Province of Pangasinan
The Republic of the Philippines

No. 1

Basic Design Study Report
on
the Project for
Infanta Impounding Irrigation and Environmental Improvement
in
the Republic of the Philippines
(the second report)

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March 1998

Japan International Cooperation Agency
JMS Corporation
NAKAI Engineering Co., Ltd.

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PREFACE

In response to a request from the Government of the Republic of the Philippines, the Government of Japan decided to conduct a Basic Design Study on the Project for the Infanta Impounding Irrigation and Environmental Improvement and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent a study team to the Republic of the Philippines in April and from October to November in 1996. The team held discussions with the officials concerned of the Government of the Philippines , and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then a mission was sent again to the Philippines from February to March in 1997 in order to discuss a Draft Basic Design.

However, it was decided in May 1997 that the additional survey should be carried out to increase the accuracy of survey especially in the fields of geology and embankment materials. JICA sent a study team from June 16 to July 12 and from August 17 to September 6 respectively in 1997. After the team returned to Japan, the previous design was modified according to the results of additional survey. Then, a mission was sent to the Philippines from February 12 to February 19 in 1998 in order to discuss a revised draft basic design , and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relation between the two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of the Philippines for their close cooperation extended to the teams.

March 1998

Kimio Fujita
President
Japan International Cooperation Agency

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for the Infanta Impounding Irrigation and Environmental Improvement in the Republic of the Philippines.

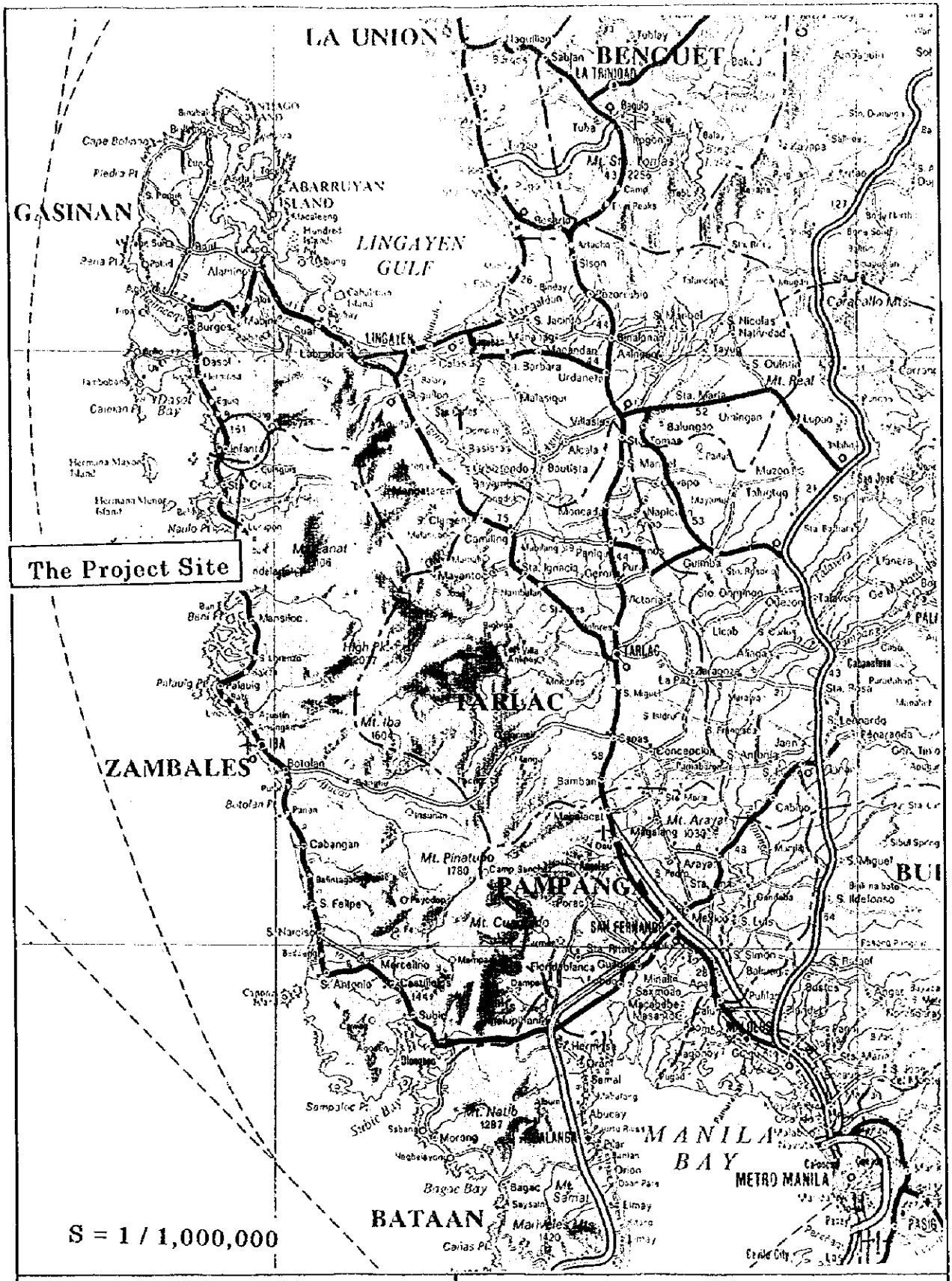
This study was conducted by Joint Venture of INA Corporation and Naigai Engineering Co., Ltd., under a contract to JICA during the period from June 5 ,1997 to March 31 , 1998 . In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of the Philippines and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Hiroshi Okada
Project Manager,
Basic Design Study Team on the
Project for the Infant Impounding
Irrigation and Environmental
Improvement

INA Corporation

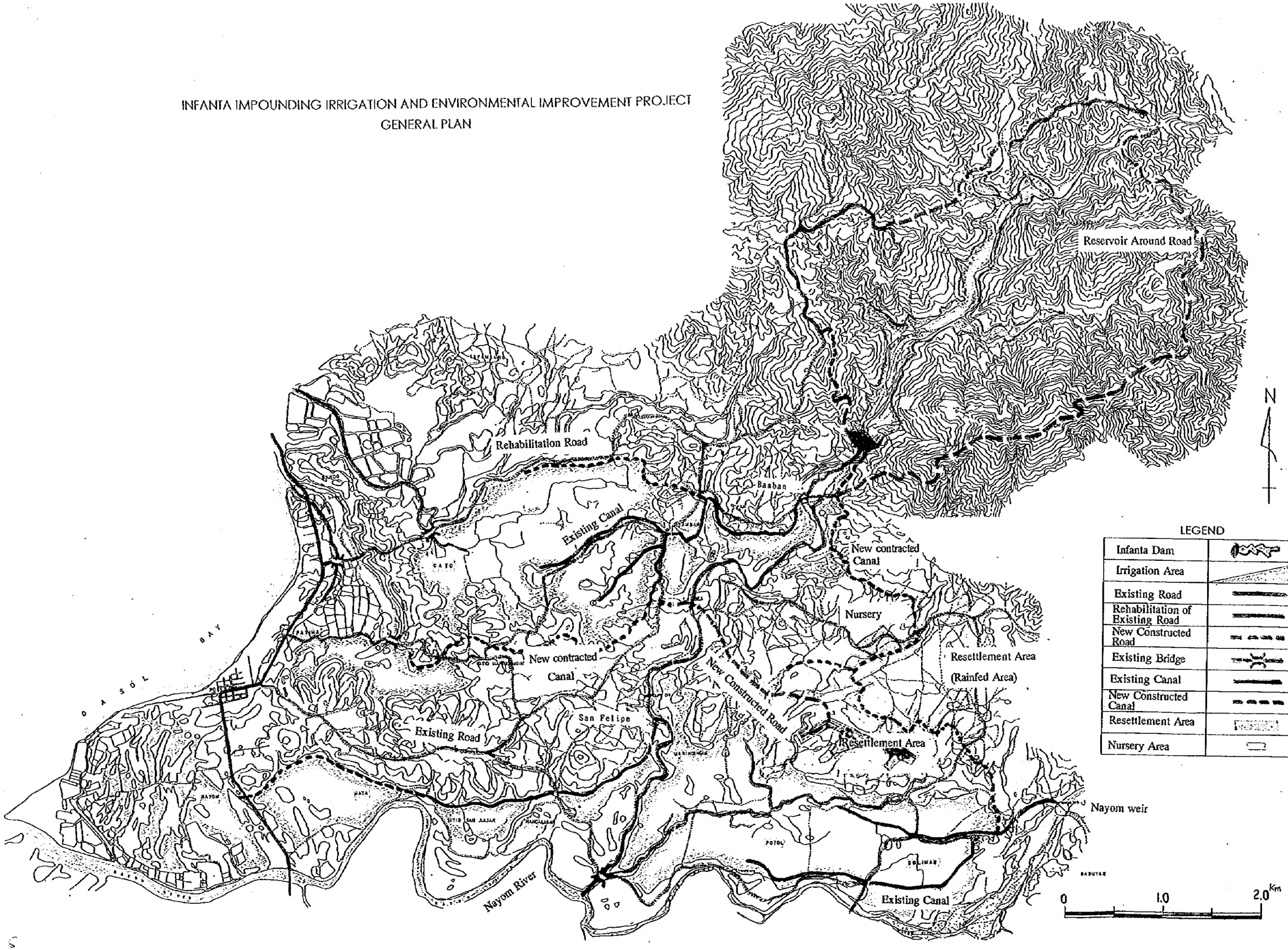


BASIC DESIGN FOR
INFANTA IMPOUNDING IRRIGATION AND
ENVIRONMENTAL IMPROVEMENT PROJECT

JAPAN INTERNATIONAL COOPORATION AGENCY

Location Map

INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT
GENERAL PLAN



Abbreviation

ASEAN	Association of Southeast Asian Nations
BGY	Barangay (Village)
BHN	Basic Human Needs
BSWM	Bureau of Soils and Water Management
CIS	Communal Irrigation System
DA	Department of Agriculture
DAR	Department of Agrarian Reform
DENR	Department of Environment and Natural Resources
DFA	Department of Foreign Affairs
DOF	Department of Finance
DPWH	Department of Public Works & Highways
DSWD	Department of Social Welfare & Development
ECA	Environmental Critical Area
ECC	Environmental Compliance Certificate
ECP	Environmental Critical Project
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMB	Enviromental Management Bureau
E/N	Exchange Note
GDP	Gross Domestic Product
GNP	Gross National Product
IA	Irrigator's Association
ICC	Investment Coordination Agency
JICA	Japan International Cooperation Agency
LGU	Local Government Unit
MAFF	Ministry of Agriculture,Forestry and Fishery (Japan)
MFA	Ministry of Foreign Affairs (Japan)
MG	Municipal Government
MPC	Mount Pinatubo Commission
MPDO	Municipal Planning and Development Office
NAPCOR	National Power Corporation
NEDA	National Economic & Development Authority
NIA	National Irrigation Administration
NIES	New Industrial Economics
O&M	Operation and Maintenance
OMAG	Office of Municipal Agriculturist
OMM	Office of Municipal Mayor
OPAG	Office of the Provincial Agriculturist
PANELCO I	Pangasinan Electric Cooperative I
PAO	Provincial Assessor's Office

PARO	Provincial Agrarian Reform Office
PCA	Philippine Coconut Authority
PD	Project Description
PENRO	Provincial Environment and Natural Resources Office
PEO	Provincial Engineer's Office
PG	Provincial Governer
PGO	Provincial Governer's Office
PGP	Provincial Government of Pangasinan
PHO	Provincial Health Office
PHUDC	Provincial Housing Urban Development Center
PLO	Provincial Legal Office
PM	Project Manager
PMG	Project management Group
PNP	Philippine National Office
PP	Project Proponent
PPDO	Provincial Planning and Development Office
PPO	Provincial Population Office
PSU	Pangasinan State University
PTO	Provincial Treasurer's Office
RDC	Regional Development Council
SWIP	Small Water Impounding Project

Contents

{Appendices}

Chapter 1 Background of the Project

In the Republic of the Philippines, the agricultural sector is a key industry for the nation's economy as well as an essential industry directly connected to the people's living. However, the income as well as the living standard in rural districts is comparatively low and the difference of economic standard between the rural area and the urban area has been expanding year by year.

