Table 3-7-1 Assumed Number of Households and Area of Irrigated Land, to be Submerged in Reservoir

Name of Barrios	Households		Irrigated Land (ha)		Percent of Submersion
	Total	Submerged	Total	Submerged	
Siguem	80	40	202	101	50
Dine	255	127	24.5	12	50
Catarawan	115	57	59	29	50
Biyoy	103	51	105	52	50
Kakiduguen	39	19	40.33	20	50
Camamasi	100	50	51.5	26	50
Belet	50	25	29.75	15	50
Capisaan	120	60	129	64	50
Malabing	50	25	72	36	50
Total	912	454	713.08	355	-
Round up		500		400	50

Table 3-7-2 Areas Suitable for Resettlement in Kasibu M.P.

(Unit : ha)

	Statics (1) Site (2) Gradient (3) Elevation	Gradient : Under 10% Elevation : Under EL 800 m	Gradient : 14% - 10% Elevation : Under EL 850 m	Total
A	(1) South part between Kasibu - Pudi (2) 1/10 - 1/15 (3) EL 750 m	220	110	330
B	(1) South Siguem (2) 1/15 or under (3) EL. 720 m	110	320	430
C	(1) Around Muta (2) (3) EL 700 - 800 m	630	660	1,290
D	(1) South Dine (2) (3) EL 780 m	270	550	820
E	(1) North Dine (2) (3) EL 700 m	270	270	540
F	(1) Around Kakiduguen (2) (3) EL. 680 - 800 m	270	270	540
G	(1) Around Belat (2) (3) EL. 740 m	150	260	410
H	(1) Around Capisaan (2) (3) EL 740 m	510	100	610
I	(1) Around Malabing (2) (3) EL 700 - 970 m	800	330	1,130
J	(1) Around Biyoy	370	580	950
Total		3,710	3,440	7,150

Table 3-7-3 Comparative Study of Three Resettlement Alternatives

	Case I	Case II	Case III
1. Development of Agriculture			
1.1. Potential of Agriculture	x	Δ	o
1.2. Possibility of Technical Gradual Leveling-up of Land Utilization	x	o	Δ
1.3. Water Supply to Agricultural Field	o	Δ	x
1.4. Land Reclamation	x	Δ	o
1.5. In Case of Same Land Reclamation Condition, Hardness of Profit Share to Farm Households	x	Δ	o
1.6. Problems of Natural Environmental Conservation in Reclaimed Lands	x	Δ	o
2. Development of Human Life			
2.1. Possibility of Modernization by Developing Wider Communication with Other Areas	x	Δ	o
2.2. Possibility of Change from Isolated Agricultural Areas to Surrounding Economic Societies by Developing Communication with Other Areas	x	Δ	o
2.3. Difficulty of Unity of Newly Resettled Villages	Δ	x	o
2.4. Dialectal and Religious Problems of Newly Resettled Villages	o	Δ	x
2.5. Efficiency of Investments to Environmental Matters of Newly Resettled Villages	x	Δ	o
2.6. Possibility of Objection of Resettlers, Which Will Be Estimated from their Traditional Life Manner	o	Δ	x
3. Conservation of Natural Environment			
3.1. Hardness of Environmental Conservation in Reservoir Area	Δ	x	o
3.2. Influence upon Downstream River	Δ	o	x
3.3. Influence upon Animals and Plants	Δ	x	o
3.4. Change of Environment in Developed Areas	o	Δ	x
4. Administrative Problems			
4.1. Administrative Readjustment of Newly Developed Areas	o	Δ	x
4.2. Hardness of Administrative Control	x	Δ	o
5. Others			
5.1. Acceptability of Change in Life	o	Δ	x
5.2. Anxiety for Livelihood, etc., after Resettlement	o	Δ	x
5.3. Distance to Big Cities and Towns	x	Δ	o

Table 3-Ⅶ-4 Comparative Cost Study of Resettlement

(Unit: x 10^3₱)

Resettlement The approximate number of families to be resettled and rehabilitated is assumed to be 500 households for all cases

	Case I	Case II	Case III
1. Lot Acquisition or Lot Development			
1) Residential Lots (₱7,500 x 500)	3,750	3,750	3,750
2) Farm Lots (Details will be given separately)	64,250	70,700	95,748
Subtotal	68,000	74,450	99,498
2. Compensation			
1) Farm Lots			
a. Irrigated (500x2 ha.x0.2x₱10,000)	2,000	2,000	2,000
b. Non-irrigated (500x2 ha.x0.8x₱5,000)	4,000	4,000	4,000
2) Residential Lots (500x0.25 ha.x₱10,000)	1,250	1,250	1,250
3) Fruit Trees (500 x ₱1,200)	600	600	600
4) Shade Trees (500 x ₱450)	225	225	225
Subtotal	8,075	8,075	8,075
3. Development of Resettlement Sites			
1) Barrio Roads (500x0.06 ha,x₱35,000)	1,050	1,050	1,050
2) Water System	225	225	225
3) Lighting System	445	445	445
4) Houses and Lots (500 x ₱10,000)	5,000	5,000	5,000

Table 3-7-4 (Continued)

	Case I	Case II	Case III
5) School Building	4 elem.school ($300m^2$ x 4x ₱800) 960	4 elem.school 960	4 elem.schools & 1 high shool ($300m^2$ x 4+$500m^2$ x1) @₱800 1,360
6) Chapel (200 m^2 x 2 x ₱800)	320	320	320
7) Community Center ($300m^2$ x4x₱800)	960	960	960
8) Building for Common Use	($9x1500m^2$ x₱50) 825	($9x1500m^2$ x₱50 +1x1500^2 x₱50) 1,275	1,275
9) Improvement of School Grounds	-	-	300
10) Recreation Facilities	125	125	125
11) Ornamental Plants	25	25	25
Subtotal	9,935	10,385	11,085
4. Transfer of Families (Hauling)	(20kmx5.4₱/km x500) 54	(50kmx5.4₱/km x500) 135	(200kmx5.4₱ x500) 540
5. Information Drive and Census	1,000	1,000	1,000
6. Reservoir Clearing ($27km^2$ x ₱85,000)	2,295	2,295	2,295
7. Socio-Economic Program (Including Funding for the Transitory Period) (500 x ₱5,000)	2,500	2,500	2,500
8. Equipment Supplies and Materials (500 x ₱5,000)	2,500	2,500	2,500
Total	94,359	101,340	127,493
Round-up Total	94,000	101,000	127,000

Table 3-7-5 Net Production Value of Irrigation Plan Studied (1)

	Without Project	With Project (Paddy)		
		Wet season	Dry Season	Total
I. Yield (t/ha)	0	3.5	4.0	
II. Unit Price (₱)		1,127	1,127	
III. G.P.V. (₱/ha)		3,945	4,508	
IV. Production (₱/ha)		1,647	1,695	
V. N.P.V. (₱/ha)		2,278	2,813	
VI. Cropped Area (ha)	0	1,800	2,000	
VII. Production of Paddy		6,300	8,000	14,300
VIII. Total N.P.V. ($₱10^3$)		4,136	5,626	9,762
Incremental N.P.V. ($₱10^3$)		9,762		

Table 3-7-6 Internal Rate of Return of Irrigation Plan Studied

(Unit: ₱1,000)

Year	Cost	Benefit			Discount at 3%		Discount at 2%	
		N.P.V.	O & M	Total	Cost	Benefit	Cost	Benefit
1	34,089				33,096		33,421	
2	44,360				41,814		42,637	
3	53,261				48,741		50,187	
4	14,614	1,600	410	1,190	12,984	1,057	13,501	1,097
5		2,400	410	1,990		1,717		1,802
6		6,000	800	5,200		4,355		4,617
7 - 30		9,762	800	8,962		127,112		150,519
12	2,000				1,403		1,577	
20	2,000				1,107		1,346	
28	2,000				374		1,149	
Total	152,324				140,099	134,241	143,820	150,037

Table 3-7-7 Summary of Irrigation Project Cost

(Unit : ¥1,000)

	1st Year	2nd Year	3rd Year	4th Year	Total
1. Preparation Work	1,000	1,000	1,000	1,000	4,000
2. Construction Work					
a. Construction for farm land	20,000	20,000	30,000		70,000
b. Weir and Sedimentation Basin (2 places)	2,234	2,234			4,468
c. Pumping Facility (3 places)	8,240	8,240	8,240		24,720
d. Canal		10,000	10,000	10,000	30,000
e. Road	1,134	1,134	2,268	2,268	6,804
3. Land Acquisition	260				260
4. Engineering	200	170	180	80	550
5. Government Administration	150	230	230	105	760
6. Contingency	600	1,000	1,000	1,000	3,600
7. Price Escalation	271	352	423	116	1,162
8. Total	34,089	44,360	53,261	14,614	146,324

Table 3-748 Net Production Value of Irrigation Plan Studied (2)

		Without Project					With Project		
		Paddy					Paddy		
		Rainfed	Irrigated Wet	Irrigated Dry	Corn	Total	Wet	Dry	Total
I.	Yield (ton/ha)	1.1	2.1	2.2	0.7		3.5	4.0	
II.	Unit Price (₱/ton)	1,127	1,127	1,127	800		1,127	1,127	
III.	G.P.V. (₱/ha)	1,240	2,367	2,479	560		3,945	4,508	
IV.	Production Cost (₱/ha)	495	1,058	1,039	241		1,647	1,695	
V.	N.P.V. (₱/ha)	745	1,309	1,440	319				
VI.	Cropped Area (ha)	2,443	345	80	4,858		13,000	13,200	26,200
VII.	Production of Paddy (ton)	2,687	725	176	-	3,588	45,500	52,800	98,300
VIII.	Total N.P.V. (₱10^3)	1,820	452	115	1,550	3,937	29,874	37,132	67,006

Incremental N.P.V. : ₱ 63,069,000 (Project Benefit)

Incremental Production of Paddy: 94,712 tons

Table 3-7-9 **Summary of Irrigation Project Cost (2)**

(unit : ₱1,000)

	1st Year	2nd Year	3rd Year	4th Year	Total
1. Preparatory Works		2,000	2,000	2,000	6,000
2. Construction Works					
a. Weir & Sedimentation Basin	7,740	7,740			15,480
b. Pumping Facility	24,720	24,720			49,440
c. Canal		39,380	39,380	39,380	118,140
d. Road			17,008	17,008	34,015
3. Land Acquisition	1,500	2,000			3,500
4. Engineering Fee	3,000	2,000	1,500	1,500	8,000
5. Government Administration	1,000	1,500	1,500	1,000	5,000
6. Contingency	4,000	6,000	6,000	6,000	22,000
7. Price Escalation	3,357	6,827	5,391	5,351	20,926
Total	45,317	92,167	72,779	72,239	282,502

Note: (1) Contingency is an allowance of 10% on the above sum-total estimated construction costs

(2) Price Escalation is counted for an annual increase at 8%.

