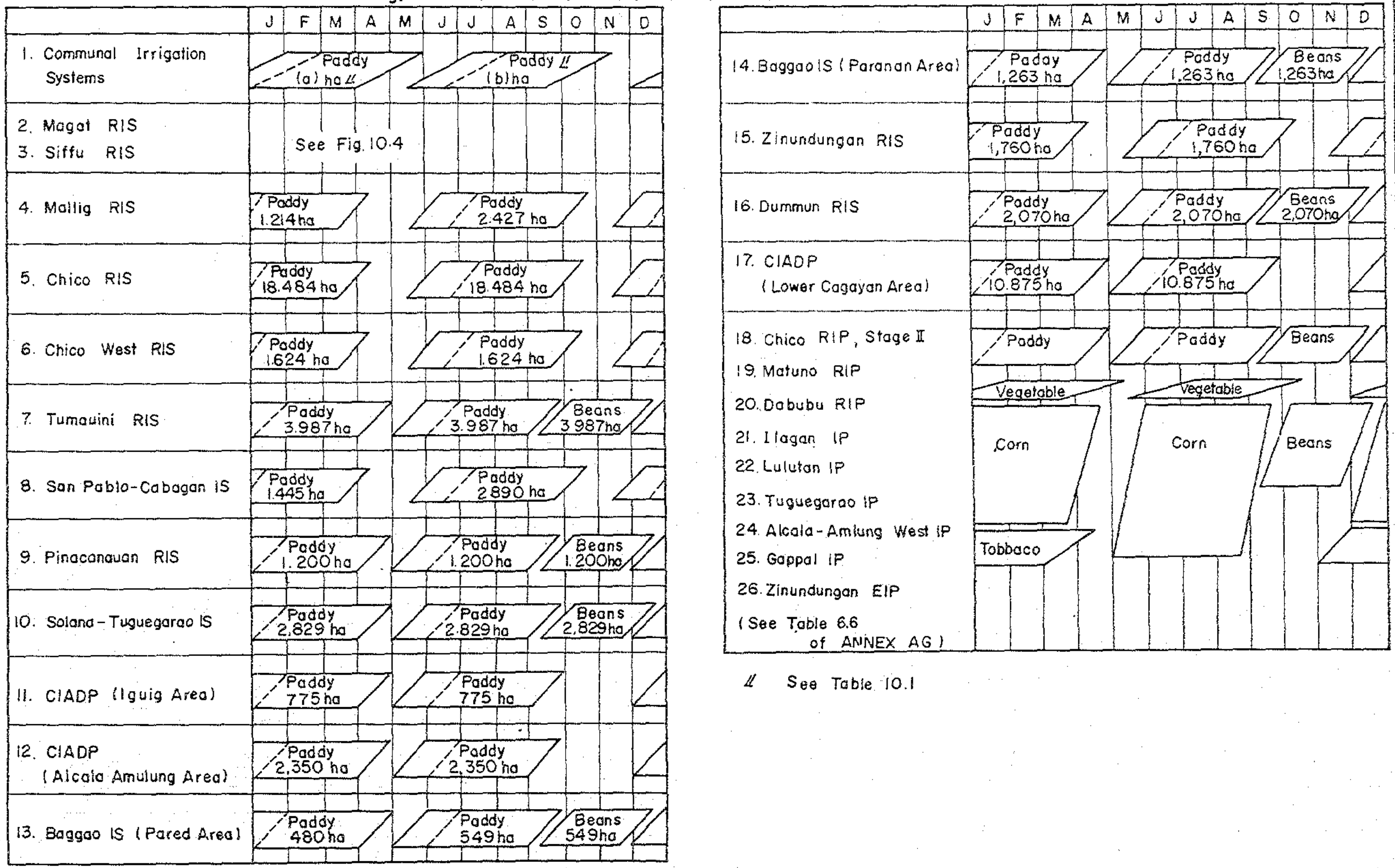
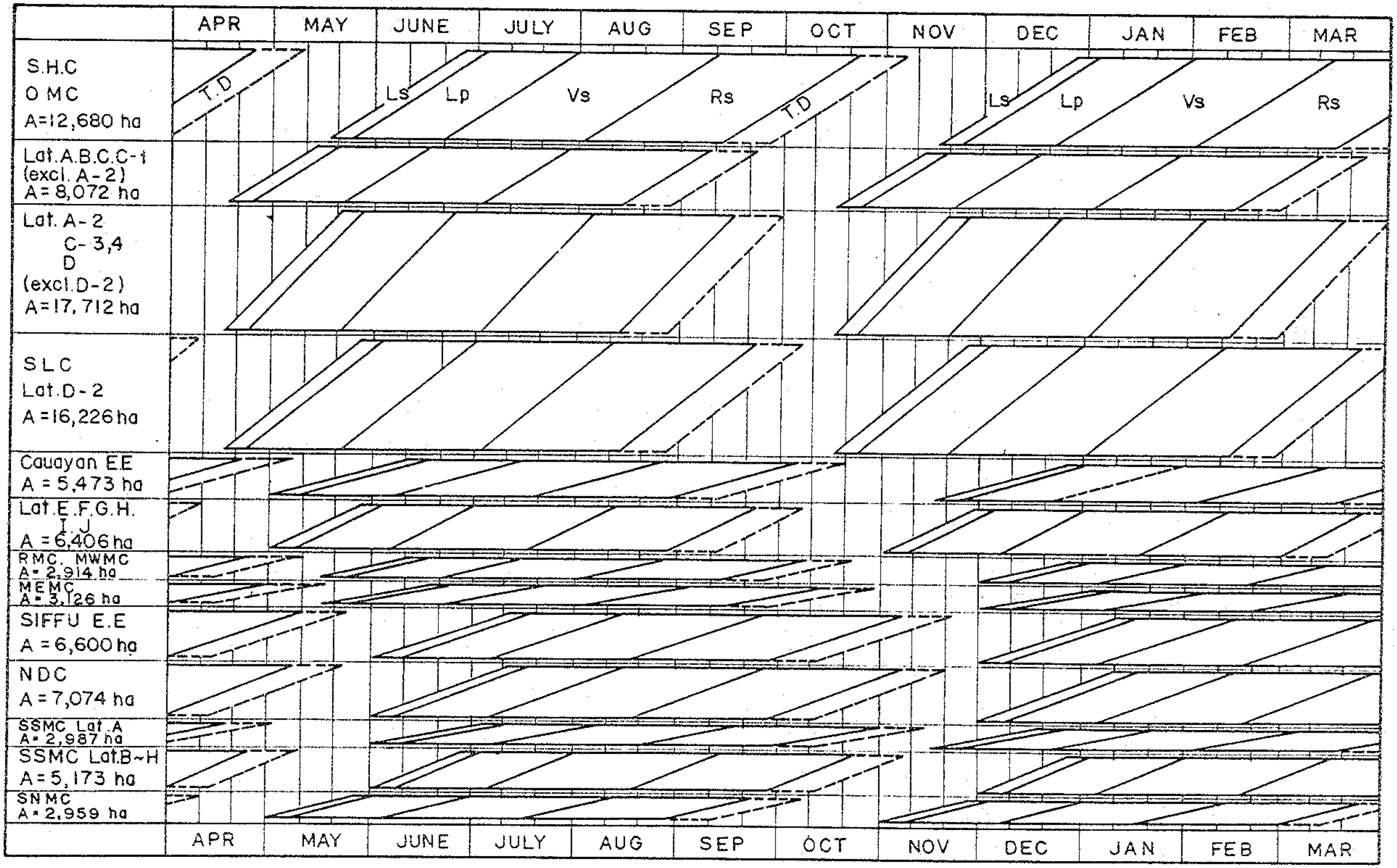
Fig. 10.3 FUTURE CROPPING PATTERN



// See Table 10.1

Fig. 10.4 PROPOSED CROPPING SCHEDULE OF MARIIS



Source : IR – 222

Attachment A. List of Collected Data

Ref.No.	Title	Author	Date of Issue
IR-101	Inventory Report, Tumauini Irrigation Project	O&M office, NIA	May '84
IR-102	General Information, Mallig River Irrigation Project	Project office, NIA	
IR-103	Average River Discharge by Month, San Pablo-Cabagan Irrigation System	Regional office, NIA	Nov. '85
IR-104	Average River Discharge by Month, Mallig River Irrigation System	"	Nov. '85
IR-105	Average River Discharge by Month, Zinundungan River Irrigation System	"	Oct. '85
IR-106	Average River Discharge by Month, Dummun River Irrigation System	"	Dec. '85
IR-108	Average River Discharge by Month, Tumauini Irrigation System	"	Oct. '85
IR-109	Average River Discharge by Month,	"	Nov. '85
	Baggao Irrigation System (Paranan R.)	"	Nov. '85
IR-110	" " (Pared R.)	"	"
IR-111	Average Daily Discharge Record, Chico Division Dam Intake	Project office, NIA	Dec. '85
IR-112	Average Discharge Diverted by Month, Zinundungan River Irrigation System	Regional office, NIA	Oct. '85
IR-113	Average Discharge Diverted by Month, Dummun River Irrigation System	"	Dec. '85
IR-114	Average Discharge Diverted by Month, Baggao Irrigation System (Pared intake)	"	Oct. '85

(to be continued)

(Continuation)

Ref.No.	Title	Author	Date of Issue
IR-115	Average Discharge Diverted by Month Baggao Irrigation System (Paranan intake)	Regional office, NIA	Oct. '85
IR-116	Average Discharge Diverted by Month, Pinacanauan River Irrigation System	"	Nov. '85
IR-117	Average Discharge Diverted by Month, San Pablo Cabagan Irrigation Project	"	Dec. '85
IR-118	Intake Water Record, Zinundungan River Irrigation System	"	"
IR-119	Intake Water Record, Dummun River Irrigation System	"	"
IR-120	Intake Water Record, Baggao Irrigation System	"	"
IR-121	Intake Water Record, Solana-Tuguegarao Irrigation System	" "	" "
IR-122	Intake Water Record, Mallig River Irrigation System	Project office, NIA	"
IR-123	Intake Water Record, Tumauini Irrigation System	"	"
IR-124	Intake Water Record, Pinacanauan River Irrigation System	Regional office, NIA	"
IR-125	Intake Water Record, San Pablo Cabagan Irrigation Project	"	"
IR-126	Existing Communal Irrigation System Region II, as of 1978	Head office, NIA	1978
IR-127	List of Communal Irrigation System, Cagayan	Provincial office, NIA	Nov. '85
IR-128	Farmer's Association of Irrigation System (CIS), Cagayan	"	"
IR-129	Intake Water Record (CIS), Cagayan	"	"

(to be continued)

(Continuation)

Ref.No.	Title	Author	Date of Issue
IR-130	Diversion Water Requirement (Communal Irrigation Project, Cagayan	Provincial office, NIA	Nov. '85
IR-131	List of Existing CIS, Kalinga-Apayao	"	"
IR-132	Farmer's Association of Private Irrigation System, Kalinga-Apayao	"	"
IR-133	Intake Water Record (CIS), Kalinga-Apayao	"	"
IR-134	Operation and Maintenance Cost (CIS), Kalinga-Apayao	"	"
IR-135	Diversion Water Requirement (On-going Communal Irrigation Project), Kalinga-Apayao	"	"
IR-136	List of Existing CIS, Mountain Province	"	"
IR-137	Inventory of Existing Pump Irrigation System, Kalinga-Apayao	"	Oct. '85
IR-138	List of Irrigation System (Existing), Isabela	"	Nov. '85
IR-139	List of Irrigation System (On-going & Proposed), Isabela	"	"
IR-140	Farmer's Association of Private Irrigation System, Isabela	"	"
IR-141	On-Farm Canals M/ha, Isabela	"	"
IR-142	Start of Transplanting to Start of Harvest, Isabela	"	"
IR-143	Operation and Maintenance Cost, Isabela	"	"
IR-144	Diversion Water Requirement, Isabela	"	"
IR-145	Intake Water Record, Isabela	"	"
IR-146	Diversion Water Requirement, Ifugao	"	"
IR-147	List of Existing Communal Irrigation System, Ifugao	"	"

(to be continued)

(Continuation)

Ref.No.	Title	Author	Date of Issue
IR-148	Farmer's Association of Irrigation System, Ifugao	Provincial office, NIA	Nov. '85
IR-149	Intake Water Record, Ifugao	"	"
IR-150	List of Irrigation System (Existing Communal Irrigation System), Quirino	"	"
IR-151	List of Irrigation System (On-going Communal Irrigation Project), Quirino	"	"
IR-152	Farmer's Association of Irrigation System, Quirino	"	"
IR-153	Diversion Water Requirement, Quirino	"	"
IR-154	Intake Water Record, Quirino	"	"
IR-155	List of Irrigation System, Nueva Vizcaya	"	"
IR-156	Farmer's Association of Irrigation System, Nueva Vizcaya	"	"
IR-157	Division Water Requirement, Nueva Vizcaya	"	"
IR-158	Operation and Maintenance Cost, Nueva Vizcaya	"	"
IR-159	List of Irrigation Project under FSDC	FSDC	Dec. '85
IR-160	Report Re-typhoon Damage Caused by Typhoon "ARING"	CIADP	Nov. '80
IR-161	Report Re-typhoon Damage Caused by Typhoon "MARING"	"	Sep. '84
IR-162	Water Permit Guarantees, Cagayan	NWRC	June '85
IR-163	" , Kalinga-Apayao	"	"
IR-164	" , Isabela	"	"
IR-165	" , Ifugao	"	"
IR-166	" , Nueva Vizcaya	"	"
IR-167	" , Quirino	"	"
IR-168	" , Mt. Province	"	"

(to be continued)

(Continuation)

Ref.No.	Title	Author	Date of Issue
IR-169	General Layout of Zinundungan River Irrigation Project	Regional office, NIA	
IR-170	General Layout of Dummun River Irrigation Project	"	
IR-171	General Layout of Baggao Irrigation Project	"	
IR-172	General Layout of Solana-Juguegarao Irrigation Project	"	
IR-173	Farm Level Progress Layout, Pinacanauan River Irrigation Project	"	
IR-174	General Layout of Tumauini Irrigation Project	"	
IR-175	General Layout of San Pablo Cabagan Irrigation Project	"	
IR-176	General Layout of Mallig River Irrigation Project	"	
IR-177	Location Map of Communal Irrigation System, Quirino	Provincial office, NIA	
IR-178	Location Map of Communal Irrigation System, Kalinga-Apayao	"	
IR-179	Location Map of Communal Irrigation System, Nueva Vizcaya	"	
IR-180	Location Map of Communal Irrigation System, Ifugao	"	
IR-181	Location Map of Communal Irrigation System, Isabela	"	
IR-182	Location Map of Communal Irrigation System, Cagayan	"	
IR-183	Inventory Report on Pinacanauan River Irrigation System	Regional office, NIA	July '84

(to be continued)

(Continuation)

Ref.No.	Title	Author	Date of Issue
IR-184	Inventory Report on Tumauini Irrigation System	Regional office, NIA	Apr. '84
IR-185	Inventory Report on Mallig River Irrigation System	"	Dec. '85
IR-186	Inventory of Irrigation Facilities, Baggao Irrigation System	Irrigation office, NIA	June '83

Attachment B. List of Collected Project Reports

Ref.No.	Title	Author	Date of Issue
IR-201	FEASIBILITY REPORT ON THE MATUNO RIVER DEVELOPMENT PROJECT, VOLUME 1	JICA/NPC-NIA	Feb. '84
IR-202	" , VOLUME 2	"	"
IR-203	CAGAYAN RIVER FLOOD CONTROL BASIN WIDE STUDY, VOLUME 2a; ILAGAN RIVER NO. 2 MULTIPURPOSE PROJECT, FEASIBILITY STUDY	Philtech/MPW	Jan. '83
IR-204	CAGAYAN RIVER FLOOD CONTROL BASIN WIDE STUDY, VOLUME 2b; TUGUEGARAO RIVER MULTIPURPOSE PROJECT, FEASIBILITY STUDY	Philtech/MPW	"
IR-205	CAGAYAN RIVER FLOOD CONTROL BASIN WIDE STUDY, VOLUME 3b; STA CRUZ RIVER NO. 2 MULTIPURPOSE PROJECT, PREFEASIBILITY STUDY	Philtech/MPW	"

(to be continued)

(Continuation)

Ref.No.	Title	Author	Date of Issue
IR-206	CAGAYAN RIVER FLOOD CONTROL BASIN WIDE STUDY, APPENDIX 7. IRRIGATION/WATER SUPPLY STUDIES	Philtech/MPW	July '81
IR-207	FEASIBILITY STUDY, CHICO IV HYDROPOWER PROJECT IN THE CHICO RIVER, LUZON, VOLUME 1: Main Report	Lahmeyer/NPC	May '81
IR-208	CHICO RIVER IRRIGATION PROJECT: Stage 1 APPRAISAL REPORT	IBRD	Mar. '76
IR-209	CHICO RIVER IRRIGATION PROJECT	NIA	Jun. '75
IR-210	MAGAT RIVER MULTIPURPOSE PROJECT STAGE II, PROJECT DESIGN REPORT, VOLUME 3	ECI-SECO EDCOP.DCCD/NIA	Sep. '76
IR-211	CHICO RIVER IRRIGATION PROJECT, MONTHLY PROGRESS REPORT, NOVEMBER 1985	NIA	Nov. '85
IR-212	MONTHLY PROGRESS REPORT NOVEMBER, 1985, CAGAYAN INTEGRATED AGRICULTURAL DEVELOPMENT PROJECT	CIADP	Nov. '85
IR-213	CAGAYAN INTEGRATED AGRICULTURAL DEVELOPMENT PROJECT, FEASIBILITY REPORT, MAIN REPORT	JICA/NIA	Apr. '76
IR-214	CAGAYAN INTEGRATED AGRICULTURAL DEVELOPMENT PROJECT, FEASIBILITY REPORT, APPENDIX	JICA/NIA	Apr. '76
IR-215	FEASIBILITY REPORT STUDY FOR THE IMPROVEMENT OF 18 NATIONAL IRRIGATION SYSTEM, MAIN REPORT	JICA/NIA	June '83
IR-216	FEASIBILITY REPORT STUDY FOR THE IMPROVEMENT OF 18 NATIONAL IRRIGATION SYSTEM, APPENDIX	JICA/NIA	June '83

(to be continued)

(Continuation)

Ref.No.	Title	Author	Date of Issue
IR-217	UPPER PAMPANGA RIVER PROJECT IRRIGATION-AGRICULTURE STUDY	NIA/ECI/EDCOP	Nov. '75
IR-218	WINDENERGY DEVELOPMENT AND IRRIGATION AT SOLANA AND TUGUEGARAO	HASKONING	
IR-219	FEASIBILITY STUDY ON DABUBU COMMUNAL IRRIGATION PROJECT	Regional office, NIA	1985
IR-220	OPERATION AND MAINTENANCE MANUAL FOR THE MAGAT RIVER INTEGRATED IRRIGATION SYSTEM	MARIIS, NIA	June '85
IR-221	SAN PABLO CABAGAN IRRIGATION PROJECT, PROJECT REPORT	NIA	1978
IR-222	MASTER PLAN STUDY ON THE O & M OF MAGAT RIVER INTEGRATED IRRIGATION SYSTEM, INTERIM REPORT	JICA/NIA	Oct. '86
IR-223	MASTER PLAN STUDY ON THE O & M OF MAGAT RIVER INTEGRATED IRRIGATION SYSTEM, MAIN REPORT	JICA/NIA	Mar. '87

Attachment C. List of Collected Publications

Ref.No.	Title	Author	Date of Issue
IR-301	IRRIGATION INVENTORY, 1977	NWRC	July '80
IR-302	NIA CORPORATE PLAN 1981-1990	NIA	
IR-303	FRAMEWORK PLAN, CAGAYAN VALLEY, CHICO RIVER BASIN	UNDP/NWRC	Dec. '80
IR-304	" , " , LOWER CAGAYAN BASIN	"	July '80
IR-305	" , " , UPPER CAGAYAN RIVER BASIN	"	Dec. '80
IR-306	" , " , MAGAT RIVER BASIN	"	Dec. '81

(to be continued)

(Continuation)

Ref.No.	Title	Author	Date of Issue
IR-307	" , " , ILAGAN RIVER BASIN	"	Dec. '81
IR-308	NIA CORPORATE PLAN, 1983-1992	NIA	Mar. '83
IR-309	BILLING AND COLLECTION MANUAL ON IRRIGATION SERVICE FEE	NIA	Sep. '82
IR-310	EVAPOTRANSPIRATION FROM RICE FIELDS	IRRI	Aug. '79
IR-311	THE PHILIPPINES RECOMMENDS FOR IRRIGATION WATER MANAGEMENT VOL. 1	PCARRD	1983
IR-312	THE PHILIPPINES RECOMMENDS FOR IRRIGATION WATER MANAGEMENT VOL. 2	PCARRD	1982
IR-313	DESIGN GUIDES AND CRITERIA FOR IRRIGATION CANALS, O & M ROADS, DRAINAGE CANALS & APPURTENANT STRUCTURES	NIA	Jan. '79
IR-314	PHILIPPINES WATER CODE	NWRC	1982
IR-315	OPERATION AND MAINTENANCE PLAN FOR STRUCTURES, CHAPTER-1 DESIGN	NIA	
IR-316	MANUAL ON CANALS AND CANAL STRUCTURES, CHAPTER-1 DESIGN OF CANAL SYSTEM (Draft)	NIA/WARCOS	Apr. '82
IR-317	MANUAL ON CANALS AND CANAL STRUCTURES, CHAPTER II GENERAL FEATURES OF CANAL STRUCTURES (Draft)	NIA/WAPCOS	Jun. '82
IR-318	IRRIGATION PROGRAM REVIEW	WB	Jan. '82
IR-319	FAO IRRIGATION AND DRAINAGE PAPER 24, CROP WATER REQUIREMENT	FAO	1977
IR-320	FAO IRRIGATION AND DRAINAGE PAPER 25, EFFECTIVE RAINFALL	FAO	1977
IR-321	MANUAL OF STANDARDS AND CRITERIA FOR PLANNING WATER RESOURCES PROJECT NO. 26	UN	1964
IR-322	YEAR-END REPORT TO THE PRESIDENT	NIA	Dec.1986

ANNEX PO

HYDROPOWER

ANNEX PO

Table of Contents

List of Tables

List of Figures

I DESIGN OF GENERATING EQUIPMENT

1.1 General

The Generating Equipment (G/E) consists of the water turbine, the generator, the step-up transformer and the associated apparatus such as control board, switchgear, over-head crane, etc.

