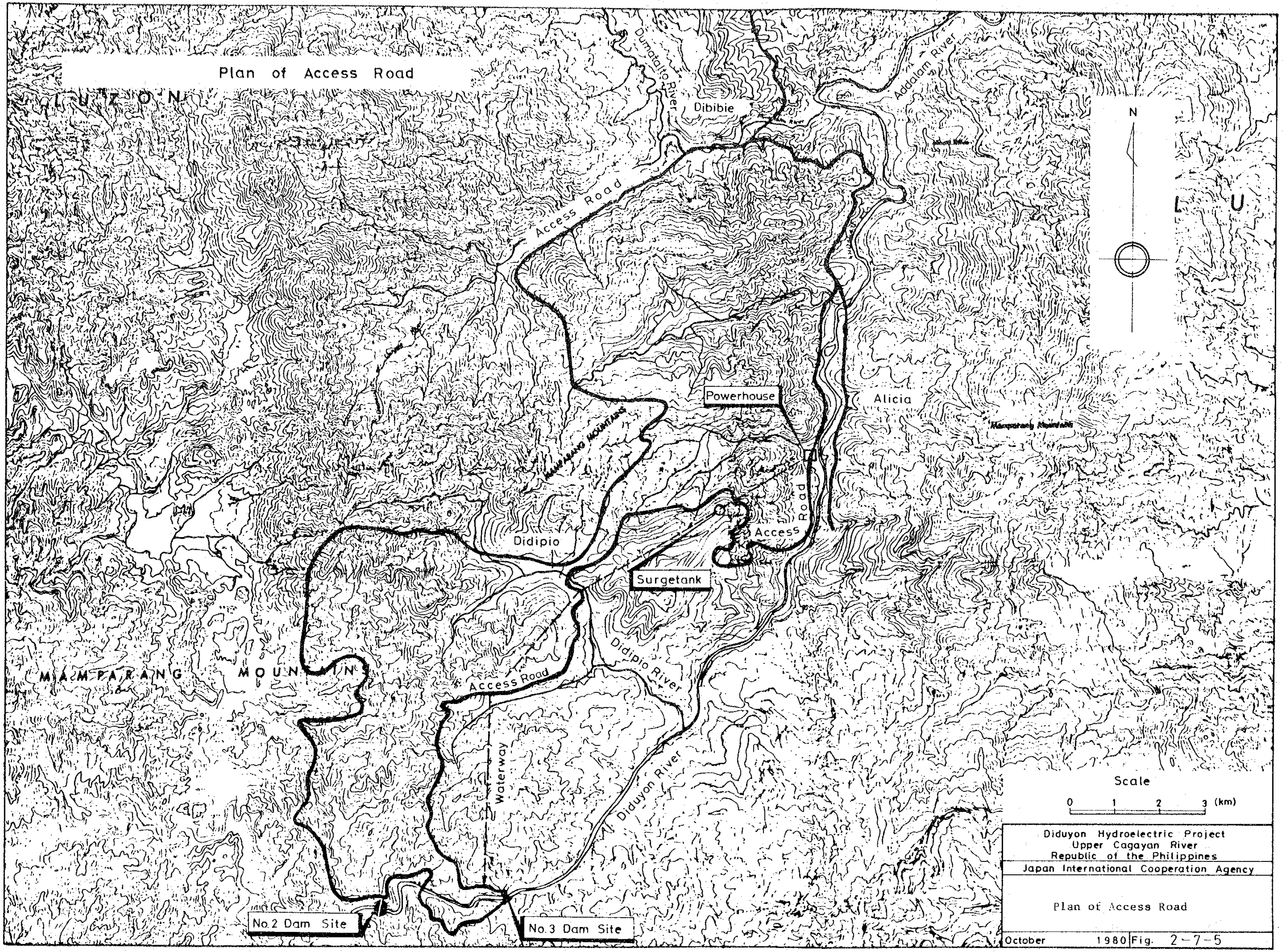
Lane Number	2 Lanes (3.35 m x 2)
Design Velocity	Flat Ground Portion 80 ∿ 100 km/h Hill Portion 60 ∿ 80 km/h Mountain Portion 40 ∿ 60 km/h
Longitudinal Slope	Maximum 6% (Exceptionally 7%)
Minimum Radius	50 m (40 km/h) 300 m (100 km/h)

Diduyon Hydroelectric Project Upper Cagayan River Republic of the Philippines	
Japan International Cooperation Agency	
Standard Section of Existing Road	
October 1980	Fig. 2-7-3