Table 3-7-10 Internal Rate of Return of Irrigation Plan Studied (2)

(Unit : ₱1,000)

Year	Cost	Benefit			Discount at 3%		Discount at 2%	
		N.P.V.	O & M	Total	Cost	Benefit	Cost	Benefit
1	45,317				39,927		39,752	
2	92,167				71,546		70,920	
3	72,779				99,776		49,124	
4	72,239	8,100	2,500	5,600	43,530	3,375	42,771	3,316
5		12,000	2,500	9,500		5,044		4,934
6		24,000	5,000	19,000		8,887		8,656
7		63,000	5,000	58,069				23,206
8 - 30		63,000	5,000	58,069		167,645		157,621
12	5,000				1,094			
20	5,000				397			
28	5,000				144			
Total					206,414	208,883	204,097	197,733

Table 3-7-11 Production Cost of Farming Without Project

(₱/ha)

Item	Paddy						Corn	
	Rainfed		Irrigated					
			1st Crop		2nd Crop			
	Q'ty	Cost	Q'ty	Cost	Q'ty	Cost	Q'ty	Cost
I. Labor Requirement								
a. With animal (Man-day)	19	171	19	171	19	171	9	81
b. Without animal (-do-)	44	264	52	312	52	312	22	132
II. Fertilizer (kg)								
a. Urea			50	94	50	94		
b. Ammosul			100	112	100	112		
c. 16-20-0			25	38	25	25		
d. 14-14-14			75	107	70	99		
III. Insecticide								
a. Liquid (Qt)			40	92	40	92		
b. Granular (kg)			1.0	3	1.0	3		
IV. Herbicide								
a. Liquid (Qt)			2.0	56	1.6	45		
b. Granular (kg)			1.0	3	1.0	3		
V. Miscellaneous		10		20		20		
VI. TOTAL		445		1,008		976		223

Table 3-7-12 Production Cost of Palay with Project

(Unit : ₱/ha)

	Unit	Wet Q'ty	Wet Cost	Dry Q'ty	Dry Cost
I. Labor Requirement					
a. With Animal	man-day	22	198 P	22	198
b. Without Animal	man-day	92	552	92	552
II. Seed	kg	44	58	44	58
III. Fertilizer					
a. Urea	kg	56	105	67	126
b. Ammosul	kg	119	133	143	160
c. Superphosphate of line	kg	177	269	177	269
IV. Insecticides					
a. Carbonfuran, G	kg	2.3	14	2.3	14
b. Cloroimeforn, G	kg	17	82	17	82
c. Diazinon, G	kg	14	124	14	124
d. Diphacinone, P	g	250	12	250	12
V. Herbicide					
a. 2-4-D Ethyester	kg	25	70	25	70
VI. Miscellaneous			30		30
VII. Total Cost			1,647		1,695

Remarks;

Unit Price

Labour

With Animal	₱ 9/day
Without Animal	₱ 6/day

Fertilizer

Urea	₱94/50kg
Ammosul	₱56/50kg
Superphosphate of line	₱76/50kg

Herbicide

2-4-D Eghylester ₱2.8/kg

Insecticide

Carbofuran, G	₱ 6.2/kg
Cloroimeforn, G	₱ 4.8/kg
Diazinon, G	₱ 8.9/kg
Diphacinone, P	₱48.0/kg

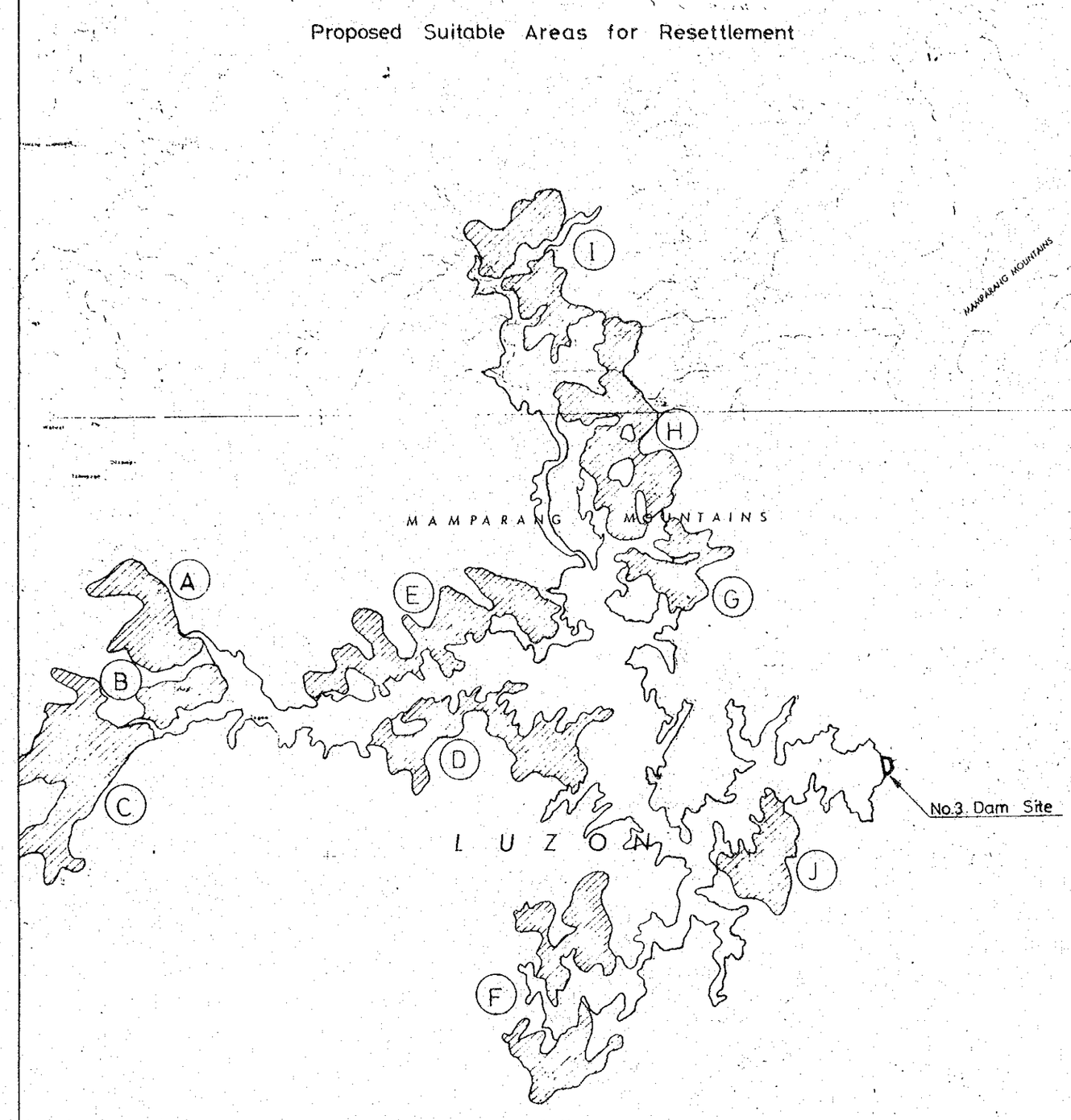
Note:

G - Granula

P - Power

Qt- Quart = 0.946 ℓ

Proposed Suitable Areas for Resettlement



N

Legend

Inundated Area

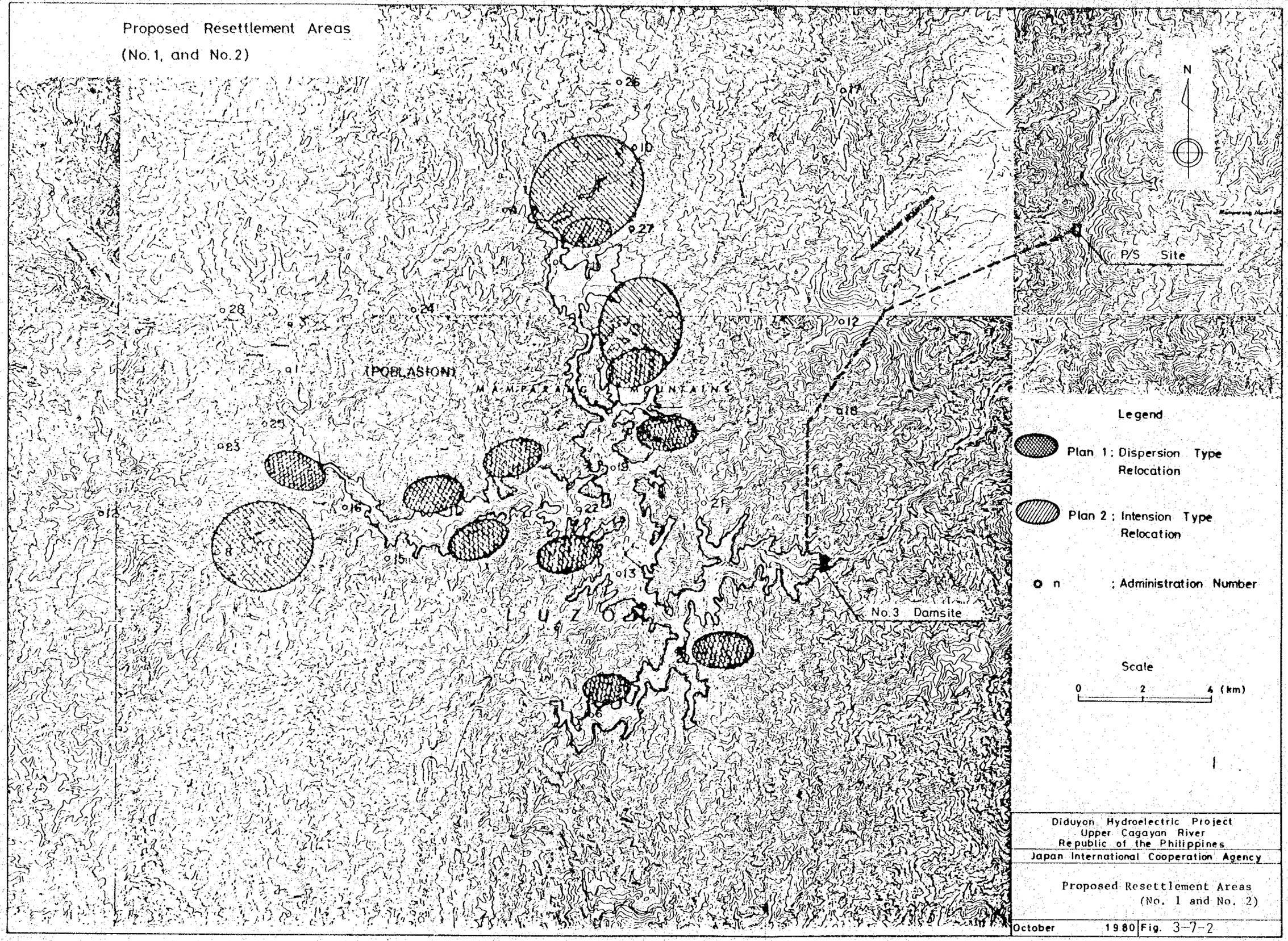
Suitable Area

Scale

0 5 (km)

Diduyon Hydroelectric Project Upper Cagayan River Republic of the Philippines
Japan International Cooperation Agency
Proposed Suitable Areas for Resettlement
October 1980 Fig. 3-7-1

Proposed Resettlement Areas
(No. 1, and No. 2)



Diduyon Hydroelectric Project
Upper Cagayan River
Republic of the Philippines
Japan International Cooperation Agency

Proposed Resettlement Areas
(No. 1 and No. 2)

October 1980 Fig. 3-7-2

Legend

Plan 3 : Complete Removal Type Relocation

Scale

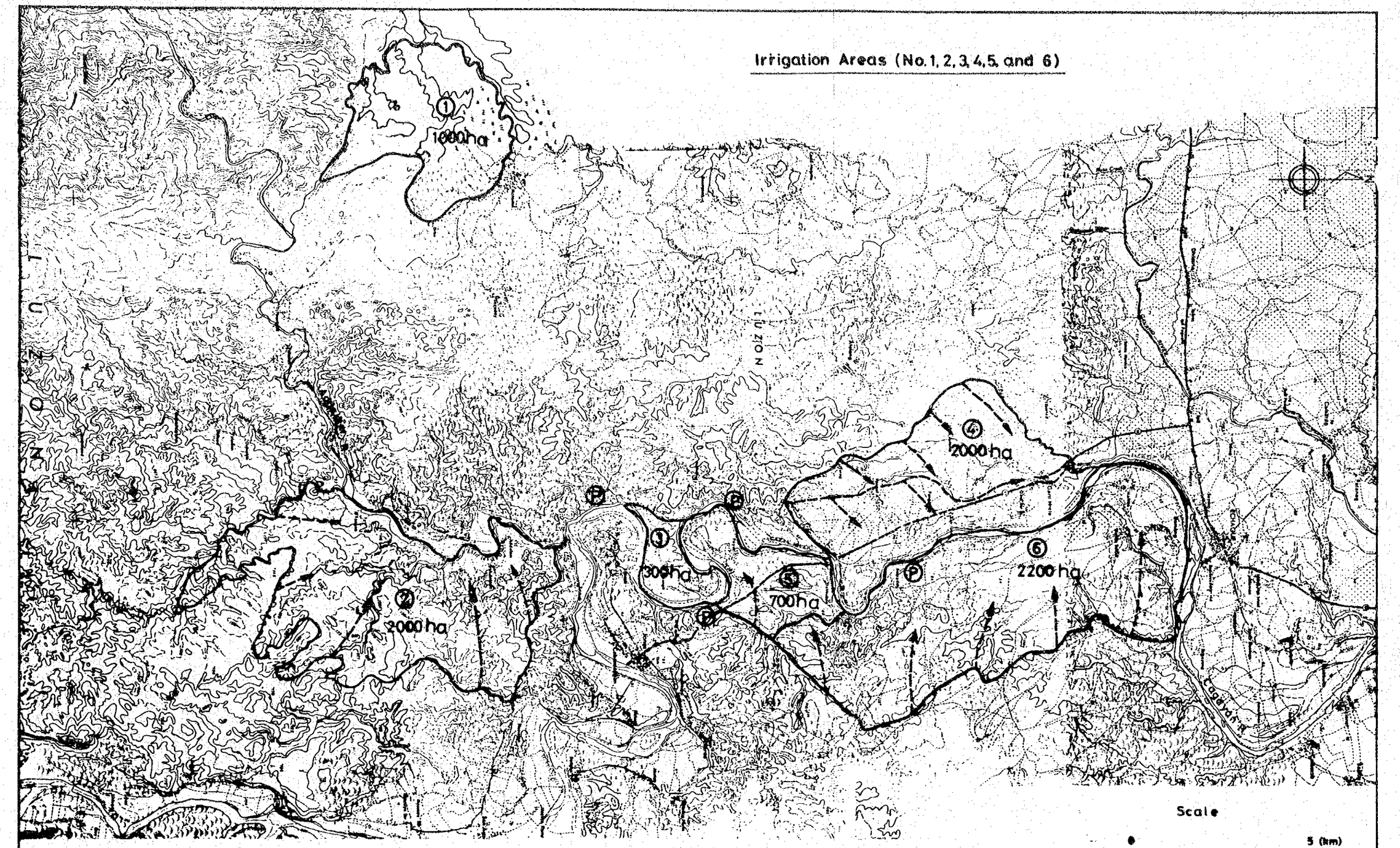
0 2 4 (km)

Diduyon Hydroelectric Project
Upper Cagayan River
Republic of the Philippines
Japan International Cooperation Agency

Proposed Resettlement Area (No. 3)

October 1980 Fig. 3-7-3

Irrigation Areas (No. 1, 2, 3, 4, 5, and 6)



Scale

0 5 (km)

Legend

Ⓟ Pump Station

——— Irrigation Canal

Diduyon Hydroelectric Project Upper Cagayan River Republic of the Philippines	
Japan International Cooperation Agency	
Irrigation Areas (No. 1,2,3,4,5 and 6)	
October 1980	Fig. 3-7-4 (1)

Irrigation Area (No. 7)

N

Scale

0 5 (km)