Figure 1.1 is illustrated the generating equipment of the mini-hydro power plant.

Hydraulic turbines may be grouped in two general classes: the impulse type which utilizes the kinetic energy of a high-velocity jet, and the reaction type which develops power from the combined action of pressure and velocity of the water.

The reaction group is divided into two general types: the Francis, sometimes called the reaction type, and the propeller type. The propeller class is also further subdivided into the fixed-blade or propeller type, and the adjustable-blade type of which the Kaplan is representative.

Generators may be grouped in two general classes: the synchronous generators and induction generators.

Induction motors occasionally are driven slightly above synchronous speed and operated as generators, but these instances are very rate.

Horizontal-shaft and vertical-shaft generators are essentially the same electrically, merely being modified mechanically to suit the particular type of construction. The position of the shaft generally is chosen so as to obtain the most favorable turbine design.

1.2 Basic Design

1.2.1 Determination of Design head, Number of units and Maximum unit discharge

a) Design head

Design head Hd is defined as a net head at which the peak efficiency is attained when operating at the rated speed.

The design head of the power station is determined as a head on which annual energy generation become largest.

The design head is the basic index to determine the dimension of turbine.

For reference, various heads and water levels are illustrated in Fig. 1.2.

The ultimate capacity of a power plant is dependent upon the weighted average head available and the quantity of the discharge economically developable.

Above the rated head of the plant, its capacity is limited by the total kilowatt capacity of the generators, but below that head the full gate capacity of the turbine is the absolute limit of the output.

b) Number of units

Following considerations will be taken into account to decide the number of units in the case study.

In general, the hydroelectric power plant has to operate in a wide range of the operating heads and in many cases a considerable and seasonable variation of the flow.

In this connection, large units operating with the small gate openings have a low efficiency, excessive vibration, and accelerated damage from cavitation.

If the maximum discharge of the power plant becomes more than three times the firm discharge, the number of the units should be more than two.

c) Rated discharge per each unit

Rated discharge per unit is obtained from the maximum discharge of the power plant and the number of the units.

However, the following minimum operating discharge per each unit has to be maintained within the range of the safety operating.

Minimum operating discharge per each unit:

Francis turbine	- 40%	of the rated discharge per unit
Kaplan turbine	- 25%	"
Pelton turbine	- 20%	"

1.2.2 Utilization of Irrigation Dams

The utilization of irrigation dams for the purpose of hydroelectric power generation has been studied by many developing countries for the electrification of isolated districts. The characteristics of this method are the low head and the wide range of head change. Recently, many turbine makers started to develop water turbines for variable low head, of which specifications have gradually become standardized.

The problem of irrigation dam power generation is that the quantity of water available is determined by the amount of water needed for irrigation. As a result, there may be a lack or low supply of water during certain seasons so that power is not available during that interval. Therefore, the benefits of this type of power generation must be measured by energy-value (kWh-value), and not peak-value (kW-value), and be compared to by the extra fuel needed for supplement thermal (or diesel) generation. Although more than one half of dam construction costs are attributed to irrigation work, the costs of this type of generator is expensive because of the complexity for adjusting to variable low head. Thus, from the standpoint of kWh-value only, it might not be economical.

1.2.3 Selection of the type of turbine

In principle, the type of turbine is selected in accordance with the head and discharge as shown in Fig. 1.3.

However, the type of turbine has to be determined finally based on the technical and economical analysis.

1.2.4 Calculation of output

Rated output of generating unit will be calculated from following formula.

Output $P = 9.8\ Q.H.q$ (kw)

where,

Q = discharge per unit (m^3/s)

H = rated net head (m)

q = combined efficiency of water turbine and generator

However, in case of master-plan study, output of unit for mini-hydro can be obtained by following equation.

Output $P = 8\ QH$ (kw)

For example, following value of efficiencies are utilized this calculation.

Efficiency of Turbine

Francis	85.5%	at Ns = 300, Head = 50 m, Turbine output = 1000 kw class
Kaplan	87.5%	at Ns = 440, Head = 30 m, Turbine output = 1000 kw class

Efficiency of Generator

94%   at power factor = 0.8,
generator rating = 1000 KVA class

The power station output should be calculated as follows;

Station output = output of generating unit X number of unit (kW)

1.3 Study of Cagayan Hydropower

1.3.1 Basic Data

Following data are obtained from dam development plan.

Name of Site	Head (m)	Utilized Water for hydro power (m^3/s) Max.	Min.
Dummon A	18.9	4.0	0.5
Dummon B	17.6	4.0	0.5
Paranan A	28.4	2.8	0.3
Paranan B	26.1	2.8	0.3
Zinundungan A	24.3	7.2	0.7
Zinundungan B	22.5	7.2	0.7
Siffu No. 1	32.0	19.9	6.4
Alimit No. 1	56.3	26.0	5.7

1.3.2 Calculation of output

Number of unit is determined as 2 so that the maintenance flow of river should be supplied 12 hours per day and minimum discharge of runner should be maintained 25% of rated discharge.

Result of calculation of output is as follows:

Number of Power Station	No. of units	Output per unit	Type of Turbine
Dummon A	2	300	cross flow
Dummon B	2	300	cross flow
Paranan A	2	300	cross flow
Paranan B	2	300	cross flow
Zinundungan A	2	700	cross flow
Zinundungan B	2	700	cross flow
Suffu No. 1	2	2,700	Francis
Alimit No. 1	2	6,100	Francis

II COST ESTIMATE

2.1 General

2.1.1 Capital Cost of Hydroelectric Plants

The capital cost of a hydroelectric development or project includes the cost of all lands and water rights; the cost of road, bridge and other public-utility changes; and the cost of construction, engineering supervision, and overhead for all items of the development.

The reason for the greater range of cost for hydro plants than for steam plants is not difficult to find. Only about 15% of the total cost of steam plants is influenced by topographical and geological conditions, whereas, with hydroelectric developments, 75 to 85% of the total cost is thus affected.

Factors affecting the capital cost of hydroelectric development are:

(a) Water rights and control of site.
(b) Topography of the site.
(c) Geological conditions at dam site and reservoir site.
(d) Extent and value of lands submarged.
(e) Public utilities required to be relocated such as roads, bridges, railroads, etc.
(f) Towns and communities under water.
(g) Quantity and character of stream flow, i.e., as steady or subject to wide variation with extreme floods.
(h) Available head.
(i) Capacity of the development.
(j) Price level (prevailing costs of labor, materials, and equipment at the time and place of construction).
(k) Skill of the engineer.
(l) Foresight of executives.
(m) Efficiency of the construction organization.

The above factors are not listed in the order of importance. It would be entirely impracticable to rank them, as the order of importance would change materially from project to project. However, it is probable that, in most cases (h) the skill of the engineer, (i) the foresight of executives, and (j) the efficiency of the construction organization are the most important factors determining the capital cost of the development.

From the above it is clear that hydro developments are quite individualistic and that problem and costs are sure to vary over a wide range.

Although it would be possible to give an extensive compilation of the cost of existing hydroelectric developments. From the data of this kind, it is evident that there is nothing consistent about the cost of hydroelectric developments. It is almost literally true that each is a law unto itself. Furthermore there is no adequate simple yardstick for measureing the reasonableness of the cost of a hydro development.

2.1.2 Cost of Generating Facilities

As mentioned above, the cost of hydroelectric developments varies widely, and total cost may not bear any direct relation to the amount of installation. However, for any given site, certain portions of the total cost are at least roughly proportional to the capacity installed. In general these parts are intakes, conduits, powerhouse, and equipment.

Because the cost of these four items varies so nearly with installation capacity they may be termed the cost of generating facilities.

If a hydroelectric project is being considered for construction in any river, the site and practicable head will be determined as the result of field investigations and office studies. The next problem is to determine how much capacity to install. The cost of lands and water rights, of relocation of public utilities, and of the dam will remain practically constant regardless of the amount of capacity installed. The remaining costs of generating facilities (powerhouse and equipment including intake and conduits) will vary almost directly with the capacity which it is decided to install.

Whether it will be economically advantageous to develop a hydroelectric project will depend on (a) nearness to a load center, (b) shape and size of the load curve to which it might be connected, and (c) the annual cost of the project as compared to that of some other plant, steam or hydro, which might perform the same function.

2.1.3 Transmission Cost

Steam plants are usually relatively near the load centers which they serve, although there are plants which, in order to secure an adequate source of condenser water and/or cheaper transportation for fuel, are located at some distance from the center of gravity of the loads which they serve.

The steam plant engineer usually has considerable option in locating his plant to the greatest economic advantage. The hydroelectric engineer, on the other hand, does not have nearly as much freedom in his choice, as the location is largely determined by questions of topography, available water supply, and available head.

Consequently, hydro plants are likely to be located far from the center of gravity of the loads to be served and frequently a transmission line of large capacity must be constructed for the delivery of substantially all the output to a load center.

For this reason the cost of transmission must usually be considered in connection with hydro plants. The cost varies greatly with the voltage utilized, the capacity of the line and the degree of reliability required.

It is never satisfactory to have the output of a hydro plant dependent on a single transmission line. The arrangement should always be such that, if from any cause one transmission line goes out of service, the line or lines available can still deliver the full plant capacity. Otherwise the capacity could not be relied on. It is much better, but not always practicable, to have the transmission lines carrying power from a hydro plant follow different rights of way to the market.

2.2 Construction Cost Estimate

2.2.1 Cost Estimate of the Project

The construction cost estimate of the project should be carefully executed taking into account the detailed characteristics of the Basic Design and the better knowledge of the Project area gathered during the site investigation.

For the elaboration of the cost of the civil works, the basic unit prices listed in the Overall Report have been used, sometimes with some adjustments to better take into account the typical conditions of the work.

Distribution between the local and the foreign currency component has been done according to the Consultant past experience in similar projects. Whereas the currency distribution for the electro-mechanical works cannot very much since most of the materials and equipment are to be imported, the one of the civil works is more variable depending on the importance of the share of the local Contractors.

The cost estimate of the civil works may be made under the assumptions that the works are awarded to a single contractor or joint venture. The splitting of the works in two lots as requested the Employer management will certainly increase the total contract price, specially its foreign component, since this would involve the duplication of a large portion of the constructional plant.

The cost of the preparatory works (including the rehabilitation of the access road to the Project) and the local supervision and administration may not been taken into account since they are frequently bared by the

Employer own services.

2.2.2 Cost of Generating Equipment

The construction cost of generating equipment was elaborated by preparing separate estimates for each major component, such as turbine, generator, transformer, switchgear, control panel, etc.

The following sources of information were used to derive the cost.

- tenders for various committed power stations in Europe and Asia
- actual cost of recently commissioned power stations in Europe and Asia
- information provided by equipment manufacturers

The cost of generating equipment will be obtained by the following equation for this master plan study. (Refer to Table 2.1 and Fig. 2.1)

$$Cge = 580 \times (MW/\sqrt{H})^{0.768} \times 10^6 \text{ ¥}$$

where; Cge = cost for supply and erection
MW = power station output (MW)
H = rated head (m)

2.2.3 Cost of Substation Equipment

The construction cost of substation equipment was elaborated preparing separate estimates for each materials.

The cost of erection and incidental works including land and building may not been taken account since they are frequently bared by the Employer.

In general, the construction cost might be assumed as function of bay. And it is said that all ancillary equipment are including in the estimated prices.

2.2.4 Cost of Transmission Line Materials

The construction cost of transmission line materials was elaborated preparing separate estimates for each materials.

The cost of erection and incidental works including right of way may not been taken account since they are frequently bared by the Employer.

In general, the construction cost might be assumed as function of line length. And it is said that all charge for incidental works are including in the estimated costs.

III LOAD CHARACTERISTICS

NAPOCOR prepared a typical daily load curve for study. From this, the typical load duration curve for dry season is shown on main report was drawn.

The daily load factor is calculated to be 87.5% based on this typical load curve.

On the other hand, actual load records in various days on the Luzon Grid are available, and shown in Figs. 3.1 to 3.3.

IV ECONOMIC BENEFIT

As for the power generation benefit, the least power cost among the alternative thermal power plants is adopted. In addition the adjusting factors for kW and kWh values are taken into consideration the different loss rates between hydropower and thermal power plants.

As for the alternative thermal plant, diesel power plant is choiced for comparison purpose.

The power cost of thermal plant consists of the following three factors:

1) Amortization cost of the initial investment under a certain annual interest with respective economical life. (Capital recovery cost).

2) Annual fixed and variable cost of operation.

3) Fuel cost

The unit construction cost of 8 MW diesel power plant is estimated to be 600 $/kW for comparison.

The unit fuel oil price is estimated 37.5 $/barrel from the domestic price of fuel oil.

Based on the above, the power cost of the above thermal plant is calculated as follows:

1) kW Benefit

a) kW value

i)	Amortization cost	88 $/kW
ii)	Annual fixed cost of operation	24 $/kW
		112 $/kW

b) Adjustment factor

Loss factor	Hydro	Diesel
Loss at T/L	0.8 %	0 %
Aux. power use	0.7	4.4
Forced outage	0.5	2.0
Overhaul	0.4	10.0

$$\text{Capacity adjustment factor} = \frac{(1-0.008)(1-0.007)(1-0.005)(1-0.004)}{(1-0.044)(1-0.02)(1-0.1)}$$

$$= 1.16$$

$$\text{Energy adjustment factor} = \frac{(1-0.008)(1-0.007)}{(1-0.044)} = 1.03$$

c) kW benefit = 112 $/kW x 1.16 = 130 $/kW

2) kWh Benefit

a) kWh value

i) Fuel cost

0.24 I/kWh x 37.5 $/159 I x 1000 = 56.6 mills/kWh

ii) Variable O & M 3.9 mills/kWh

Total = 60.5 mills/kWh

b) kWh benefit = 60.5 mills/kWh x 1.03 = 62.3 mills/kWh.

Table 2.1 Cost for Generating Equipment

No.	P. S.	$MW/\sqrt{H}$	$\times 10^6$ ¥
1	K'kates 1st	7.9	1,701
2	" 2nd	4	928
3	Kali Konto	0.8	361
4	R'Kanan 1st	3.2	916
5	Wlingi 1st	5.9	2,671
6	" 2nd	5.9	2,861
7	Wonogiri	2.7	1,107
8	Garung	1.9	997
9	Siguragura	19.4	11,510
10	Tanga	21.0	10,709
11	Maninjau	4.7	1,901
12	Lodoyo	1.5	698
13	Sengguruh	6.8	2,083
14	Chungju No.1	52.8	7,269
15	" No.2	4	2,414
16	Hapcheon No.1	10.3	2,278
17	Kulekhani No.1	2.5	2,755
18	" No.2	1.9	1,392
19	Tenom Pangi	8.5	2,692
20	Da Nhim	10.8	3,632

In accordance with above relations, the cost of supply and erection for generating equipment C_{GE} can be estimated by the following equation.