The Philippines government , in its Medium-Term Philippine Development Plan 1993-1998 , aims to alleviate poverty in the rural areas and identifies the agriculture as one of the highest priority sectors. In line with this , it is significant to increase the agricultural productivity and stabilize the production.

The Pangasinan province is located in middle-west part of Luzon island and approx. 200 km away from Manila to the northwest direction. The province faces to the South-china sea on the west and the Lingayen gulf on the north. The province has a land area of 5,368 km^2 and has a population of approx. 2.02 million people (1990). Lingayen is the capital of the province and Dagupan is the largest city. The province also has its development plan based on the national development plan and both agricultural development and afforestation are the main objectives with high priority. Then the tourisum development, industrial development and infrastructure improvement are the other sectors with priority.

The municipality of Infanta is located in the south-west end of the province and faces on the sea. Although the province is comparatively high in economic standard as a regional province, the municipality of Infanta is classified as one of the lowest municipalities in terms of revenue contribution to the province. That is, Infanta is unable to effectively capitalize the potentials of its land with approx. 25,000 ha where approx. 18,000 people are living.

The background /status which caused the necessity of the Project is explained as follows:

Low agricultural productivity (due to shortage of water resources for irrigation)

The arable land area of Municipality of Infanta is presently estimated at approx. 1,650 ha in total which includes the existing three irrigation areas , that is, Bamban

CIP System, San Felipe/Mana CIP System, and Nayom River/DPL NIA System. The present total irrigation area is approxi. 620 ha during rainy season and approxi. 250 ha in the dry season. The expansion of the irrigation area especially during dry season is the great concern for the municipality of Infanta as the agriculture production is the most essential economic sector. However, the most arable land actually has to depend on rain water due to shortage of available irrigation water in rivers. That is, the municipality has a difficulty to incresase the agricultural production due to ineffective use of water resources.

Extensive Reduction of forest area and devastation of the basin

It is informed that approxi. 80 % of the total land (approx. 25,000 ha) of Infanta is categorized as the governmental forest area, according to the official classification of land and forest has ever used for the sufficient source of supply of lumber materials for fuel and building. However, in these decades, remarkable logging and cultivation has been carried out without environmental consideration on the mountainous slopes and caused the remarkable decrease of forest area. Consequently, the weathering and erosion of ground surface occurred widely and most of the mountainous area is now covered with grasses. At present, the municipality has to procure logs/lumbers from other municipalities. On the other hand, the provincial government has enthusiastic intention for forestation in the Zambares mountains including the Infanta area.

Necessity of Resettlement area for Mt. Pinatubo victims

Mt. Pinatuvo is located approximately 85 km south of Infanta and caused serious disasters in wide areas in the provinces of Zambalez and Tarlac by mud flow accompanied by the eruption. It is expected that the mud flow disaster will continue in the long term even if the eruption activity becomes calm, due to the runoff of the huge volume of sedimentation. Many inhabitants in the surrounding area of Mt. Pinatubo lost their houses and lands. The reconstruction of their houses in the same area is difficult and dangerous so that they need the resettlement area. The Philippines government has duty to provide them the resettlement area where they can live semi-permanently and MPC has carried out various countermeasures/plans to improve the situation. However the supply of resettlement area is not yet sufficient. The Pangasinan province decided to make some contribution for receiving a part of victims and the Infanta area became a site proposed for the resettlement.

Deterioration of Roads

In the municipality, the barangay roads are mostly not paved and many parts become damaged during rainy season. That is , some sections are cut off and some other sections are muddy. And consequently, it causes serious inconvenience for the inhabitants' daily needs and also hindrance for the economic/agricultural activities due to difficulty of traffic/transportation.

It is a great concern for the local government (the Province and the Municipality) to improve the above situations, thus, " The Project for the Infanta impounding Irrigation and Environmental Improvement (hereafter referred to as "the Project") " was planned with their high expectation. However, it was almost impossible for the local government to implement the project by themselves due to shortage of finance as well as engineering experiences. Accordingly, the provincial government requested the official aid to the government of Japan through the central governmental agencies of the Philippines.

The project components in the original request were as follows:

(A) Reservoir and dam construction including its appurtenant structures
(Effective capacity 9.5 MCM with the dam height 28m and length 267 m)
(B) Construction of main irrigation canals
(Unlined open channel of 19.8km long)
(C) Preparation of resettlement area of 220 ha
(D) Preparation of tree nurseries of 5 ha
(E) Roads construction
- Around reservoir area 17 km
- Along the water distribution line 4.5 km
- Road improvement 5 km

In response to the request, JICA dispatched the preliminary study team in November 1995 to confirm the necessity and appropriateness of the request as well as its contents. After the survey by the preliminary study team , JICA decided to carry out the basic design study for the project. And the first field survey by the basic design study team was made in April,1996 when the main objective is the discussion on the inception report.

Chapter 2 Contents of the Project

2.1 Objectives of the Project

The main objectives of the project are the following four points:

- The dam and irrigation canal structures are to be constructed to enhance the agricultural production through increasing the irrigation water supply. In addition, solar dryer yards are also to be constructed for improving the post-harvest facilities.

- The tree nursery is to be constructed for the afforestation activities in the reservoir surounding area to prevent erosion , increase the capacity of water cultivation, create a natural environment for fauna & flora, and improve the living standard of the inhabitants.

- Some barangay roads with bridges are to be improved or newly constructed to improve the traffic and transportation conditions for the daily & economic activities of inhabitants in the municipality and also to promote the afforestation activities.

- The resettlement area for the Mt. Pinatubo victims is to be prepared for providing them the basic living conditions such as houses, water supply, electric power supply, access road, etc.

2.2 Basic Concept of the Project

The study team carried out the field survey based on the contents of official request and reconfirmed the appropriateness of the request and carried out the alternative study of locations/alignment, scale/capacity, quality , utilization type, and so on for each scheme of the proposed plan. The study team also made occasional discussion on the study contents with the Pangasinan province and the other related agencies in the Philippines.

The study results for basic design of structures are explained in the succeeding section 1.3 (Basic Design) . Only the essential considerations/methods for the study to decide the most suitable plans are presented in this section as follows:

(A) Dam & Reservoir

The damsite is located just upstream side of the outlet of the San Felipe river valley. The alternative study of appropriate dam axis was carried out among upper, middle and lower axes. And the upper axis is adopted as the most appropriate one from the comprehensive viewpoints including the topography, geology, structural stability, construction plan & schedule, and economic preference.

The most appropriate zoning for fill-type dam was decided after the overall study based on the results of embankment materials survey & analyses and also considerations of economic & construction aspects.

The dam foundation design was made in consideration of excavation depth and foundation treatment method(grouting) & depth in accordance with the results of geological survey.

A flood of 100 year return period is generally adopted as the design flood of dam in the Philippines. However, it was decided to take a probable maximum flood (PMF) for the design in consideration of insufficiency of the meteo-hydrological data. The flood hydrograph with 200 year probability was prepared by the unit-hydrograph method as the impounding effect can be expected in the reservoir. And the hydrograph was adjusted to have a peak discharge of PMF.

It was difficult to obtain the reliable data or methods for estimating the sediment

volume in a reservoir in the Philippines. The sediment volume in the reservoir was thus decided from a comprehensive viewpoints but in reference to the examples of the similar projects/dams in the Philippiness as well as in Japan.

Although the higher dam is advantageous in general from the point of only effective use of water resources in the river, the reservoir capacity and the dam height were decided basically from the requirement for irrigation water based on the water balance calculation on the proposed irrigation scheme, however in reference to the results of geological survey.

(B) Agriculture and Irrigation Plan

It was deceded that the irrigation water is to be used only for paddy. The other crops are excluded fron the irrigation scheme due to the farmers' desire and the suitability of soils in the objective area.

The irrigation area was decided at 1,180 ha in total from the topographic conditions and the location of dam. Then the irrigation water requirement was decided to supply complete (100%) irrigation for the existing irrigation area of 620ha in the dry season even in a very dry year which happens once 5 years. In this case, the irrigable area in the rainy season becoms 1,180 ha.

The main canal system was planned finally by 9 systems with approx. 22 km in total length in consideration of using the existing structures as much as possible and also effective system to supply the water to all the objective areas.

(C) Road & Bridge Plan

The improvement /construction of barangay roads with bridges, located in the lower land area was decided to be approx. 7 km in total length . The design criteria were decided in reference to the Philippines design standard as well as the examples of existing roads. The route selection was made from the results of preliminary survey for the necessity and utilization extent and in consideration of desire from the Municipality. In addition, it was decided to include the replacement of existing two bridges located on a selected road route and also the new construction of two submeged type bridges crossing the San Felipe river .

The alignment of road surrounding the proposed reservoir was selected in consideration of locations of existing roads, topographic condition, utilization for inhabitants living in the mountain area, and accessibility for afforestation activities. The selected route was decided to be mostly located on ridges of the low mountains after a overall study from the viewpoints of economic advantage, construction method, landscape, and so on.

(D) Resettlement Plan

The suitability of the resettlement area to be prepared by the Province was studied. And it was confirmed appropriately to use the land for the resettlement from the viewpoints of easier land acquisition (due to comparatively low landuse condition at present), comparatively gentle topography, and no remarkable obstacles for new landuse. However, it was decided that the area of approximately 220 ha, which was proposed for farming land, would not be used for farming due to poor soil conditions. The number of resettlers was decided at 70 families from the Mt. Pinatubo victims already living in the Municipality of Infanta or the neiboring municipalities.

The Japanese side will construct the road in the housing area and water supply facility for the housing area. However, it was already agreed that the PGP side has to take responsibility for the further construction of housing, power supply, and so on.

(E) Tree Nursery Plan

The location of the tree nursery area was selected at the west side of the proposed resettlement area in consideration of land acquisition, topography, accessibility, construction of water supply facility and so on .The area was decided to be approx. 2.35 ha to carry out sufficient and practical activities as a nursery for the wide area of afforestation.

The Japanese side will construct the major structures & facilities including the roads and water supply facility. However, the Provincial side has to construct

comparatively simple facilities and also to prepare the working equipment & tools without delay, expecting the earlier start of operation.