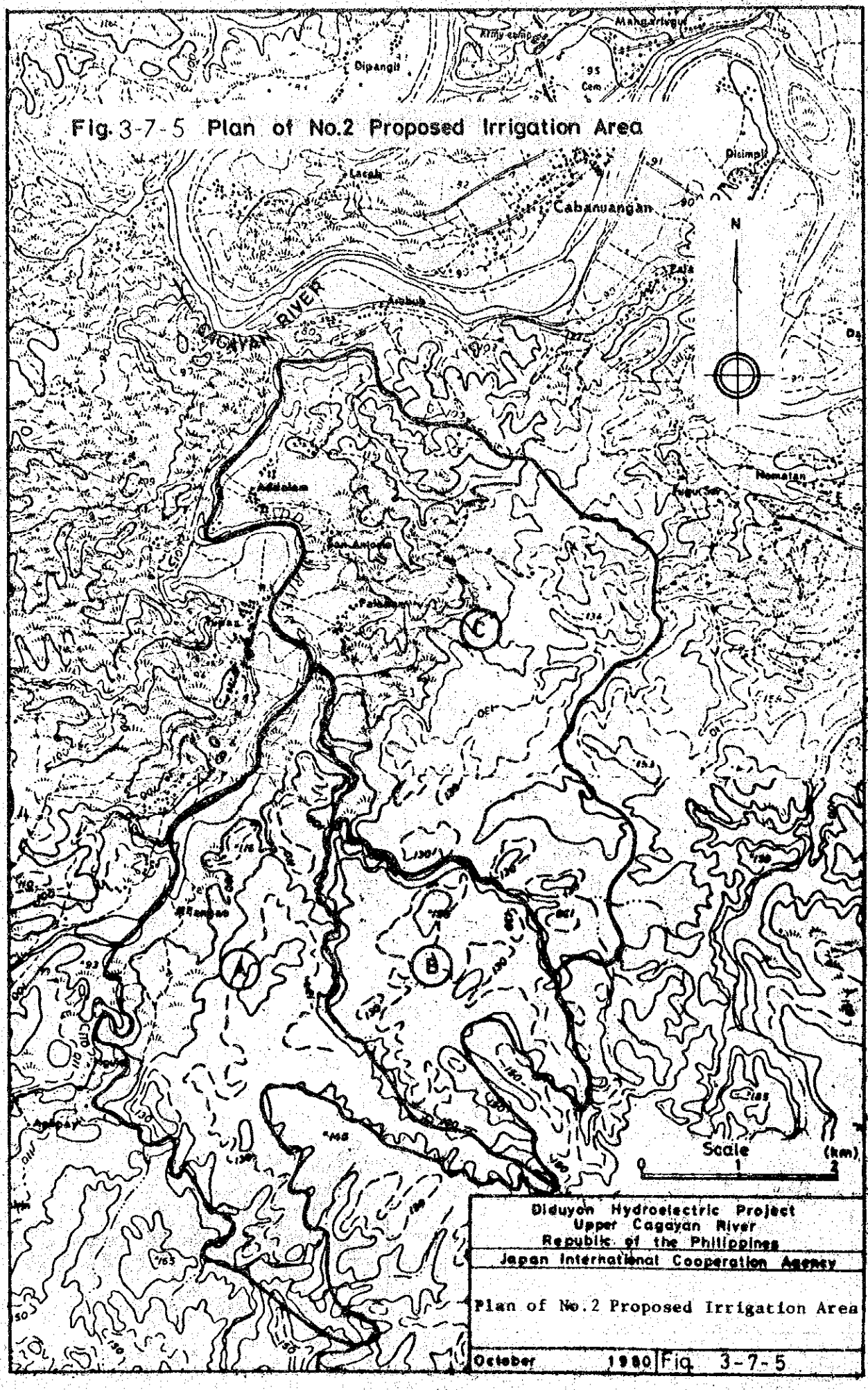
Legend

Ⓟ Pump Station

——— Irrigation Canal

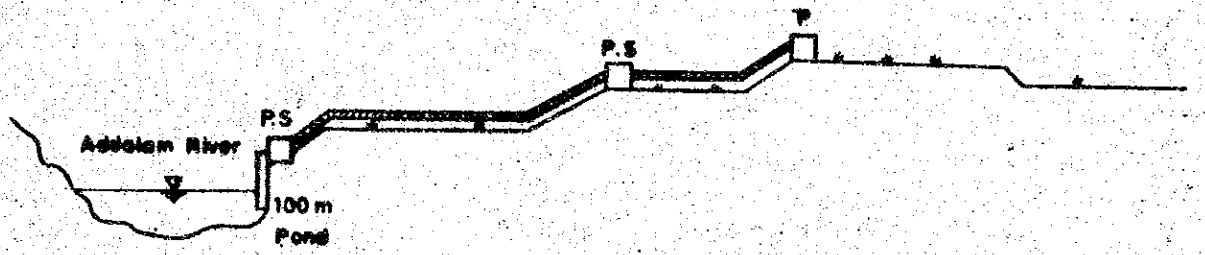
Diduyon Hydroelectric Project Upper Cagayan River Republic of the Philippines
Japan International Cooperation Agency
Irrigation Area (No. 7)
October 1980 Fig. 3 74 (2)

Fig. 3-7-5 Plan of No.2 Proposed Irrigation Area



Diduyon Hydroelectric Project Upper Cagayan River Republic of the Philippines	
Japan International Cooperation Agency	
Plan of No.2 Proposed Irrigation Area	
October 1980	Fig. 3-7-5

Assumed Profile of Pumping System



Legend

P : Small Pump

P.S : Pump Station

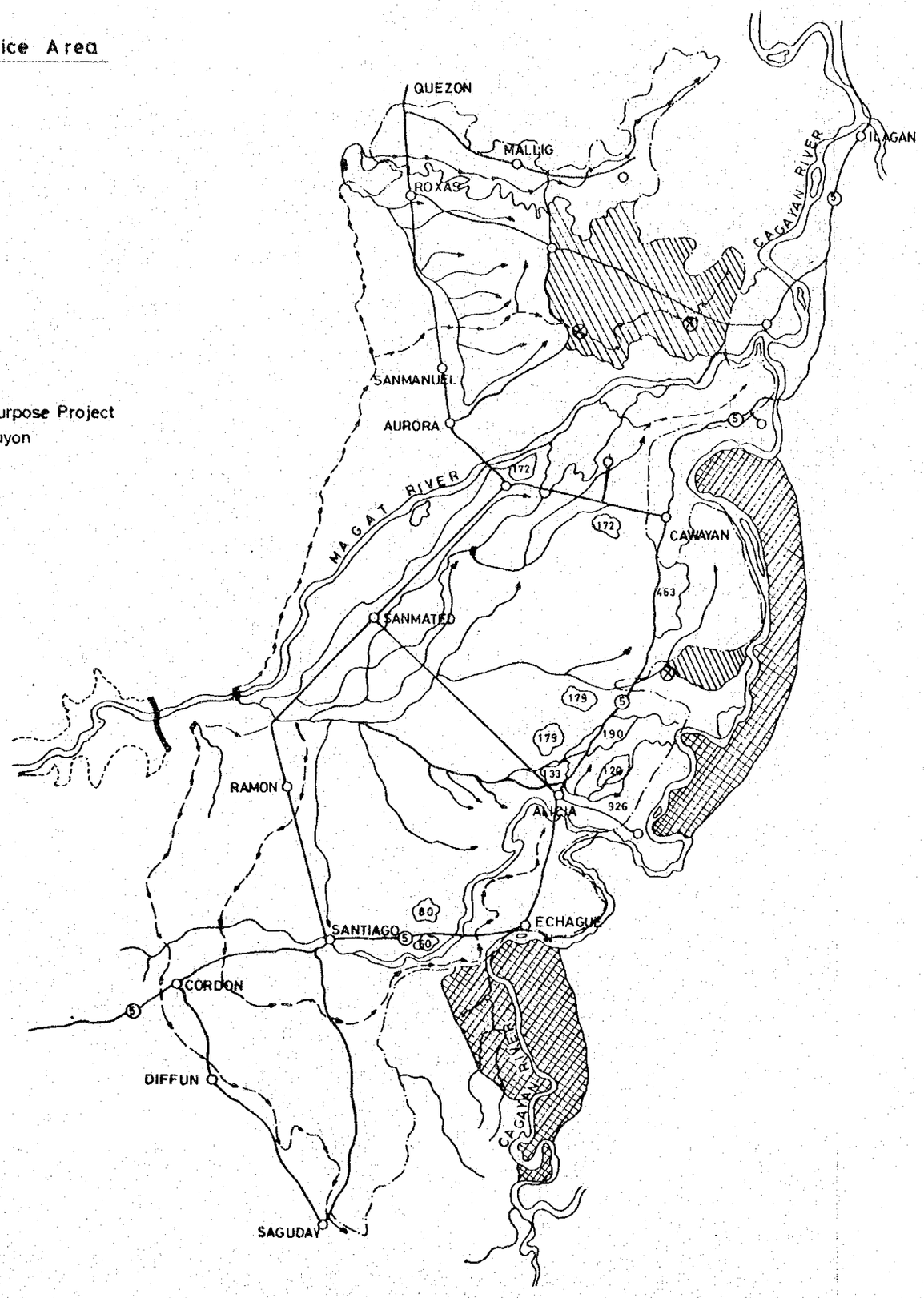
: Paddy filed

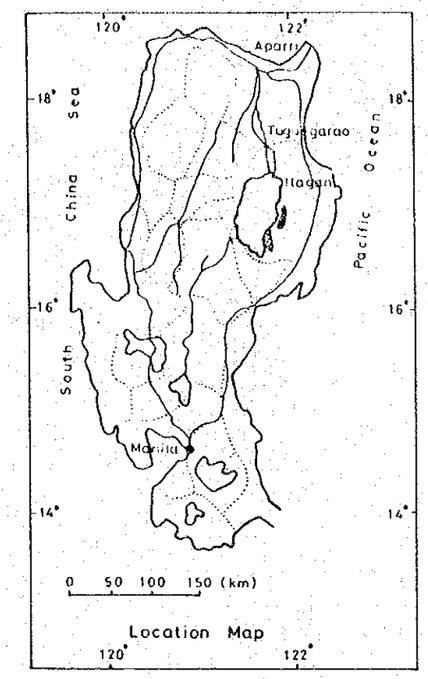
: Pipe

Diduyan Hydroelectric Project Upper Cagayan River Republic of the Philippines
Japan International Cooperation Agency
Assumed Profile of Pumping System
October 1990 Fig. 3-7-6

Irrigation Service Area

Source: Magat River Multi-Purpose Project
with addition of Diduyon
Irrigation Study





Legend

- Proposed Irrigation Areas
- Magat Project Area
- Magat Project Area (Pumped Up)

Siffu East Extension
3654 has - Area Served by Pump 1
2946 has - Area Served by Pump 2
CAUAYAN East Extension
1340 has - Area Served by Pump