$$C_{GE} = 580 \times (MW/\sqrt{H})^{0.768} \times 10^6 \text{ (¥)}$$

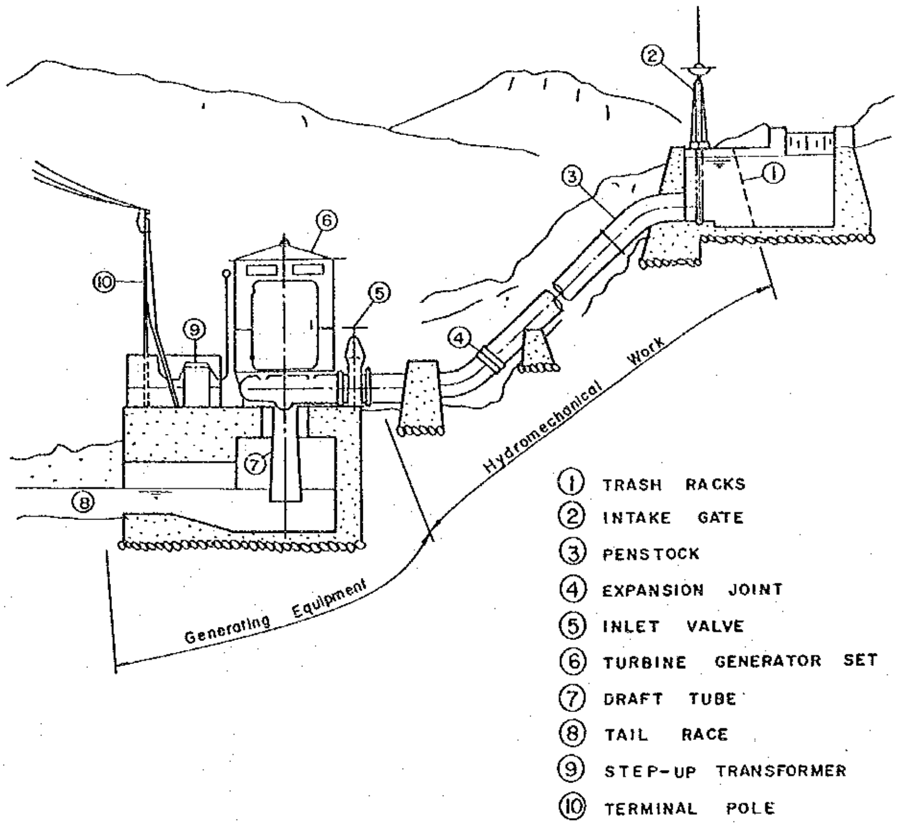


Fig. 1.1 GENERAL ARRANGEMENT OF POWER PLANT

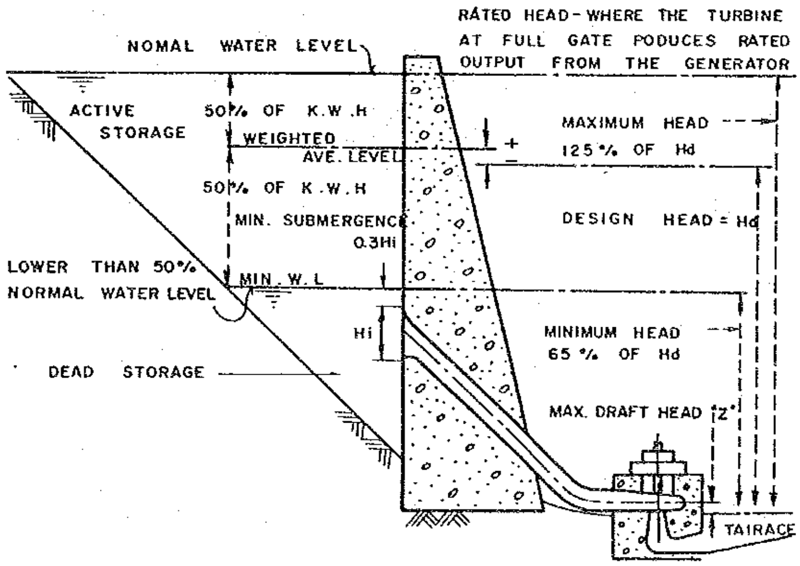


Fig. 1.2 WATER LEVELS AND HEADS

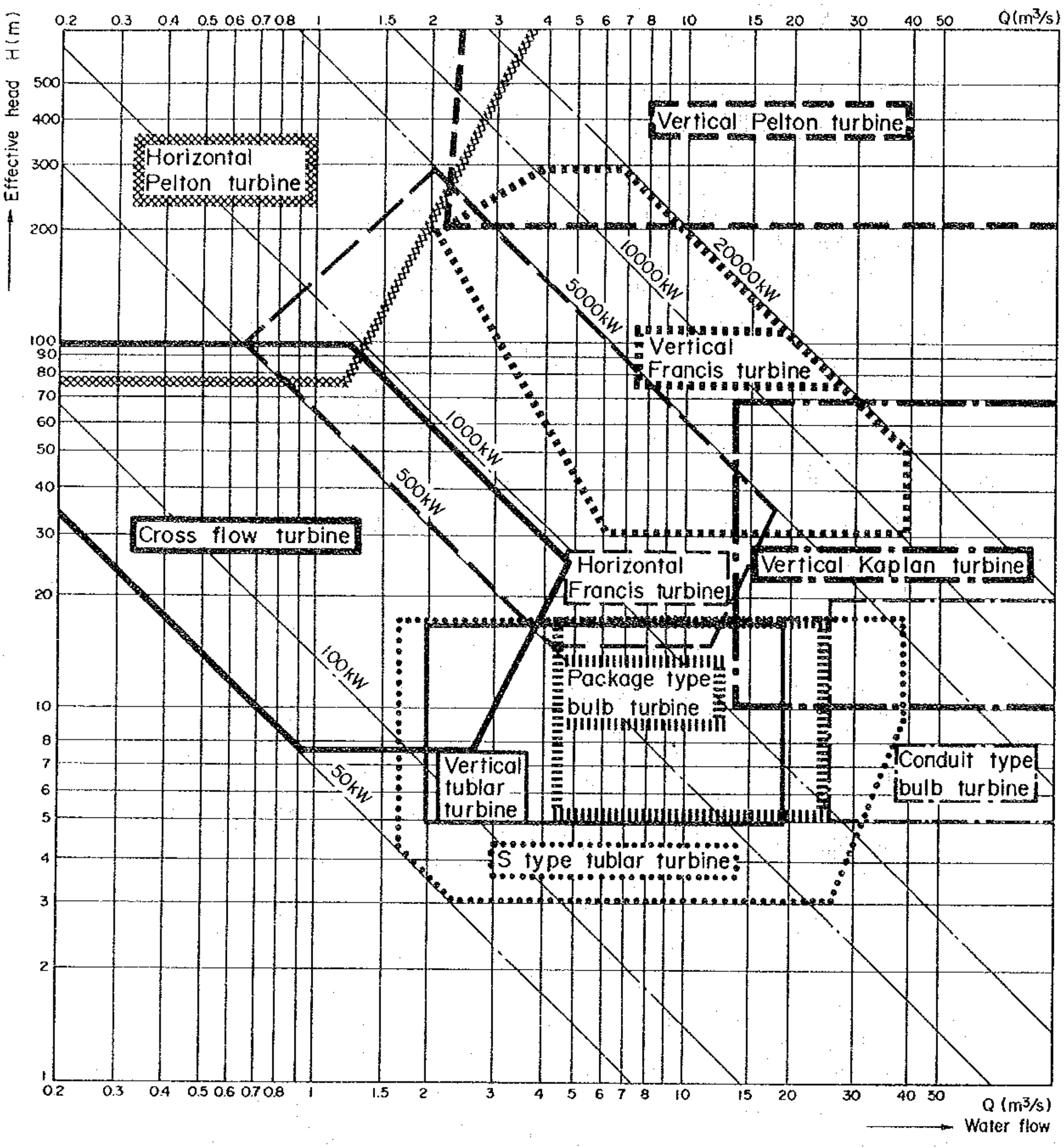


Fig. 1.3 SELECTION DIAGRAM OF TURBINE TYPE

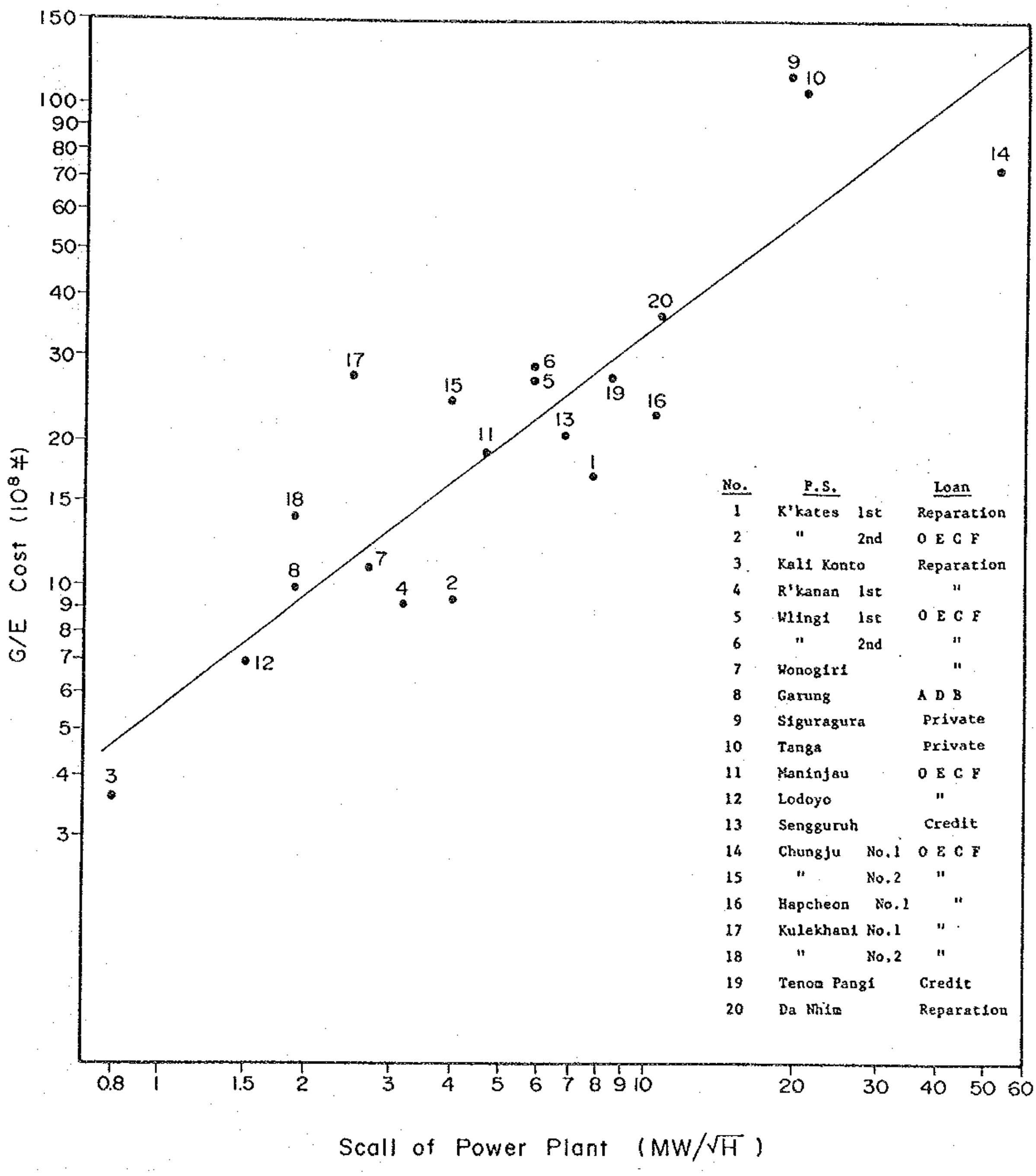
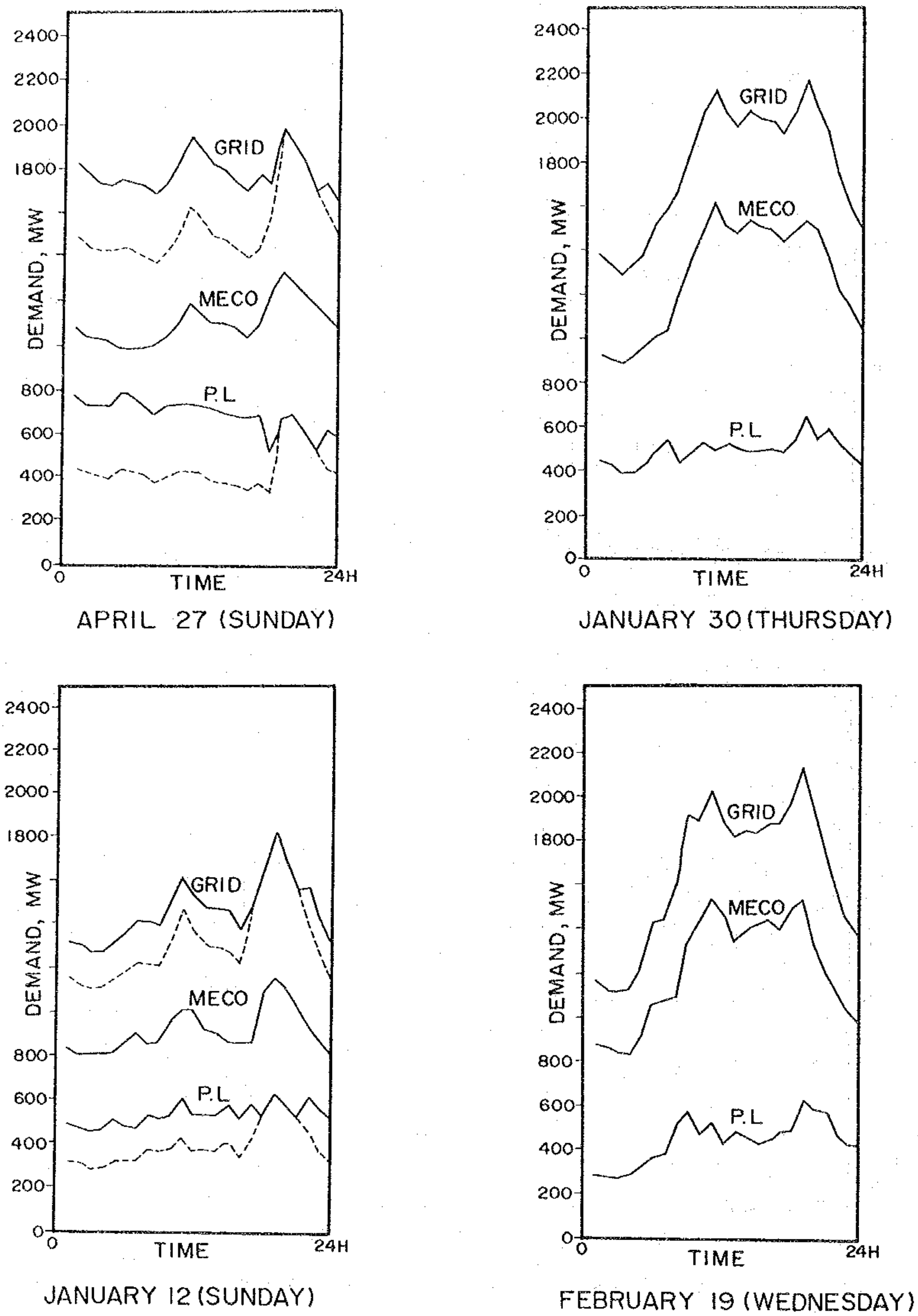


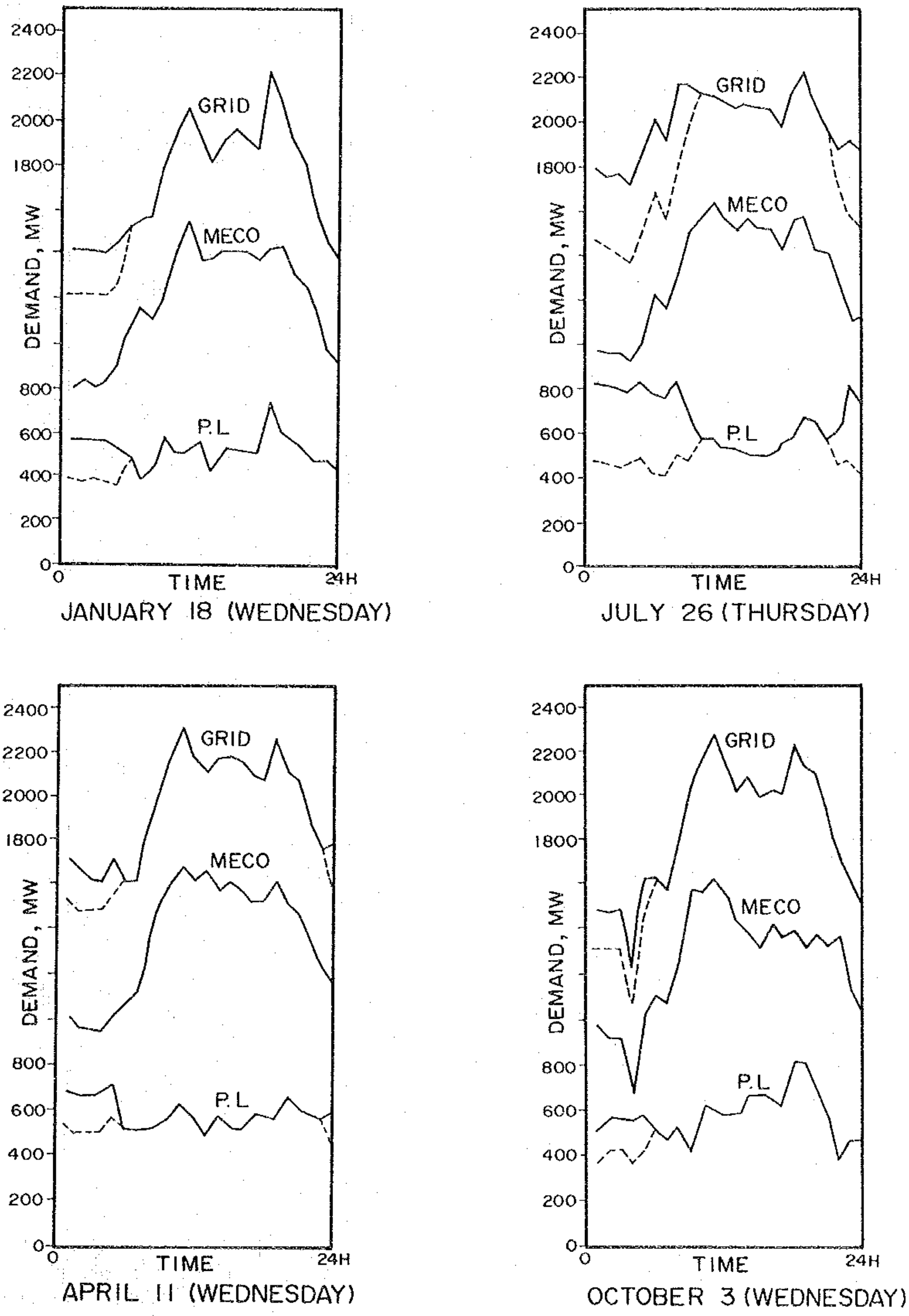
Fig. 2.1 G/E Cost (Supply and Erection)

(Export Contract for Hydro-power Plant)



(LEGEND) GRID : NPC LUZON GRID LOAD
MECO : MERALCO LOAD
P.L : PROVINCE LOAD
------ : Without Kalayaan Pumping

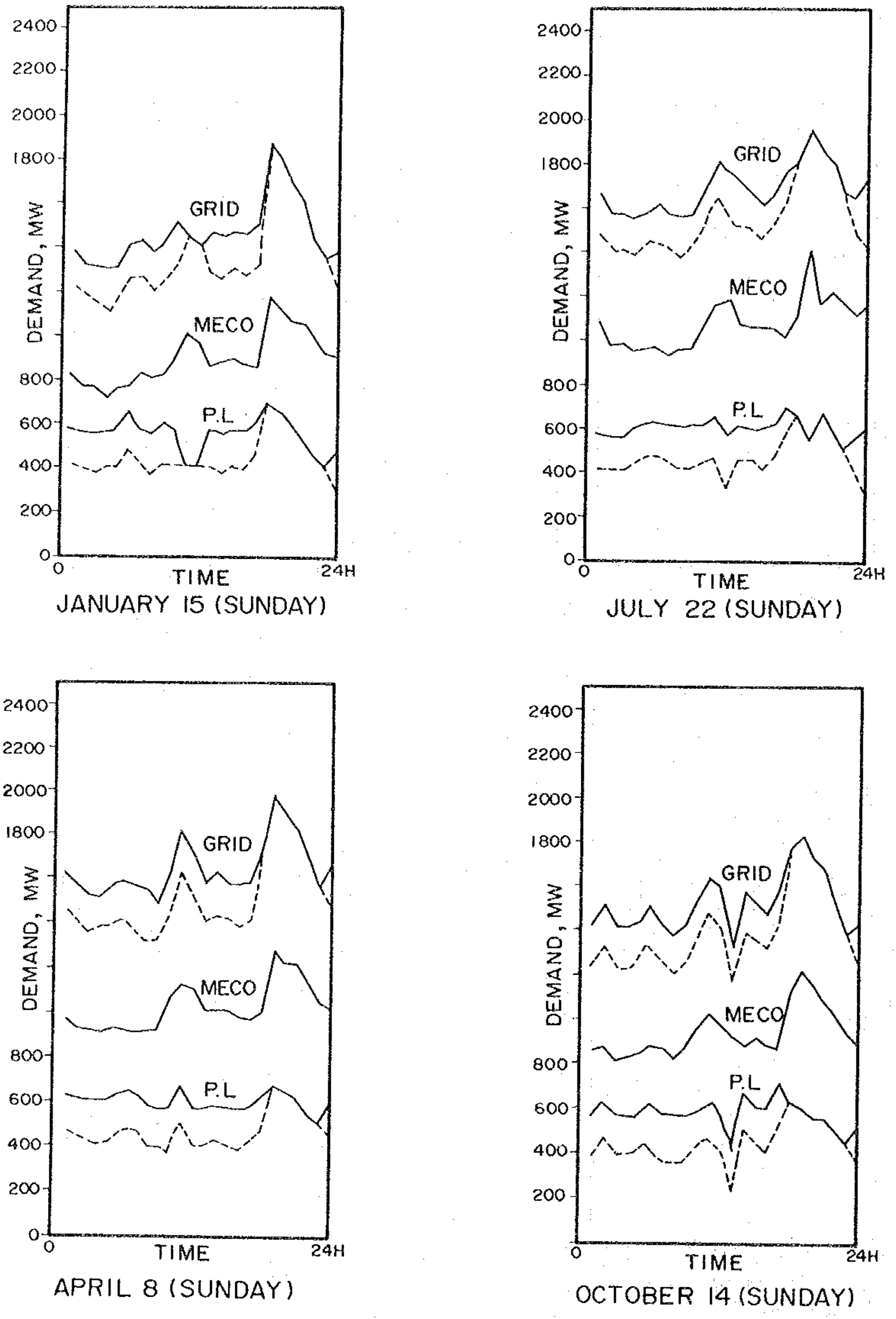
Fig. 3.1 TYPICAL DAILY LOAD CURVE IN 1986



(LEGEND)

GRID	:	NPC LUZON GRID LOAD
MECO	:	MERALCO LOAD
P.L	:	PROVINCE LOAD
------	:	Without Kalayaan Pumping

Fig. 3.2 TYPICAL DAILY LOAD CURVE ON WEEKDAY IN 1984



(LEGEND)

GRID	:	NPC LUZON GRID LOAD
MECO	:	MERALCO LOAD
P. L	:	PROVINCE LOAD
------	:	Without Kalayaan Pumping

Fig. 3.3 TYPICAL DAILY LOAD CURVE ON SUNDAY IN 1984

ANNEX DA

DAM

ANNEX DA

Table of Contents

List of Tables

List of Figures

List of Attachment

I SELECTION OF MULTIPURPOSE DAMSITES

1.1 Objective of Study

Agriculture dominates the industry of the Cagayan river basin at present and may continue to remain the same in the future in principle up to the year 2005 earmarked as the target year for the Master Plan to be formulated under this JICA Study. It can be said that fundamental problems in terms of the water resources development in the Cagayan river basin are flood inundation and land erosion in the agricultural area along the river due to flood during rainy season and water shortage for irrigation during dry season. Water resources development objectives are therefore to be set forth on flood control and irrigation development.

Dam and reservoir development is considered the most effective means of achieving such objectives. Dam construction, once realized will naturally bring about possible hydropower development in addition to the above purposes. Based on these considerations, multipurpose dams are evaluated on their irrigation, flood control and hydropower potentials.

There are so many potential damsites either of single purpose or multipurpose dam development. NIA and NAPOCOR have undertaken studies on various possible dam development schemes. Among these studies are the Chico No. 4 Hydropower Development Project, Diduyon Hydropower Development Project, Casecnan Transbasin Project, and Matuno Dam Project of which their feasibility studies are completed. DPWH has also studied the Cagayan River Basin Flood Control with forty four (44) dam schemes identified. The Magat dam is the only completed dam within the objective river basin at this stage.

In this study, fifty five (55) damsites including alternative sites have been identified including forty four (44) damsites identified by the NWRC and additional eleven (11) damsites which have been identified with special emphasis on the possible development for flood control purpose. On the other hand, there are other potential damsites for hydropower in the upper reaches of the river. Such single purpose hydropower development dam schemes have been studied by the other JICA Study Team named as " Study on Hydropower Potentials in Luzon Island". Realization of these single-purpose hydropower dam schemes would be premature under the present situation of the existing generating plant capacity of Luzon system since the multipurpose dam schemes should be accorded higher priority than the single-purpose hydropower development in view of its requirement for irrigation and flood control. Therefore, single-purpose hydropower dam schemes in the upper reaches of the river are not identified in this study except for those which feasibility study and pre-feasibility study have been completed. The location of all the identified damsites are shown in Fig.1.1.

Needles to say, it would be practically impossible to implement all the prospective dams at once simultaneously or within a limited short period. It would be advisable to implement by stages particularly those having higher efficiency.

The Master Plan which is to be formulated by this JICA Study should present implementation plan up to the year 2005 as well as overall basin development plan.

In line with the above basic concept, about ten (10) to fifteen (15) high priority dam projects are to be selected for further detailed studies.

1.2 Methodology and Criteria

1.2.1 Overall Study Procedure

The study on selection of prospective damsites is proceeded through two steps as shown in the flow chart in Fig.1.2, First Screening and Second Screening.

The First Screening is carried out through the following procedures and simple criteria in terms of storage efficiency are adopted;

(a) To identify the possible damsites on 1/50,000 topo-maps in due consideration of the needs of development for flood control, irrigation and hydropower.

(b) To make river profile of each subbasin.

(c) To calculate basic figures of damsites, such as their catchment area, reservoir surface area and storage curve and make profile of dam axis.

(d) To decide dam scale and estimate dam volume.

(e) To select damsites by storage efficiency.