Schematic Map of Diduyon River Basin

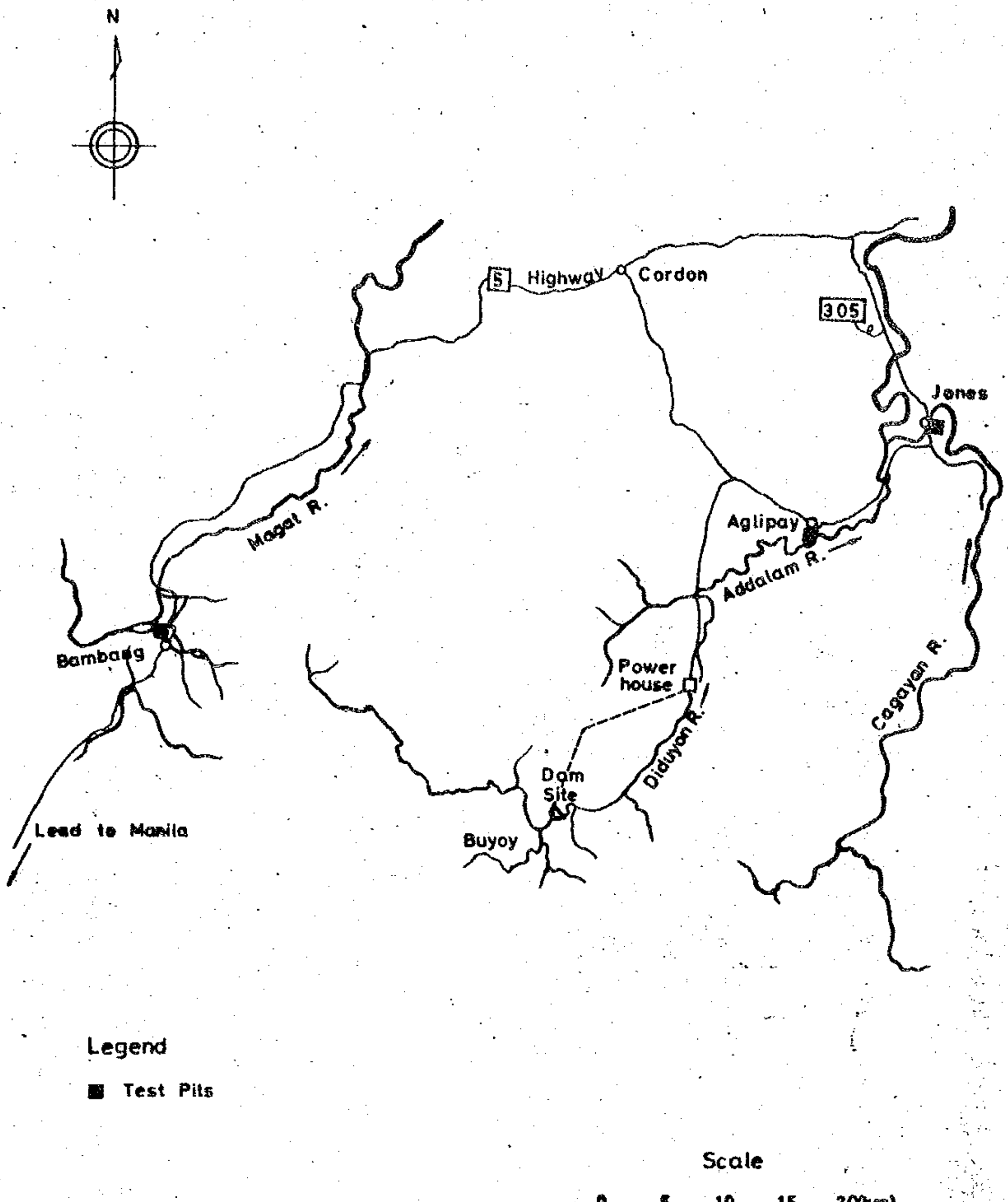


Diduyon Hydroelectric Project Upper Cagayan River Republic of the Philippines
Japan International Cooperation Agency
Schematic Map of Diduyon River Basin
October 1980 Fig. 2-7-4



Diduyon Hydroelectric Project Upper Cagayan River Republic of the Philippines	
Japan International Cooperation Agency	
Plan of Access Road	
October 1980	Fig. 2-7-5

Location of Test Pits for Concrete Aggregate



Diduyon Hydroelectric Project Upper Cagayan River Republic of the Philippines	
Japan International Cooperation Agency	
Location of Test Pits for Concrete Aggregate	
October 1980	Fig. 2-7-6

Chapter 3 DEVELOPMENT OF FEASIBILITY GRADE DESIGN

Chapter 3 Development of Feasibility Grade Design

3.1. Review of Optimum Development Plan

3.1.1. Introduction

As described previously in Vol. I, Chapt. 3, 3-3-3, at the preliminary stage of study it was considered that two plans out of various development schemes were most economically favourable — the scheme with an underground powerhouse in the middle point of the waterway and the scheme with an open type powerhouse to be constructed at the terminal of the waterway, both schemes to be developed in one stage.

It was also recommended at the first stage of study that though the underground powerhouse scheme apparently seemed economically fabourable, this type of development might sometimes include geological difficulties, and that the final decision would be made after the termination of necessary explorations.

Along with the general layout of the development scheme, the type and magnitude of the reservoir dam was also suspended to the time of actually implementing the necessary survey work.

Tnis section will discuss the review and selection of the optimum development scheme and design.

3.1.2. Selection of Optimum Development Plan

(1) Optimum Development Scheme Reviewed

The details of the drilling exploration at the proposed powerhouse site are described in Vol. II, Chapt. 2, 2.2.4. Summing up the result of a 400 m deep drillings, the geologist reports the occurrence of a whole leakage of circulation water. The drillers resumed the work after cement and bentonite grouting around the point, but the succeeding drilling work went on very poorly. An intense geologic reconnaissance around the location led to a suspicion of the presence of a large-scale fault or similar geologic disturbances in this area and in the proposed tailrace tunnel route.

The drilling conducted around the open type powerhouse site shows, on the other hand, that the geologic conditions were conparatively sound and that the construction there would be easy and safe.

Based on these geological results, a review was made of the preliminary comparative analysis on powerhouse type as well as development scheme in general.

With the reservoir dam fixed at the Damsite No.3, design of an underground powerhouse and an open type powerhouse was made as shown in Figs.3-1-1 ∿ 3-1-4 and Fig. 3-1-5 respectively, together with the pertinent components of structures.

The salient figures of these two schemes are presented in the following summary.

Item	Unit	Scheme I (Open Powerhouse)	Scheme IV (Underground Powerhouse)
Total construction cost	$\$x10^6$	470.8	483.2
Maximum Plant discharge	m^3/sec.	85.2	85.2
Loss head	m	35	30
Dam height	m	111	111
Length of headrace tunnel	m	11,700	5,500
Length of penstock	m	2,013	440
Length of tailrace tunnel	m	203	6,940
Length of transmission line	km	45	52
Annual plant generation	GWh	957	967
Peaking capacity	MW	345	349
Firm output	MW	308	312

The table shows that the Scheme IV requires a surplus cost of $12.4 million against a gain of 4 MW in peaking capability and firm output and 10 GWh in annual generation.