As the results of study, the project components were decided to achieve the project objectives in appropriate scale and contents. The salient features of the project are summarized as follows:

Dam & Reservoir		
Basin	Catchment area	23.68 km^2
Reservoir	Total Volume	5,000,000m^3
	Effective Volume	4,500,000m^3
	Design Flood W. L.	EL 54.66m
	Normal High W. L.	EL 52.0m
	Low W. L.	EL 37.0m
Dam	Type	Center Core Fill Type Dam
	Dam Height	34.0m (from the bottom of the foundation rock)
	Crest Length	270.0m
	Crest Width	7.0m
	Dam Volume	304,000m^3
	Crest Elevation	EL 57.00m
Spillway	Type	Ungated side channel type
	Design Discharge	565 m^3/s
Intake	Type	Inclined type
	Gate	Diameter 600mm、3 Nos.
	Energy Dissipater	Sluice Valve Diameter 600mm、2 Nos.
	Conduit	Steel Pipe 1,800 mm in diameter

Irrigation Canal		
Irrigation Area	1,180 ha	
Main Canal	9 System、21.6 km in total	
	(New canal 14.5 km and improved canal 7.1 km)	
	O & M road (4m wide, gravel pavement of 3m wide)	
Appurtenant Structures	Canal Structure	(Open canal, Conduit pipe, Drop, Road crossing)
	Diversion/Gauging Stru.	(Large diversion , small

diversion, Gauging stru.)
Energy Dissipater
Inspection & maintenance (O & M road,
Aqueduct)
Others (Washing step、Drainage conduit)

Road & Bridge

Barangay Road 7.2 km in total length
(Improvement road : 3 routes, 5.3 km in total
and New road: 1 route, 1.9 km in total)
Appurtenant stru.: Road bridge (Span 18 m , 2 Nos. ,
2nd class bridge box culvert type)
Submerged bridge (Crossing Sanfelipe river,
2 locations)

Reservoir surrounding road 16.8 km in total length
(Newly constructed section : 13.4 km,
Improvement section: 3.4 km)
Appurtenant structure (Submerged bridge : 3 Nos.
Crossing culvert : approxi. 10 locations)

Resettlement Area

Area Approxi. 12 ha
Appurtenant Stru./Works Access Road (400 m in length, 5 m wide gravel road)
Road in the housing area (2,090 m in length, 5 m wide concrete road)
Water Supply Facility (Intake、Conduit pipe, Purification facilities,
Distribution pipe, water supply tap)

Tree Nursery

Area 2.35 ha
Nursery Facility Pot Nursery Bed : Area 8,160 m^2
(Pot nursery net area 4,320m^2)
Sunshade Facility (Area 4,320 m^2)
Irrigation water facility (Objective Area 4,320 m^2)
Water Storage
Building Warehouse, Administrative office(Area 90 m^2)
Germination house (Area 48 m^2)

Workshop (Area 250 m^2)

Road	672 m in total length (5 m wide with side ditches)

Post - Harvest Facilities

Solar Dryer Yard	Area 875 m^2 (25m x 35m), 8 Locations Concrete Pavement (15 cm thick), With Store house (5m x 8m)

Maintenance Equipment

Motor grader	(3.7m Class)	1 Unit
Dump truck	(11t Class)	1 Unit
Backhou	(0.35 m^3 Class)	1 Unit
Buldozer	(D6/15t Class)	1 Unit

2.3 Basic Design

2.3.1 Design Concept

It is essential to study about the natural conditions, socio-economic conditions, construction & procurement conditions, stability of structure, environmental conservation, and so on for planning the most suitable design. The basic design is to be carried out based on the following concepts:

(A) Concept for Natural Conditions

The objective area is located in the typical monsoon climate zone , characteristic of the southeast Asia. The temperature is high all the year round and the rainfall & river discharge is quite different between the rainy season and the dry season. The cost for river diversion works becomes remarkably high in case of the construction during the rainy season. Accordingly the construction works in the river, especially dam construction, is scheduled to be carried out only during the dry season. The study for deciding the dam scale needs to consider the available construction period during the dry season and also the appropriate construction methods for the safety.

The project site is generally located in the gently sloped hills with weathered surface layers. Although there would be no remarkable difficulty for the construction of canals, roads and so on, a special care should be taken for the foundation treatment of dam by deciding the appropriate excavation depth and also for the design of grouting works based on the results of the geological survey.

(B) Concept for Inhabitants' Opinion

Approximately 65% of the people (18,000 persons in total) of Infanta depend their income source on agriculture , mostly paddy. There are three irrigator's associations in the objective area at present and they have good experience and knowledge on the river water utilization. In addition, the construction of secondary and tertiary canals has to be basically carried out by the farmers. Accordingly it is considered reasonable to get their opinions or desires on the design of canal facilities concerning the locations, capacity, type, and so on. Further, the considerations on the local custom, religion, and culture are also to be taken into the planning and design, if any.

(C) Concept for Agricultural Conditions

It is decided to assume only paddy due to the desire of farmers, insufficient facilities for the other crops, difficulty of marketing and so on, although the percentage of irrigation area in the dry season could be increased if the other crops (especially corn) is included in the cropping schedule.

(D) Concept for Selection of Irrigation Area

There are three irrigation systems at present. Two systems depends its water source in the Sanfelipe river and One system in the Nayom river. However, the river discharge become very low during the dry season, that is, 0.1 - 0.3 m^3/s in the Sanfelipe and 0.3 - 2.5 m^3/s in the Nayom. In addition , the fluctuation in the natural river flow is remarkable even in the same month. The cropping intensity varies every year depending on the rainfall and the water shortage occasionally happens even in the rainy season. It is considered desirable to steadily supply the reliable irrigation water even to the existing irrigation area. And it is also considered appropriate to involve the existing facilities/structures in the new system as much as possible for the effective water use and the cost saving. Accordingly the irrigation area for the project is to be selected from all the irrigable land by gravity function from the dam , but excluding the steep slopes, roads, housing areas and so on.

The beneficial area is located in the low-land area including the existing paddy fields. The paddy in the objective area is approx. 1,180 ha , of which generally 620 ha is the existing irrigation area , but only 250 ha in the dry season, and the rest is the rainfed area. As the result of study, it is estimated that the 100% paddy irrigation is possible in the rainy season and nearly 53 % during the dry season (even in a driest year of one 5 years), but 100% in the existing irrigation area. The percentage of irrigable area in the dry season will be increased and the third crop will be possible in some areas in a usual year.

(E) Concept for Construction Conditions in the Philippine

The investment from the foreign countries to the Philippine has been increasing remarkably in these years and the construction works also be increased for many

kinds of infrastructures and buildings. This situation probably caused the improvement of capacity of local contractors and also the increase of available construction equipment in quality as well as in quantity. However, it is considered to be difficult to find comparatively large equipment in working capacity for effective construction works at the dam site and in addition the experience for peculiar fields of works, such as some advanced technology for foundation treatment works and tunneling works, is not always sufficient yet. Accordingly it is decided to design the dam in consideration of the available capacity of equipment (such as dumptruck and bulldozer), reliable construction methods in the Philippine, and the limit of construction period .

(F) Concept for the Capacity of Executing Agency

The executing agency of this project is the Pangasinan province. It seems that the existing irrigator's association has good capacity for O & M of canal structures, if NIA can assist them. And O & M for roads also could be carried out without serious difficulty by the municipality/province with the maintenance equipment to be procured from Japan and the assistance from the provicial government. However, it seems that O & M for dam needs special care as it would be not easy to provide an experienced operator with sufficient engineering knowledge for dam. Dam is a large scale structure so that the accident related to mis-operation or improper management would cause a serious damage. Therefore it is considered to be appropriate to make design of structures and facilities with simple operation during the O & M stage. For example the flood way is designed as an ungated type.

(G) Concept for Construction Schedule & Period

The construction schedule especially for the dam is the critical factor as it depends mostly on the natural conditions such as rainfall & river runoff, foundation geology, topography, and so on. The construction during the rainy period seems to be ineffective, dangerous, and costly. Accordingly, the dam construction is planned to be carried out in the period excluding the four months with intensive rainfall in the rainy season by splitting the construction period into two years. The construction for the other components is also planned to be carried out only during dry seasons or excluding the middle 3-4 months of rainy season in consideration of the effective works.

(H) Concept for Safety

The Philippines is a country with frequent natural disasters, especially caused by typhoons and earthquakes. The volcanic disaster seems to be serious in some areas but not in the project area. The dam site is located at the outlet of the valley so that the damage could be large if any accident happens. Accordingly, the dam design is to be made through the safety check against the seepage, seismic force, flood flow, reservoir water fluctuation, and so on.

(I) Concept for Effective Use of Existing Structures

There are two weirs located in the San Felipe river and there are three irrigation systems with canals at present. Accordingly it is considered to be appropriate and beneficial to utilize these headworks and canals effectively in the new project.

(J) Concept for Related Development Plan or Supplementary Use

It is considerable to use the project facilities more effectively by creating a related development scheme or by supplementary use in the future. Although no definite features would be seen in the design for the present project components, some considerations are to be made for the planning and design on the following matters.

- Land scape of the dam & reservoir site for the tourist or recreational attraction
- Recreational site in or at the side of canals (swimming, resting, etc.)
- Construction road using for a permanent road in the future
- Fishing cultivation in the reservoir
- Income through afforestation (timber logging, fruits, etc.)

(K) Concept for Design Criteria

NIA has its deign standard for irrigation canals and appurtenant structures based on the USBR standards. And it is usual to use the American standards for the structural design in the Philippines. However, it is decided to adopt basically the Japanese criteria and/or a criteria used in the overseas projects by the consulting study in consideration of a safety side, although the Philippines criteria also to be

compared for a reference. The Japanese criteria are generally more conservative on the safety.

(L) Concept for Cost Estimate

Although the detailed design will be carried out later, it is required to estimate the project cost at the basic design stage with high and reliable accuracy. Accordingly the cost estimate is to be carried out quite in detail with careful checking.

(L) Concept for Reference of Similar Project

It would be necessary and useful to make design of dam in reference to the similar cases, in consideration of the comparatively short survey & study period. Therefor it is decided to make reference to the examples of dam design in Japan as well as in the Philippines. Especially the dams of the Western Barrios Impounding Irrigation Project are considered to be the most appropriate example as the project with similar structures is located in the similar natural conditions and it is also constructed by the Japanese grant aide.

(M) Concept for Studying the Appropriateness of the Project

The feasibility study on this project was carried out approx. 5 years ago. There are more or less some different points between the two project schemes in the components, the features, the cost, and so on. It would be necessary to review and confirm the appropriateness for the project implimentation, especially from the viewpoint of construction cost.

2.3.2 Basic Design

2.3.2.1 Agriculture and Irrigation Plan

(1) Farming program

(A) Land use plan

The agricultural land in the project area covers 1,385 ha. The present use of agricultural land is mostly paddy. However the irrigated area is approximately 250 ha during the dry season out of this area, and the rest is left to unstable rainfed water agriculture. Therefore, the average income of the inhabitants of this area is low, and it creates a poor farming village area in the Province of Pangasinan.

It is inevitable to increase the rice production, which has a higher potential in the project area, to improve the economic & living standard and get out of the present low livelihood situation. However, the expansion of paddy area is difficult due to geological limitation. Accordingly it is essential to make more effective land use plan, that is, the increase of average yield per unit area by a irrigation project. Maize cultivation was studied as an alternative, but double cropping of rice is introduced due to the fact that the maize cultivation technique has not been established and also farmers have no maize harvesting machines, processing equipment, or sales route. The farmers and the Agricultural Administration Department of the Infanta Municipal Government prefers rice production.

A reservoir will be constructed at an elevation 30 m of the San Felipe River which flows through the center of the project area, and it will be used as the source of irrigation water. The benefited area is approximately 1,180 ha around the San Felipe River based on the geographical conditions that limited by the gravity irrigation from the reservoir.