The second Screening is then carried out to make a detailed evaluation of the damsites selected in the First Screening. In this study, single purpose dams with irrigation, hydropower and flood control respectively are considered and irrigation efficiency, hydropower efficiency and flood control efficiency are adopted for the selection.

General procedures to estimate each efficiency are as follows;

- Irrigation efficiency
  - a) To estimate available runoff at damsite
  - b) To estimate active storage
  - c) To estimate unit value for benefit
  - d) To calculate irrigation efficiency

- Power generation efficiency
  - a) To set up HWL, LWL and TWL and estimate dam volume
  - b) To calculate annual energy output
  - c) To estimate energy value
  - d) To calculate power generation efficiency

- Flood control efficiency
  - a) To estimate flood inflow volume at damsite
  - b) To calculate dam volume
  - c) To estimate flood runoff at each base point
  - d) To calculate reduction of dike volume and inundation area (without dam - with dam)

e) To calculate unit price of dike volume and unit value of flood damage

f) To calculate benefit from reduction of dike volume and inundation area

g) To estimate flood control efficiencies

Through the First and Second Screening, about ten (10) to fifteen (15) high priority dam projects will be selected for further detailed studies.

As aforementioned, following four (4) dam projects which have been already studied in the feasibility study or detailed design stages are included in this study;

(a) Chico No. 4 Project (Irrigation and Hydropower Project)

The location of the proposed damsite is in Tamiangan, Kalinga-Apayao on the Chico river about 21 km upstream of irrigation intake weir at Tabuk. The feasibility study has been completed by NAPOCOR/NIA, but the implementation of works is suspended due to social problems. This project is expected to generate power with an installed capacity of 360 MW. The dam will supply irrigation water to 49,000 ha of land incorporated with the Chico River Irrigation Project (CRIP).

(b) Matuno No. 1 Project (Irrigation and hydropower project)

The damsite is proposed at Barat, Nueva Vizcaya along the Matuno river, a left tributary of the Magat river. The feasibility study has been completed by JICA/NIA. Installed capacity of the dam is 180 MW.

(c) Diduyon Project (Hydropower project)

The dam is planned at Kamamasi, Kaisbu, Nueva Vizcaya on the Diduyon river, a left tributary of upper Cagayan. The feasibility study has been completed by JICA/NAPOCOR. Installed capacity of the dam is 352 MW.

(d) Casecnan Project (Irrigation and hydropower project)

The damsite is proposed just downstream of the confluence of the Conwap and Casecnan rivers on the upper Cagayan river. The feasibility study has been completed and detailed design is being undertaken by NAPOCOR/NIA at present. The dam project is a component of the Casecnan Transbasin Diversion Project. Irrigation and power generation purposes are included in the dam project.

Aside from the multipurpose dam projects mentioned above, Chico No. 1, No. 2 and No. 3 dam projects have been completed in the prefeasibility study stage by NAPOCOR.

1.2.2 Criteria of First Screening

Storage efficiencies, which are defined below, are used for the selection index in the First Screening.

$$SE\ 1 = \frac{\text{Effective Storage}}{\text{Dam Volume}}$$

$$SE\ 2 = SE\ 1 \times \text{Catchment area}/1{,}000$$

$$SE\ 3 = SE\ 2 \times \text{Dam height}/1{,}000$$

SE 1 as a simple storage efficiency implies that its large efficiency gives a more efficient dam scheme. Dam having SE 1 of more than 60 are selected.

The storage efficiency and IRR of Magat dam are estimated at 65 and 12.4% respectively. Accordingly, it implies that a dam having a storage efficiency of 63 or more can bring about an IRR of 12.0% or more. Taking into consideration the difficulties encountered in spillway construction, access road, etc., dam having the storage efficiency of SE 1 of more 60 are selected.

To eliminate overlooking some prospective (competitive) damsites, which cannot pass through the SE 1 criteria but are probably superior for flood control and hydropower generation, two additional indexes are considered as follows.

SE 2 is adopted especially for searching prospective damsite for flood control in consideration that a larger catchment area is more effective for flood control. Dam having SE 2 of more than 40 are selected.

SE 3 is adopted for searching the prospective damsites for hydropower generation, i.e. assuming that dam height is a representative figure for hydraulic head and catchment area as a representative of available water. Dam having SE 3 of more than 5 are selected.

Furthermore, dam and hydropower schemes, which are conceivable special schemes for creating a much higher water head by means of long headrace tunnel, transbasin, etc., are selected even if these cannot pass through the criteria of SE 1, SE 2 and SE 3.

To decide dam scale, following criteria is adopted.

(a) Dam height:

(i) Dams of which their respective feasibility studies or prefeasibility studies are completed.

Dam height = Proposed H.W.L (in F/S or pre F/S report) + free board (5m)

(ii) Other dams

Lowest dam heights among the following is adopted:

- Topographically possible maximum height
- Maximum height assumed at 150 m
- Hydrological limit height

Effective storage $\leq$ Total runoff volume in wet season

Where; Effective storage = Gross storage - 100 yrs sediment

100 yrs sediment = 1,500 m^3/km^2 x catchment area x 100 yrs

(b) Dam type: The geological conditions in the identified damsites seem not so good except for a special site like Chico No. 2. Therefore, fill-type dam (homogenous) is assumed for all the identified damsites.

(c) Dam volume: The dam volume is calculated by the following formula based on the profile of dam axis.

$$\text{Dam volume} = 1/2\ BH\ (L1 + L2) + 1/6\ (m + n)\ H^2\ (L1 + 2L2)$$

where;
- B = Dam crest width (= 12 m)
- m = Upstream slope of dam (=2.4)
- n = Downstream slope of dam (= 1.8)
- H = Dam height
- L_1 = Dam length at the crest
- L_2 = Dam length at the bottom

Note 1: Foundation excavation is assumed at 5 m below river bed.

Note 2: The dam volume calculated by the above formula was verified to be accurate enough being within 10% difference from those in the feasibility study for such dams at those with F/S were completed.

1.2.3 Criteria of Second Screening

In the Second Screening, irrigation efficiency, hydropower efficiency and flood control efficiency are adopted for the selection. Each dam is classified into classes of A, B and C and evaluated individually from the results of the efficiencies defined as follows.

$$\text{Irrigation Efficiency} = \frac{\text{Irrigation Benefit}}{\text{Dam Volume}}$$

$$\text{Hydropower Efficiency} = \frac{\text{Hydropower Benefit}}{\text{Dam Volume}}$$

$$\text{Flood Control Efficiency} = \frac{\text{Flood Control Benefit}}{\text{Dam Volume}}$$

In this study, single purpose dams with irrigation, hydropower, and flood control components are considered.

Irrigation water is defined as an indefinite water requirement not only for pure irrigation but also for domestic water supply, river maintenance flow supply assuming that if natural river is to be extracted for irrigation purpose without dam, the river flow downstream further should be compensated by some means in order to maintain low flow in the river as it is. Irrigation water primarily used to estimate the unit value of water is the benefit derived from dam construction. Irrigation water supply benefit is thus estimated as the water newly created by the dam construction multiplied by the irrigation water value.

Unit water value, which is defined as the cost allotted for water source development, is estimated based on the Report on "Feasibility Study on the Matuno River Development Project" under the following assumptions, and details are shown in Appendix 1.

Irrigation area without project	5,150 ha
with project	16,280 ha
Project cost excluding dam construction	31,660,000 US$
Project benefit	6,770,000 US$/yr
O/M cost	120,000 US$/yr
Construction period	6 yrs
Economic life	50 yrs
Discount rate	12%
Unit value of water	0.02 US$/$m^3$

Hydropower development scheme is also considered as a single purpose dam. The benefit from the hydropower generation is estimated based on the alternative thermal powder plan (coal fired thermal plant).

Energy value is estimated based on the alternative coal-fired thermal power plant cost (Isabela Power Plant 100,000 kW) as follows, and details are shown in Appendix 2.

Initial investment	1,200 $/kW
Construction period	3 yrs
(Annual investment rate, 1st/2nd/3rd)	(30, 40, 30%)
Economic life	30 yrs
Discount rate	12%

Fuel cost	45 US$/ton or 0.016 US$/kWh
Operation cost	10 $/kW/yr
Capacity factor	70%
Adjustment factor/kW	1.373
Adjustment factor/kW	1.084
Energy value	0.06 US$/kWh

Annual energy is calculated by the following simple method:

Annual energy = Hf x 9.8 x He x Q x 24 hrs x 365 days

Hf: Generating efficiency (= 0.85)

He: Effective head (= 0.9 x (HWL-TWL-1/2 [HWL-LWL]))

Q : Annual average discharge

Flood control dams are considered also as single purpose dam. The benefit derived from the dam is estimated by two methods: one is the alternative cost of flood control by means of diking system to confine the river and the other is the reduction benefit of the flood inundation.

Reduction of dike embankment volume is taken as the benefit of the dam construction as an alternative case. The dike volume is calculated based on the standard cross section of dike and discharge rating curves at selected cross sections referring to the Report on "Nationwide Flood Control Plan and River Dredging Program". Standard cross section of dike and discharge rating curves are shown in Figs.1.3 and 1.4.

Reduction of annual flood damage due to dam construction is accounted for as the flood control benefit as another alternative case. Reduction of inundation area is estimated by referring to the Report on "Nationwide Flood Control Plan and River Dredging Program". Inundation area estimated under present river condition is shown in Fig. 1.5.

Flood control unit values are calculated as follows:

(a) Assuming the Cagayan river and its tributaries are confined by dikes in both cases of with-dam and without-dam conditions, the difference of the dike embankment volume is accounted for as the benefit of dam construction.

Dike construction cost	1.5 US$/$m^3$
Construction period	5 yrs
Economic life time	50 yrs
O/M cost	2% of construction cost
Unit value	0.15 US$/$m^3$/yr

(b) Reduction of inundation area due to dam construction is accounted for as the benefit derived from dam construction. Inundation area and unit flood damage amount are derived from the Report on "Nationwide Flood Control Plan and River Dredging Program".

Unit flood damage	750 US$/ha/yr

To decide dam scale for a single purpose dams with irrigation, hydropower and flood control components, following criteria area adopted:

	Irrigation	Hydropower	Flood Control
Dam height	Lowest height	- do -	- do -
	(1) Topographically possible maximum height	(1) - do -	(1) - do -
	(2) Maximum height of 150 m	(2) - do -	(2) - do -
	(3) Dam height corresponding to required storage capacity for full utilization of natural runoff		(3) Dam height corresponding to required storage capacity for storing 25-yr probable flood volume
Dam type	Fill-type	Fill-type	Concrete
Crest width	12 m	12m	8m
Dam slope U/S	1:2.4	1:2.4	1:0.1
Dam slope D/S	1:1.8	1:1.8	1:0.7
Foundation excavation	5 m	5 m	5 m

Thus irrigation efficiency, hydropower efficiency, and flood control efficiency are estimated as indexes of damsite evaluation.

In addition to the above, the following technical and economic assessment were made:

(a) From the point of view of equitable regional development and effective development for flood control which are deemed to be of primary importance in this basin, one dam is in principle selected on one major tributary. This principle enables to supplement the water deficit in any tributary by the water release from the dam in the tributary.

(b) Dams, which would be located in the weathered limestone zone have been basically discarded at this stage since a detailed geologic investigation would be needed and foundation treatment would in general be costry.

(c) Land/property compensation is one of the most important factors to be considered in this region. Dams which are not particularly attractive for some purpose yet have anticipated compensation problems have been discarded.

1.3 First Screening

1.3.1 Potential Damsites

The identification of the potential damsites are made taking into account the maximum development of the river for flood control, irrigation and hydropower. The potential damsites are identified on 1/50,000 scale topo-maps in view of topographical condition at the first, and then, these damsites are plotted on the river profile to confirm the possibility of the dam development. From these procedures, 55 damsites including alternative damsites are identified in this study. The location of these damsites are shown by each tributary in Fig.1.6 with the river profile.

The following damsites are studied;

Sub-basin	Name of Dam
Dummon	Dummon
Chico	Tanudan, Chico No. 1, No. 2, No. 3, No. 4 & No. 5, Chico-Mallig, Pasil, Matalag, Nabuangan, Pinukpuk, Saltan, Babaca
Pared	Bitag, Pared, Dadap, Paranan
Tuguegarao	Aggugaddan, Tuguegarao, Natutud
Pinacanauan	Pinacanauan
Tumauini	Tumauini
Siffu-Mallig	Siffu No. 1(A), No. 1(B) & No. 2 Mallig No. 1 & No. 2
Ilagan	Ilagan No. 1, No. 2 & No. 3, Abuan No. 1 & No. 2, Disabungan, Catalangan
Magat	Tao-tao No. 1 & No. 2, Alimit No. 1(A), No. 1(B) & No. 2, Ibulao No. 1 & No. 2, Matuno No. 1 & No. 2 Sta. Cruz No. 1 & No. 2, Benay, Marang
Upper Cagayan	Cagayan No. 1 & No. 2, Casecnan, Addalam (A) & (B), Diduyon, Dibuluan

1.3.2 Results of First Screening

According to the estimated features and screening criteria, following damsites are selected in the First Screening.

Selection Index	Name of Dam	Comments
(1) SE 1 > 60	Dummon	Effective for irrigation
	Matalag	High efficiency, however, subject to land compensation
	Pinukpuk Babaca	Alternative with each other. One of these will be finally selected.
	Bitag	High efficiency, however, subject to land compensation
	Aggugaddan	High efficiency, however, subject to geological condition
	Siffu No. 1(A) Siffu No. 1(B) Siffu No. 2	Alternative with each other. One of these will be finally selected.
	Mallig No. 1 Mallig No. 2	Alternative with each other. One of these will be finally selected.
	Ilagan No. 1 Ilagan No. 2	Alternative with each other. One of these will be finally selected.
	Disabungan Catalangan	Alternative with each other. One of these will be finally selected.
	Alimit No. 1(A) Alimit No. 1(B)	Alimit No. 1(A) is selected on the basis of higher storage efficiencies.
	Cagayan No. 1	Alternative with Cagayan No. 2. Subject to land compensation and geological condition
	Cagayan No. 2	Alternative with Cagayan No. 1. Subject to geological condition
	Casecnan	F/S completed, D/D is on going now. Transbasin diversion scheme
	Addalam (A)	High efficiency for irrigation and flood control
	Diduyon	F/S completed, hydropower project with high head through long headrace tunnel
Sub-total	22 damsites	

Selection Index	Name of Dam	Comments
(2) /1 SE 2 > 40	Chico No. 5	Effective for flood control, however, subject to land compensation
	Chico No. 4	F/S completed, alternative with Chico No. 2, high efficiency for power generation
	Chico-Mallig	High efficiency for power generation and flood control, however, subject to compensation for a new intake weir
	Sub-total 3 damsites	
(3) /2 SE 3 > 5	Chico No. 2	Alternative with Chico No. 4, high efficiency for power generation
	Sub-total 1 damsite	
(4) /3 Hydropower with High Head Scheme	Matuno No. 1	F/S completed, hydropower project with high head through long headrace tunnel
	Dibuluan	Hydropower project with transbasin diversion scheme
	Sub-total 2 damsites	
	Total 28 damsites	

Notes: /1; Except damsites which are selected in (1)

/2; Except damsites which are selected in (1) or (2)

/3; Except damsites which are selected in (1) or (2) or (3)

Among the selected twenty eight (28) damsites, Alimit No. 1 (B) and Chico No. 5 are discarded for further study by following reason,

- Alimit No. 1(B)
  On the basis of higher storage efficiencies, Alimit No. 1(A) which is an alternative damsite of Alimit No. 1(B) is selected.

- Chico No. 5

  Reservoir area of this dam covers the highly developed area and it is judged that the compensation for this area is difficult.

Then, twenty six (26) damsites are selected for Second Screening. Principal features and results of the First Screening are shown in Table 1.1.

1.4. Second Screening

1.4.1 Available Data

Hydrological figures (runoff duration curves and flood peak and volume) are estimated based on the Report on "Nationwide Flood Control Plan and River Dredging Program" as follows:

Low flow

Runoff data at Minanga, Oscarize and Pangal gauging station which locations are shown in Fig. 1.7 are used to estimate specific duration curve. These specific duration curves are shown in Fig. 1.8. Based on the above specific duration curve, runoff duration curve at each damsite is calculated by multiplying catchment area and adjustment factor for altitude. Tables 1.2 and 1.3 show the adjustment factor for altitude and the runoff duration curves at each damsite.

Flood

Basin mean rainfall at certain given base point is obtained from the Report for 25 yr probable storm which is equivalent to the recorded maximum flood in the Cagayan river basin and runoff coefficient is taken at 0.7, thus flood runoff volume at each damsite is estimated. Based on the flood runoff distributions in with-dam and without-dam cases (with Magat dam) which are referred to the Report, flood peak runoff at certain given base point is simply estimated by;

$$Qp' = Qp \times A/(A + A')$$

Where,

Qp' = Flood peak with-dam at the base point

Qp = Flood peak without-dam at the base point

A' = Catchment area at damsite

A = Catchment area at base point excluding catchment area at damsite

Distributions of flood runoff at each basepoint under present river condition and under flood control scheme with confining dikes are shown in Figs. 1.9 and 1.10, and 25 years probable flood runoff at each basepoint for both cases are shown in Tables 1.4 and 1.5.

1.4.2 Geology

Foundation rocks in the Cagayan river basin are represented by a thick sequence of pre-tertiary metamorphic and plutonic rocks. These were uplifted by igneous intrusions during the Late Tertiary and Quaternary. An Oligocene to Pliocene marine section occupies the main basin area. It is up to 9,000 m thick along the flanks but attains a maximum thickness of over 12,000 m at the center of the basin. The Oligocene section consists of basic lava flows, metamorphosed conglomerate, tuff breccia, tuffaceous sandstone and siltstone. Late Pleistoncene to Recent sands, sillts, gravels and pyroclastics are found generally in the central basin area and the sequence is entirely non-marine.

Rocks exposures in the area divided into West side and East side of the Cagayan valley and they are classified according to rock formation. From top to bottom, they are,

West Side	East Side
Halocene Deposit	Halocene Deposit
Awiden Mesa Formation	Awiden Mesa Formation
Ilagan Formation	Ilagan Formation
Mabaca River Group	Callao Limestone
Sicalao Limestone	Gatangan Creek Formation
Basement Complex	Basement Complex

The geological map of the Cagayan river basin is shown in Fig. 1.11.

The geological survey was carried out at the prospective damsites for the sake of judging the possibility of dam construction. The results of geological survey are summarized in Table 1.6.

1.4.3 Results of Second Screening

The irrigation efficiency, hydropower efficiency and flood control efficiency are estimated by the hydrological figures and criteria as explained in the former parts of this ANNEX. Each efficiency is classified into classes of A, B and C as follows,

(a) Irrigation Efficiency

class "A" $\geqq$ 2.4, 2.4 > class "B" $\geqq$ 1.2 , 1.2 > class "C"

(b) Power Generation Efficiency

class "A" $\geqq$ 3.3, 3.3 > class "B" $\geqq$ 1.7, 1.7 > class "C"

(c) Flood control Efficiency

i) Under flood control scheme with confining dikes

class "A" $\geqq$ 2.2, 2.2 > Class "B" $\geqq$ 1.1, 1.1 > class "C"

ii) Under present river condition

class "A" $\geqq$ 5, 5 > class "B" $\geqq$ 3, 3 > class "C"

The results of Second Screening divided into irrigation, hydropower and flood control purposes are shown in Tables 1.7, 1.8 and 1.9, and summary of Second Screening is shown in Table 1.10.

Final selection is carried out based on the efficiency index mentioned above, geological condition, compensation, accessibility and equitable regional development, and following twelve (12) damsites are discarded,

- Low efficiency index
  Dummon, Chico-Mallig, Catalangan and Dibuluan

- Geological problem
  Aggugaddan

- Compensation problem
  Metalag and Bitag

- In view of a basic criteria to select one damsite in one tributary
  Babaca, Siffu No. 1 (B), Siffu No. 2, Mallig No. 1 and Ilagan No. 2

Then, the following fourteen (14) damsites are selected for the further study.

(1) Chico No. 4

Located on Chico river. The feasibility study has been completed by NAPOCOR/NIA, but the implementation of works is suspended due to social problem. This project is expected to generate power with an installed capacity of 360 MW and an annual energy of 955 GWh in the feasibility study, however, flood control function is not considered. Therefore, the possibility of revising the proposed dam schemes will be examined in view of the flood control function in further study.

(2) Chico No. 2

Located on the upstream reaches of Chico river. The pre-feasibility study has been completed by NAPOCOR. Topographical and geological condition of this damsite are fairly good and the concrete arch dam is proposed in the pre-feasibility study. As for Chico No. 2 and Chico No. 4, final selection will be done after getting more detailed information on the security situation in consultation with the GOP.

(3) Pinukpuk

Located on Saltan river which is a left tributary of Chico river. Efficiencies for each purpose are fairly good. However, this damsite and reservoir is located in Chico river basin and has the same social problem with Chico No. 2 and Chico No. 4. Therefore, careful study will be made in further study.

(4) Siffu No. 1(A)

Located on Siffu river which is a left tributary of Cagayan river. Among Siffu No. 1(A), No. 1(B) and No. 2 in Siffu basin, Siffu No. 1(A) is the highest in its efficiencies. Flood prone area lies in the downstream reaches of this damsite. Then, flood control function will be given as the main purpose to this damsite in further study.

(5) Mallig No. 2

Located on Mallig river which is a left tributary of Cagayan river. Between Mallig No. 1 and No. 2, the latter is selected since its efficiency is higher than the former. This damsite is also located in the upstream reaches of the flood prone area and has the high efficiency for flood control. Therefore, special emphasis for flood control will be given to this damsite.