To assess the economic priority, a method of cost-benefit analysis is applied, with the result as follows:

	Scheme I		Scheme IV	
	Benefit-cost ratio B/C	Net-benefit B-C ($\$x10^6$)	Benefit-cost ratio B/C	Net-benefit B-C ($\$x10^6$)
Power station w/o transmission line	1.79	30	1.77	29
Power station w/ transmission	1.74	29	1.72	28

Thus, the review shows that the Scheme IV (open type powerhouse) is slightly more economical than the Scheme I.

As a matter of fact, such a small difference of benefit calculated might be practically regarded of no significance. But, with such figures in mind, it will be concluded from a view point of engineering that the most sound development scheme is the conventional open type powerhouse constructed at the terminal of waterway at one stage, if the beneficial difference is so small.

(2) Selection of Damsite and Dam Type

Along with the progress of topographical and geologic surveys, a comparative study of the reservoir dams was made (see Figs. 3-1-6 ∿ 3-1-10). For the damsite No.2 only fill type dam is considered applicable, while for damsite No.3 either fill type dam or concrete gravity type may be adopted. The salient features of these proposed dams are as stated below:

Dam type \ Damsite	Unit	No.2	No.3	
		Fill dam	Fill dam	Concrete dam
Design flood of spillway	m^3/s	10,500	10,700	8,900
Dam height	m	86	113	111
Dam crest length	m	692	422	415
Dam volume	$x10^6 m^3$	6.04	6.88	1.2
Concrete volume of spillway	$x10^6 m^3$	0.24	0.64	-
H.W.L. of reservoir	EL m	653	648	648

The dam height for each type of dams was optimized by a benefit-cost analysis method as shown in Figs.3-1-11/3-1-12.

It must be noted that the fill dams at No.2 and No.3 damsites are designed for comparison. From the result of the feasibility surveys, it is reported that any suitable places for acquiring the necessary fill materials with sufficient volume and quality are not available in the vicinity. Cost estimates are made, however, on the assumption that these materials are available at quarries within a distance of 10 km.

Based on the design data, a comparative economic analysis was done on the selection of dam types in relation to the whole scheme, as represented in Table 3-1-1. As the basic project scheme, one-stage open powerhouse plan as described previously was adopted.

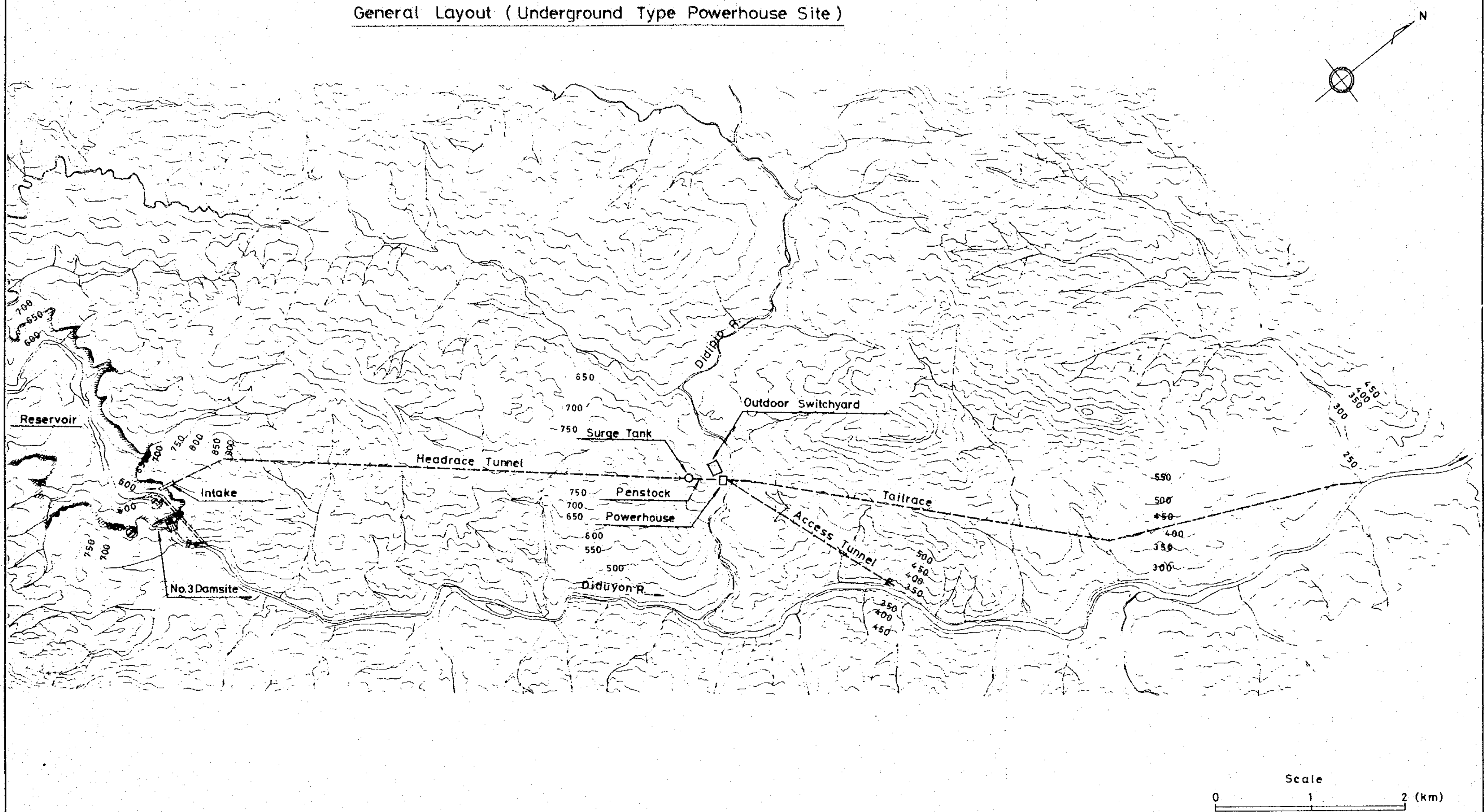
From this table, it will be easily seen that the most economical plan is that of a concrete gravity dam at No.3 damsite.