(B) Cropping pattern

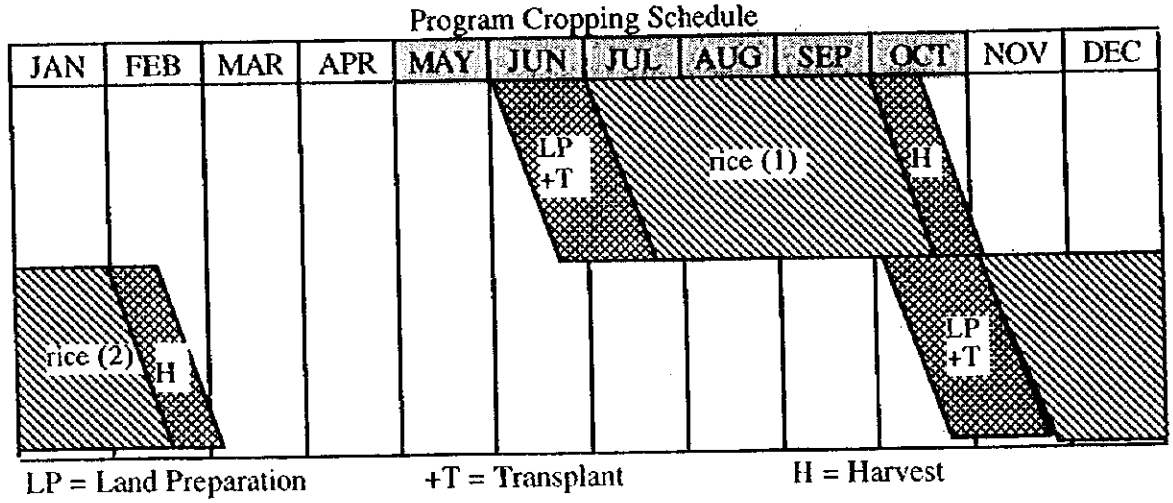
The double cropping is planned basically. The cropping schedule is shown in the attached figure. The irrigation plan is prepared for the cropping period of 4.5 months each for the rainy and the dry seasons. The proposed cropping area is 1,180 ha during the rainy season which is all of project area and 620 ha during the dry season where it have performed the double cropping in the high water year with irrigation facilities in consideration of the operation efficiency of facilities and cultivation efficiency of the double cropping. The water balance calculation was performed to estimate the effective storage capacity based on the above conditions. As a result, the current cropping intensity of 113% is expected to be increased to 153%.

Table 2.3.2.1-1 Currently Planned Cultivation Area and Cropping Efficiency

	Irrigated Cultivation Area (ha)		Rainfed Cultivation Area (ha)	Total (ha)	Cropping Efficiency (%)
	Rainy season	Dry season	Rainy season		
Current cultivation	620	250	460*	1,330	113
Post-project cultivation	1,280	620	0	1,800	153

*: Rainfed water agricultural area in the project area cover 560 ha, however approximately 100 ha is not cultivated. Finally rainfed water agricultural area is 460 ha.

The first cropping period covers June to mid September, and the second October to mid February. The cropping schedule is shown in the following figure. Especially, it is planed that the preparation of plowing for the dry season cultivation is started after having finished the harvest of the rainy season cultivation at once to avoid the ineffective discharge of the dam as much as possible. In case that the storage capacity is more than 100 million cubic meters in late February, three cropping will be possible at approximately 100 ha to 150 ha.



(2) Irrigation plan

(A) Irrigation water requirement

(a) Irrigation method

The rice paddies are provided with a 24-hour irrigation system. Since twice as much water volume is required for the puddling period, rotation irrigation method should be performed per unit area. The irrigation area is roughly divided into three blocks: Bamban C.I.S. and San Felipe C.I.S. on the right bank of the San Felipe River, and Nayom C.I.S. on the left.

(b) Design water requirement

To obtain the irrigation water requirement, the effective rainfall during rice growing period was

deducted from the sum of the crop evapotranspiration, the puddling water requirement, and the paddy field percolation, and the irrigation efficiency was multiplied. The unit design water requirement is the largest in October of the dry season, equivalent to 1.8 l/ha. This is the water requirement to design irrigation facilities. The design conditions are as follows.

(1) Crop evapotranspiration

The crop evapotranspiration (ETcrop) can be calculated as below using the rice field evapotranspiration (ETo) and the crop coefficient (Kc).

$$ETcrop = Kc \times ETo$$

The rice field evapotranspiration is planned by the pan evaporation method as follows. Data of the evaporation is obtained at the San Manuel Observatory of the Pangasinan Province.

- Preparation water requirement (Puddling water requirement and maintenance water requirement)

Water requirements for field preparation and puddling of the rainy season cropping can be preserved in paddy fields after arrival of the rainy season, and supplementary water is supplied to compensate for irregular demand from the reservoir. In this project, 120 mm (based on the Bamban irrigation system record) for puddling water, and 30 mm for maintenance water, totaling 150 mm, is supplied.

- Soil percolation

2.0 mm/day is adopted as the paddy field soil percolation based on the record of the Bamban and Nayom irrigation system that are 1.5 to 2.0 mm/day, for this project.

- Effective rainfall

The effective supply of rainfall during the irrigation period is calculated based on the rainfall data of Santa Cruz which is near the project site. The effective rainfall is calculated every 5 days. Daily rainfall of less than 5 mm is regarded as ineffective, and 150 mm in 5 days, which would exceed the height of the levee, is regarded as ineffective. 67 % (2 times per 3 years) of the average effective rainfall on past 20 years is adopted as the design effective rainfall.

- Irrigation efficiency

The irrigation efficiency has been decided in consideration with three elements; a) field application efficiency, b) conveyance efficiency, and c) operational efficiency, in the NIA design standard. Applying this standard, 55% is adopted for rice as the irrigation efficiency for the project.

Irrigation Efficiency

(unit: %)

	Item	Paddy	Upland
1	Field application efficiency	85	72
2	Conveyance efficiency	77	77
3	Operational efficiency	85	90
	Overall efficiency	55	50

Under the above given irrigation conditions, the water requirement for the project can be calculated as shown in a table of the following page.

(B) Irrigation water requirement and irrigated area

The irrigated area is 1,180 ha during the rainy season and 620 ha during the dry season. In short, stable cultivation will be established in the entire project area during the rainy season and 620 ha during the dry season where it has performed the double cropping in the high water year with irrigation facilities. The water balance calculation was performed based on the above proposed irrigated area and the water requirement as well as the average runoff of the San Felipe River for the past 20 years. As the result, the storage capacity that may suffer from a shortage of water once in 4 - 5 years is approximately 4.5 million cubic meters. The result of calculation on water balance is shown in Appendix 6 "Data 2.3.2.1-2 Dam and Reservoir Plan".

(C) Water supply and network plan

The dam to be constructed through this project will have the design storage capacity of approximately 4.5 million cubic meters. The existing 1,180 ha is irrigated by the storage water. The existing irrigation system will be used for the proposed water supply network, and it is roughly divided into the following three networks.

	Name of water supply network	Benefited area (ha)	Water source facility
1	Bamban network	493	Dam and Bamban intake weir
2	San Felipe network	272	Dam and San Felipe intake weir
3	Nayom network	415	Dam
	Total	1,180	

The above three systems of irrigation blocks are shown in Figure 2.3.2.1-1.

(3) Canal design

(A) Selection of canal route

Proposed irrigation canal route of the Bamban intake weir irrigation network and the San Felipe intake weir irrigation network are planned that these will be prepared by widening and extending

Design water requirement

Month		Pan Evaporation Epan	Pan Coefficient Kp	Crop Evapotranspiration Eto	Crop Coefficient (1) Kc	(2) Kc	(3) Kc	(4) Kc	(5) Kc	Average	Crop Evapotranspiration Et	Land Preparation Water Kb	P	Total Water volume mm/Sday	Effective Rainfall mm/Sday	Crop Irrigation Requirement mm/Sday	Water Requirement 0.55 mm/Sday	Rainy season(ha) 1,350 Dry season(ha) 620
Jun.	1	32.7419355	0.75	24.56	1.05	1.05	1.05	1.05	1.05	1.05	25.78		10	35.78	0	35.78	65.06	403,386
	2	32.7419355	0.75	24.56	1.05	1.05	1.05	1.05	1.05	1.05	25.78		10	35.78	0	35.78	65.06	403,386
	3	32.7419355	0.75	24.56	1	1.05	1.05	1.05	1.05	1.04	25.54		10	35.54	0	35.54	64.62	400,618
	4	32.7419355	0.75	24.56	1	1	1.05	1.05	1.05	1.03	25.29		10	35.29	0	35.29	64.17	397,850
	5	32.7419355	0.75	24.56	1	1	1	1.05	1.05	1.02	25.05		10	35.05	0	35.05	63.72	395,082
	6	39.2903226	0.75	29.47	1	1	1	1	1.05	1.01	29.76		10	39.76	0	39.76	72.30	448,231
Feb.	1	44.6428571	0.75	33.48		1	1	1	1	0.8	26.79		8	34.79	0	34.79	63.25	392,150
	2	44.6428571	0.75	33.48			1	1	1	0.6	20.09		6	26.09	0	26.09	47.44	294,097
	3	44.6428571	0.75	33.48				1	1	0.4	13.39		4	17.39	0	17.39	31.62	196,065
	4	44.6428571	0.75	33.48					1	0.2	6.70		2	8.70	0	8.70	15.81	98,032
	5	44.6428571	0.75	33.48														0
	6	26.7857143	0.75	20.09														0
Mar.	1	41.7741935	0.75	31.33														0
	2	41.7741935	0.75	31.33														0
	3	41.7741935	0.75	31.33														0
	4	41.7741935	0.75	31.33														0
	5	41.7741935	0.75	31.33														0
	6	50.1290323	0.75	37.60														0
Apr.	1	38.3333333	0.75	28.75														0
	2	38.3333333	0.75	28.75														0
	3	38.3333333	0.75	28.75														0
	4	38.3333333	0.75	28.75														0
	5	38.3333333	0.75	28.75														0
	6	38.3333333	0.75	28.75														0
1-May		23.7096774	0.75	17.78														0
	2	23.7096774	0.75	17.78														0
	3	23.7096774	0.75	17.78														0
	4	23.7096774	0.75	17.78														0
	5	23.7096774	0.75	17.78											18.7	0.00	0.00	0
	6	28.4516129	0.75	21.34											38.3	0.00	0.00	0
Jun.	1	22.5	0.85	19.13											28.7	0.00	0.00	0
	2	22.5	0.85	19.13											28.1	0.00	0.00	0
	3	22.5	0.85	19.13											36.7	0.00	0.00	0
	4	22.5	0.85	19.13									25	25.00	29.5	0.00	0.00	0
	5	22.5	0.85	19.13									25	25.00	51.7	0.00	0.00	0
	6	22.5	0.85	19.13									25	25.00	36.4	0.00	0.00	0
Jul.	1	19.8333333	0.85	16.86	1.1					0.22	3.71		25	30.71	34.2	0.00	0.00	0
	2	19.8333333	0.85	16.86	1.1	1.1				0.44	7.42		25	36.42	35.7	0.72	1.30	15,397
	3	19.8333333	0.85	16.86	1.1	1.1	1.1			0.66	11.13		25	42.13	27.1	15.03	27.32	322,387
	4	19.8333333	0.85	16.86	1.1	1.1	1.1	1.1		0.88	14.84			22.84	52	0.00	0.00	0
	5	19.8333333	0.85	16.86	1.1	1.1	1.1	1.1	1.1	1.1	18.54			28.54	46.4	0.00	0.00	0
	6	23.8	0.85	20.23	1.1	1.1	1.1	1.1	1.1	1.1	22.25			32.25	66.2	0.00	0.00	0
Aug.	1	22.9032258	0.85	19.47	1.1	1.1	1.1	1.1	1.1	1.1	21.41			31.41	43.6	0.00	0.00	0
	2	22.9032258	0.85	19.47	1.1	1.1	1.1	1.1	1.1	1.1	21.41			31.41	50.7	0.00	0.00	0
	3	22.9032258	0.85	19.47	1.05	1.1	1.1	1.1	1.1	1.09	21.22			31.22	61.9	0.00	0.00	0
	4	22.9032258	0.85	19.47	1.05	1.05	1.1	1.1	1.1	1.08	21.03			31.03	42.8	0.00	0.00	0
	5	22.9032258	0.85	19.47	1.05	1.05	1.05	1.1	1.1	1.07	20.83			30.83	57.2	0.00	0.00	0
	6	27.483871	0.85	23.36	1.05	1.05	1.05	1.05	1.1	1.06	24.76			34.76	40.3	0.00	0.00	0
Sep.	1	23.1666667	0.85	19.69	1.05	1.05	1.05	1.05	1.05	1.05	20.68			30.68	53.1	0.00	0.00	0
	2	23.1666667	0.85	19.69	1.05	1.05	1.05	1.05	1.05	1.05	20.68			30.68	41.5	0.00	0.00	0
	3	23.1666667	0.85	19.69	0.95	1.05	1.05	1.05	1.05	1.05	20.28			30.28	39.3	0.00	0.00	0
	4	23.1666667	0.85	19.69	0.95	0.95	1.05	1.05	1.05	1.01	19.89			29.89	52	0.00	0.00	0
	5	23.1666667	0.85	19.69	0.95	0.95	0.95	1.05	1.05	0.99	19.49			29.49	23.1	6.39	11.63	137,136
	6	23.1666667	0.85	19.69	0.95	0.95	0.95	0.95	1.05	0.97	19.10			25.10	25.8	3.30	6.00	70,820
Oct.	1	25.6451613	0.85	21.80		0.95	0.95	0.95	0.95	0.76	16.57			24.57	28.3	0.00	0.00	0
	2	25.6451613	0.85	21.80			0.95	0.95	0.95	0.57	12.43			18.43	11.9	6.53	11.86	139,993
	3	25.6451613	0.85	21.80				0.95	0.95	0.38	8.28			12.28	13.2	0.00	0.00	0
	4	25.6451613	0.85	21.80					0.95	0.19	4.14		25	31.14	16.4	14.74	26.80	316,276
	5	25.6451613	0.85	21.80									25	25.00	14.3	10.70	19.45	120,618
	6	30.7741935	0.85	26.16									25	25.00	15.7	9.30	16.91	104,836
Nov.	1	22.8333333	0.75	17.13	1.1					0.22	3.77		25	30.77	0	30.77	55.94	346,834
	2	22.8333333	0.75	17.13	1.1	1.1				0.44	7.54		25	36.54	0	36.54	66.43	411,849
	3	22.8333333	0.75	17.13	1.1	1.1	1.1			0.66	11.30		25	42.30	0	42.30	76.91	476,865
	4	22.8333333	0.75	17.13	1.1	1.1	1.1	1.1		0.88	15.07			23.07	0	23.07	41.95	260,062
	5	22.8333333	0.75	17.13	1.1	1.1	1.1	1.1	1.1	1.1	18.84			28.84	0	28.84	52.43	325,077
	6	22.8333333	0.75	17.13	1.1	1.1	1.1	1.1	1.1	1.1	18.84			28.84	0	28.84	52.43	325,077
Dec.	1	25.6451613	0.75	19.23	1.1	1.1	1.1	1.1	1.1	1.1	21.16			31.16	0	31.16	56.65	351,227
	2	25.6451613	0.75	19.23	1.1	1.1	1.1	1.1	1.1	1.1	21.16			31.16	0	31.16	56.65	351,227
	3	25.6451613	0.75	19.23	1.05	1.1	1.1	1.1	1.1	1.09	20.96			30.96	0	30.96	56.30	349,059
	4	25.6451613	0.75	19.23	1.05	1.05	1.1	1.1	1.1	1.08	20.77			30.77	0	30.77	55.95	346,891
	5	25.6451613	0.75	19.23	1.05	1.05	1.05	1.1	1.1	1.07	20.58			30.58	0	30.58	55.60	344,723
	6	30.7741935	0.75	23.08	1.05	1.05	1.05	1.05	1.1	1.06	24.47			34.47	0	34.47	62.66	388,520