(6) Ilagan No. 1

Located on Ilagan river which is a right tributary of Cagayan river. Between Ilagan No. 1 and No. 2, the former is selected because of its higher efficiences than the latter. Catchment area of this project is big and flood control effect will be expected. This dam is important for planning of the Cagayan river basin development and careful study will be made.

(7) Disabungan

Located on Disabungan river which is a right tributary of Ilagan river. Efficiency is not so high in comparison with the other damsites, but flood control effect will be expected because flood prone area lies in the downstream reaches of this damsite.

(8) Alimit No. 1(A)

Located on Alimit river which is a left tributary of Magat river and just upstream of the reservoir of the Magat dam. This damsite is selected for the alternative water supply reservoir for the Magat dam in case the storage of Magat dam is partly allocated for flood control purpose. In the further study, the possibility of revising present reservoir operation of existing Magat dam will be examined in view of emphasis for flood control.

(9) Matuno No. 1

Located on Matuno river which is a left tributary of Magat river. The feasibility study has been completed by NIA/JICA. Feasibility study proposes to generate power with an installed capacity of 180 MW and an annual energy of 528 GWh, however flood control function is not considered. Therefore, the flood control function will be examined in further study.

(10) Cagayan No. 1 and Cagayan No. 2

Located on the upstream reaches of Cagayan river. Cagayan No. 1 is classified as a superior damsite provided that its compensation problem be settled. Both damsites are located in limestone zone. Either Cagayan No. 1 or Cagayan No. 2 will be selected finally after due study on compensation and geological conditions. Boring test/geological exploration will be needed.

(11) Casecnan

Located on the just downstream of the confluence of Conwap and Casecnan rivers on the upper reaches of Cagayan river. The feasibility study has been completed and detailed design is being undertaken by NAPOCOR/NIA at present. Proposed power generation and irrigation service area in the feasibility Study are as follows,

- Power generation

	San Juan P/S	Pantabangan P/S	Masiway
Installed capacity	156 MW	100 MW	12MW
Annual energy	917 GWh	417 GWh	45GWh

- Irrigation service area 92,300 ha

(12) Addalam (A)

Located Addalam river which is a left tributary of the upstream reaches of Cagayan river. Diduyon project is proposed in the upstream of this damsite and the reservoir water level of Addalam (A) dam is restricted by the tailwater level of Diduyon power station. Therefore, careful study in combination with Diduyon project will be made.

(13) Diduyon

Located on Diduyon river which is the upstream reaches of Addalam river. The feasibility study has been completed by NAPOCOR/JICA. Feasibility study proposes to generate power with an installed capacity of 352 MW and an annual energy of 957 GWh.

1.5 Selected Dams

1.5.1 General

Fourteen (14) potential damsites have been selected for hydropower, irrigation and flood control purposes as a result of screening works. Among the 14 dams, 8 dams which are located at the lowest site of each tributary are effective for flood control, since they are closest to the areas to be protected and have direct effects for flood peak reduction.

According to the previous study, Cagayan No. 1, Mallig No. 2, Siffu No. 1 and Ilagan No. 1 dams out of the 8 dams have been evaluated as class-A dams of higher efficiency for flood control. Remaining 4 dams are Pinukpuk, Addalam, Chico No. 4 and Disabungan dams.

Site of the existing Magat dam is also appropriate for flood control, since it is located at the outlet from the mountainous area covering 81% of the whole Magat river basin. To provide flood control capacity in the existing Magat reservoir, Alimit No. 1 dam is proposed in order to complement the capacity of Magat reservoir and to allow an allocation for flood control purposes.

1.5.2 Site Conditions

(a) Damsite Geology

Through field investigation in two stages, geological conditions at the selected damsites were confirmed to be suitable for dam construction. Table 1.11 shows in summary the results of the geological survey.

From the results of these survey at the proposed damsites it would appear that Pinukpuk, Siffu No. 1, Mallig No. 2, Disabungan and Addalam damsites would only be suitable for fill type dams due to the foundation conditions of the sites. Meanwhile, the proposed Ilagan No. 1, Alimit No. 1, Cagayan No. 1 and Cagayan No. 2 damsites are suitable for both concrete dams and fill type dams. Potential construction material for each dam was also studied through field surveys as shown in Table 1.12.

The depth of overburden of surface soil or weathered rock layers in the dam foundations of each proposed damsite were assessed from exposures at river banks and sites of land slides. Thus the required depth of foundation excavation was classified into one of three groups; Class A with 3 meters, Class B with 5 meters, and Class C with 7 meters excavation.The classification assumed for each proposed damsite are as follows,

Class A : Mallig No. 2, Ilagan No. 1, Alimit No. 1
Class B : Pinukpuk, Siffu No. 1, Addalam
Class C : Disabungan, Cagayan No. 1, Cagayan No. 2

(b) Land use and building numbers in the reservoir area

Present land use and numbers of buildings in the reservoir area were estimated on the basis of available topo-maps and field investigations. The results in respect of each damsite are shown in Table 1.13 and summarized below,

Name of	Elevation	Land Use (ha)			No. of Building
Dam	(El.m)	Paddy	Agriculture	Others/1	(Nos.)
Pinukpuk	120	76	314	1,420	965
Siffu No.1	120	340	590	1,610	492
Mallig No.2	160	140	270	1,560	409
Disabungan	100	90	540	1,350	727
Ilagan No.1	160	0	270	1,820	415
Addalam/2	160	0	320	766	0
Cagayan No. 1	160	240	1,430	3,370	3,458
Cagayan No. 2	240	0	180	1,220	288
Alimit No.1/2	320	116	0	2,090	0

Note; /1: Include forest and grass land
/2: Data source. DAF Region II's investigation. Other sites are estimated on the basis of the topographic map in a scale of 1 to 25,000.

(c) Accesibility

Length of necessary access road from an existing National road or Provincial road to a proposed damsite was measured from existing topo-maps. Estimated length of necessary access road to each proposed damsite are as follows:

Name of Dam	Length of Access Road (km)		
	New Road	Improvement of Existing Road	Total
Pinukpuk	0	0	0
Siffu No.1	1	6	7
Mallig No.2	11	4	15
Disabungam	2	2	4
Ilagan No.1	11	15	26
Addalam	4	0	4
Cagayan No.1	12	0	12
Cagayan No.2	0	0	0
Alimit No.1	30	0	30

II SELECTION OF SMALL DAM AND POND

2.1 General

Development of rural area, especially undeveloped hilly area is vital in the Cagayan river basin regional development. It has been noted that the present fundamental problem in these areas is water shortage during dry season. For the purpose to supply the water to these areas, two alternative water resources are considered. One is the small dam plan and the other is the pond plan. The pond plan is to tap water from river to divert it to a hollow area to impound during wet season.

2.2 Criteria

In order to come up with prospective small damsites and pond sites, the study on selection of candidates has been carried out under the criteria adopted.

2.2.1 Criteria for Selection

To identify the possible damsites and pond sites in due consideration of the needs of development for the hilly areas, the following criteria are adopted.

(a) Topography - Dam with a height of more than 10 m is possible to construct

(b) Geology - Sites located in the limestone zone are discarded

(c) Land Use - Hilly area with the development possibilities are located in the vicinity of the sites upstream and/or downstream,
- Irrigable areas are distributed along the downstream reaches, and/or
- Residential areas are distributed along the downstream reaches.

2.2.2 Criteria for Screening

Storage efficiencies, which are defined below, are adopted as the index to show the advantageousness of a damsite and a pond site in the screening.

SE 1 = Effective storage/Dam volume

SE 2 = Effective storage/Length of intake channel

where: Intake channel is the connection channel from intake site to pond.

SE 1 is applied for both plans and SE 2 is applied for pond plan.

To decide the dam scale, the following assumption are applied for this screening.

(a) Dam height: Lowest dam height among the following is adopted.

- Topographically possible maximum height
- Assumed maximum height of 30m
- Hydrological limit height

  Effective storage ($10^6 m^3$) = CA x R x F x W x S

  where, Effective storage = Gross storage - 25 yrs sediment ($1,500 m^3/km^2/yr$)

  CA: Catchment area (km^2)

  R: Annual rainfall (m)

  W: Ratio of runoff in wet season per year (=0.8)

  S: Storage ratio in wet season (=0.7)

  F: Runoff coefficient (=0.6)

  Note: Freeboard from HWL is assumed 5m for small dam and 3m for pond.

(b) Dam type: Earthfill type dam is assumed for all the identified sites.

(c) Dam volume: The dam volume is estimated by the following formula applying the data of respective profile of dam axis.

$$\text{Dam volume} = 1/2\ BH(L1 + L2) + 1/6\ (m+n)H^2\ (L1 + 2L2)$$

where, B: Dam crest width (=8m)

H: Dam height

L1: Dam length at the crest

L2: Dam length at the bottom

m: Upstream slope of dam (=4.0)

n: Downstream slope of dam (=3.0)

Note: Foundation excavation was assumed at 3m below riverbed.

2.3 Selection and Screening

Small damsites and pond sites are selected on the existing map in a scale of 1 to 25,000 which covers almost all the hilly area.

Based on the above criteria, fifty six (56) potential small damsites and four (4) potential pond sites are identified. The locations of these sites are shown in Fig. 2.1.

According to the estimated features and screening criteria, ten (10) small damsites and one (1) pond site with high storage efficiency are selected as an alternative measure of water resources development for upland agriculture. The location thereof are shown in Fig. 2.1. Principal features and results of the screening are shown in Tables 2.1 and 2.2.

2.4 Priority Ranking

Of ten screened, three (3) sites (Sta Maria, Calaocan and Colorado) are considered as alternative water resources for Gappal irrigation scheme which has been studied in the irrigation sector. Accordingly, these three (3) sites are excluded from those to be studied.

In order to examine the feasibility of these small dams, preliminary economic features were assessed for the seven (7) proposed damsites. In this assessment, two alternative cases are studied. One is the use of impounded water for both cattle grazing and paddy irrigation located nearby. The other is to use the impounded water only for cattle grazing. The cost components comprises costs incurred by dam and related facilities, irrigation facilities if included, cattle farm facilities, compensation and access roads. Overall benefits comprises the benefits derived from irrigation if involved for paddy cultivation and cattle grazing.

The economic evaluation are conducted for each proposed site on the basis of the estimated costs and benefits. In this assessment, a discount rate of 10% per annum was adopted.

Among the seven (7) proposed small damsites, the most economical damsite judged from the economic internal rate of return (EIRR) and benefit cost ratio (B/C) is the proposed Santor dam. EIRR and B/C ratio of this dam are 16.5% and 1.35 respectively if the dam is planned as single purpose dam for cattle grazing. The results of economic evaluation and priority rankings for the proposed sites are shown in Table 2.3.

In addition to this, an economic evaluations was also made for the proposed Carmencita Pond. Two alternative cases over again evaluated for this scheme. Carmencita Pond scheme is economically more advantageous than the Santor dam scheme if irrigation development is not contemplated. However, the Santor dam scheme appears to be more profitable than the Carmencita Pond scheme in both cases as summarized below.

Alternatives	Net Present Value (₱ x 10^6)		Benefit Cost Ratio		EIRR (%)	
	Santor	Carmencita Pond	Santor	Carmencita Pond	Santor	Carmencita Pond
With Irrigation	13.6	0.7	1.17	1.02	12.6	10.3
Without Irrigation	18.7	9.9	1.35	1.44	16.5	18.6

The economic indices of each proposed scheme are presented in Table 2.3. The table shows that substantial schemes are economically advantageous if they are planned as the single purpose dams for cattle grazing. However, there are some which indicate that irrigation purposes may be well contemplated due to their site conditions.

III FACILITY PLANNING

3.1 General

A preliminaly level planning for dam and the related facilities are made for three or four different dam heights at each damsite on the basis of topographic maps in a scale of 1 to 25,000 if it is available. If not, one in 1 to 50,000 is used.

New aerophoto maps at 25,000 scale were developed by JICA for the proposed damsites and reservoir areas of Siffu No. 1, Mallig No. 2, Ilagan No. 1, Disabungan, Cagayan No. 1 and Cagayan No. 2. These maps were made full use in the study.

3.2 Design Criteria

For dam and related facilities design, the following basic design criteria were applied for each damsite, except for which pre-feasibility and feasibility studies are already completed.

(a) Dam and reservoir

- Sediment level is set at the estimated 100-yr sediment level for a multipurpose dam. For a small dam, 25-yr sediment storage is provided.

- Surcharge water level (SWL) is estimated from the required flood control space of a 100-yr probable flood. The constant-ratio/constant-amount outflow method is assumed as the reservoir operation method.

- Flood water level is set at the estimated level which could discharge the peak inflow of a 200-yr probable flood for the concrete dam, however, 1.2 x 200-yr probable flood is applied for the fill-type dam.

- Dam type is selected from the following types with due regard to the topography, geology and the availability of construction materials of each damsite.

  i) Rockfill dam with an impervious zone
  ii) Earthfill dam
  iii) Concrete gravity dam

- Dam slope and crest width are applied for the following value:

Type of dam	Upstream slope	Downstream slope	Crest width
Rockfull	1:2.9	1:2.0	12 m
Earthfill (Multipurpose)	1:3.9	1:2.7	12 m
" (Small)	1:4.0	1:3.0	8 m
Concrete gravity	1:0.1	1:0.8	8 m

(b) Spillway

- Gated or a side overflow type for fill type dam, and free overflow crest with gated conduit type for concrete dam for multipurpose dam.

- Non-gated overflow type spillway is provided for a small dam.

- Stilling basin type is applied for energy dissipator.

- Design discharge to be adopted for each portion is the following probable flood without retarding effect in reservoir,

  i) Entrance and Chute
     - 200-yr probable flood for concrete dam
     - 1.2 x 200-yr probable flood for fill dam

ii) Stilling Basin
- 100-yr probable flood

(c) Diversion System

- Tunnel type is adopted for diversion systems during construction for a multipurpose dam.

- Open channel type or tunnel type are adopted for diversion sytems during construction for small dam depending on topographical conditions.

- The following probable floods are applied for diversion systems:

(a) Fill dam ------ 25-yr probable flood
(b) Concrete dam -- 2-yr probable flood

Waterway and Powerhouse are designed such as intake, headrace tunnel, penstock line and power house.

3.3 Dam Type

The dam and the related facilities were laid out with reference to the design criteria. Prior to dam layout, the dam type was decided considering the available construction material, topographical and geological conditions as follows:

Pinukpuk	Rockfill
Siffu No.1	Earthfill
Mallig No.2	Rockfill
Disabungan	Rockfill
Ilagan No.1	Concrete gravity
Alimit No.1	Concrete gravity
Addalam	Rockfill
Cagayan No.1	Concrete gravity
Cagayan No.2	Concrete gravity
Santor	Earthfill
Carmencita Pond	Earthfill

IV COST ESTIMATE

4.1 Unit Price

Unit prices to be used for calculation of construction costs were estimated by referring to the unit prices adopted for Chico IV, Gumain, Panay, Binongan and Casecnan Projects. In order to decide principal figures, such as exchange rates and price indices, December 1985 was adopted as the time basis. Table 4.1 shows unit prices for dam construction.

In addition to the construction costs estimated from the work quantities and unit prices, the following provisions were made:

- Miscellaneous civil works	: 10 % of the sum of the estimated cost
- Preparatory works (except access road and bridge)	: 8 % of the sum of the estimated cost of civil works including miscellaneous cost
- Engineering services cost	: 10 % of the direct construction cost
- Government administration cost	: 5 % of the direct construction cost
- Physical contingency	: 15 % of the sum of the direct construction cost, engineering services cost, government administration cost and compensation cost.

Applying the conditions described as above, construction costs of civil works for dam, spillway and diversion works were calculated on the basis of the unit prices and work quantities which were estimated through the facility planning. Cost curves of total construction cost of civil works for dam, spillway and diversion works at each dams were shown in Fig. 4.1, and these curves will be utilized in the stage of optimization study.

Compensation costs at each dam were estimated from the land use and building numbers in the reservoir. Estimated compensation cost curves of each dam are shown in Fig. 4.2.

4.2 Updated Project Cost of Feasibility Study Completed Dams

Among the selected fourteen (14) damsites, feasibility study had been completed for four (4) damsites such as Chico IV, Matuno No.1, Diduyon and Casecnan Project. However, these project costs were estimated two to thirteen years ago and the prices have changed during the laps of time. Therefore, it was necessary to update the project costs at the price level as of December 1985. These updated project costs were estimated by the JICA Luzon Hydropower Potential Study Team as follows,

Unit (10^6\$)

Project	Cost
Casecnan	909.8
Matuno No. 1	267.0
Diduyon	469.2
Chico No. 4	534.9

V REQUIRED DAMS IN THE MASTER PLAN

5.1 General

The development plans for flood control, agriculture and hydropower are formulated and described in the Main Report. The water demands in the Cagayan river basin are projected including the inflated demands due to the development plans. On the other hand, the municipal water demand are projected on the basis of the projected regional population and the regional GVAs for industry and services. The total water demands are thus projected for the target year 2005. The demands are compared with the available water to identify water deficits as mentioned in ANNEX WB.

In order to augment the natural flow and to supplement the water deficit, following dams are proposed;

i) Dams to compensate and supplement Magat reservoir; Matuno No. 1 dam, Alimit No. 1 dam and Siffu No. 1 dam.

ii) Water supply and hydropower dams; Dummon dam, Paranan dam and Zinundungan dam.

iii) Water supply dams; Mallig No.2 dam, Santa Maria dam, Calaocan dam, Colorado dam, Santo Niño dam and San Vicente dam.

iv) Hydropower generating dams; Casecnan dam, Diduyon dam and Matuno No. 1 dam.

In addition, small dams and ponds are proposed as water sources for the development of hilly areas. The objectives of such facilities are not only economic development but the social impacts in the rural area. Furthermore the water demand in these areas is not quantifiable and not located exactly in this master plan study. In this regard, the optimum scales have not been studied for the identified small dams and a pond.

5.2 Optimum Scale of Matuno No. 1, Alimit No. 1 and Siffu No. 1 Dams

These dams are to compensate for reservoir capacity for irrigation and municipal water supply and hydropower generation of the Magat dam allocated to flood control purpose. Meanwhile, the water demand and supply balance study indicates that the existing reservoir may entail a water deficit and that an additional storage of $94 \times 10^6 m^3$ is necessary to compensate for the deficit and to suffice the whole water demand for irrigation water supply to 97,400 ha and for local municipal water supply. The dams are also to cover this required storage as well.

The required storage volume which has the function equivalent to the unit storage volume of the Magat dam is estimated for each dam through water demand and supply balance study. The necessary alternative storage is thus estimated for each dam to apportion the water supply space of the Magat dam. The dam cost is estimated corresponding to each storage of the dams. Consequently the necessary dam cost for storage saving or flood control space generation in the Magat reservoir is estimated for each dam as shown in Fig. 5.1.

Each of the dams mentioned above, however, has its own specific purpose and benefits other than the apportionment of water supply functions of the Magat dam. The dam cost less these benefits is considered as the net cost attributable to the generation of the Magat storage to be allocated to flood control and to complement the water deficit due to the Magat irrigation and municipal water supply. The results of the study on cost and benefit for each dam prove that the cost of storage saving or generation is proportional to the storage generated for each dam. Accordingly the optimum combination of three dams with optimum scale is obtained for a given generated storage of the Magat dam by the Linear Programming method. In this method, the objective is the minimum of the total generated cost and the variable is the storage to be generated by each dam. The constraints are: i) the sum of storage generated by each dam is equivalent to or more than the given storage in question, ii) the hydrologic or topographic limit of each dam and iii) the minimum storage to be provided to suffice the specific requirements to the dam. The results of the study furnished the least costly alternatives for several given Magat storages to be generated. They are plotted and illustrated in Fig. 5.2. The optimum combinations of dams can be obtained in the figure against a given flood control space. The overal costs and benefits, which include the costs and benefits specific to each dam are estimated against each given flood control space of Magat reservoir. The overall costs and benefits estimated are plotted and the Benefit-Cost curve is developed as shown in Fig. 5.3. It shows that the generated space of 233 x $10^6 m^3$ entails the highest overall NPV of ₱1,336 x 10^6 with a discount rate of 12%. Consequently the scales of these dams are proposed as follows;

Alimit No. 1 dam;	Required storage volume:	156 x $10^6 m^3$,	height 89 m
	Generated Magat volume :	156 x $10^6 m^3$	
Matuno No. 1 dam;	Required storage volume:	97 x $10^6 m^3$,	height 147 m
	Generated Magat volume :	36 x $10^6 m^3$	
Siffu No. 1 dam ;	Required storage volume:	93 x $10^6 m^3$,	height 58 m
	Generated Magat volume :	41 x $10^6 m^3$	
Magat dam ;	Generated flood control space:	139 x $10^6 m^3$	
	Generated supplemental volume:	94 x $10^6 m^3$	

5.3 Optimum Scale of Water Supply and Hydropower Generating Dam

The Dummun, Paranan and Zinundungan dams have functions to generate hydropower as well as to supply water for irrigation purposes. The water supply benefit was estimated by applying the unit source water value of ₱0.38/m^3 for irrigation to the supplied volume for the period of project life. Meanwhile, the hydropower generating benefit was estimated applying the kWh value for several alternative scales. The project cost of each dam is also estimated for each alternative scale. The present worths of total benefit and cost were estimated by applying a discount rate of 12%. The estimated benefits and costs are plotted and shown on Fig. 5.4. The figure indicates the scale which yields the maximum NPV of each dam. The obtained optimum scales of the dams are summarized as follows;

Dummon dam	: Storage volume	$24.1 \times 10^6 m^3$	height	36.0 m
Paranan dam	: "	$18.1 \times 10^6 m^3$	"	50.0 m
Zinundungan dam	: "	$53.1 \times 10^6 m^3$	"	48.0 m

The optimum scales which are defined as the scales with the maximum net present values of schemes are these which satisfy the projected water demand in the year 2005. After these data the rate of water demand increase will become very small and NPV will decrease with increase in scale of the project.