Table 3-1-1 Summary of Comparative Study of the Optimum Plan Among Alternative Development Plans

Item		Unit	Description			
Damsite		-	No. 3	No. 3	No. 3	No. 2
Type of Dam		-	Concrete	Concrete	Fill*	Fill*
Reservoir H.W.L.		EL.m	648.	648.	648.	653.
Type of Powerhouse		-	Conventional	Underground	Conventional	Conventional
Total Construction Cost		$\times 10^8$ ¥	1,177.	1,208.	1,498.7	1,357.5
- " -		$\times 10^6$ $	470.8	483.2	599.5	543.
Associated Tr. Line		$\times 10^8$ ¥	24.	27.2	24.	24.
- " -		$\times 10^6$ $	0.96	1.09	0.96	0.96
Design Flood of Spillway		m^3/sec.	8,900	8,900	10,700	10,300
Dam Height		m	111.	111.	113.	86.
Dam Crest Length		m	415.	415.	422.	692.
Dam Volume		$\times 10^6 m^3$	1.2	1.2	6.68	6.04
Concrete Volume of Spillway		$\times 10^6 m^3$	-	-	0.64	0.24
Annual Energy Generation		GWh	956.8	967.	956.8	975.1
Max. Plant Discharge		m^3/sec.	85.2	85.2	85.2	88.
Loss Head		m	35.	30.	35.	35.
Effective Head		"	451.	456.	451.	456.
B-C	for Total Construction Cost	$\times 10^6$ $	29.3	28.9	15.2	24.1
B/C		-	1.74	1.72	1.37	1.56
$B-C_1$	for Construction Cost excluding Transmission Line	$\times 10^6$ $	30.	29.	16.1	24.8
B/C_1		-	1.79	1.77	1.40	1.60

* Note: Fill dams at No.2 & No.3 damsites are designed for comparison.
Cost estimates are made on the assumption that the necessary materials for fill dams are available at the quarries within a distance of 10 km.

General Layout (Underground Type Powerhouse Site)



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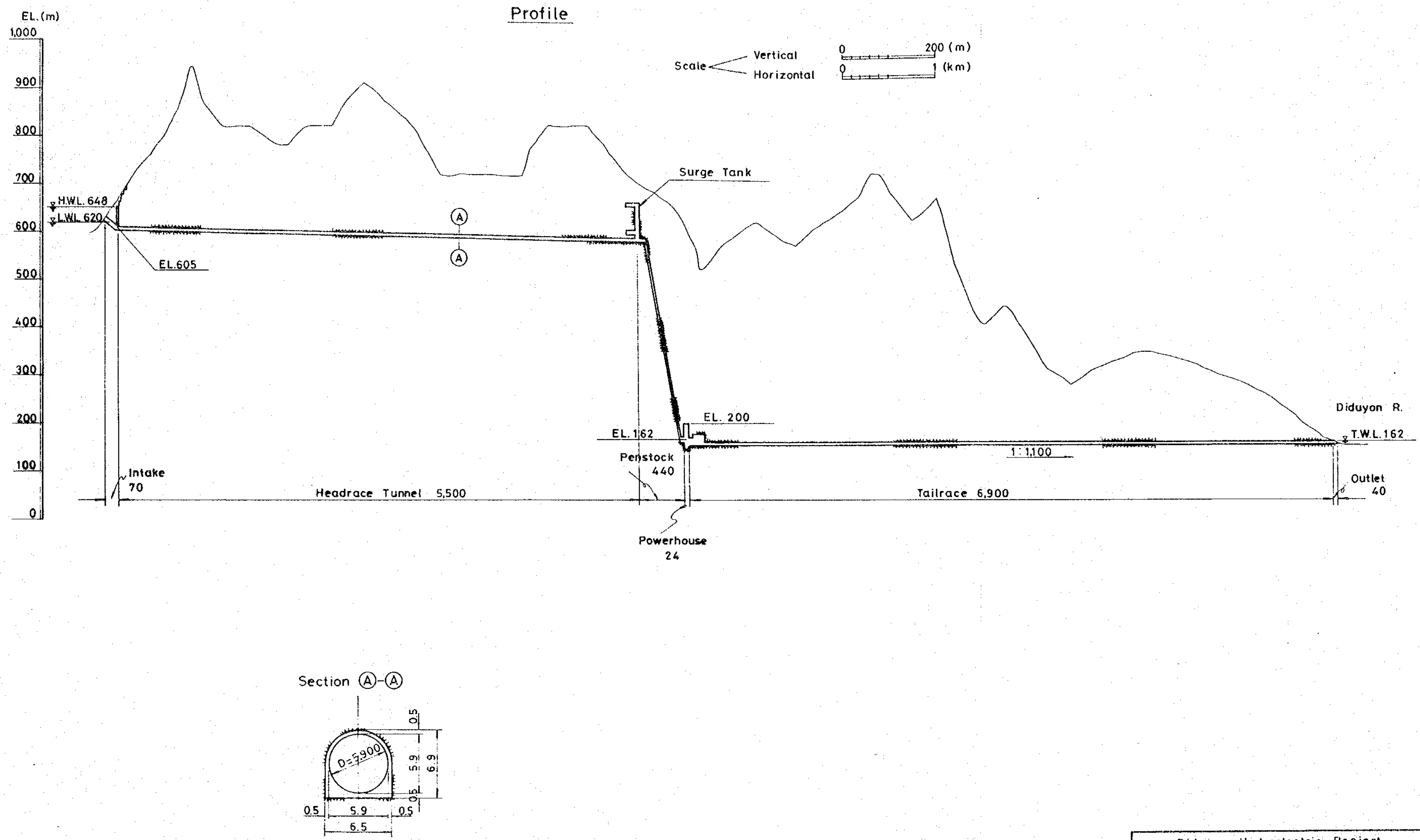
Japan International Cooperation Agency	
General Layout (Underground Type)	
October 1980	Fig. 3-1-1