the existing canals. Since these systems have topographical additional irrigable areas at down stream, two routes for the Bamban irrigation network (B-2, B-5) and one route for the San Felipe irrigation network (S-2), totaling three routes of new irrigation canals, are planned.

On the left river bank side of the San Felipe River, irrigation canals are newly constructed to take water directly from the dam and conduct it to the Nayom area. These canals are designed with the gentlest possible slope from the storage water level of the dam to be constructed so that they can irrigate the existing rainfed water cultivation area located at a higher elevation.

(B) Design discharge

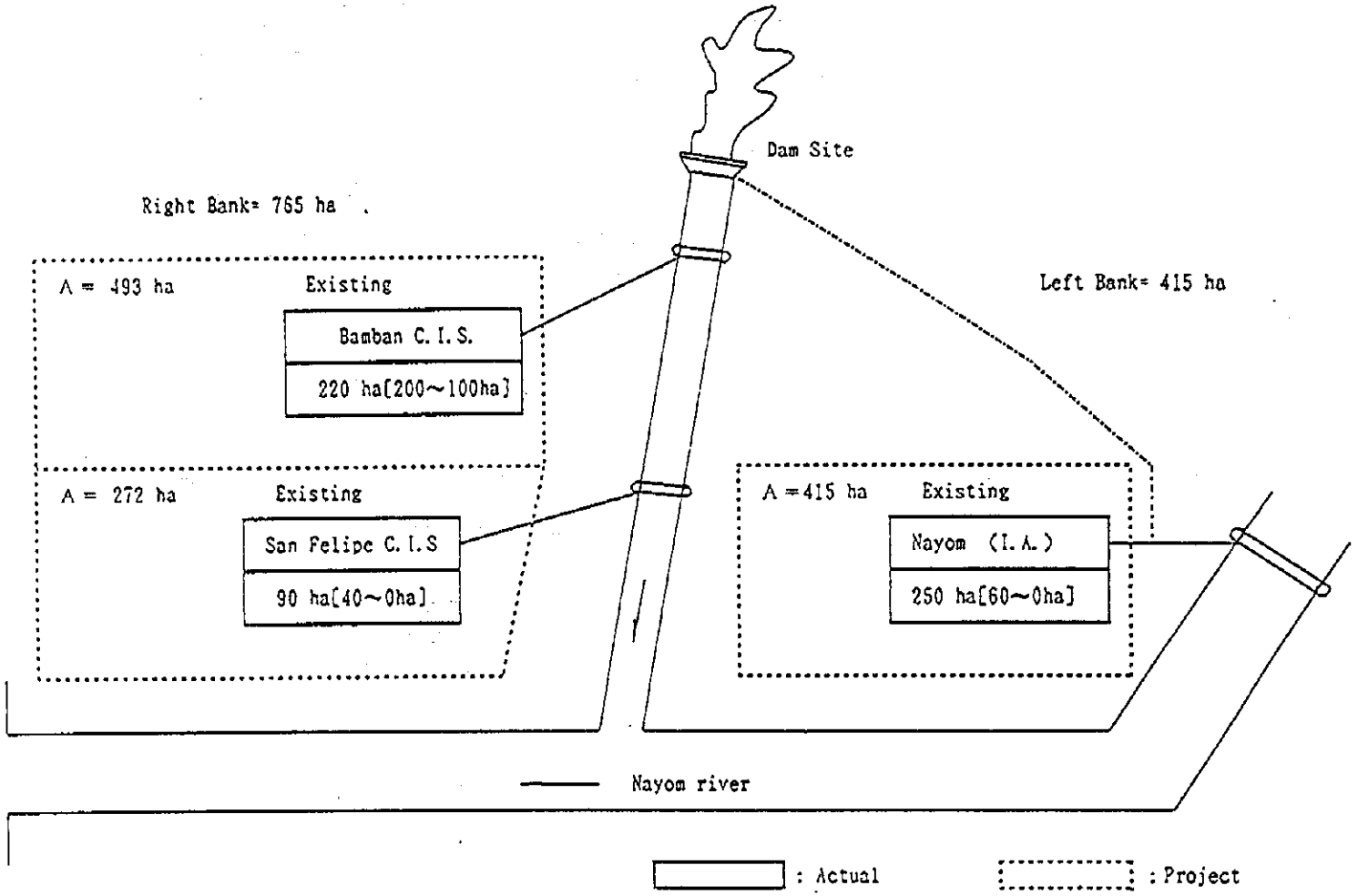
Since the seasonal maximum unit discharge is estimated 76 mm/month equivalent to 1.8 lit./sec (October) for the irrigation plan, 2.0 lit./sec/ha is taken as the unit design discharge of the canal. Generally 1.7 to 2.3 lit./sec/ha is employed as the design discharge of irrigation canals specified by the NIA in the Philippines. Therefore, the 2.0 lit./sec/ha is considered reasonable. The proposed irrigation diagram based on the above calculation is shown in Fig. 2.3.2.1-2.

(C) Canal design policy

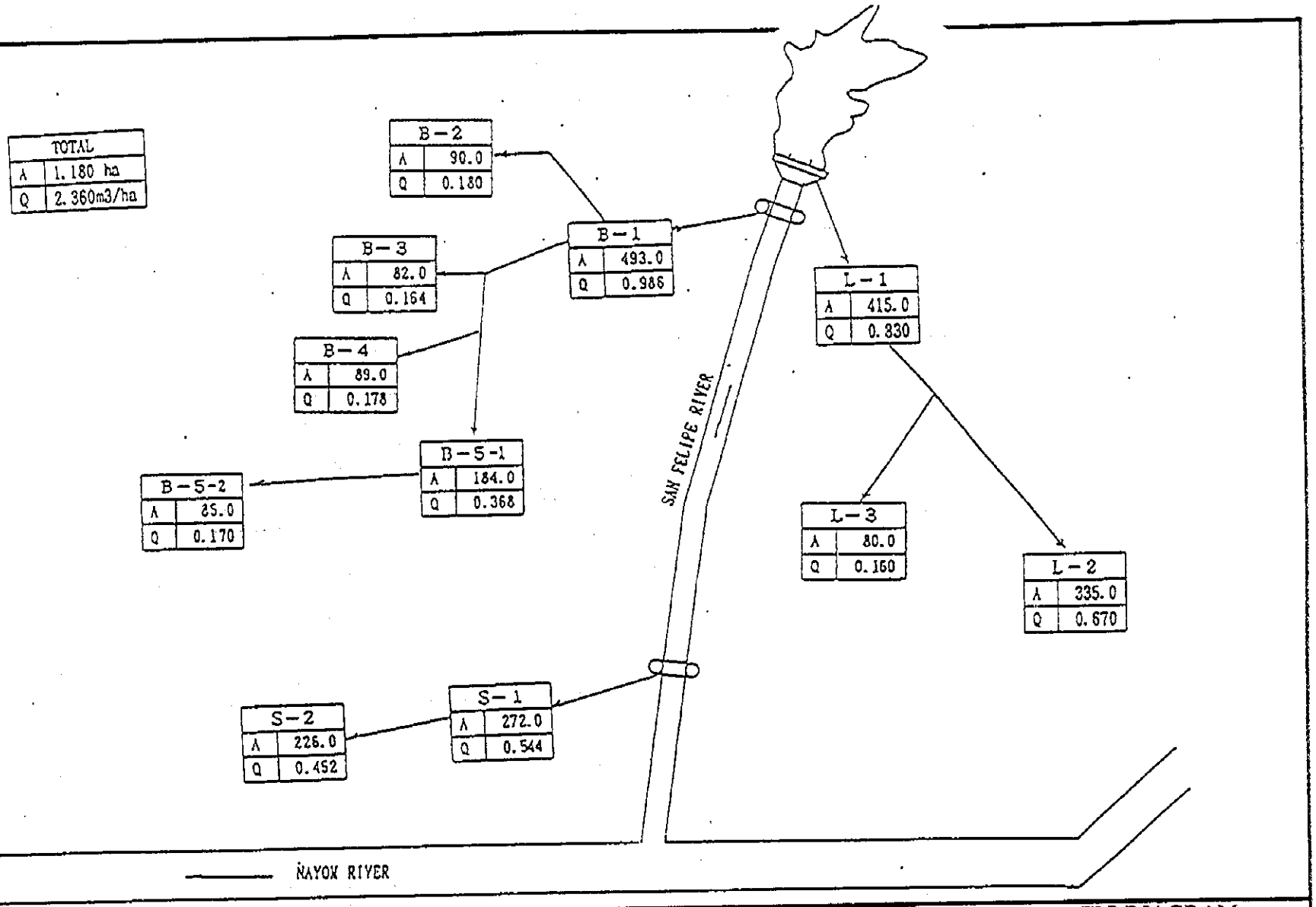
The Bamban intake weir irrigation network and the San Felipe intake weir irrigation network are planned that these will be prepared by widening and extending the existing canals. Since the soil around these canals are clay soil, and the canals are located on relatively plane land, the earth canal system that is currently used for the existing canals, is employed. The flow capacity of the related structures such as diversion facilities and road crossing culverts will be examined, and they will be improved if their capacity is found to be insufficient.