In addition to the above mentioned purposes, these dams have flood control function because floods are regulated in the flood impounding capacities between the proposed HWLs and FWLs although the functions are incidental. The benefit resulting from this function is not evaluated in this Study.

5.4 Optimum Scale of Water Supply Dam

There are some dams which have the function of irrigation and/or municipal water supply. The water supply benefit in this case is estimated applying the unit source water value of ₱1.0/m^3 for municipal water and ₱0.38/m^3 for irrigation water to the supplied volume. The benefits to be derived from several scales of dams are thus obtained. The dam cost is estimated for each corresponding scale. The present worths of both benefit and cost are estimated applying a discount rate of 12%. The discounted benefit and cost are plotted and shown in Fig. 5.4. The figure enunciates the optimum scales of the dams. They are summarized as follows;

Mallig No. 2 dam	: Storage volume	$545.0 \times 10^6 m^3$	height	84.0 m
Santa Maria	: "	$18.1 \times 10^6 m^3$	"	26.5 m
Calaocan	: "	$41.0 \times 10^6 m^3$	"	30.5 m
Colorado	: "	$58.4 \times 10^6 m^3$	"	32.5 m
Sto. Niño	: "	$2.0 \times 10^6 m^3$	"	18.0 m
San Vicente	: "	$6.9 \times 10^6 m^3$	"	30.0 m

The optimum scale turn to be the scale which suffices the projected water demand in the year 2005.

In addition to this, following study is executed for Mallig No. 2 dam. The Mallig No. 2 dam scheme includes the transbasin tunnel with a length of 4.0 km to divert the river runoff in the Chico river to the Mallig reservoir. The required storage capacity of the Mallig No. 2 dam relates to the discharge capacity of this tunnel. In order to determine the tunnel capacity by economical comparison, the relation is examined between the tunnel capacity and the storage volume of the Mallig No. 2 dam applying the water demand of Chico-Mallig irrigation project as described in ANNEX WB. Applying this results, overall costs such as dam, spillway, diversion tunnel and transbasin tunnel are estimated for some alternative cases and find out the minimum construction cost. As shown in Fig. 5.5, the minimum cost is obtained at the discharge capacity of 30 m^3/sec.

5.5 Cost Allocation of Dam

The cost of multipurpose dam is allocated to each purpose by means of the Separable Cost-Remaining Benefit method. In this respect, the cost excluding a purpose is estimated to assume separable costs for the purpose. The benefit to be derived and the justifiable expenditures are estimated for each dam and for each purpose. The allocated costs are summarized in Table 5.1. The figures of proposed Siffu No. 1 dam and Mallig No. 2 dam presented in the table include the costs incurred for flood control purpose. The proposed flood control spaces are 115 x $10^6 m^3$ for the Siffu No. 1 dam and 112 x $10^6 m^3$ for the Mallig No. 2 dam.

5.6 Selected Dam Development in the Proposed Master Plan

In the proposed Master Plan, following dams are selected and location of damsites are shown in Fig. 5.6.

Siffu No. 1 dam for Siffu project:

The project comprises the schemes of Siffu flood control, Siffu hydropower generation with a capacity of 5.4 MW and energy output of 41.1 GWh and the supplement of the water deficit forecast in Magat reservoir. The project is to be supported by the proposed Siffu No. 1 multipurpose dam with a height of 58 m, an embankment volume of 1,660 x 10^3 m^3, an effective storage capacity of 93 x 10^6 m^3, a flood control space of 115 x 10^6 m^3. The layout the proposed dam is presented in Fig. 5.7, and principal features and estimated construction cost of dam are shown in Tables 5.2 and 5.3.

Matuno No. 1 dam for Matuno project:

The project comprises the schemes of Matuno hydropower generation with a capacity of 180 MW and energy output of 528 GWh, Matuno irrigation of 12,860 ha, municipal water supply and the supplement of the water deficit forecast in Magat reservoir. The highlight of the project is the proposed Matuno multipurpose dam with a height of 147 m and an effective storage capacity of 97 x 10^6 m^3. The required embankment is 10,000 x 10^3 m^3.

Mallig No. 2 dam for Mallig project:

The project comprise the schemes of Chico Mallig irrigation with a proposed service area of 31,200 ha and Mallig flood control. In order to support the project, Mallig No. 2 dam, a rockfill dam, with a height of 84 m, an embankment volume of 2,365 x 10^3, a storage capacity of 545 x 10^6 m^3 and a flood control space of 112 x 10^6 m^3 is proposed. A layout of the proposed dam is presented in Fig. 5.8, and principal features and estimated construction cost of dam are shown in Tables 5.4 and 5.5.

Alimit No. 1 dam for Alimit project:

The main purpose of the project is to provide a flood control space in the Magat reservoir. In order to subrogate the storage volume of Magat reservoir ceded to flood control volume, Alimit No. 1 dam is proposed. The height of the concrete dam is 89 m with an effective storage capacity of 156 x 10^6 m^3. The concrete volume is estimated to be 647 x 10^3 m^3. The project provides a flood control volume of 139 x 10^6 m^3 to Magat reservoir. Power generation of 12,200 kW and energy output of 80.6 GWh are expected.

The layout of the proposed dam is presented in Fig. 5.9, and principal features and estimated construction cost of dam are shown in Tables 5.6 and 5.7.

Santo Niño dam for Dabubu irrigation scheme:

Service area of 1,200 ha. Santo Niño earthfill dam with a height of 18 m, embankment volume of 145.1 x 10^3 m^3. Main canal with a maximum discharge capacity of 1.2 m^3/s and a length of 13.6 km. The layout of the proposed dam is presented in Fig 5.10, and principal features and estimated construction cost of dam are shown in Tables 5.8 and 5.9.

Santa Maria dam, Calaocan dam and Colorado dam for Grappal irrigation scheme:

Service area of 4,400 ha. Santa-Maria, Calaocan and Colorado earthfill dams with heights of 26.5 m, 30.5 m and 32.5 m. Total embanked volume of 1,083.1 x 10^3 m^3. Main canal with a maximum discharge capacity of 5.98 m^3/s and a length of 40.3 km. The layouts of the proposed dam are presented in Figs. 5.11 to 5.13, and principal features and estimated construction costs of dams are shown in Tables 5.10 to 5.15.

Paranan dam for Baggao irrigation scheme:

Service area of 1,812 ha. Paranan multipurpose rockfill dam with a height of 50 m and earth embankment volume of 640 x 10^3 m^3. Effective storage volume of 18.1 x 10^6 m^3. Power generation of 0.6 MW and energy output of 4.96 GWh are expected. Main canal with a maximum discharge capacity of 2.2 m^3/s and a length of 24.8 km. The layout of the proposed dam is presented in Fig. 5.14, and principal features and estimated construction cost of dam are shown in Tables 5.16 and 5.17.

Dummon dam for Dummon irrigation scheme

Service area of 2,070 ha. Dummon multipurpose rockfill dam with a height of 36 m and embankment volume 493.3 x 10^3 m^3. Effective storage volume of 24.1 x 10^6 m^3. Power generation of 0.6 MW and energy output of 4.21GWh are expected. Main canal with a maximum discharge capacity of 4.9 m^3/s and a length of 20.4 km. The layout of the proposed dam is presented in Fig. 5.15, and principal features and estimated construction cost of dam are shown in Tables 5.18 and 5.19.

Zinundungan dam for Zinundungan irrigation scheme:

Service area of 1,750 ha. Zinundungan multipurpose concrete gravity dam with a height of 48 m and embankment volume of 60.5 x 10^3 m^3. Power generation of 1.4 MW and energy output of 10.21 GWh are expected. Effective storage capacity of 53.1 x 10^6 m^3. Main canal with a maximum discharge capacity of 5.9 m^3/s and a length of 27.6 km. The layout of the proposed dam is presented in Fig. 5.16, and principal features and estimated constructon cost of dam are shown in Tables 5.20 and 5.21.

San Vicente dam for Tumauini irrigation scheme:

Service area of 3,987 ha. San Vicente earthfill dam with a height of 30 m and embankment volume of 384 x 10^3 m^3. Storage volume of 6.9 x 10^6 m^3. Main canal with a maximum discharge capacity of 9.2 m^3/s and a length of 23.5 km. The layout of the proposed dam is presented in Fig. 5.17, and principal features and estimated construction cost of dam are shown in Tables 5.22 and 5.23.

Diduyon dam for Diduyon hydropower scheme:

Installed capacity of 352 MW and Energy output of 957 GWh. Francis type turbine 2 units with maximum gross head of 486 m.

In addition to the dam development as above, the model schemes of small dam and pond are included in the proposed Short Term Plan. These model schemes are expected to furnish a valuable information regarding the development of upland which is considered as one of the urgent and key measures for the development of the Cagayan river basin.

Santor Dam:

Development area of 31 km^2 for pasture land area and 310 ha for paddy fields. Santor earthfill dam with height of 23 m and embankment volume 139 x 10^3 m^3. Effective storage volume of 4.7 x 10^6 m^3. The layout of the proposed dam is presented in Fig. 5.18, and principal features and construction cost of dam are shown in Tables 5.24 and 5.25.

Carmencita Pond:

Development area of 21 km^2 for pasture land area and 80 ha for paddy field. Carmencita pond with height of 18 m and embankment volume 120 x 10^3 m^3. Effective storage volume of 1.2 x 10^6 m^3. The layout of the proposed pond is presented in Fig. 5.19, and principal features and construction cost of pond are shown in Tables 5.26 and 5.27.

Reservoir storage volume and surface area curves of damsites, which are selected in the Master Plan, are shown in Fig. 5.20.

VI SUMMARY OF PREVIOUSLY STUDIED PROJECTS

Ref. No. DA-201

TITLE: Feasibility Study Chico IV Hydropower Project in the Chico River, Luzon

PREPARED BY: LAHMAYER, EDCOP and NAPOCOR

DATE: May 1981

STATUS OF THE PROJECT: Feasibility Stage

PROJECT FEATURES:

Location: Chico River at Tomiangan, Kalinga-Apayao

Catchment Area	:		1,410 km^2
Reservoir	:	Reservoir area at HWL	13.6 km^2
		Capacity, gross	740 MCM
		effective	430 MCM
		HWL	EL.451 m
		LWL	EL.411 m
Dam	:	Type, Rockfill with a inclined core zone	
		Height above riverbed	155 m
		Crest, length	890 m
		width	15 m
		Slope, upstream	1 : 1.85
		downstream	1 : 1.85
		Volume	17.8×10^6 m^3
Spillway	:	Type, Gated and open chute spillway	
		Design flood discharge	7,500 m^3/s
		Gate	15.0m(H) x 10.5m(W) x 6 units
		Overflow crest length	63 m
		Crest elevation	EL.436 m
		Chuteway, length	429.4 m
		width	79 m to 50 m
		Energy dissipator	Plunge pool
Power Facilities	:	Maximum discharge	355 m^3/s
		Installed capacity	360 MW
		Annual energy	955 GWh

CONSTRUCTION COST:

Price Level : July/August 1980

Exchange Rate : 1 US$ = 7.5 Pesos

Item	Cost (₱ x 10^6)		
	Foreign	Local	Total
Direct Cost			
Dam	1,044.5	253.5	1,298.0
Spillway	41.4	104.4	145.7
Intake & Tunnel	20.3	62.8	83.1
Power station	22.0	93.1	115.1
Steel structures	150.6	25.5	176.0
G/E, T/L & S/S	554.5	43.1	597.6
Others	222.5	165.1	387.6
Sub-total	2,055.7	747.5	2,803.1
Indirect Cost			
Contingency			330.8
Engineering & Administration			168.2
Interest during construction			1,082.0
Sub-total			1,581.0
Total			4,384.1

PROJECT BENEFIT AND EVALUATION:

Annual Benefit : Irrigation 144.6 x 10^6 Pesos

Hydropower, Evaluated but not specifically stated

IRR : 10.1

Benefit Cost Ratio: 1.01

CONSTRUCTION PERIOD: 5.5 years

OTHER PARTICULARS:

(a) Geological condition
The outcropping rocks in the foundation area of damsite are sequence of conflomerate and sandstone, agglomerate with thin siltstone.

(b) Expenditures arising from relocation and resettlement efforts are not incorporated in the cost estimate.

Ref. No. DA-202

TITLE: Feasibility Report on Diduyon Hydroelectric Development Project

PREPARED BY: JICA and NAPOCOR

DATE: December 1980

STATUS OF THE PROJECT: Feasibility Stage

PROJECT FEATURES:

Location: Diduyon River at Kamamasi, Kasibu, Nueva Vizcaya

Catchment Area	:		477 km^2
Reservoir	:	Reservoir area at HWL	27.3 km^2
		Capacity, gross	579 MCM
		effective	454 MCM
		FWL	EL.648 m
		HWL	EL.648 m
		LWL	EL.620 m
Dam	:	Type, Concrete gravity	
		Height	111 m
		Crest, length	375 m
		width	8 m
		Slope, upstream	1 : 0.1
		downstream	1 : 0.8
		Volume	1.2 x 10^6 m^3
Spillway	:	Type, Gated and open chute spillway	
		Design flood discharge	8,900 m^3/s
		Gate	15.5m(H) x 15.0m(W) x 3 units
		Overflow crest length	46.5 m
		Crest elevation	EL.633 m
		Chuteway, length	146 m
		width	51 m
		Energy dissipator	Stilling basin
Power Facilities	:	Discharge, firm	21.3 m^3/s
		maximum	85.2 m^3/s
		Installed capacity	352 MW
		Annual energy	957 GWh

CONSTRUCTION COST:

Price Level : Early 1980

Exchange Rate : 1 US$ = 8.0 Pesos

Item	Cost (US$ x 10^6)		
	Foreign	Local	Total
Dam and spillway	60.8	53.9	114.7
Power associated cost	97.5	101.2	198.7
Compensation	0	13.2	13.2
Engi. and Admini.	8.9	28.3	37.2
Contingency	14.7	14.4	29.1
IDC	-	77.9	77.9
Total	181.9	288.9	470.8

PROJECT BENEFIT AND EVALUATION:

Annual Benefit : Hydropower 68.8×10^6 US$

IRR : 24.1 %

Benefit Cost Ratio: 1.74

Benefit - Cost : 29.3×10^6 US$

CONSTRUCTION PERIOD:

Investigation and Design: 4 years

Construction : 5.5 years

Total : 8.5 years

OTHER PARTICULARS:

(a) Geological conditions

The foundation rocks underlying this damsite is composed of agglemerate intruded by andesite dikes. The important geologic problem on this site lies on the saddle part of the right abutment. Drill core indicate that a weak zone exists in the area.

(b) A considerable amount is allocated for the construction of the access road (37 x 10^6 US$) which have two year implementation period.

TITLE: Casecnon Transbasin Diversion Project Feasibility Study

PREPARED BY: ELC, CHAS T. Main, DCCD, TECHNOSYSTEM, TECHNOSPHERE and NIA

DATE: January 1983 (May 1981 - February 1983)

STATUS OF THE PROJECT: Detailed Design Stage

PROJECT FEATURES:

Location: Downstream of Junction of Casecnan River and Conwap River at Madela, Quirino

Catchment Area	:		1,150 km^2
Reservoir	:	Reservoir area at FWL	36.1 km^2
		Capacity, gross	2,213 MCM
		effective	1,183 MCM
		FWL	EL.426.53 m
		HWL	EL.424.5 m
		LWL	EL.382.0 m
Dam	:	Type, Rockfill with a center core zone	
		Height from core foundation	197 m
		Crest, length	868.6 m
		width	15 m
		Slope, upstream	1 : 2.0
		downstream	1 : 1.9
		Volume	27.68 x 10^6 m^3
Spillway	:	Type, Gated and open chute spillway	
		Design flood discharge (PMF routed)	12,226 m^3/s
		Overflow crest length	90 m
		Crest elevation	EL.410.0 m
		Gate	15.5m(H) x 15.0m(W) x 6 units
		Chuteway, length	400 m
		width	110 m to 70 m
		Energy dissipator	Plunge pool
Transbasin Tunnel	:	Diameter	6.25 m
		Total length	25,739 m
		Design capacity	110 m^3/s

Other facilities :

Irrigation :	DCI	Masiway	Bongabon
Discharge (m^3/s)	78.2	66.8	11.9
Service area (ha)	46,000	39,300	7,000

Power generation :	San Juan	Addi. Pantabangan	Addi. Masiway
Installed cap. (MW)	156	100	12
Ann. energy, firm (GWh)	761	290	-
Total (GWh)	917	417	45

CONSTRUCTION COST:

Price Level : End of 1982

Exchange Rate : 1 US$ = 9.0 Pesos

Item	Cost (₱ x 10^6)		
	Foreign	Local	Total
Casecnan Project Cost			
Casecnan Project	3,014.7	2,601.1	5,615.8
Pantabangan extension	181.1	66.0	247.1
Masiway extension	29.6	13.0	42.6
Transmission lines	51.8	77.8	129.6
Sub-total	3,277.3	2,757.9	6,035.1
Irrigation Project Cost			
DC1' service area	185.6	413.8	599.4
Masiway service area	307.9	520.1	828.0
Bongabon service area	47.9	94.2	141.7
Sub-total	540.9	1,028.2	1,569.1
Total	3,818.2	3,786.0	7,604.2

PROJECT BENEFIT AND EVALUATION:

Annual Benefits : Irrigation 1,160 x 10^6 Pesos
Power generation 785 x 10^6 Peso
Total 1,945 x 10^6 Pesos

EIRR : 15.2 %

Benefit Cost Ratio: 1.36

Benefit - Cost : 1,613 x 10^6 Pesos

CONSTRUCTION PERIOD:

Construction of Dam, tunnel & Power plants: 7 years

Construction of irrigation facilities : 9 years

Total: 11 years

OTHER PARTICULARS:

(a) Geological condition
No special difficulties are predicted for the dam foundation at either abutment. The rocks at the damsite showed a low permeability.

(b) Resettlement
The total number of the houses in the proposed reservoir area is 58. Resettlement cost has been estimated to be 20 million Pesos.

(c) Environmental Impact
Salt water intrusion in Aparri and the estuarine region of the Cagayan river may increase with the transfer of the water from the Cagayan river basin. However, the low flow augmentation from Magat and Chico river projects are more than sufficient to offset the 10% reduction of the Cagayan river flow due to the diversion of the water from Casecnan river basin.

TITLE: Feasibility Study on the Matuno River Development Project

PREPARED BY: JICA and NIA

DATE: February 1984 (January 1982 - February 1984)

STATUS OF THE PROJECT: Feasibility Stage

PROJECT FEATURES:

Location: Matuno River at Nueva Vizcaya

Catchment Area	:		550 km^2
Reservoir	:	Reservoir area at HWL	3.5 km^2
		Capacity, gross	137 MCM
		effective	97 MCM
		FWL	EL.524.7 m
		HWL	EL.520 m
		LWL	EL.480 m
Dam	:	Type, Rockfill with a center core zone	
		Height	147 m
		Crest, length	580 m
		width	14 m
		Slope, upstream	1 : 3.3
		downstream	1 : 2.1
		Volume	10 MCM
Spillway	:	Type, Gated and open chute spillway	
		Design flood discharge (10,000 yr)	10,300 m^3/s
		Gate	16m(H) x 12m(W) x 4 units
		Overflow crest length	48 m
		Crest elevation	EL.504 m
		Chuteway, length	225 m
		width	57 m
		Energy dissipator	Stilling basin
Other Facilities	:		
Irrigation	:	Water requirement	21.4 m^3/s
		Service area	13,680 ha
Power	:	Discharge, firm	37.4 m^3/s
		maximum	112.2 m^3/s
		Installed capacity	180 MW
		Annual energy, firm	356 GWh
		Total	528 GWh

CONSTRUCTION COST:

Price Level : May 1983

Exchange Rate : 1 US$ = 10 pesos = 240 yen

Item	Cost (US$ x 10^3)		
	Foreign	Local	Total
Dam	59,000	24,000	83,000
Spillway	13,358	5,382	18,740
Waterway	20,702	16,198	36,900
Power station	13,337	4,763	18,100
G/E, T/L & S/S	24,090	6,055	30,145
Irrigation	18,797	14,130	32,927
Others	19,981	15,134	35,115
Compensation	0	2,698	2,698
Engi. & Admini.	19,096	10,716	29,812
Physi. Contingen.	17,166	8,968	26,134
Total	205,527	108,044	313,571

PROJECT BENEFIT AND EVALUATION:

Annual Benefits :	Flood control	0.75 x 10^6 US$
	Irrigation	8.59 x 10^6 US$
	Hydropower	43.09 x 10^6 US$
	Total	52.43 x 10^6 US$
EIRR :	Irrigation & flood control	18.9%
	Hydropower	14.1%

CONSTRUCTION PERIOD:

Investigation and Design:	2 years
Construction of Agricultural Development:	5 years
Construction of Hydropower Development :	5 years
Total:	12 years

OTHER PARTICULARS:

(a) Geological conditions

The foundation rocks are composed of hard to moderately hard conglomerates.