Headrace & Tailrace of Underground Type Powerhouse



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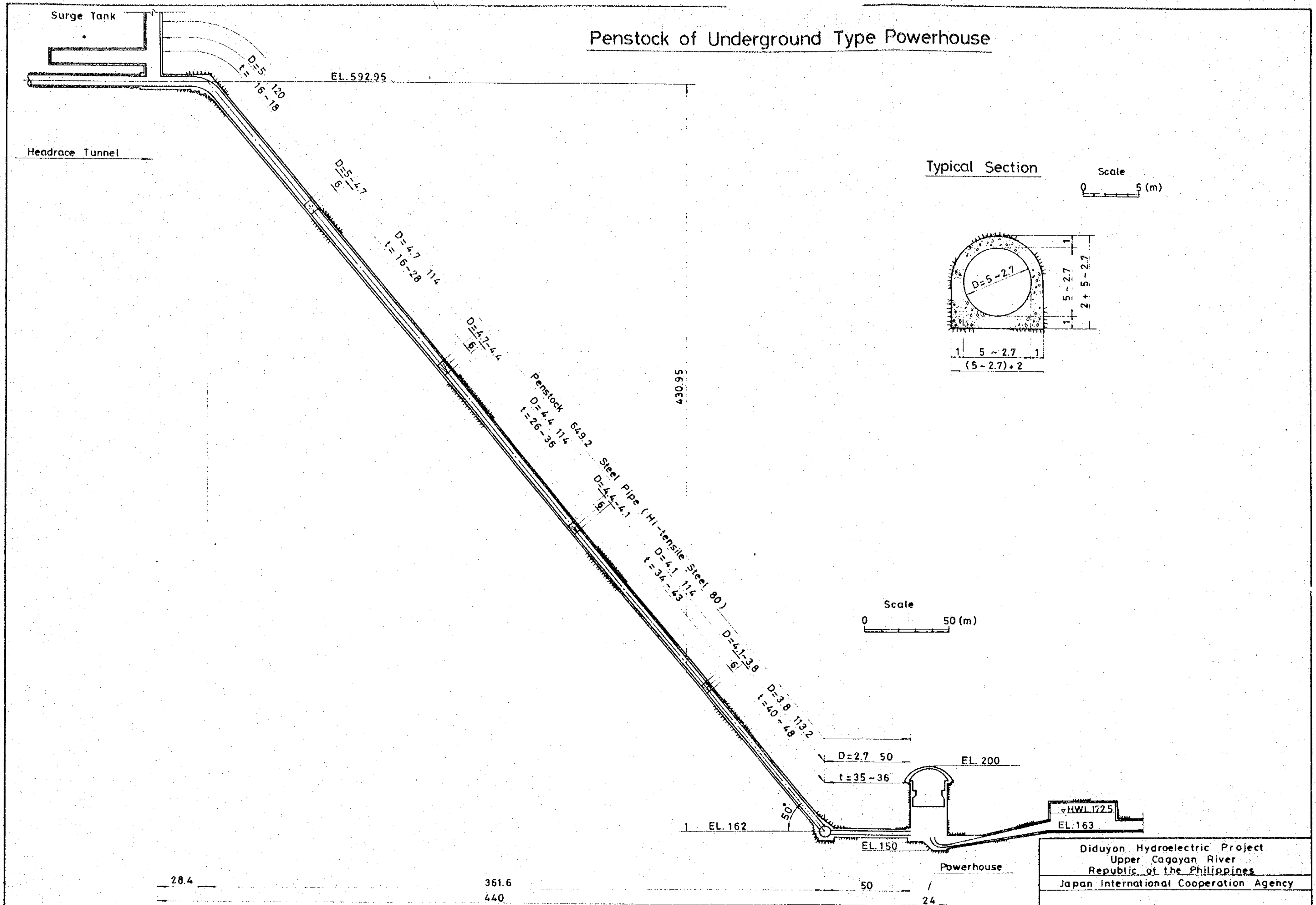
Headrace & Tailrace of Underground Type Powerhouse
October 1980 Fig. 3-1-2