The newly constructed canal to take water directly from the dam and conduct it to the Nayom area goes down through the mountainside of the relatively conglomeratic hills covering a distance of approximately 6.3 km. For the purpose of leakage prevention, therefore, the canal will be paved with boulder concrete lining.

These canals will be designed according to NIA design standards.



BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT JAPAN INTERNATIONAL COOPORATION AGENCY	Fig. 2.3.2.1-1 PLAN OF IRRIGATION SYSTEM AND BLOCK



BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT

JAPAN INTERNATIONAL COOPORATION AGENCY

Fig. 2.3.2.1-2 SCHEMATIC DIAGRAM OF IRRIGATION SYSTEM

(D) Hydraulic parameter

Hydraulic parameter of the irrigation canal are calculated as follows.

Item	Hydraulic parameter
1. Average velocity formula	Manning formula: Roughness coefficient n = 0.030 (earth canal) n = 0.018 (boulder concrete canal)
2. Allowable minimum velocity	Approximately 0.40 m/sec (prevention of sedimentation of suspended sand and soil)
3. Freeboard	0.30 m (determined as minimum freeboard)

(E) Main irrigation canal

A 19.8 km of new construction and improvement of the main canal linked with the dam construction is requested. After surveying the conditions of the existing canal (route, cross section, structure, etc.) based on a 1/5,000 topographical map, a proposed irrigation diagram has been prepared. In order that the irrigation area can be expanded as far as possible for each irrigation network in the future, nine routes of new and improvement (total length is 21.6 km) have been selected. Out of these, new constructed canals cover 14.5 km, and widened and improved canals cover 7.1 km.

The main canal, except the route where existing road is found, will be provided in principle with a inspection road for each (effective width 3.0 m, total width 4.0 m, gravel pavement). The inspection road is used as an agricultural road depending on the location, therefore, will be effective for the use of secondary purposes as well.

Location of diversion structures on each proposed canals such as improved canal, new constructed canal, are shown in the attached Fig. 2.3.2.1-3 respectively. The standard cross section of the proposed canal and inspection road are shown in the attached Fig. 2.3.2.1-4. Length, water discharge, and calculation of cross section of each route are shown in Table 2.3.2.1-2 and Table 2.3.2.1-3.

Diversion structures of main canals are constructed at places where reasonable water distribution can be done, water management by a hydraulic gate will be available.

Name of Main Canal	Irrigated area (ha)	Number of Diversion Structures	Name of Main Canal	Irrigated area (ha)	Number of diversion Structures
L-1	415	5	B-5-1	184	5
L-2	310	4	B-5-2	85	6
L-3	80	2	S-1	272	6
B-1	493	6	S-2	226	4
B-2	90	5			

(F) Related structures

The proposed canal construction needs related structures including diversion structures (separation gate diversion), small diversion structures (T-shaped diversion), road crossing culverts, drops, and canal crossing footbridges. These structures should be easy to maintain and safe, and they should be made by concrete using ready made local products, in principle, such as pipes, gates.

There are some places along the existing canals that housewives often use for washing. Washing places will be constructed at such locations.

The related facilities for this project are shown below.

Facility Name	Related Structure	Quantity
1. Water conveying facilities	• Open canals	20,650 m
	• Conduits	1,060 m
	• Drops	21 places
	• Road-crossing structures	20 places
2. Diversion and water measuring facilities	• Large diversion structures	5 places
	• Small diversion structures	34 places
	• Water measuring facilities	39 places
3. Pressure control facilities	• Energy dissipater	3 places
4. Management facilities	• Inspection roads	20,650 m
	• Canal crossing footbridges	24 places
5. Others	• Washing places	4 places

Note : Location of these facilities are shown in profiles respectively.

(G) Secondary and tertiary canals

a) General

Secondary and tertiary canals to be connected to the main canal will be constructed by the Philippine Government (constructed by local farmers under instruction NIA). Secondary and

tertiary canals will be allocated to irrigate to the terminal paddy field.

- Secondary canal: The secondary canal is diverged from the main canal and is extended to benefited area of down stream. The canal is designed at a high-leveled location of each benefited area or along the levee of paddy field. The canal is constructed as an earth canal basically.

- Tertiary canal: The tertiary canal is diverged from the secondary canal and is extended to the paddy field where can irrigate the water lot to lot. The benefited area of the canal is approximately 10 ha to 20 ha according to the topographic condition. The canal is designed at a high-leveled location of the existing paddy field and is constructed by the benefited farmer.

b) Canal plan of each irrigation network

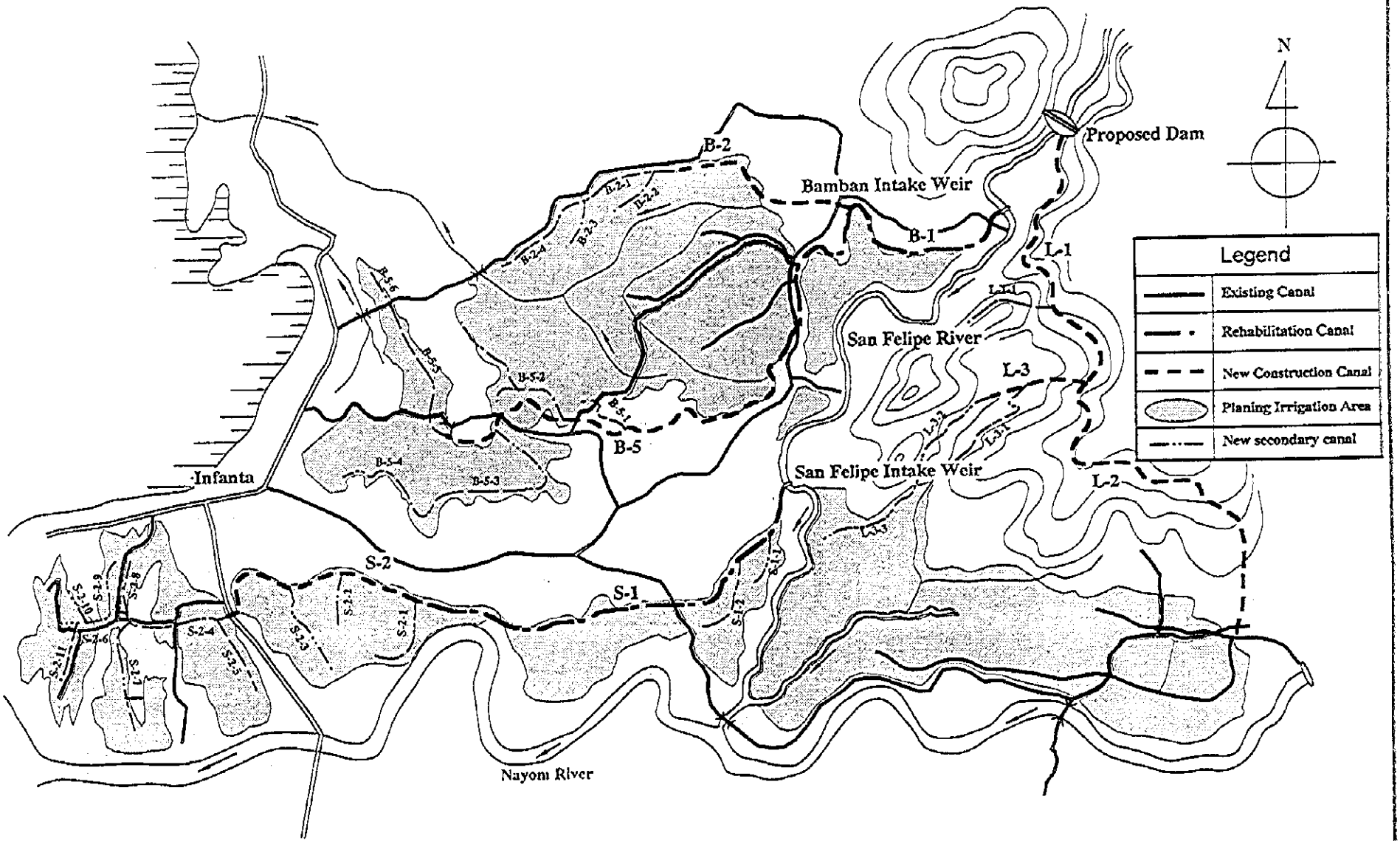
There are three existing irrigation networks such as Bamban network, San Felipe network and Nayom network, in the project area. The main canal are located at the high-leveled location of each networks. The secondary and tertiary canal length of each irrigation networks are following.

Irrigation network	description	Number of route	Length (m)
Bamban network	Secondary canal	5	5,980
	Tertiary canal	5	2,590
San Felipe network	Secondary canal	6	3,830
	Tertiary canal	7	3,740
Nayom network	Secondary canal	3	3,010
	Tertiary canal	1	800
Total	Secondary canal	14	12,820
	Tertiary canal	13	7,130

All of these canal are constructed as an earth canal according as the progress of main canal construction. After the construction of these canal, the irrigation canal length of the project area are 21.6 km of the main canal, 20.0 km of the secondary and tertiary canal and 13.0 km of the existing canal, totaling 54.6 km. The canal density is 46.3 m/ha. This density is near the improvement standard (50 to 80 m/ha) which is suggested by the ADB.

(3) Design of Canal

Canal and Related structures are shown in as follows. Longitudinal of canal also are shown in Technical reference.



BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT	FIG. 2.3.2.1-3 PLAN OF IRRIGATION CANAL NETWORK
JAPAN INTERNATIONAL COOPORATION AGENCY	

Table-2.3.2.1-2 Detail Information of the Irrigation Canal

Route name	Irrigation area (ha)	Design Discharge (m3/s)	Length (m)	Improvement Plan	Remarks
L-1	415	0.830	3,100	New construction	
L-2	335	0.670	3,230	New construction	
L-3	80	0.160	600	New construction	
B-1	493	0.986	2,720	Improvement of existing canal	
B-2	90	0.180	1,800	New construction	
B-3	82	0.164	(1,380)	Use the existing canal	
B-4	89	0.178	(1,100)	Use the existing canal	
B-5-1	184	0.368	3,880	New construction (2,400m) Improvement of existing canal (1,480m)	
B-5-2	85	0.170	900	New construction	
S-1	272	0.544	3,250	Improvement of existing canal	
S-2	226	0.452	2,230	New construction	
Total	1,180	2.360	21,710	New construction: 14,260m Improvement of existing canal: 7,450m	

Table-2.3.2.1-3 Hydraulic Calculation of Canal

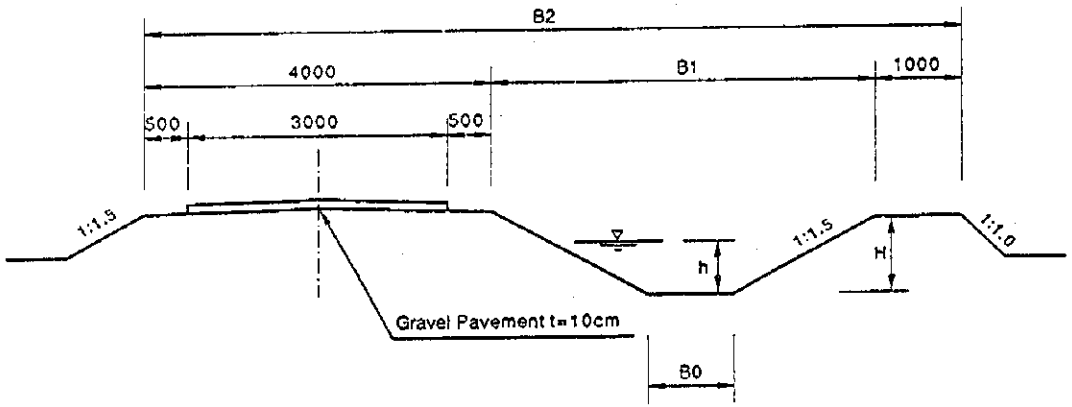
Name	Discharge	b(m)	H(m)	m	I	n	Bo(m)	A(m^2)	P(m)	R=A/P	R2/3	1/n	(I)1/2	V(m/s)	Q(m^3/s)	Remarks
L-1	1.03	1.35	0.66	0.5	1000	0.018	2.01	1.1088	2.8258	0.3924	0.536	55.56	0.0316	0.9416	1.04402	
L-2	0.82	1.2	0.62	0.5	1000	0.018	1.82	0.9362	2.5864	0.362	0.5079	55.56	0.0316	0.8923	0.83535	
L-3	0.16	0.6	0.31	1.5	500	0.03	1.53	0.3302	1.7177	0.1922	0.333	33.33	0.0447	0.4965	0.1639	
B-1	0.986	1.4	0.69	1.5	1000	0.03	3.47	1.6802	3.8878	0.4322	0.5716	33.33	0.0316	0.6025	1.0123	
B-2	0.18	0.6	0.35	1.5	500	0.03	1.65	0.3938	1.8619	0.2115	0.3549	33.33	0.0447	0.5291	0.20833	
B-3	0.164	0.65	0.36	1.5	1000	0.03	1.73	0.4284	1.948	0.2119	0.3643	33.33	0.0316	0.384	0.16452	
B-4	0.178	0.65	0.38	1.5	1000	0.03	1.79	0.4636	2.0201	0.2295	0.3748	33.33	0.0316	0.3951	0.18317	
B-5	0.368	1	0.47	1.5	1000	0.03	2.41	0.8014	2.6946	0.2974	0.4455	33.33	0.0316	0.4696	0.37633	
B-5	0.17	0.6	0.32	1.5	500	0.03	1.56	0.3456	1.7538	0.1971	0.3386	33.33	0.0447	0.5048	0.17445	B-5-1
S-1	0.544	1.1	0.56	1.5	1000	0.03	2.78	1.0864	3.1191	0.3483	0.495	33.33	0.0316	0.5218	0.566882	B-5-2
S-2	0.452	1	0.52	1.5	1000	0.03	2.56	0.9256	2.8749	0.322	0.4697	33.33	0.0316	0.4951	0.4583	

Table 2.3.2.1-4 Detail Information of Secondary and Tertiary Canal

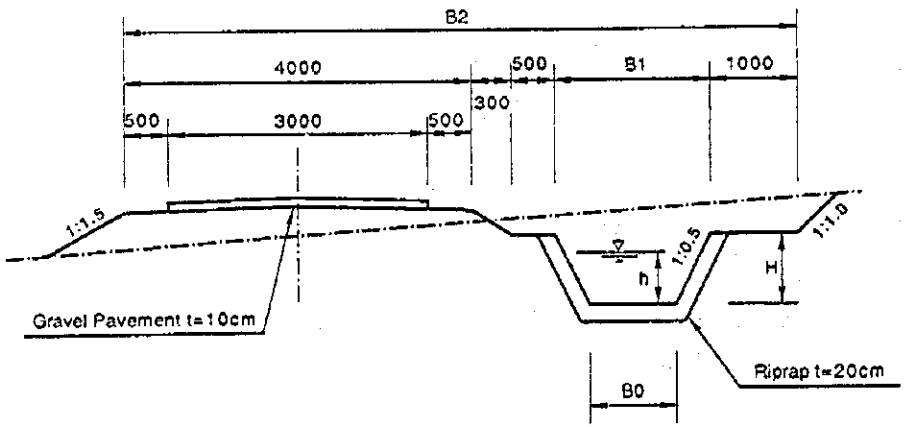
Network	Route Name	Type	Irrigation Area (ha)	Length (m)	Starting Elevation	Final Elevation	Design Slope
Bamban	B-2-1	Secondary	38.3	1,100	9.5	5.0	1/300
	B-2-2	Tertiary	15.0	480	9.5	3.0	1/300
	B-2-3	Tertiary	13.2	350	7.0	4.0	1/300
	B-2-4	Tertiary	10.1	370	5.0	2.5	1/300
	B-5-1	Secondary	13.1	600	14.0	12.0	1/500
	B-5-2	Secondary	28.7	1,450	12.0	3.5	1/300
	B-5-3	Secondary	45.2	1,670	7.0	3.0	1/500
	B-5-4	Tertiary	19.8	940	3.0	2.0	1/1,000
	B-5-5	Secondary	24.2	1,160	5.0	3.5	1/1,000
	B-5-6	Tertiary	9.5	450	3.5	3.0	1/1,000
(Sub-total)				(8,570)			
San Felipe	S-1-1	Secondary	7.2	600	8.7	7.0	1/500
	S-1-2	Secondary	6.3	650	7.9	7.0	1/1,000
	S-2-1	Secondary	24.7	460	2.1	1.5	1/1,000
	S-2-2	Secondary	27.6	470	3.5	2.4	1/500
	S-2-3	Secondary	14.6	720	2.7	2.0	1/1,500
	S-2-4	Secondary	80.0	930	2.5	1.9	1/1,500
	S-2-5	Tertiary	26.4	800	2.3	1.5	1/1,000
	S-2-6	Tertiary	26.2	600	1.9	1.3	1/1,500
	S-2-7	Tertiary	14.2	770	1.9	1.3	1/1,500
	S-2-8	Tertiary	6.8	450	1.8	1.2	1/1,000
	S-2-9	Tertiary	6.0	400	1.8	1.2	1/1,000
	S-2-10	Tertiary	3.1	320	1.7	1.4	1/1,500
	S-2-11	Tertiary	5.8	400	1.7	1.4	1/1,500
(Sub-total)				(7,570)			
Nayom	L-1-1	Secondary	10.0	580	34.0	25.0	1/300
	L-3-1	Secondary	11.5	1,050	14.5	10.0	1/300
	L-3-2	Secondary	68.5	1,380	12.5	10.0	1/1,000
	L-3-3	Tertiary	41.4	800	10.0	7.5	1/500
(Sub-total)				(3,810)			
Total	(27 routes)			19,950			

TYPICAL CANAL SECTION

(Main Canal TYPE I)



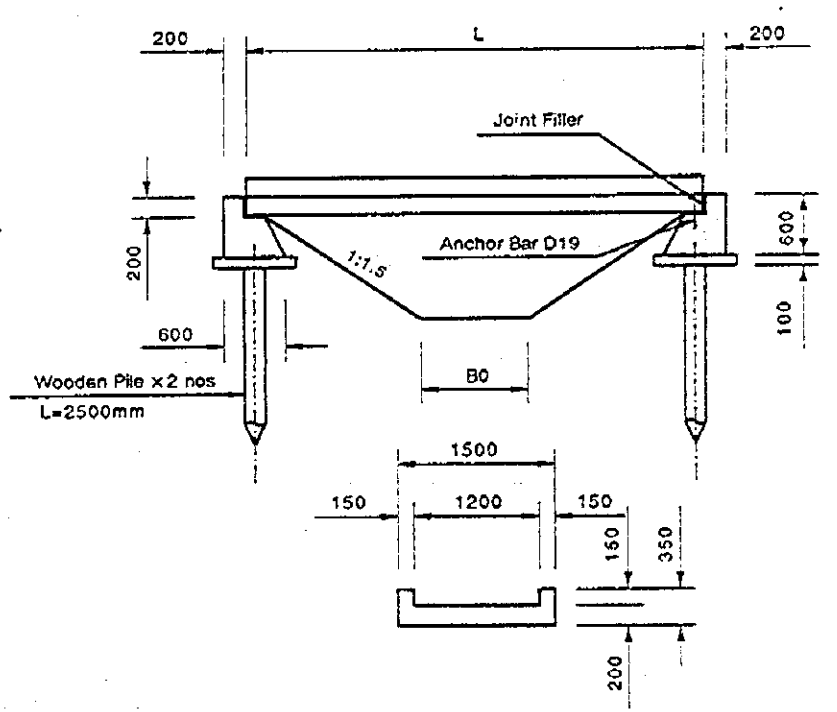
(Main Canal TYPE II)



Unit; m

TYPE		B0	H	h	B1	B2	Remarks
TYPE I	I-1	1.40	1.00	0.69	4.40	9.40	
	I-2	1.10	0.90	0.56	3.80	8.80	
	I-3	1.00	0.80	0.47~0.52	3.40	8.40	
	I-4	0.65	0.70	0.36~0.38	2.75	7.75	
	I-5	0.60	0.65	0.32~0.35	2.55	7.55	
TYPE II	II-1	1.35	1.00	0.66	2.35	8.15	
	II-2	1.20	0.90	0.62	2.10	7.90	
	II-3	1.00	0.80	0.48	1.80	7.60	