(b) Others

Imprementation of the project is divided into two stages. The first stage is for agricultural development while the second stage is for hydropower development. Compensation for this project is very minimal.

Ref. No. DA-205

TITLE: Magat River Project Feasibility Report

PREPARED BY: USBR, USAID and NIA

DATE: June 1973

STATUS OF THE PROJECT: Completed in 1984

PROJECT FEATURES:

Location: Magat River at Barrio Planas, Ramon, Isabela

Catchment Area	:		4,143 km^2
Reservoir	:	Reservoir area at HWL	44.6 km^2
		Capacity, gross	1,254 MCM
		effective	968.8 MCM
		FWL	EL.197.45 m
		HWL	EL.193.00 m
		LWL	EL.157.80 m
Dam	:	Type, Composite earth & rockfill - concrete gravity	
		Height	114 m
		Crest, length	2,925 m
		width	12 m
		Slope, upstream	1 : 3.0
		downstream	1 : 2.5
		Volume, earth & rockfill	10.0 x 10^6 m^3
		concrete	2.0 x 10^6 m^3
Spillway	:	Type, Gated and integrated in the concrete dam	
		Design flood discharge (PMF)	30,400 m^3/s
		Overflow crest length	225 m
		Crest elevation	EL.180.5 m
		Gate	13.22m(H) x 12.5m(W) x 18 units
		Chuteway width	276 m
		Energy dissipator	Slotted bucket type
Other Facilities	:		
Irrigation	:	Maximum discharge	139.2 m^3/s
		Service area	104,600 ha
Power	:	Installed capacity	300 MW
		Annual energy, firm	363.61 GWh
		Total	990.69 GWh

CONSTRUCTION COST:

Price Level : January 1973

Exchange Rate : 1 US$ = 6.7 Pesos

Item	Cost (₱ x 10^3)
Access & resettlement	13,110
Dam	712,596
Irrigation facilities	282,675
G/E, T/L & S/S	253,052
Others	10,910
Total	1,272,343

PROJECT BENEFIT AND EVALUATION:

Annual Benefits :	Irrigation	101,845 x 10^3 ₱
	Hydropower	39,777 x 10^3 ₱
	Total	141,622 x 10^3 ₱
IRR :		12.44 %
Benefit Cost Ratio:		1.71
Benefit-Cost :		59,030 x 10^3 ₱

CONSTRUCTION PERIOD:

Investigation and Design:		2 years
Construction:	1st Stage	6 years
	2nd Stage (Add. two units of G/E)	1 year
	Total:	9 years

OTHER PARTICULARS:

(a) Geological conditions

The rocks within the damsite consist mainly of metamorphosed sedimentary rocks interbedded with layers of metavolcanics which were later on intruded by dikes.

(b) Cropped farm land and inhabitants in the reservoir

The reservoir inundates 30 ha of residential land and 765 ha of cropped farm land. An estimated 500 inhabitants are affected.

(c) Environmental Impacts

The reservoir and canal sytem might become breeding places for mosquitoes, snails and other disease vectors. The construction of a dam restricts the movement of fishes especially the eel and mullet.

TITLE: Binongan Hydroelectric Project Feasibility Study

PREPARED BY: Shawinigan and NAPOCOR

DATE: April 1985

STATUS OF THE PROJECT: Feasibility Stage

PROJECT FEATURES:

Location: Binongan River at Alaoa, San Juan, Abra

Catchment Area	:	377 km^2 at Binongan dam and 306 km^2 at Tineg Weir	
Reservoir	:	Reservoir area at HWL	3.54 km^2
		Capacity, gross	121 MCM
		effective	79 MCM
		FWL	EL.383 m
		HWL	EL.380 m
		LWL	EL.350 m
Dam	:	Type, Rockfill with a center core zone	
		Height	112 m
		Crest, length	375 m
		width	12 m
		Slope, upstream	1 : 1.8 & 1 : 2
		downstream	1 : 1.8 & 1 : 2
		Volume	3.35×10^6 m^3
Spillway	:	Type, Gated and open chute spillway	
		Design flood discharge (PMF routed)	4,420 m^3/s
		Gate	12m(H) x 10m(W) x 4 units
		Overflow crest length	40 m
		Crest elevation	EL.368 m
		Chuteway length	240 m
		width	52 m to 40 m
		Energy dissipator	Plunge pool
Power Facilities	:	Maximum discharge	90 m^3/s
		Installed capacity	175 MW
		Annual energy, firm	426 GWh
		Total	718 GWh

CONSTRUCTION COST:

Price Level	:	End of 1984
Exchange Rate	:	1 US$ = 20 Pesos

Item	Cost ($ x 10^6)
Dam	29.4
Spillway	17.9
Waterway	71.5
Power Station incl. G/E	33.8
Tineg Diversion	18.8
Others	21.8
Contingency	23.8
Engi. & Admini.	19.3
Supplementary Costs	6.9
IDC	62.4
Total	305.4

PROJECT BENEFIT AND EVALUATION:

IRR	:	13.8%
Benefit cost Ratio	:	1.31

CONSTRUCTION PERIOD:

Preliminary Works	:	2 years
Main Works	:	4.5 years
Total	:	6 years

OTHER PARTICULARS:

(a) Geological conditions

The project area is generally underlain by volcanic rocks: agglomerates and lavas of andesitic and dacitic composition. They are locally intruded by basaltic dykes.

(b) Social and Environmental Impacts

- About 400 people in the reservoir area would be displaced and hence have to be resettled from this area.
- Downstream of the reservoir, a stretch of about 15 km of the Binongan river would be essentially dried-up due to the diversion of flow through the power facilities. A population of about 500 inhabits in this area. A serious impact is the loss of fishing, an important source of food for this people.

Ref. No. DA-207

TITLE: Technical Pre-Feasibility Study of the Hydroelectric Development in the Chico River

PREPARED BY: LAHMAYER, EDCOP and NAPOCOR

DATE: June 1973

STATUS OF THE PROJECT: Pre-Feasibility Stage, Chico 1, 2 and 3
Feasibility Stage, Chico 4

PROJECT FEATURES:

Location: Chico River at Kalinga-Apayao and Mountain Province

Item	Chico 1	Chico 2	Chico 3	Chico 4
Catchment Area (km^2)	371.0	720.0	920.0	1,408.0
Reservoir, Area (km^2)	4.40	10.20	1.68	11.25
Capacity, gross (MCM)	219	560	43	650
effective (MCM)	124	313	27	360
HWL (EL.m)	1,016	827	560	456
LWL (EL.m)	976	787	540	416
Dam, Type	Rockfill	Arch	Gravity	Rockfill
Height above riverbed (m)	160	160	64	160
Crest, length (m)	550	400	215	885
Width (m)	15	10	12	15
Slope, upstream	1 : 1.8	-	1 : 0.1	1 : 2.2
downstream	1 : 1.6	-	1 : 0.7	1 : 2.0
Volume ($\times 10^6$ m^3)	8.39	0.8	0.25	16.44
Spillway, Type	Tunnel	Free-drop	Chute on dam	Chute on abutment
Design discharge (m^3/s)	4,100	4,500	5,000	9,000
Gate H x W x Units	15x9x4	15x8.2x5	15x9x5	15x10.5x8
Overflow crest length (m)	36	41	45	84
Crest elevation (EL.m)	1,001	815	545	441
Chuteway, length (m)	630	15	80	400
width (m)	D=10			110/50
Power Facilities				
Max. discharge (m^3/s)	81	168	185	390
Installed capacity (MW)	100	360	100	450
Annual energy (GWh)	253.4	784.5	238.1	930.8

CONSTRUCTION COST:

Price Level: End of 1972

Item	Cost (₱ x 10^6)			
	Chico 1	Chico 2	Chico 3	Chico 4
Dam	206.5	192.0	77.5	391.3
Spilway	56.1	22.9	-	86.3
Waterway	23.5	88.9	18.7	76.1
Powerhouse	18.1	27.2	22.8	35.3
Electrical equipment	33.0	91.1	38.7	130.3
Otheres	13.7	16.2	5.9	24.0
Contingency	52.6	65.7	24.5	111.5
Engineering	21.0	26.3	9.9	44.6
IDC	59.6	96.4	27.8	163.5
Total	484.1	626.7	225.8	1,062.9

UNIT COST AND COST OF ENERGY:

Unit costs and the cost of the peak energy generated by the projects, excluding operation and maintenance costs, are tentatively estimated as follows,

Item	Chico 1	Chico 2	Chico 3	Chico 4
Unit Cost (Const. Cost/kW)	4,840	1,740	2,260	2,360
Cost of Energy (Const. Cost/kWh)	0.191	0.080	0.094	0.114

CONSTRUCTION PERIOD:

Item	Chico 1	Chico 2	Chico 3	Chico 4
Feasibility Study	1.5	1.5	1.5	1.5
Tendering Works	1.0	1.0	1.0	1.0
Construction	3.0	4.0	3.0	4.0
Total	5.5	6.5	5.5	6.5

OTHER PARTICULARS:

(a) This report is a Technical Pre-Feasibility Report and consequently does not include detailed economic evaluation on the basis of costs and benefits.

(b) Geological Condition
- Chico 1 ... Agglomerate, Andesite and Tuff
- Chico 2 ... Basalt
- Chico 3 ... Basalt, Agglomerate with Basalt Lavers
- Chico 4 ... Greywacke/Conglomerate, Clay Shale and Claystone

Ref. No. DA-208

TITLE: Magat River Multipurpose Project, Stage II, Project Design Report

PREPARED BY: ECI, SECO, EDCUP, DCCD and NIA

DATE: September 1976

STATUS OF THE PROJECT: Completed in 1984

PROJECT FEATURES:

Location: Magat River at Barrio Planas, Ramon, Isabela

Catchment Area	:		4,143 km^2
Reservoir	:	Reservoir area at HWL	45 km^2
		Capacity, gross	1,250 MCM
		effective	933 MCM
		FWL	EL.196.3 m
		HWL	EL.193 m
		LWL	EL.160 m
Dam	:	Type, Rockfill with a center core zone	
		Height	105 m
		Crest, length	4,100 m
		width	12 m
		Slope, upstream	1 : 2.65
		downstream	1 : 2.40
		Volume	13.2×10^6 m^3
Spillway	:	Type, Gated and open chute spillway	
		Design flood discharge	30,600 m^3/s
		Overflow crest length	140 m
		Crest elevation	EL.174 m
		Gate	19.31m(H) x 15.56m(W) x 9 units
		Chuteway length	453 m
		width	164 m
		Energy dissipator	Plunge pool
Other Facilities	:		
Irrigation	:	Maximum discharge	230 m^3/s
		Service area	102,000 ha
Power	:	Maximum discharge	478 m^3/s
		Installed capacity	360 MW
		Annual energy	1,237 GWh

CONSTRUCTION COST:

Price Level : January 1976

Exchange Rate : 1 US$ = 7.4 Pesos

Item	Cost ($ x 10^6)		
	Foreign	Local	Total
Diversion	17.6	16,3	33.9
Main Civil	106.9	80.1	187.0
Electric & Mechanical	60.0	4.5	64.5
Transmission	2.7	0.8	3.5
Irrigation Facilities	20.7	31.1	51.8
Others	5.6	14.0	19.6
Engineering & Administration	15.5	15.5	31.0
Total	229.0	162.3	391.3

PROJECT BENEFIT AND EVALUATION:

Annual Benefits : Irrigation 350×10^6 ₱
Hydropower 192×10^6 ₱
Total 542×10^6 ₱

IRR : 14.3%

Benefit Cost Ratio: 1.22

Benefit-Cost : 53.6×10^6 ₱

CONSTRUCTION PERIOD:

Design & Tender : 2 years

Construction : 6 years

Total : 7 years

OTHER PARTICULARS:

(a) Geological Conditions
The damsite area is dominantly underlain by volcanic igneous rocks. The damsite area is characterized by numerous faults and shear zones having a variety of orientation.

(b) Creation of the Magat reservoir have a direct influence on several human settlements and directly affect the lives of between 1,000 and 1,500 people. The cost of moving and relocation is estimated to be approximately 7.2 million Pesos

(c) Migrating eel and shrimp will be eliminated from Magat river upstream of the dam but this is not seen as a major problem as the watershed involved is only a small portion of the Cagayan river basin.

TITLE: Cagayan River Flood Control Basin-Wide Study

PREPARED BY: Philtech and MPWH

DATE: July 1981

Ref. No. DA-209

Name of Dam	C.A.	Reservoir					Dam			
		Gross	Effective	FWL	HWL	LWL	Type/1	Height	Clest L.	Volume
	(km^2)	($x10^6m^3$)	($x10^6m^3$)	(EL.m)	(EL.m)	(EL.m)		(m)	(m)	($x10^6m^3$)
Dummon	112	308	155	167.1	157.6	135.2	R	66	480	2.5
Babaca	253	236	132	216.5	211.5	177.5	R	95	242	2.3
Saltan	406	306	222	333.8	327.0	269.5	R	122	492	6.1
Nabuangan	195	65	46	182.6	178.0	149.0	R	76	205	1.5
Chico-Mallig	1,987	Run-of-river type					C	12	466	0.1
Chico No.4	1,408	650	360	-	456.0	416.0	R	160	885	16.4
Chico No.3	920	43	27	-	560.0	540.0	C	64	215	0.3
Chico No.2	720	560	313	-	827.0	787.0	A	160	400	0.8
Chico No.1	371	219	124	-	1,016.0	976.0	R	160	550	8.4
Tanudan	370	608	351	477.0	457.5	394.0	R	180	485	10.0
Pasil	244	80	47	790.9	784.0	737.0	R	149	430	8.6
Paret	110	90	60	124.1	121.0	96.5	E	60	550	2.4
Paranan	64	93	50	197.0	188.6	161.0	E	70	320	1.7
Dadap	74	51	31	78.5	76.5	63.6	E	34	730	1.6
Natutud	81	213	127	177.0	166.9	128.2	R	100	240	2.4
Tuguegaroa	220	212	127	179.6	170.0	130.0	R	114	397	6.7
Pinacanauan	115	239	155	257.0	245.7	183.1	R	149	712	10.5
Tumauini	165	125	85	230.0	227.0	186.5	R	103	370	4.0
Mallig No.1	436	408	248	139.0	135.0	111.4	E	64	340	2.9
Mallig No.2	362	410	226	156.4	152.5	136.0	C	50.5	280	0.1
Siffu No.1	626	380	190	127.0	123.0	111.0	E	54	460	2.5
Siffu No.2	367	579	282	277.0	264.0	222.5	R	113	330	5.3
Catarangan	235	517	275	232.0	221.6	185.0	R	122	475	5.7
Abuan No.1	474	732	386	184.5	168.8	122.5	R	130	550	9.4
Abuan No.2	271	796	459	317.0	304.7	248.0	R	151	650	12.2
Ilagan No.1	1,350	690	330	157.7	150.0	135.0	R	64	600	3.4
Ilagan No.2	876	2,030	1,100	291.5	280.0	229.0	R	145	706	14.4
Ilagan No.3	366	843	467	517.0	495.5	441.0	R	150	831	22.5
Tao-Tao No.1	64	28	14	136.4	133.6	123.2	E	32	190	0.2
Tao-Tao No.2	75	32	19	276.5	273.5	260.8	E	39	232	0.4
Alimit No.1	559	1,340	688	336.0	319.2	271.0	R	144	580	11.8
Alimit No.2	431	1,024	563	437.0	422.1	365.0	R	162	580	13.3
Ibulao No.1	595	760	538	382.1	375.0	315.5	R	124	1,790	28.7
Ibulao No.2	396	379	223	652.0	627.4	551.2	R	200	780	22.6
Matuno No.1	526	887	466	638.0	614.7	543.0	R	199	480	13.7
Matuno No.2	220	163	116	783.7	779.0	721.0	R	137	595	11.3
Benay	37	29	18	446.0	443.0	442.0	R	55	470	2.1
Marang	51	28	23	600.5	598.5	568.0	R	53	490	1.3
Sta. Cruz No.1	67	67	38	717.0	699.1	650.0	R	124	610	7.8
Sta. Cruz No.2	62	66	46	676.3	670.0	621.7	R	97	312	3.0
Addalam	864	1,350	905	214.0	210.0	168.5	R	105	1,110	12.2
Diduyon	478	749	416	676.7	667.1	632.5	R	110	464	5.2
Dibuluan	159	252	161	397.0	378.5	283.0	R	160	554	12.1
Cagayan	400	344	204	309.1	300.0	265.8	R	92	461	4.8

(To be continued)

Note: /1; R .. Rockfill dam, E .. Earthfill dam, C .. Concrete gravity dam, A .. Arch dam

(Continuation)

Name of Dam	Spillway Design Inflow (m^3/s)	Spillway Gate (HxWx Units)	Irrigation Area (ha)	Installed Capacity (MW)	Annual Energy (GWh)	Annual Benefit (₱x10^6)	Project Cost (₱x10^6)	Benfit Cost Ratio
Dummon	2,090	6 x 6 x 3	7,760	9.6	35.9	76.7	413.0	1.49
Babaca	4,270	8 x 7 x 5	260	30.4	99.9	84.5	482.9	1.38
Saltan	6,070	9 x 8 x 5	140	129.2	471.3	344.9	1,535.0	1.72
Nabuangan	3,330	8 x 8 x 4	2,970	7.0	56.0	66.9	390.5	1.37
Chico-Mallig	–	Non gate	28,300	100.0	219.0	327.9	1,656.6	1.79
Chico No.4	9,000	15 x 10.5 x 8	–	450.0	930.8	694.3	3,670.5	1.46
Chico No.3	5,000	15 x 9 x 5	–	100.0	238.1	188.5	1,107.3	1.33
Chico No.2	4,500	15 x 8.2 x 5	–	360.0	784.5	578.8	2,108.6	2.03
Chico No.1	4,100	15 x 9 x 4	–	100.0	253.4	190.6	1,415.5	1.06
Tanudan	5,150	8 x 8 x 7	23,500	77.0	285.8	362.7	2,000.3	1.43
Pasil	4,270	8 x 6 x 5	5,250	28.8	225.6	206.1	1,235.3	1.32
Paret	2,080	6 x 6 x 5	2,880	6.4	40.7	50.8	351.6	1.16
Paranan	1,170	5 x 5 x 5	4,680	4.8	24.5	48.4	326.7	1.18
Dadap	1,440	6 x 6 x 4	930	1.9	12.9	16.7	232.7	0.58
Natutud	1,480	4 x 4 x 6	7,000	26.0	39.0	73.3	465.2	1.25
Tuguegarao	3,470	18 x 8 x 4	14,130	16.0	94.0	179.8	974.4	1.46
Pinacanauan	2,110	8 x 6 x 4	6,520	30.0	91.4	110.7	1,057.7	0.84
Tumauini	2,700	8 x 8 x 4	10,000	19.6	84.0	127.0	743.2	1.37
Mallig No.1	5,670	10 x 8 x 5	16,900	17.6	50.6	144.7	875.4	1.32
Mallig No.2	5,320	9 x 8 x 5	15,500	12.0	34.2	123.5	682.8	1.45
Siffu No.1	8,530	8 x 8 x 10	–	31.2	136.8	107.5	616.5	1.39
Siffu No.2	6,240	9 x 8 x 6	–	35.9	95.9	75.6	836.3	0.73
Catarangan	3,970	10 x 8 x 4	3,710	47.0	109.2	107.4	880.7	0.96
Abuan No.1	6,250	10 x 8 x 6	3,710	72.2	247.5	210.6	1,426.8	1.17
Abuan No.2	4,610	8 x 8 x 4	3,710	70.0	206.8	178.2	1,410.0	1.00
Ilagan No.1	12,760	10 x 10 x 7	26,590	113.5	322.2	403.3	1,446.0	2.16
Ilagan No.2	9,170	18 x 10 x 6	4,160	150.0	392.9	355.5	2,579.0	1.33
Ilagan No.3	5,570	10 x 8 x 3	3,710	93.2	221.8	185.9	2,209.7	0.67
Tao-Tao No.1	1,150	5 x 4 x 5	320	0.5	1.4	3.6	73.1	0.43
Tao-Tao No.2	1,410	5 x 5 x 5	820	3.2	8.3	12.2	125.9	0.84
Alimit No.1	6,830	10 x 8 x 5	–	146.5	357.3	263.4	1,765.4	1.17
Alimit No.2	6,730	12 x 8 x 5	–	136.6	319.8	235.0	1,841.4	1.00
Ibulao No.1	8,090	9 x 8 x 6	–	216.0	577.0	420.7	3,281.1	1.00
Ibulao No.2	6,860	11 x 8 x 6	–	104.0	379.0	277.2	2,452.0	0.90
Matuno No.1	6,500	8.5 x 8 x 5	16,200	272.0	812.0	731.1	3,791.8	1.43
Matuno No.2	3,710	8 x 6 x 6	15,400	39.2	161.9	234.5	1,383.4	1.36
Benay	874	6 x 4 x 3	2,200	2.1	6.8	30.5	257.4	0.96
Marang	1,350	8 x 6 x 3	1,700	3.5	8.3	25.4	280.3	0.72
Sta. Cruz No.1	1,300	5 x 4 x 4	1,580	8.4	34.5	44.1	713.5	0.50
Sta. Cruz No.2	1,140	10 x 10 x 1	1,420	5.2	27.8	55.2	492.0	0.94
Addalam	9,190	10 x 10 x 6	16,500	121.5	333.8	358.6	1,956.0	1.45
Diduyon	6,450	10 x 10 x 5	–	303.0	933.4	646.3	2,528.6	1.91
Dibuluan	2,490	7 x 6 x 4	2,820	60.0	152.8	134.9	1,383.8	0.77
Cagayan	7,100	8 x 8 x 5	2,220	37.8	124.3	130.1	875.5	1.18