Penstock of Underground Type Powerhouse



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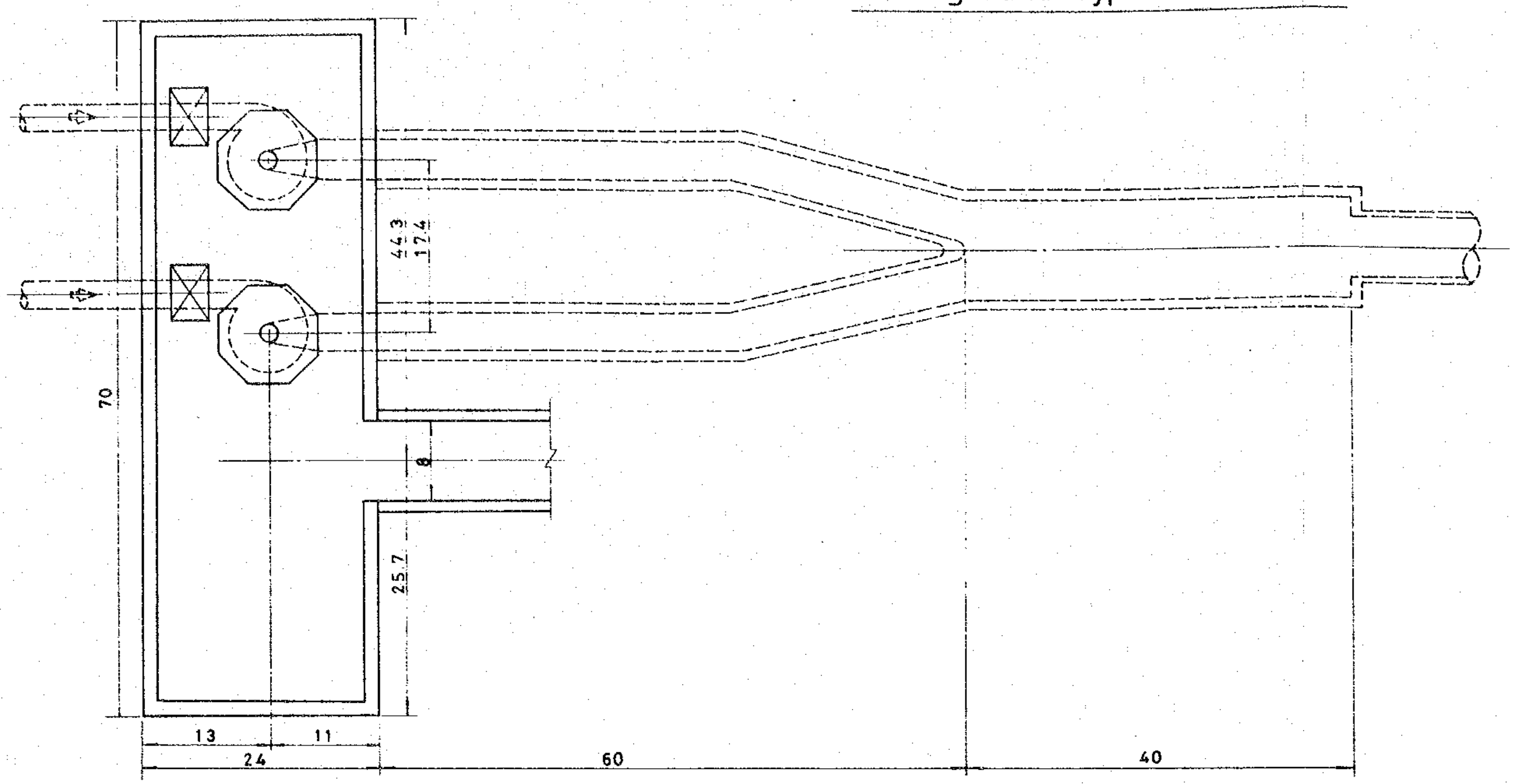
Penstock of
Underground Type Powerhouse