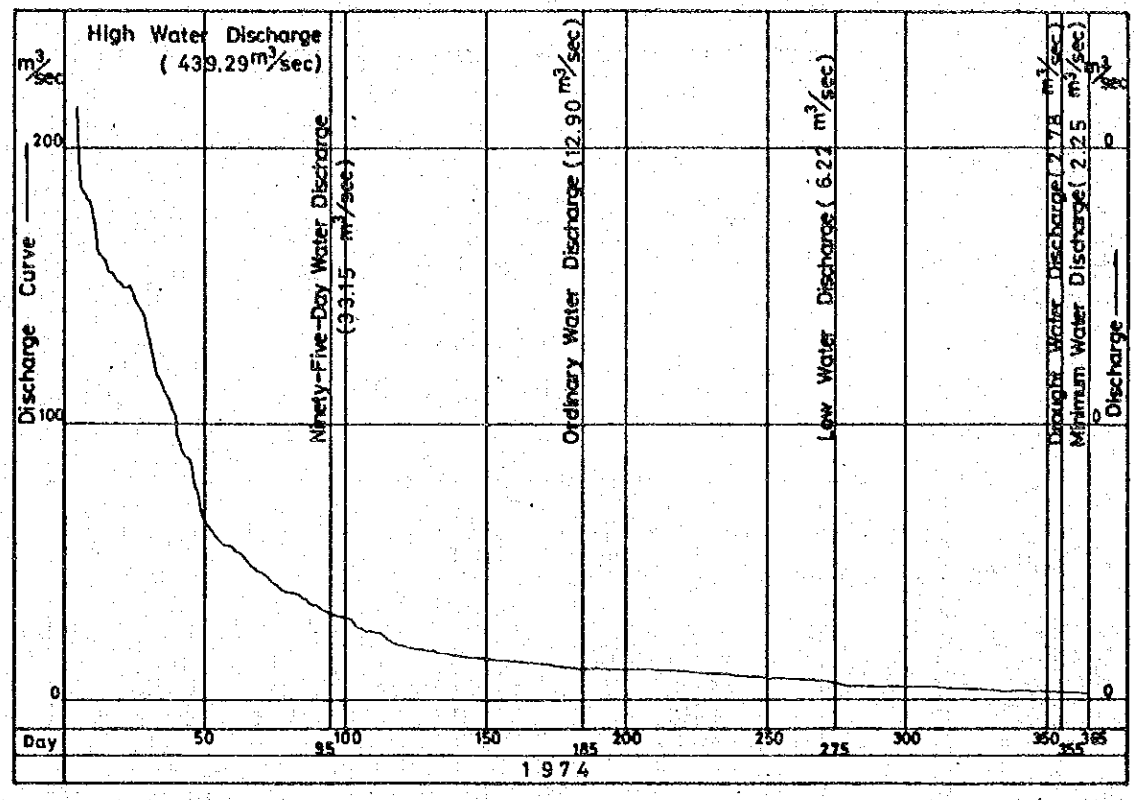
- Existing Main Canals
- Proposed Main Canals
- Existing Lateral Canals
- Proposed Dams and Reservoirs
- National Highway
- Other Roads
- Rivers and Existing Dams
- Project Boundaries
- Division Office
- Relift Pump

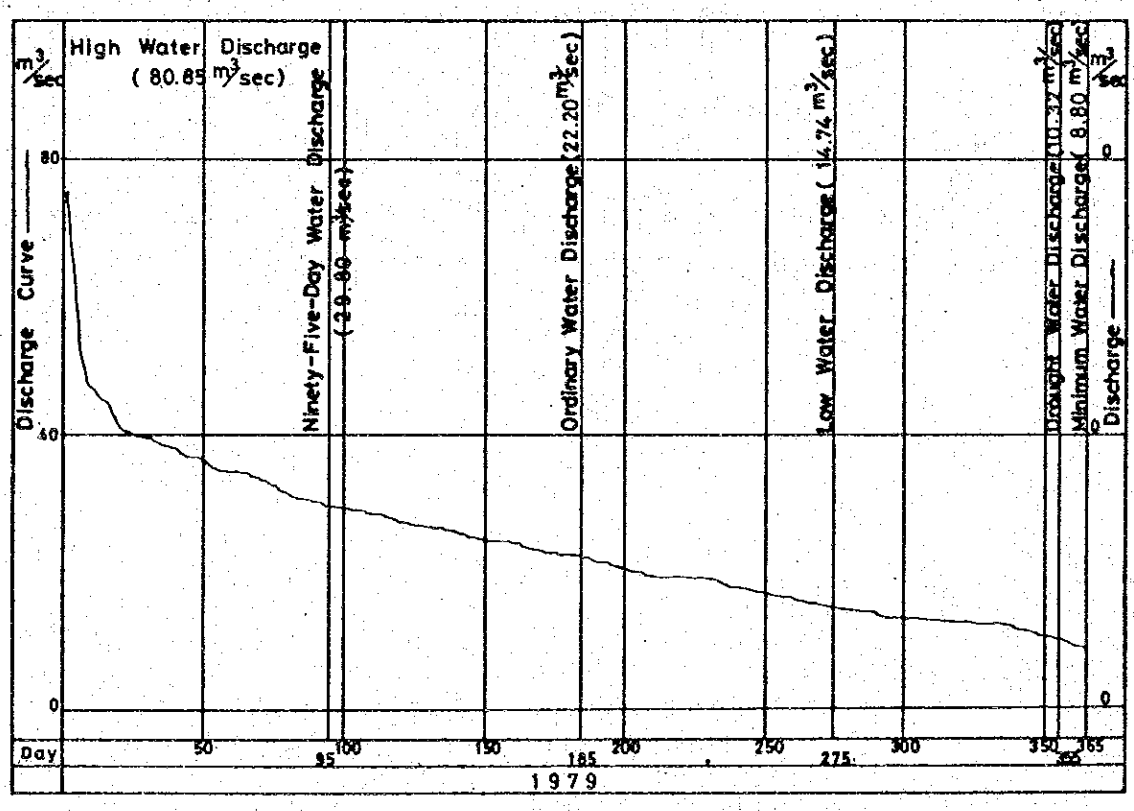
Scale
0 5 10 (km)

Diduyon Hydroelectric Project Upper Cagayan River Republic of the Philippines
Japan International Cooperation Agency
Irrigation Service Area
October 1980 Fig. 3-7-7

Duration Curve at No.3 Damsite (8)

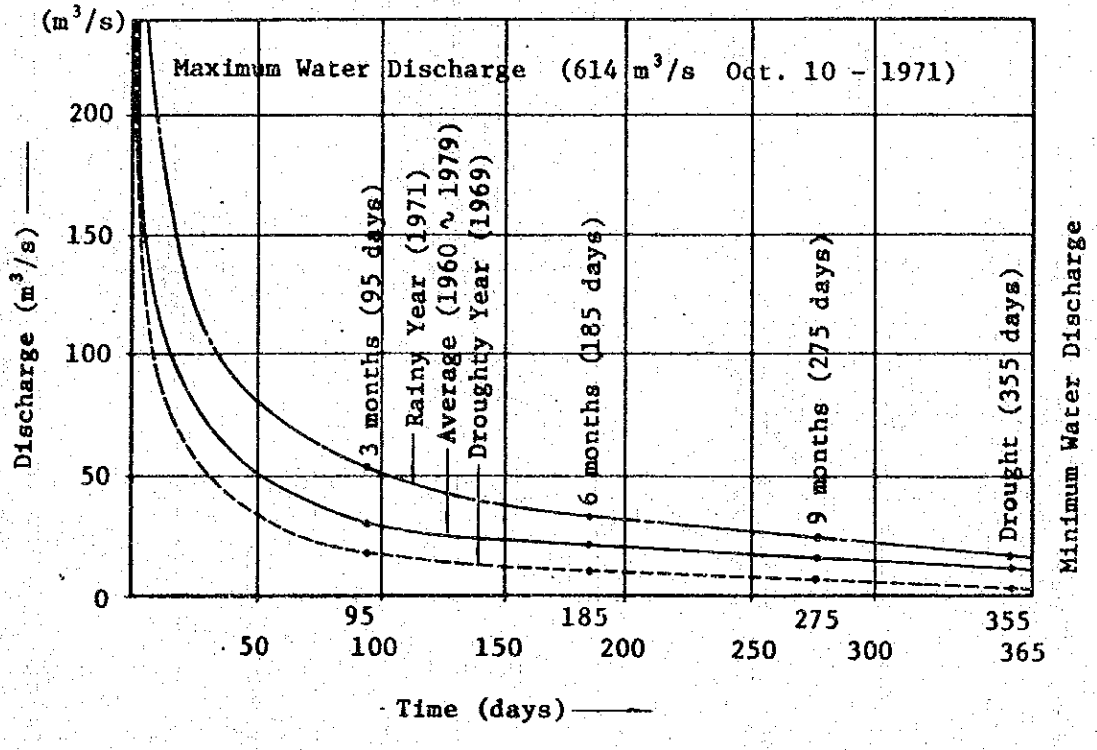
Station Name : No.3 Damsite
Catchment Area :477 km²





Diduyon Hydroelectric Project Upper Cagayan River Republic of the Philippines	
Japan International Cooperation Agency	
Duration Curve at No.3 Damsite (8)	
October 1980	Fig. 2-4-22 (8)

Discharge Duration Curve at No.3 Damsite



Diduyon Hydroelectric Project Upper Cagayan River Republic of the Philippines	
Japan International Cooperation Agency	
Discharge Duration Curve at No.3 Damsite	
October 1980	Fig. 2-4-23

CHAPTER 4. COST, CONSTRUCTION SCHEDULE, AND ECONOMICS AND FINAICIAL STUDY OF THE PROJECT

Chapter 4. Cost, Construction Schedule, Economics and Financial study of the Project

4.1. Estimated Construction Costs

4.1.1. Overview of estimated construction cost

Total construction cost of this project is estimated as US$392.9 million. This total cost can be broken down by type of work into the power station and the associated transmission line and substation as well as by currency into foreign exchange cost and local currency cost, as shown in Table 4-1-1 below.