Table 1.1 Results of First Screening

	NO.	NAME OF DAM	SUB-BASIN	RIVER	(A) CATCHMENT AREA (sq.km)	(B) DAM HEIGHT (m)	CREST ELEVATION (EL.m)	HWL (EL.m)	SEDIMENT LEVEL (EL.m)	RIVERBED ELEVATION (EL.m)	GROSS STORAGE (Mcm)	(C) EFFECTIVE STORAGE (Mcm)	SEDIMENT STORAGE (Mcm)	(D) EMBANKMENT VOLUME (Mcm)	STORAGE EFFICIENCY (1) (C)/(D)	EFFICIENCY (2) (1)*(A)/1000	EFFICIENCY (3) (2)*(B)/1000	SE(1) >60	SE(2) >40	SE(3) >5	HYDRO HIGH HEAD SCHEME	SELECTED DAMSITES	REMARKS
	1	Dummon	Dummon	Dummon	112	54	153	148	122	104	145	128	17	1.4	91.4	10.2	0.5	o				o	
Δ	2	Tamudan	Chico	Tamudan	370	150	445	440	385	300	295	239	56	7.3	32.7	12.1	1.8						
×	3	Chico No.5	Chico	Chico	3354	55	105	100	96	55	685	182	503	4.5	30.0	120.7	6.6		o	o			Discarded due to difficult compensation
	4	Chico No.4	Chico	Chico	1410	186	456	451	396	295	740	529	211	18.2	29.1	41.0	6.8		o	o		o	
	5	Chico No.3	Chico	Chico	920	70	565	560	600	500	43	-	136	1.7	-	-	-						
	6	Chico No.2	Chico	Chico	720	167	832	827	756	670	560	452	108	10.2	44.3	31.9	5.3			o	o	o	
	7	Chico No.1	Chico	Chico	371	186	1021	1016	957	880	219	163	56	10.1	16.1	6.0	1.0						
	8	Chico-Mallig	Chico	Chico	1990	135	305	300	236	175	2120	1822	298	37.7	48.3	96.1	13.0		o	o		o	Subject to compensation for an intake weir
	9	Pasil	Chico	Pasil	244	150	790	785	756	645	70	33	37	8.3	4.0	1.0	0.2						
×	10	Matalag	Chico	Matalag	855	70	90	85	47	25	900	800	100	2.2	363.6	238.2	16.7	o	o	o		o	Subject to land compensation
	11	Mabuangan	Chico	Mabuangan	195	75	180	175	164	110	49	20	29	1.5	13.3	2.6	0.2						
×	12	Pinukpuk	Chico	Saltan	856	92	162	157	106	75	1150	1022	128	5.6	182.5	156.2	14.4	o	o	o		o	
	13	Saltan	Chico	Saltan	406	130	340	335	278	215	305	244	61	7.4	33.0	13.4	1.7						
	14	Babaca	Chico	Babaca	253	120	240	235	160	125	340	302	38	3.8	79.5	20.1	2.4	o				o	
×	15	Bitag	Pared	Pared	605	40	60	55	38	25	950	846	104	1.1	769.1	531.5	21.4	o	o	o		o	Subject to land compensation
	16	Pared	Pared	Pared	110	50	142	137	95	67	150	133	17	5.0	26.6	2.9	0.2						
	17	Dadap	Pared	Dadap	74	51	94	89	62	46	100	89	11	3.6	24.7	1.8	0.1						
	18	Paranan	Pared	Paranan	64	75	200	195	155	130	88	78	10	2.1	37.1	2.4	0.2						
×	19	Agguanddan	Tuguegarao	Tuguegarao	441	55	85	80	52	35	448	382	66	1.2	318.3	140.4	7.7	o	o	o		o	Subject to geological condition
	20	Tuguegarao	Tuguegarao	Tuguegarao	220	130	200	195	127	75	300	267	33	7.7	34.7	7.6	1.0						
	21	Matutud	Tuguegarao	Matutud	81	85	160	155	113	80	110	98	12	1.7	57.6	4.7	0.4						
	22	Pinacanauan	Pinacanauan	Pinacanauan	115	131	237	232	181	111	155	138	17	8.4	16.4	1.9	0.3						
	23	Tumauini	Tumauini	Tumauini	165	127	252	247	181	130	223	108	25	7.0	28.3	4.7	0.6						
×	24	Siffu No.1(A)	Siffu-Mallig	Siffu	656	65	125	120	91	65	540	442	98	1.7	260.0	170.6	11.1	o	o	o		o	One damsite to be selected considering geological condition
	24'	Siffu No.1(B)	Siffu-Mallig	Siffu	626	59	130	125	108	76	335	241	94	1.8	133.9	83.8	5.0	o	o	o		o	
	25	Siffu No.2	Siffu-Mallig	Siffu	367	113	275	270	210	167	480	425	55	4.5	94.4	34.6	4.0	o				o	
	26	Mallig No.1	Siffu-Mallig	Mallig	436	77	150	145	101	78	590	525	65	2.6	201.9	88.0	6.8	o	o	o		o	
	27	Mallig No.2	Siffu-Mallig	Mallig	362	60	165	160	131	110	498	444	54	1.0	444.0	160.7	9.6	o	o	o		o	
	28	Ilagan No.1	Ilagan	Ilagan	1350	69	160	155	137	96	628	425	203	3.6	118.1	159.4	11.2	o	o	o		o	
	29	Ilagan No.2	Ilagan	Ilagan	876	122	265	260	178	148	1125	994	131	10.9	91.2	79.9	10.0	o	o	o		o	
	30	Ilagan No.3	Ilagan	Ilagan	366	130	495	490	424	370	480	425	55	13.8	30.8	11.3	1.5						
	31	Abuan No.1	Ilagan	Abuan	474	130	183	178	107	58	640	569	71	9.9	57.5	27.3	3.6						
	32	Abuan No.2	Ilagan	Abuan	271	121	265	260	210	180	362	321	41	6.8	47.2	12.8	1.5						
×	33	Dinabungan	Ilagan	Dinabungan	652	85	105	100	72	45	606	508	98	4.4	115.5	75.3	4.9	o	o			o	
	34	Catalangan	Ilagan	Catalangan	235	107	215	210	155	113	320	285	35	4.5	63.3	14.9	1.6	o				o	
	35	Tao-tao No.1	Magat	Tao-tao	84	38	140	135	126	107	28	18	10	0.3	53.3	3.4	0.1						
	36	Tao-tao No.2	Magat	Tao-tao	75	44	280	275	265	241	28	17	11	0.5	34.0	2.6	0.1						
	37	Alimit No.1(A)	Magat	Alimit	559	125	315	310	243	195	740	656	84	7.1	92.4	51.7	6.5	o	o	o		o	Alimit No. 1 (A) is selected on the basis of higher storage efficiency
×	37'	Alimit No.1(B)	Magat	Alimit	517	95	325	320	290	235	279	201	78	2.6	77.3	40.0	3.8	o	o				
	38	Alimit No.2	Magat	Alimit	431	142	415	410	340	278	570	505	65	10.4	48.6	20.9	3.0						
	39	Ibulao No.1	Magat	Ibulao	595	125	380	375	310	200	650	561	89	33.1	16.9	10.1	1.3						
	40	Ibulao No.2	Magat	Ibulao	398	150	600	595	551	455	160	101	59	10.0	10.1	4.0	0.6						
	41	Matuno No.1	Magat	Matuno	550	133	530	525	502	402	157	75	82	8.1	9.3	5.1	0.7				o	o	Hydropower project with high head thru long headrace tunnel
	42	Matuno No.2	Magat	Matuno	220	150	795	790	724	650	190	157	33	11.4	13.8	3.0	0.5						
	43	Sta.Cruz No.1	Magat	Sta. Cruz	67	144	735	730	658	596	88	78	10	12.0	6.5	0.4	0.1						
	44	Sta.Cruz No.2	Magat	Sta. Cruz	62	103	680	675	617	582	65	56	9	3.2	17.5	1.1	0.1						
	45	Benay	Magat	Benay	37	67	455	450	418	393	35	29	6	2.3	12.6	0.5	0.0						
	46	Maramag	Magat	Maramag	51	83	628	623	574	550	68	60	8	5.4	11.1	0.6	0.0						
×	47	Cagayan No.1	Upper Cagayan	Cagayan	2364(1214) Δ2	55	165	160	139	115	956	774	182	1.2	645.0	783.0	43.1	o	o	o		o	Subject to land compensation and geological condition
×	48	Cagayan No.2	Upper Cagayan	Cagayan	1631(481)	80	245	240	208	170	383	311	72	3.1	100.3	48.2	3.9	o	o			o	Subject to geological condition
	49	Casecnan	Upper Cagayan	Cagayan	1150 Δ3	191	432	428.5	310	246	2300	2127	173	28.9	73.6	84.6	16.2	o	o	o	o	o	Transbasin diversion scheme
	50	Addalam(A)	Upper Cagayan	Addalam	864(587)	59	167	162	137	113	240	182	58	2.9	62.8	54.3	3.4	o	o			o	
×	50'	Addalam(B)	Upper Cagayan	Addalam	821(344)	47	167	162	159	125	65	13	52	1.3	10.0	8.2	0.4						
	51	Diduyon	Upper Cagayan	Diduyon	477	109	653	648	619	549	579	507	72	6.2	81.8	39.0	4.3	o			o	o	Hydropower project with high head thru long headrace tunnel
	52	Dibuluan	Upper Cagayan	Dibuluan	159	150	385	380	295	240	182	158	24	10.3	15.3	2.4	0.4				o	o	Transbasin diversion scheme

NOTES: Δ1 : Means damsite newly found out in this study.
Δ2 : Catchment areas in parenthesis of Cagayan No.1 (47) and Cagayan No. 2 (48) are excluded those of Casecnan.
Δ3 : Catchment area in parenthesis of Addalam (A) (50) and Addalam (B) (50') are excluded those of Diduyon

Table 1.2 Adjustment Factors for Altitude

No.		Name of Dam	Ave. El. of Dam Basin (El. m)	Applied Runoff Gauge	Ave. El. of Runoff Gauge Basin (El. m)	Adjustment Factor
(1)	1	Dummon	300	Pangal	500	0.9
(2)	4	Chico No. 4	1,000	Minanga	400	1.5
(3)	6	Chico No. 2	1,300	Minanga	400	1.8
(4)	8	Chico-Mallig	900	Minanga	400	1.4
(5)	10	Matalag	500	Minanga	400	1.1
(6)	12	Pinukpuk	800	Minanga	400	1.3
(7)	14	Babaca	1,000	Minanga	400	1.5
(8)	15	Bitag	300	Pangal	500	0.9
(9)	19	Aggugaddan	600	Pangal	500	1.1
(10)	24	Siffu No. 1(A)	500	Oscariz	700	0.9
(11)	24'	Siffu No. 1(B)	500	Oscariz	700	0.9
(12)	25	Siffu No. 2	700	Oscariz	700	1.0
(13)	26	Mallig No. 1	400	Oscariz	700	0.8
(14)	27	Mallig No. 2	450	Oscariz	700	0.9
(15)	28	Ilagan No. 1	500	Minanga	400	1.1
(16)	29	Ilagan No. 2	600	Minanga	400	1.2
(17)	33	Disabungan	400	Minanga	400	1.0
(18)	34	Catalangan	450	Minanga	400	1.1
(19)	37	Alimit No. 1	800	Oscariz	700	1.0
(20)	41	Matuno No. 1	1,240	Oscariz	700	1.4
(21)	47	Cagayan No. 1	600	Pangal	500	1.1
(22)	48	Cagayan No. 2	700	Pangal	500	1.1
(23)	49	Casecnan	800	Pangal	500	1.2
(24)	50	Addalam (A)	700	Pangal	500	1.1
(25)	51	Diduyon	800	Pangal	500	1.2
(26)	52	Dibuluan	700	Pangal	500	1.1

Note: Adjustment factor = $e^{h1/1480} / e^{h2/1480}$

h1: Ave. El. of dam basin

h2: Ave. El. of runoff gauge basin

Table 1.3 Available Runoff at Each Damsite

	NO.	NAME OF DAM	C.A. (sq.km)	ADJUST FACTOR	INFLOW VOLUME (Mcm)	AVERAGE DISCHARGE (cms)	RUNOFF (cms) 100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
1	1	Dummon	112	0.9	176	5.58	0.42	1.06	1.78	2.37	2.85	3.67	4.27	5.46	7.60	11.87
2	4	Chico No.4	1410	1.5	3750	118.90	20.30	31.09	45.89	63.45	76.98	97.29	117.59	135.14	162.22	216.15
3	6	Chico No.2	720	1.8	2298	72.86	12.44	19.05	28.12	38.88	47.17	59.61	72.05	82.81	99.40	132.45
4	8	Chico-Mallig	1990	1.4	4940	156.63	26.74	40.95	60.45	83.58	101.41	128.15	154.90	178.02	213.68	284.72
5	10	Matalag	655	1.1	1277	40.50	6.91	10.59	15.63	21.61	26.22	33.14	40.05	46.03	55.26	73.63
6	12	Pinukpuk	856	1.3	1973	62.56	10.68	16.35	24.14	33.38	40.50	51.18	61.87	71.10	85.35	113.72
7	14	Babaca	253	1.5	673	21.33	3.64	5.57	8.23	11.38	13.81	17.45	21.10	24.25	29.10	38.78
8	15	Bitag	695	0.9	1092	34.63	2.62	6.63	11.07	14.76	17.70	22.83	26.52	33.90	47.16	73.68
9	19	Aggugaddan	441	1.1	847	26.85	2.03	5.14	8.58	11.44	13.72	17.70	20.56	26.29	36.57	57.14
10	24	Siffu No.1(A)	656	0.9	879	27.87	3.54	5.66	8.67	11.63	14.34	18.36	23.43	30.58	39.08	57.62
11	24'	Siffu NO.1(B)	626	0.9	839	26.60	3.38	5.40	8.28	11.09	13.69	17.52	22.36	29.18	37.29	54.98
12	25	Siffu No.2	367	1.0	546	17.32	2.20	3.52	5.39	7.22	8.91	11.41	14.56	19.01	24.29	35.81
13	26	Mallig No.1	436	0.8	519	16.46	2.09	3.34	5.12	6.87	8.47	10.84	13.84	18.06	23.09	34.04
14	27	Mallig No.2	362	0.9	485	15.38	1.95	3.12	4.78	6.41	7.91	10.13	12.93	16.87	21.56	31.79
15	28	Ilagan No.1	1350	1.1	2633	83.48	14.25	21.82	32.22	44.55	54.05	68.31	82.56	94.89	113.89	151.76
16	29	Ilagan No.2	876	1.2	1864	59.10	10.09	15.45	22.81	31.53	38.26	48.35	58.44	67.17	80.62	107.43
17	33	Disabungan	652	1.0	1156	36.65	6.25	9.58	14.14	19.59	23.73	29.99	36.25	41.66	50.00	66.63
18	34	Catalangan	235	1.1	458	14.53	2.48	3.79	5.60	7.75	9.40	11.89	14.37	16.51	19.82	26.41
19	37	Alimit No.1(A)	559	1.0	832	26.39	3.35	5.36	8.21	11.01	13.58	17.38	22.19	28.95	37.00	54.55
20	41	Matuno No.1	550	1.4	1147	36.35	4.62	7.39	11.31	15.16	18.71	23.94	30.56	39.88	50.97	75.15
21	47	Cagayan No.1	1214	1.1	2332	73.93	5.60	14.15	23.63	31.51	37.79	48.74	56.62	72.37	100.68	157.31
22	48	Cagayan No.2	481	1.1	924	29.29	2.22	5.60	9.36	12.48	14.97	19.31	22.43	28.67	39.89	62.32
23	49	Casecnan	1150	1.2	2409	76.40	5.79	14.62	24.42	32.56	39.05	50.37	58.51	74.79	104.05	162.56
24	50	Addalam(A)	864	1.1	1659	52.61	3.99	10.07	16.82	22.42	26.89	34.68	40.29	51.51	71.66	111.95
25	51	Diduyon	477	1.2	999	31.69	2.40	6.06	10.13	13.50	16.19	20.89	24.26	31.02	43.15	67.42
26	52	Dibuluan	159	1.1	305	9.68	0.73	1.85	3.09	4.12	4.94	6.38	7.41	9.47	13.18	20.60

Table 1.4 25 Years Probable Flood Runoff at Each Basepoint
(under present river condition with Magat dam)

No.	Name of Dam	Drainage area (Km^2)	25 Years Probable Flood Runoff (m^3/s)								
			BP-1	BP-2	BP-3	BP-4	BP-5	BP-6	BP-7	BP-8	BP-9
(1)	1 Dummon	112	10,250								
(2)	4 Chico No. 4	1,410	9,750					3,050			
(3)	6 Chico No. 2	720	10,050					3,700			
(4)	8 Chico-Mallig	1,990	9,950					2,450			
(5)	10 Matalag	655	10,050					3,750			
(6)	12 Pinukpuk	856	9,950					3,550			
(7)	14 Babaca	253	10,200					4,150			
(8)	15 Bitag	695	10,000	10,450							
(9)	19 Aggugaddan	441	10,100	10,550							
(10)	24 Siffu No. 1 (A)	656	10,050	10,450					2,100		
(11)	24' Siffu No. 1 (B)	626	10,050	10,500					2,150		
(12)	25 Siffu No. 1	367	10,150	10,600					2,450		
(13)	26 Mallig No. 1	436	10,100	10,600					2,350		
(14)	27 Mallig No. 2	362	10,150	10,600					2,450		
(15)	28 Ilagan No. 1	1,350	9,750	10,100	11,750					2,850	
(16)	29 Ilagan No. 2	876	9,950	10,350	12,150					3,650	
(17)	33 Disabungan	652	10,050	10,450	12,350					4,050	
(18)	34 Catalangan	235	10,200	10,700	12,750					4,800	
(19)	37 Alimit No. 1	559	10,050	10,500	12,450	12,350					5,900
(20)	41 Matuno No. 1	550	10,050	10,500	12,450	12,350					5,900
(21)	47 Cagayan No. 1	2,364	9,400	9,600	10,850	10,350	5,250				
(22)	48 Cagayan No. 2	1,631	9,650	9,950	11,500	11,150	6,100				
(23)	49 Casecnan	1,150	9,850	10,200	11,900	11,700	6,650				
(24)	50 Addalam (A)	864	9,950	10,350	12,200	12,000	7,000				
(25)	51 Diduyon	477	10,100	10,550	12,500	12,450	7,450				
(26)	52 Dibuluan	159	10,200	10,700	12,800	12,800	7,850				
	Drainage area(Km^2)		27,281	21,359	14,529	11,603	6,757	4,551	2,321	2,926	4,638
Flood runoff w/o dam (m^3/s)			10,250	10,800	12,950	12,950	8,000	4,350	2,900	5,250	6,700

Table 1.5 25 Years Probable Flood Runoff at Each Basepoint
(under flood control scheme with confining dikes and Magat dam)

No.		Name of Dam	Drainage area (Km^2)	25 Years Probable Flood Runoff (m^3/s)								
				BP-1	BP-2	BP-3	BP-4	BP-5	BP-6	BP-7	BP-8	BP-9
(1)	1	Dummon	112	19,450								
(2)	4	Chico No. 4	1,410	18,500					3,500			
(3)	6	Chico No. 2	720	19,000					4,200			
(4)	8	Chico-Mallig	1,990	18,100					2,850			
(5)	10	Matalag	655	19,050					4,300			
(6)	12	Pinukpuk	856	18,900					4,100			
(7)	14	Babaca	253	19,350					4,750			
(8)	15	Bitag	695	19,050	18,900							
(9)	19	Aggugaddan	441	19,200	19,100							
(10)	24	Siffu No. 1 (A)	656	19,050	18,950					2,300		
(11)	24'	Siffu No. 1 (B)	626	19,100	18,950					2,350		
(12)	25	Siffu No. 2	367	19,250	19,200					2,700		
(13)	26	Mallig No. 1	436	19,200	19,150					2,600		
(14)	27	Mallig No. 2	362	19,250	19,200					2,750		
(15)	28	Ilagan No. 1	1,350	18,550	18,300	17,700					3,450	
(16)	29	Ilagan No. 2	876	18,900	18,700	18,350					4,450	
(17)	33	Disabungan	652	19,050	18,950	18,650					4,950	
(18)	34	Catalangan	235	19,350	19,300	19,200					5,850	
(19)	37	Alimit No. 1	559	19,100	19,000	18,750	16,300					8,750
(20)	41	Matuno No. 1	550	19,150	19,000	18,800	16,300					8,750
(21)	47	Cagayan No. 1	2,364	17,850	17,350	16,350	13,650	6,650				
(22)	48	Cagayan No. 2	1,631	18,350	18,050	17,350	14,700	7,750				
(23)	49	Casecnan	1,150	18,700	18,450	18,000	15,450	8,500				
(24)	50	Addalam (A)	864	18,900	18,750	18,350	15,850	8,900				
(25)	51	Diduyon	477	19,200	19,100	18,900	16,400	9,500				
(26)	52	Dibuluan	159	19,400	19,400	19,300	16,900	10,000				
Drainage area (Km^2)				27,281	21,359	14,529	11,603	6,757	4,551	2,321	2,926	4,638
Flood Runoff w/o dam (m^3/s)				19,500	19,500	19,500	17,100	10,200	5,000	3,200	6,350	9,900