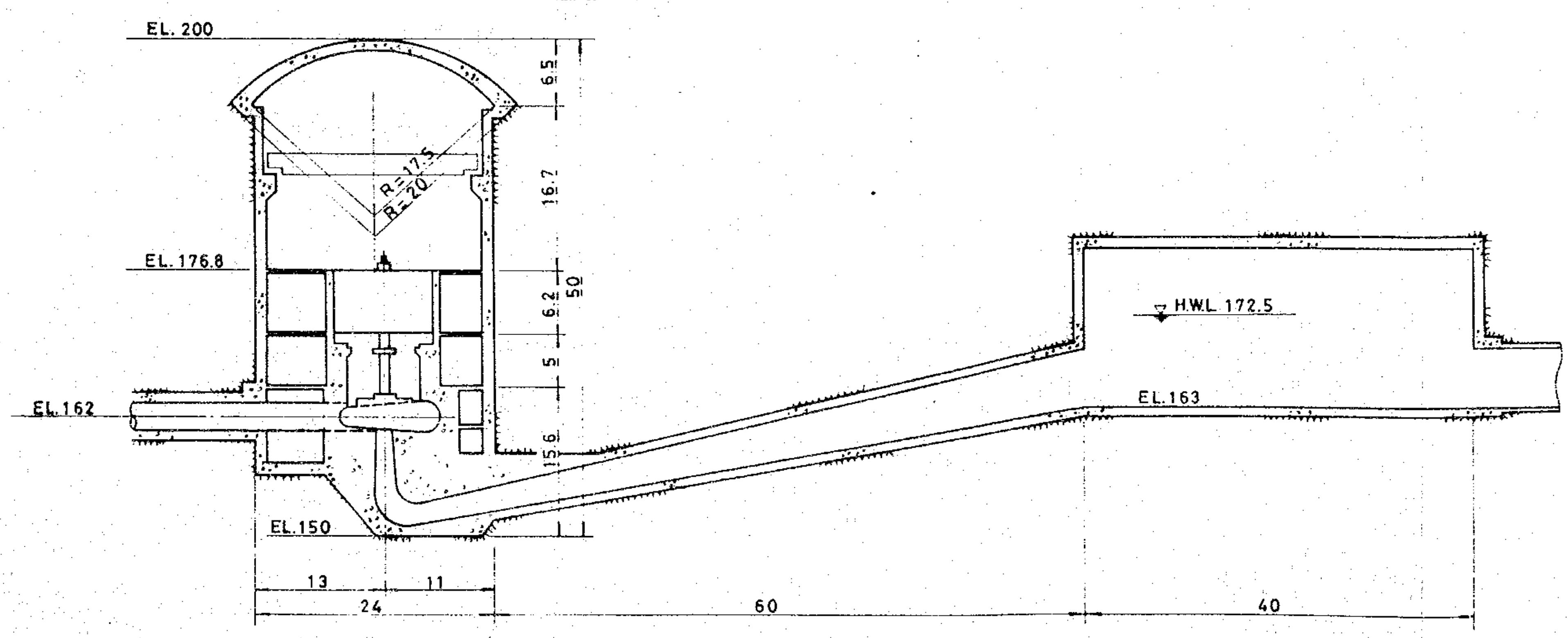
October 1980 Fig 3-1-3

Underground Type Powerhouse

Plan



Longitudinal Section



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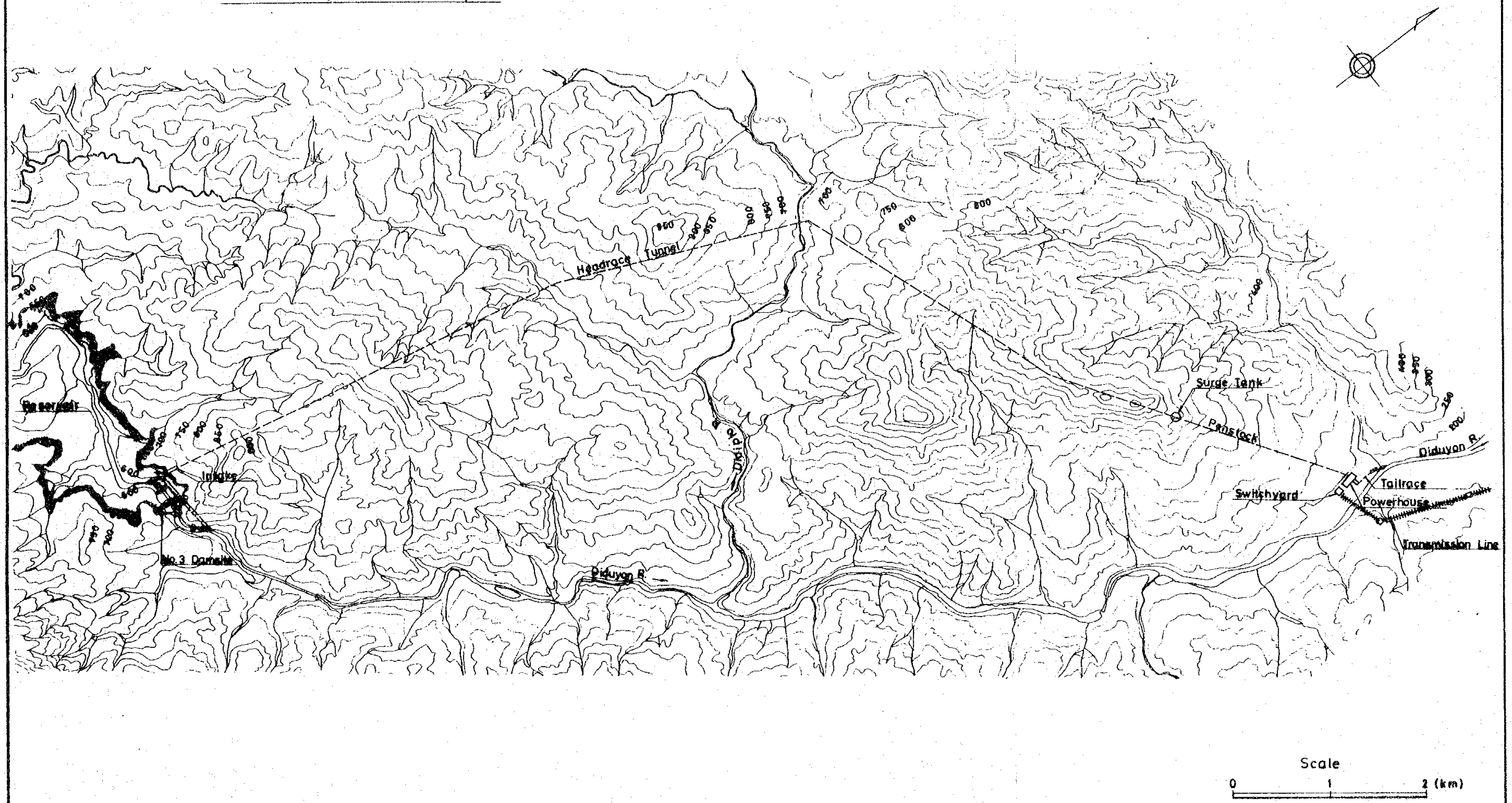
Underground Type Powerhouse