($US10^6$)

	Foreign exchange	Local currency	Total
Power station construction cost	176.7	207.6	384.3
Transmission line and substation construction cost	5.2	3.4	8.6
Total	181.9	211.0	392.9

Note : Interest during construction not included

4.1.2. Basis of estimates

The total construction cost was estimated on the basis of prices prevailing at the beginning of 1980, assuming that construction work will be undertaken by standard construction processes.

The construction cost can roughly be divided into the power station and the associated transmission line. For the power station, estimates have been made of each of the following cost items:

direct costs including preliminary work, civil engineering construction work, electrical and mechanical work, and land aquisition and compensation, and indirect costs including engineering cost, administration cost, contingencies, and interest during construction. The transmission line and substation construction costs have also been estimated in the same manner by division into direct and indirect costs. The basis of estimates is as follows:

1) Preliminary work

All necessary preliminary work costs including construction and improvement of access roads, power supply, communication facilities, temporary buildings, various test facilities, and supplies for construction work.

2) Civil engineering work

Extension of unit prices determined in early 1980 by an evaluation of labor, materials and construction plant equipment required to perform the work, applied to approximately estimated quantities computed from the layout studies of the structures.

3) Electrical and mechanical works

Manufacture, delivery, installation and commissioning of hydraulic equipment (including turbines, valves and gates), electrical equipment (including generators, transformers, and switchgear), and powerhouse mechanical equipment (including cranes and hoists)

4) Compensation

Compensation costs for land, existing structures and public facilities to be affected by construction works.

5) Contingencies during construction

a) For the power station, an allowance of 10% of net total obtained for the construction cost items 1) through 3) and compensation cost 4) in Table 4-1-1, substracting the electro-mechanical equipment as well as the steel structures such as gates and penstock of 1) through 4). For the electro-mechanical equipment and the steel structures as stated above, 5% of construction costs is counted as contingencies.

b) For the transmission line and substation, an allowance of 10% of construction cost item 8)

6) Engineering costs

The following costs will be estimated for detailed design, survey work, preparation of tender documents, tender evaluation, and supervision of construction work:

For the power station, approximately 7% of the total of construction cost items 1) through 3), compensation cost 4) and contingencies 5); while an allowance of 5.5% of the total of construction cost item 8) and contingencies 9) for the transmission line work.

7) Administration cost

The power station work and the transmission line and substation work, 3.5% of the total estimated cost to cover administration costs of the owner to undertake the project.

8) Interest during construction

To be computed at 8% per annum

Table 4-1-1 Estimated Construction Cost

(Excluding Interest during Construction)

(US$10^6 equivalent)

Item	Offshore Cost	Local Cost	Total
1. Preliminary Work	20.3	33.0	53.3
1.1. Road construction and improvement	13.8	23.2	37.0
1.2. Temporary facilities	6.5	9.8	16.3
2. Civil Engineering Work	111.8	113.8	225.6
2.1. Dam	60.8	53.9	114.7
2.2. Waterway	47.6	55.8	103.4
2.3. Powerhouse	3.4	4.1	7.5
3. Electrical and Mechanical Works	21.9	5.4	27.3
Sub-total (1 - 3)	154.0	152.2	306.2
4. Land Acquisition and Compensations	0	13.2	13.2
5. Contingencies during Construction	14.2	14.2	28.4
6. Cost for Engineering Work	8.5	15.8	24.3
7. NPC Administration	0	12.2	12.2
Sub-total (1 - 7)	176.7	207.6	384.3
8. Transmission/Substations	4.3	2.9	7.2
9. Contingencies during Construction	0.5	0.2	0.7
10. Cost for Engineering Work	0.4	0	0.4
11. NPC Administration	0	0.3	0.3
Sub-total (8 - 11)	5.2	3.4	8.6
Total (1 - 11)	181.9	211.0	392.9

9) Transmission line and substation

Manufacture, delivery, installation and test run of transmission line and substation equipment and materials for the project.

4.2. Construction Schedule

4.2.1. Construction Schedule

Construction work of this project including survey work and design will be completed in about nine years. Of this period, about one year will be required for preliminary work and about five years for the main work taking into consideration the scale of structures to be built and climatic and other local conditions.

4.2.2. Construction Program

(1) Selection of route for transportation of equipment and materials to site

There are two possible routes for transportation of equipment and materials to the site. One is the transportation from Manila to the site over a distance of 310 to 460 km. The other calls for unloading of equipment and materials at the San Fernando Port and transportation to the site by land over a distance of 390 to 480 km. The transportation distance will vary depending on the intermediate routes used.

After comparative study of these two routes, the first route, from Manila to the site, is recommended as the most suitable transportation route.

1) In the case of the transportation route from Manila, the distance to Kasibu is 310 km and to Dibibie 410 km. Some portions of this route are unpaved or poorly paved local roads. These roads need repairs and improvements, including construction of bridges. Detailed estimates for these roads will be made at the definite design stage.

2) Access roads

Access to the project site can be made either through Kasibu, Nueva Vizcaya or through Dibibie, Quirino. For further access to the project site, a 27 km-long logging road leads from Kasibu to the damsite, and a 15 km-long logging road runs from Dibibie to the powerhose site.

Besides existing roads, construction roads will be built to connect these roads with the main structures of the dam, powerstation, quarry site, intake, tunnel adits and surge tank. The extension will be around 105 km including 55 km for the Kasibu-damsite section, 38 km for the damsite - powerhouse section and 12 km for the powerhouse-Dibibie section.

No particular difficulties in road construction are expected to be encountered judging from the topographic and geologic conditions along the routes. However, maintenance of the roads after construction may be difficult, considering the characteristics of mountains covered by heavily weathered zones and unstable ground surface due to deforestation. Therefore, careful attention should be paid to drainage as well as to surface protection and stability of cut slopes when designing the construction roads.

(2) Power facilities

Diesel generators will be required as a power source during

the first period of the preparatory works because no power station of sufficient capacity exists in the vicinity of the project site. The required capacity will be around 1,500 kVA. As the main construction works begin, approximately 15,000 kVA will be needed. For this purpose, a greater part of the associated transmission line, 230 kV and 45 km long, will be constructed from Santiago to a temporary substation to be built at the powerhouse site. Damsite and tunnel construction sites are connected by means of two circuits of a 14 kV sub-transmission line for construction power supply.

(3) Temporary facilities

Main temporary facilities needed for the main construction works include aggregate plants, concrete plants, cable cranes, excavation equipment, transport roads in job sites, telecommunication facilities and water supply facilities. These temporary facilities should be completed before start of the main construction works.

(4) Temporary structures

Main temporary structures include field offices, plant offices, warehouses, living quarters, ancillary houses, repair shops, etc. Some of these structures shall be completed before the start of the main construction works while the others may be completed during their progress.

(5) Other facilities

Medical, safety, welfare, and security facilities are important for smooth progress of the project.

(6) Main construction works

Construction of the project will involve a total excavation

volume of 2.4 million cubic meters and a total concreting volume of 1.6 million cubic meters (excavation volume does not include the work for construction roads). The construction period will be five years from the commencement of the preparatory works, excluding construction roads, until commencement of operation of the power station. Of the construction works, open-air works will account for 70% and underground works for the remaining 30%.

All construction works should be carried out in an orderly manner on a mechanized system. For this purpose, the necessary temporary facilities should be completed on schedule.

4.2.3. Execution Plan and Method

(1) General

This project is considered one of the largest ever undertaken in the Philippines, even excluding excavations for road construction, and with the construction period extending over five years and nine months from the start of road building (January 1984) to the start of operation of the power station (October 1989). Construction works will be executed on a mechanized system from the standpoint of economic speed in execution and the safety of construction workers. The mechanized execution process is also required from the standpoint of both quality and safety of the hydraulic power station facilities which must be durable for long-term service life.

Provisions and installation of relevant facilities for safety of construction works as well as for safety and welfare of construction workers are indispensable to successful completion of the project with smooth progress on schedule.

At the peak of construction work, a maximum of approx. 3,600 workers are expected to be mobilized. About 25% of them (or about 900 persons) will be skilled workers and equipment operators, and their availability is a key to the success in this project. For this purpose, training will be needed.

In view of the present labor situation in the Philippines, no difficulties are anticipated in recruiting laborers (about 1,600 persons).

The commencement of operation of the power station will be set as October, 1989 based on economic execution speed. To meet this target date, the project will be implemented under the following schedule:

Start of survey and design (including those for construction roads)	January, 1981
Start of preparatory works	January, 1984
Start of main construction wroks	January, 1985
Completion of main civil works	April, 1989

(2) Scale of work and schedule for completion

1) Scale of work

The volume of excavation, concreting and other major works of civil engineering for this project are shown in the following table:

Volume of Major Works

Site of work	Excavation (m^3)	Embankment (m^3)	Concreting (m^3)	Reinforcing steel bar (t)	Gate screen steel pipe (t)
Main dam	445,300	20,000	1,198,000	1,300	gate 1,390
Diversion tunnels with coffer dam	90,000		46,000	1,300	gate 90
Intake	25,300		5,300	160	gate 100 screen 50
Headrace tunnel	510,000		195,000	6,300	steel pipe 550
Tunnel adits	34,000		4,600	50	gate 10
Surge tank	26,000		8,100	410	
Penstock	1,020,000		56,000	560	steel pipe 8,200
Tailrace	119,700		14,900	550	gate 72
Powerhouse foundation	41,000		13,400	670	
Other works	88,700		58,700	300	
Total	2,400,000	20,000	1,600,000	11,600	10,462

The volumes of excavation and concreting by open-air work and underground work are shown in the following table:

	Excavation (m^3)	Concreting (m^3)
Open-air work	1,709,700 (71%)	1,356,300 (85%)
Underground work	690,300 (29%)	243,700 (15%)
Total	2,400,000 (100%)	1,600,000 (100%)

2) Schedule for completion

with economic speed of construction in mind, completion of the civil engineering work shall be scheduled for April, 1989. Commencement of operation of the power station after test run period for equipment shall be set for October, 1989. The schedule for the works is shown in Fig. 4-2-1.

4.2.4. Execution method

(1) Dam

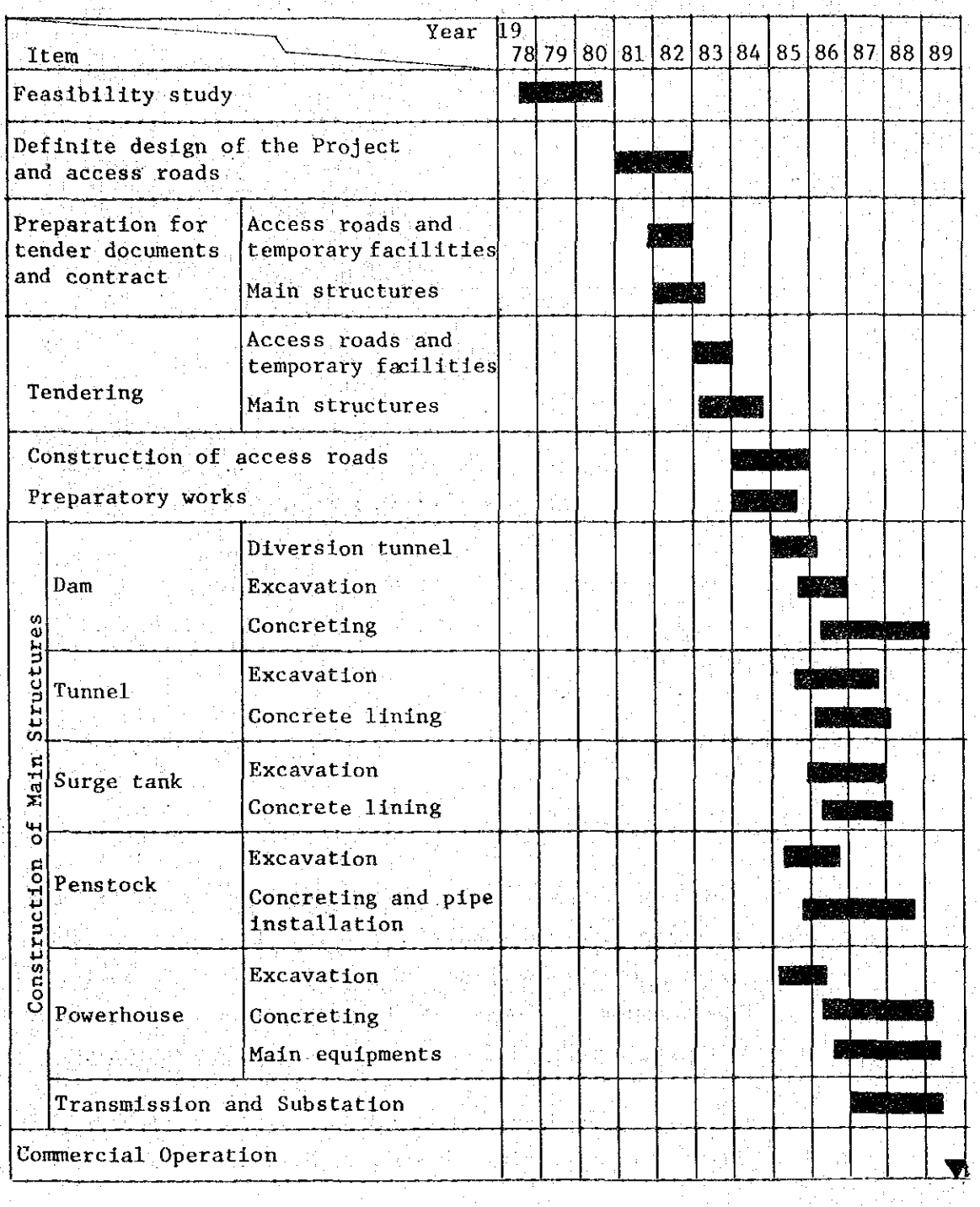
1) Diversion tunnels

Prior to commencement of the dam construction work, the existing riverflow shall be diverted to the right bank side. For this purpose, an embankment will be built. The embankment slope shall be protected against erosion with fabri-forms and cobbles contained in steel nets.

The access road shall be connected with the right bank by constructing a temporary bridge.

Two diversion tunnels shall be driven by the full face excavation method for each of them. They shall be driven from both the upper and

Fig. 4-2-1 Tentative Construction Schedule



Diduyon Hydroelectric Project Upper Cagayan River Republic of the Philippines	
Japan International Cooperation Agency	
Tentative Construction Schedule	
October 1980	Fig. 4-2-1

lower portals simultaneously to expedite work. A drill jumbo shall be used for driving the tunnel. Upon blasting, muck shall be removed from the tunnel and disposed of in a spoil ground with the combined use of shovel loaders and dump trucks. As support structure, steel support of 150-H shall be provided at a spacing of 1 m to 1.5 m according to the type of rock encountered, to ensure safety in operation. Excavation from the upper portal shall be terminated when it has reached a point 250 m from the portal, and the placing of lining concrete shall be started from the upper portal. Concrete shall be transported by concrete mixers from a concrete plant to be built near the damsite and shall be placed with a concrete pump.

A slide form shall be used as formwork for concreting and shall be of a structure that will allow continuous placing. For curved portions, the slide form shall be fabricated so that it can be used by splitting into two segments. When the lining concrete has been placed up to 350 m, the entry of concrete mixers shall be switched to the lower portal and ivert concrete shall be placed from the 350 point toward the upper portal. Upon completion of inverted lining, filler grouting shall be carried out mainly on the arch portion.

Operation shall be carried out day and night in two shifts as outlined later.

2) Temporary coffer dams

The first coffer dam of fill type and the second coffer dam of concrete type shall be built across the river, downstream of the inlet of the diversion tunnels for the upstream coffer dam and upstream of the outlet of the tunnels for the downstream coffer dam.

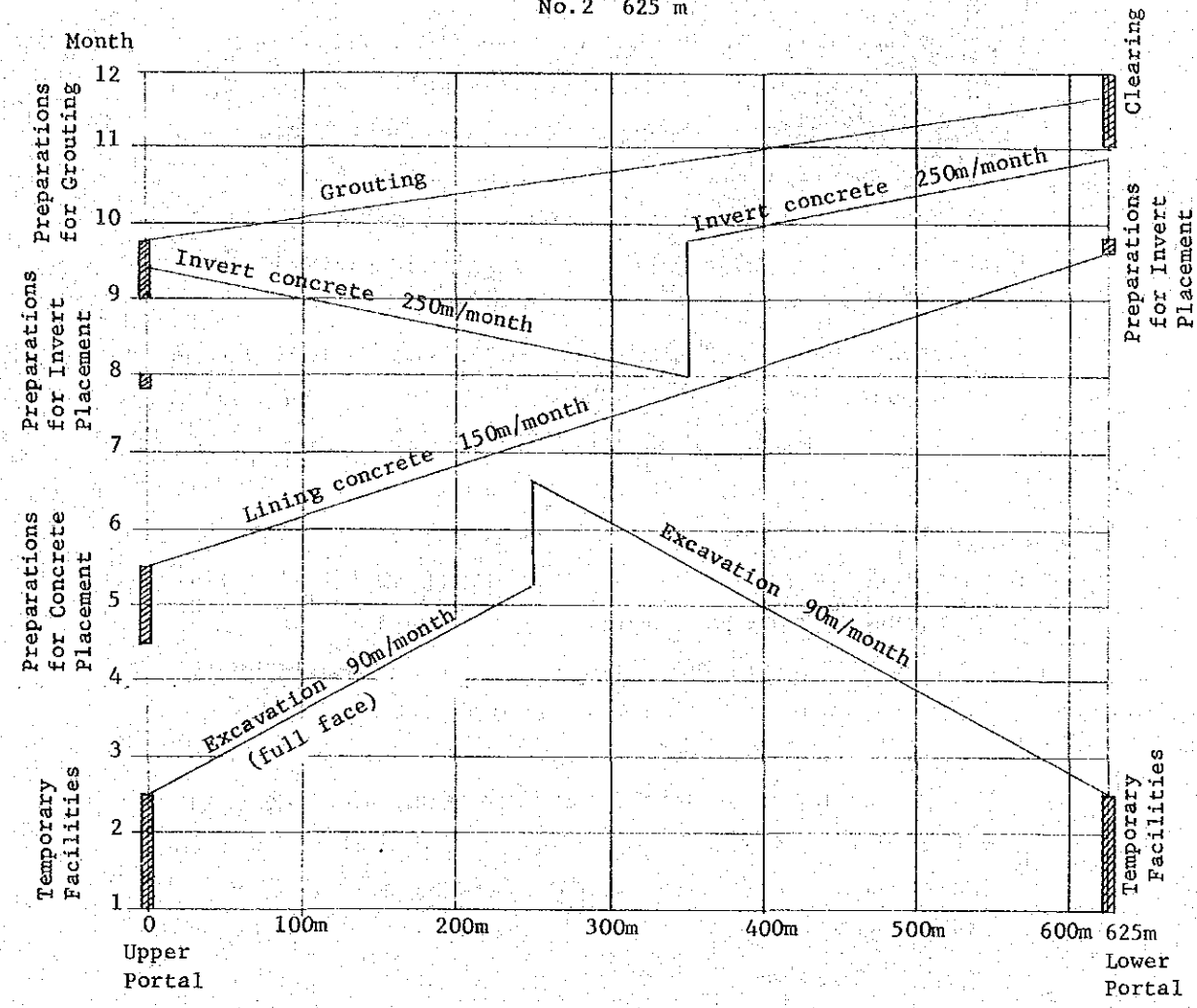
For the upstream coffer dam, after the tunnel is ready for diversion of water, water shall be led into the tunnel by bulldozing muck and earth to blockade the river course. Ripraps, gabions and cribwork shall be provided to protect the fill-up dike slope against erosion by water.