October 1980 Fig. 3-1-4

General Layout of the Project



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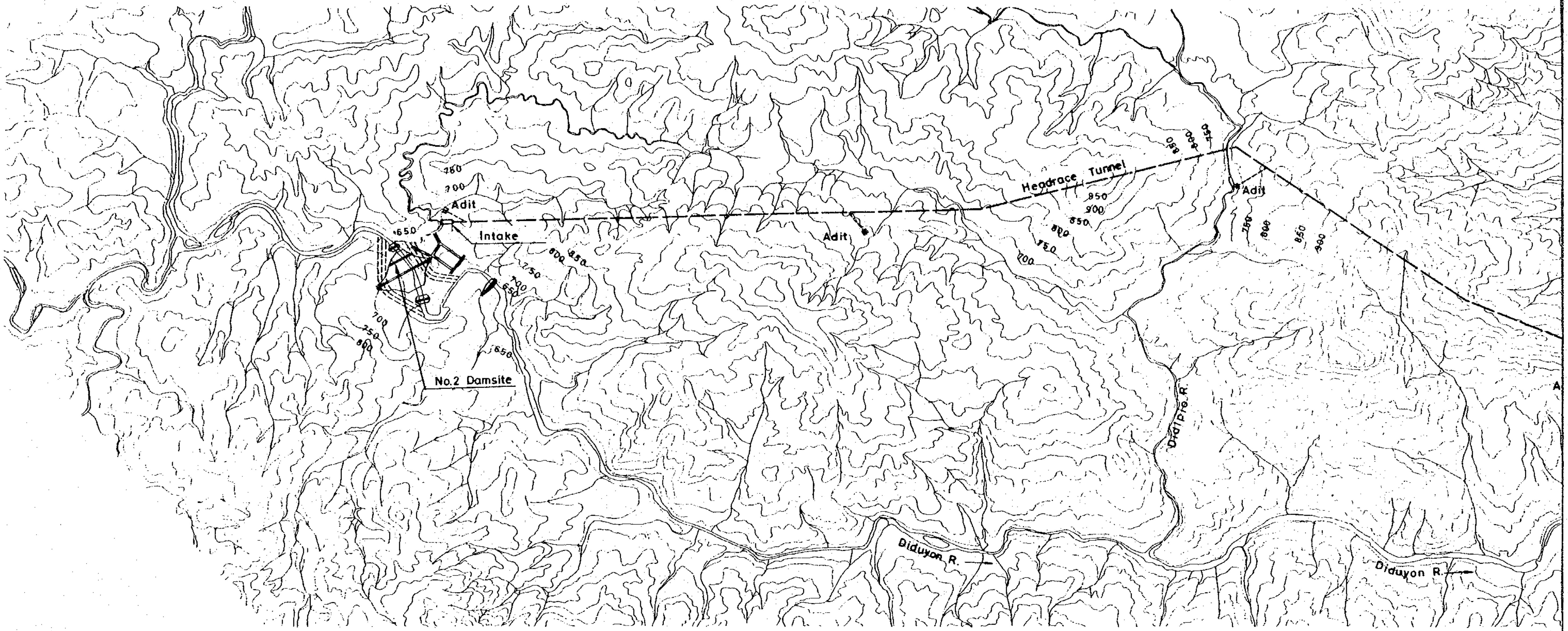
General Layout of the Project	
October 1980	Fig. 3-1-5

General Layout of the Project



General Layout of the Project

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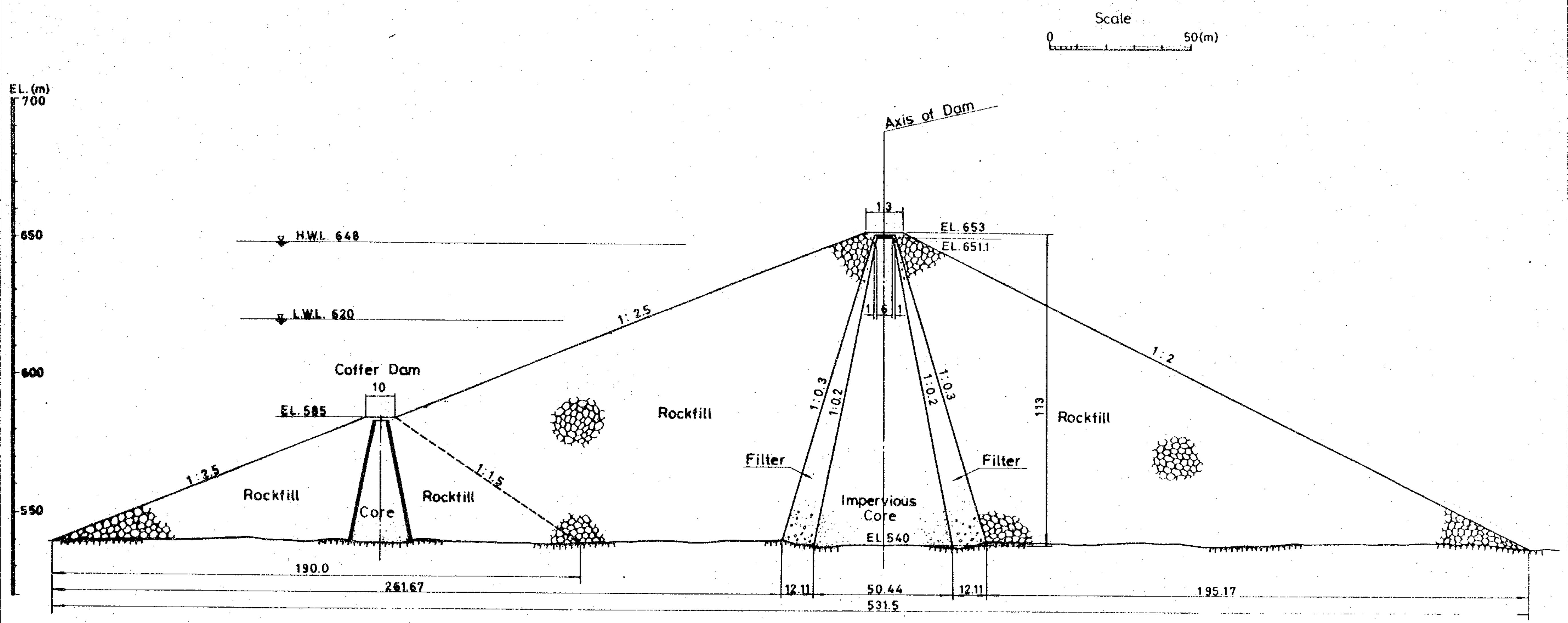
Japan International Cooperation Agency	
General Layout of the Project Rock Fill Type	
October 1980	Fig 3-1-6

Cross-Section of Reservoir Dam (No. 2. Damsite)



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Cross-Section of Reservoir Dam (No. 2 Damsite)
October 1980 Fig. 3-1-7