After the stream has been diverted to the tunnels, the second coffer dam shall be built up by placing concrete. Then, overburdens and riverbed deposits shall be excavated with bulldozers of the D-7 class and back-hoes, and removed by dump trucks. Weathered bedrock shall be blasted by drilling holes with a leg drill and placing dynamite in these holes. Removal of blasted rocks shall be done in the method described above. Concrete shall be transported by concrete mixers from the concrete plant to be built on the right bank of the dam and shall be placed by concrete pumps. The downstream coffer dam shall be built up by the same method as that upstream, and the first and second temporary coffer dams shall be constructed successively.

The construction shall be completed in about five months. The work schedule shall be arranged so that all this work is undertaken in the low water season.

Work Schedule for Diversion Channel

Extension No.1 570 m
No.2 625 m



Type of Work \ Month	1	2	3	4	5	6	7	8	9	10	11	12
Temporary facilities												Clearing
Excavation							90m/month					
Lining concrete										150m/month		
Invert concrete											250m/month	
Grouting												

3) Excavation for main dam

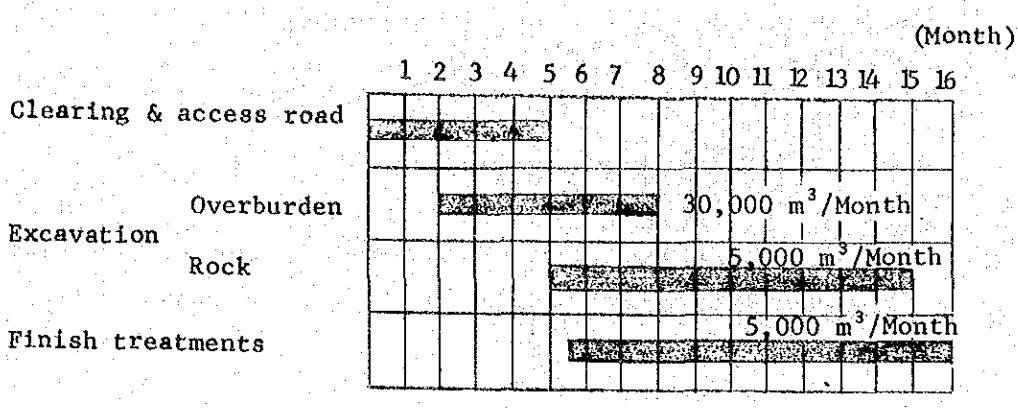
Excavation for the main dam will involve a total of 434,000 m^3, including 178,100 m^3 for overburden and 256,200 m^3 for rock. Prior to excavation, along with clearing of trees, access roads shall be built with 0.7 m^3 class hydraulic backhoes and bulldozers of the D-5 to D-7 class. These access roads shall include one on the riverbed and two others each at EL 620 m on both bank sides of the river. Each access road shall be 4.5 m to 6.0 m in width and shall be provided with turnout for smooth traffic of dump trucks. Topsoil and riverbed deposits shall be excavated and scraped by D-8 class bulldozers, and loaded on 15 t - 20 t dump trucks by 4.7 m^3 capacity class wheel loaders for removal.

Excavation of rock on the riverbed and on banks of the valley shall be carried out in the two stages as follows: at first, surface weathered or loose rock will be removed in Zone B, and then some depth (normally up to 1 m) of sound rock will be excavated in Zone A.

Zone B on the slopes shall be excavated under the bench cut process, using a DC-45 class crawler drill. Blasted rock shall be collected by D-8 class bulldozers and loaded on 15 t to 20 t dump trucks by 4.7 m^3 class wheel loaders for removal.

Excavation of Zone A shall carefully be carried out by hand breakers, power breakers, etc., so that no damage is inflicted on the foundation bedrock.

Excavated overburden and rock shall be disposed of at the specified spoil banks except for the amount required for banking, levelling or backfilling. Excavation shall be completed in 16 months under the work schedule outlined below.



4) Foundation treatments

Upon excavation, bedrock with many cracks and seams and the limited portions with deep sound bedrock shall properly be treated to seal against water seepage and ensure necessary strength using methods best suited to local conditions, based on the results of various tests. As specific measures, these rock portions shall be either replaced with concrete or treated with consolidation grout, curtain grout, etc.

5) Concrete placing

This dam is 111 m high and 415 m in crest length, and will require a concrete volume of about 1.2 million m^3 placement. The dam shall be divided into 23 blocks in the axial direction and maximum 3 blocks in the direction at right angles to the dam axis. The height of one lift shall be 2 m, except for the bedrock portion where concrete shall be placed to a height of 1 m. Concrete shall be placed from the riverbed level under the block column process.

Assuming that the concreting period will be about 35 months, the monthly average placement : v shall be,

$$v = 1,200,000\ m^3/35\ \text{months} = 34,280\ m^3/\text{month}$$

The relationship between the monthly average placement: v and monthly maximum placement: V can be obtained from the following formula:

$$V = 1.97v - 3.07$$
$$= 1.97 \times 34.28 - 3.07 = 64,470\ m^3/\text{month}$$

where V and v are represented in $10^3 m^3$.

Considering that the maximum number of work days per month is 23, the number of work hours per day 12, and the rate of operation about 75% taking into account the rainy season, the monthly maximum work hours will be

$$16\ \text{hrs/day} \times 23\ \text{days/month} \times 0.75 = 276\ \text{hrs/month}$$

Placement per hour : Vo will be

$$Vo = 64,470\ m^3/\text{month} \div 276\ \text{hrs/month} = 234\ m^3/\text{hr}$$

Thus concrete placing facilities and aggregate and concrete production plants for the dam shall be designed and supplied based on a maximum concreting volume of $235\ m^3/\text{hr}$.

No suitable riverbed deposits for concrete aggregate are available in the vicinity. There are sizable amounts of deposit layers at a point 80 km downstream but it would require a substantial cost to transport deposited aggregates from that point. Based on results of the surveys thus far conducted, it has been decided to use the area about 2 km upstream of the left bank of the dam as a quarry.

This quarry has a relatively thin layer of topsoil and consists of andesite which is considered sufficient and suitable for aggregates.

Rock extracted from this quarry shall be transported by dump trucks to an aggregate plant to be built on the right bank of the dam to produce aggregates upon preliminary crushing at the quarry site. Aggregates for the dam shall be carried to batcher plants by belt conveyor. Aggregates for the powerhouse and other remote construction sites shall be delivered by dump trucks.

The batcher plant to be built on the right bank of the dam shall consist of two units of plant. One unit shall comprise 3.0 m^3 x 4 mixers for the dam and the other 1.5 m^3 x 4 mixers for the subsidiary dam and other structures.

Under 2 transfer can system, batches of concrete shall be transported from the batcher plants in buckets of 9 m^3 and 6 m^3, using 25 t and 20 t cable cranes, respectively.

Steel slide forms shall be used for concrete surface and construction joints.

Consolidation grouting and curtain grouting for the foundation bedrock shall be performed at the proper time before and during concreting operation.

Placed concrete shall be cooled by the pipe cooling process, and two units of 300 refrigeration ton capacity plant shall be installed.

(2) Intake

The intake shall be installed provided on the left bank 400 m upstream of the dam. I shall be of a inclined type, 16 m in width and 17.2 m in inclined length, and shall consist

of a mouth section, tunnel section and shaft for the gate.

Prior to commencement of the work, access roads for removal of overburdens shall be built in the vicinities of EL 651 m and EL 610 m. For open excavation, earth and soft rock shall be removed with D-7 class bulldozers at EL 651 m. Hard rock shall be drilled and broken with a leg drill and removed to EL 610 m level. At the EL 610 m level, earth and rock shall be loaded on dump trucks by 2 m^3 class tractor shovels and disposed of at the spoil ground. The intake tunnel shall be excavated by the top heading bench cut excavation process. For the shaft, a heading shall be excavated from the tunnel side upward under the Big Man process upon excavation of the intake tunnel. When the heading has been tunneled through, a scaffold shall be assembled and the heading shall be expanded with this scaffold as the platform.

Concrete shall be transported by mixer cars from the batcher plant at the dam. Open concrete and tunnel concrete shall be placed by chutes or concrete pumps while shaft concrete shall be placed by chutes after transferring to a concrete kibble.

(3) Headrace tunnel

The headrace tunnel shall be a pressure tunnel of 11,700 m extension with the end of the intake as the starting point and the surge tank as the terminal. It shall have a circular cross-section with an inner diameter of 5.9 m (special section 5.0 m). The thickness of concrete lining shall range from 0.5 m to 0.7 m (0.9 m for special section) depending on the geological condition encountered. Reinforcing steel bars shall be inserted into the concrete for the entire length. The special section is located where the tunnel passes under mountain streams. Since it is anticipated that earth covering is thin and rock is soft at such points, steel pipes shall be laid in this section. Extension of the tunnel and construction adits shall be laid out as shown below.