O&M BRIDGE ON MAIN CANAL



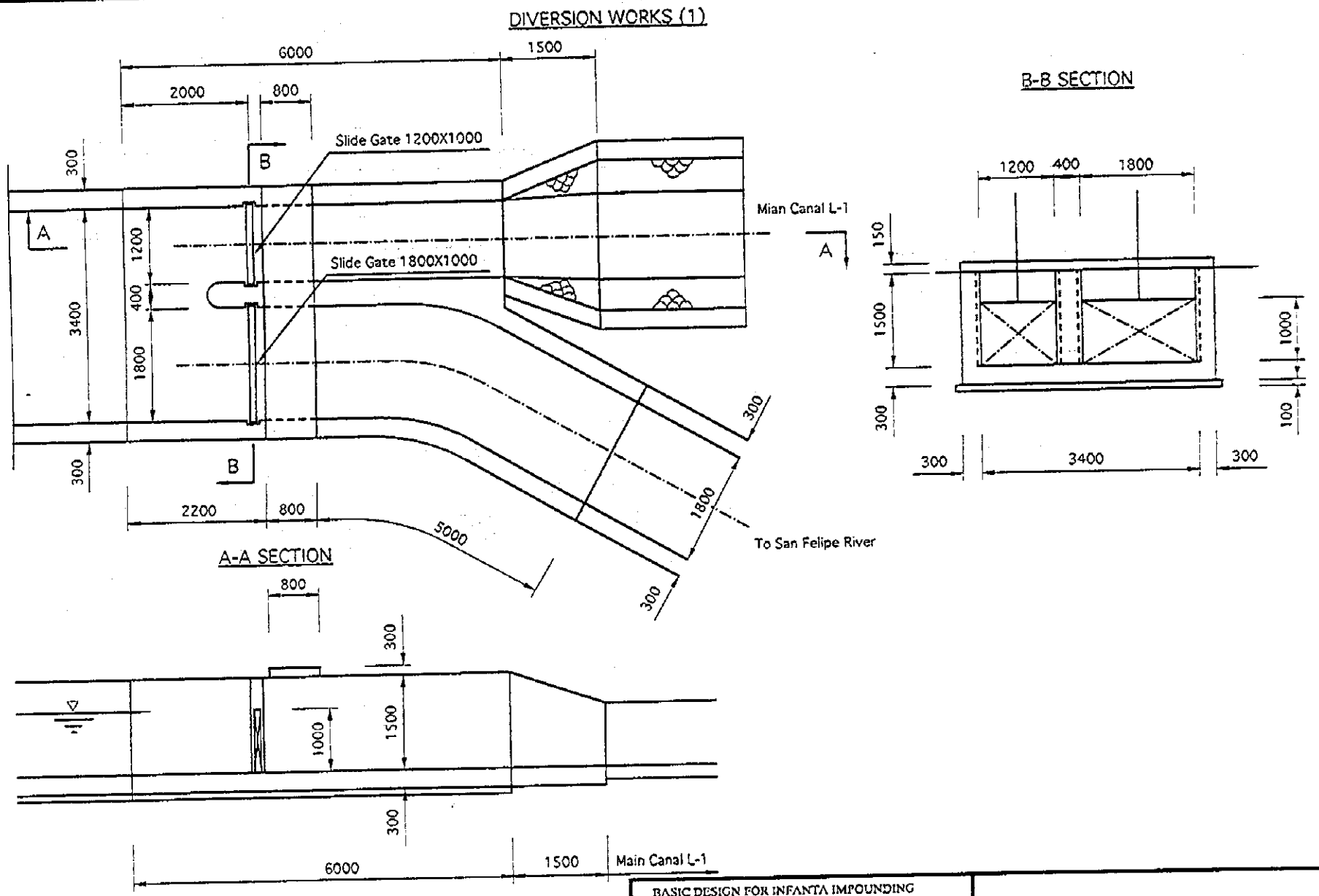
Unit: m

TYPE	L	Remarks
I	5.00	
II	4.40	
III	4.00	
IV	3.40	
V	3.00	
VI	2.70	
VII	2.40	

BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT

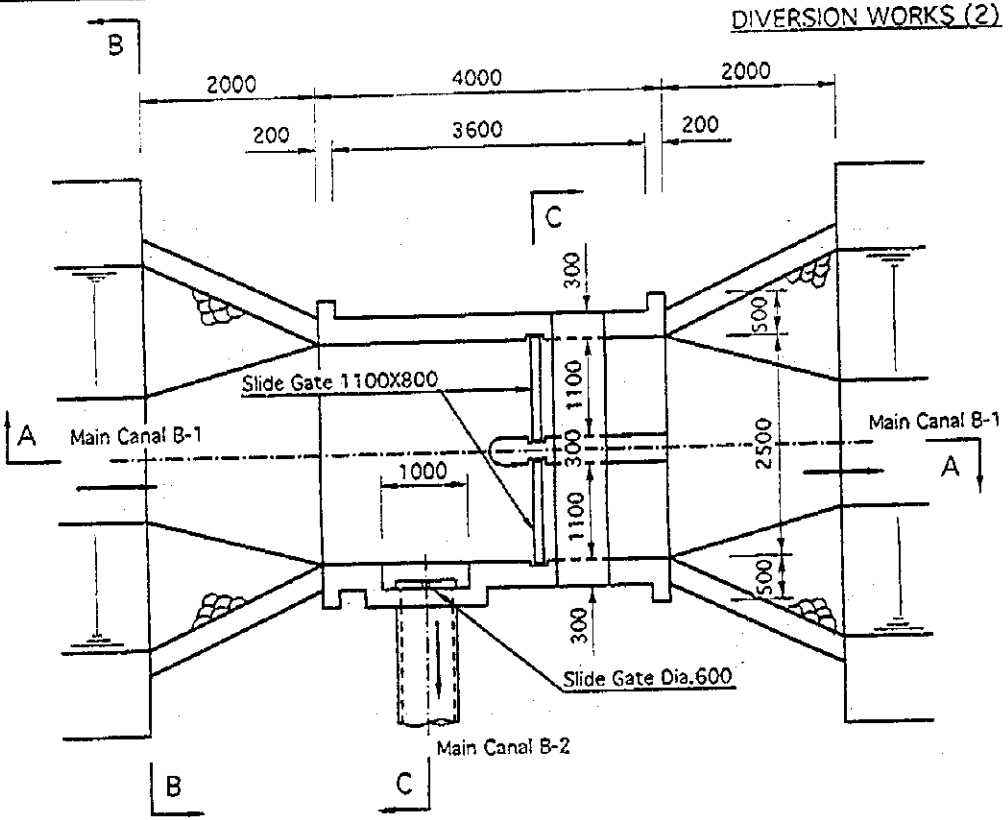
JAPAN INTERNATIONAL COOPORATION AGENCY

Fig. 2.3.2.1-4 TYPICAL CANAL SECTION

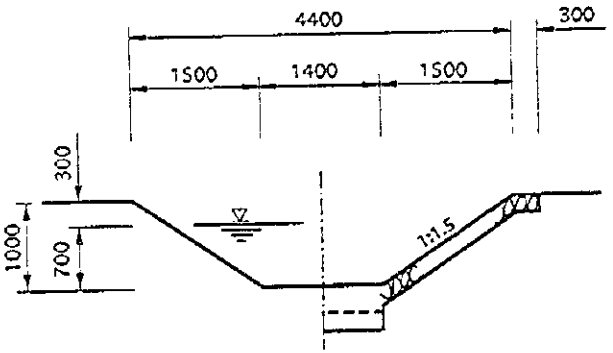


BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT	Fig. 2.3.2.1-5 DIVERSION WORKS (1)
JAPAN INTERNATIONAL COOPORATION AGENCY	

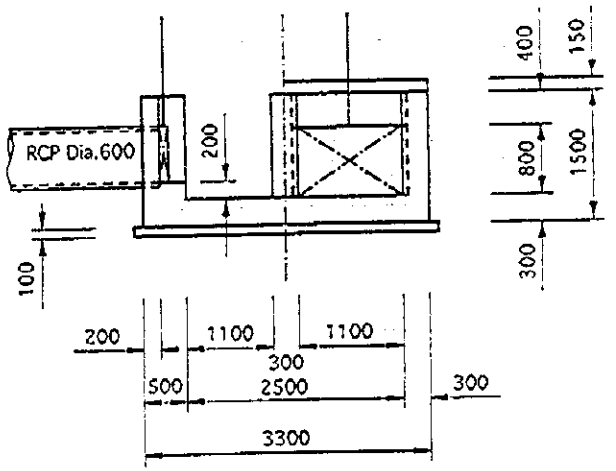
DIVERSION WORKS (2)



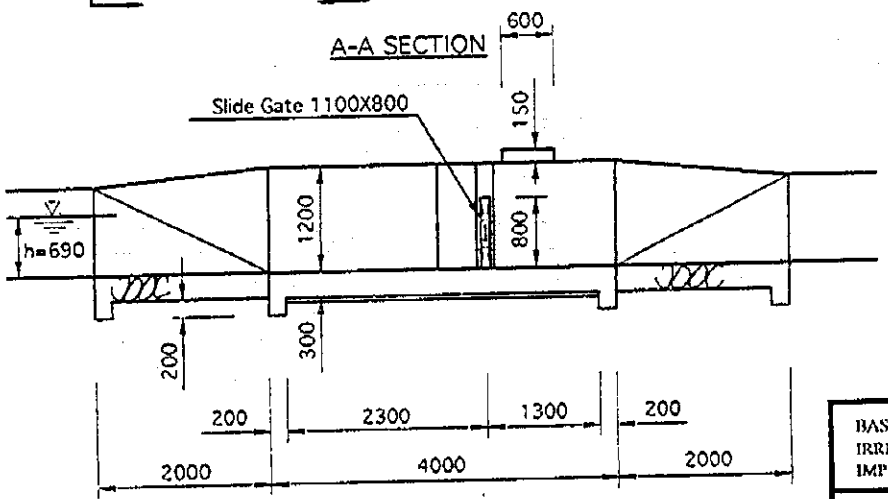
B-B SECTION



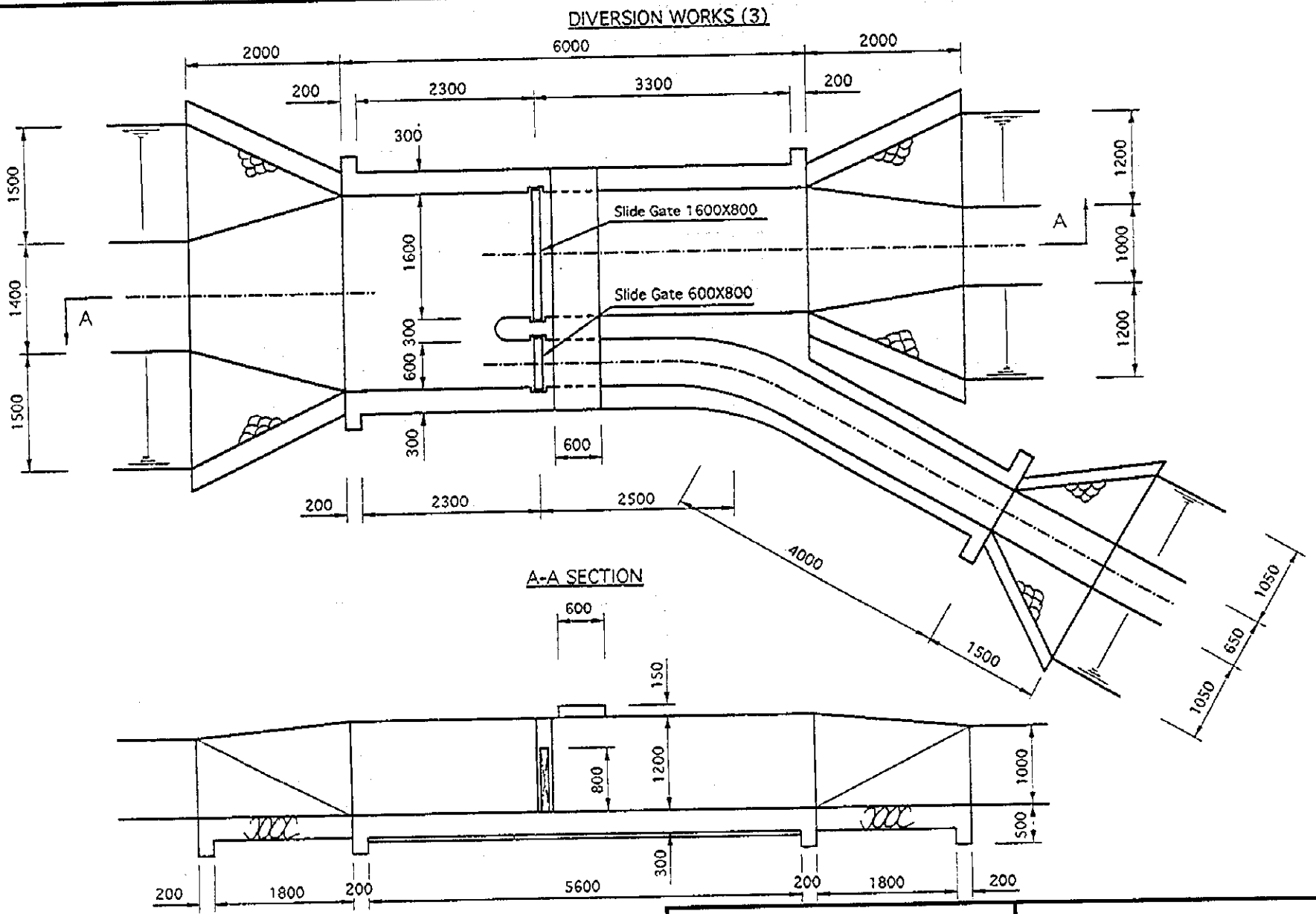
C-C SECTION



A-A SECTION



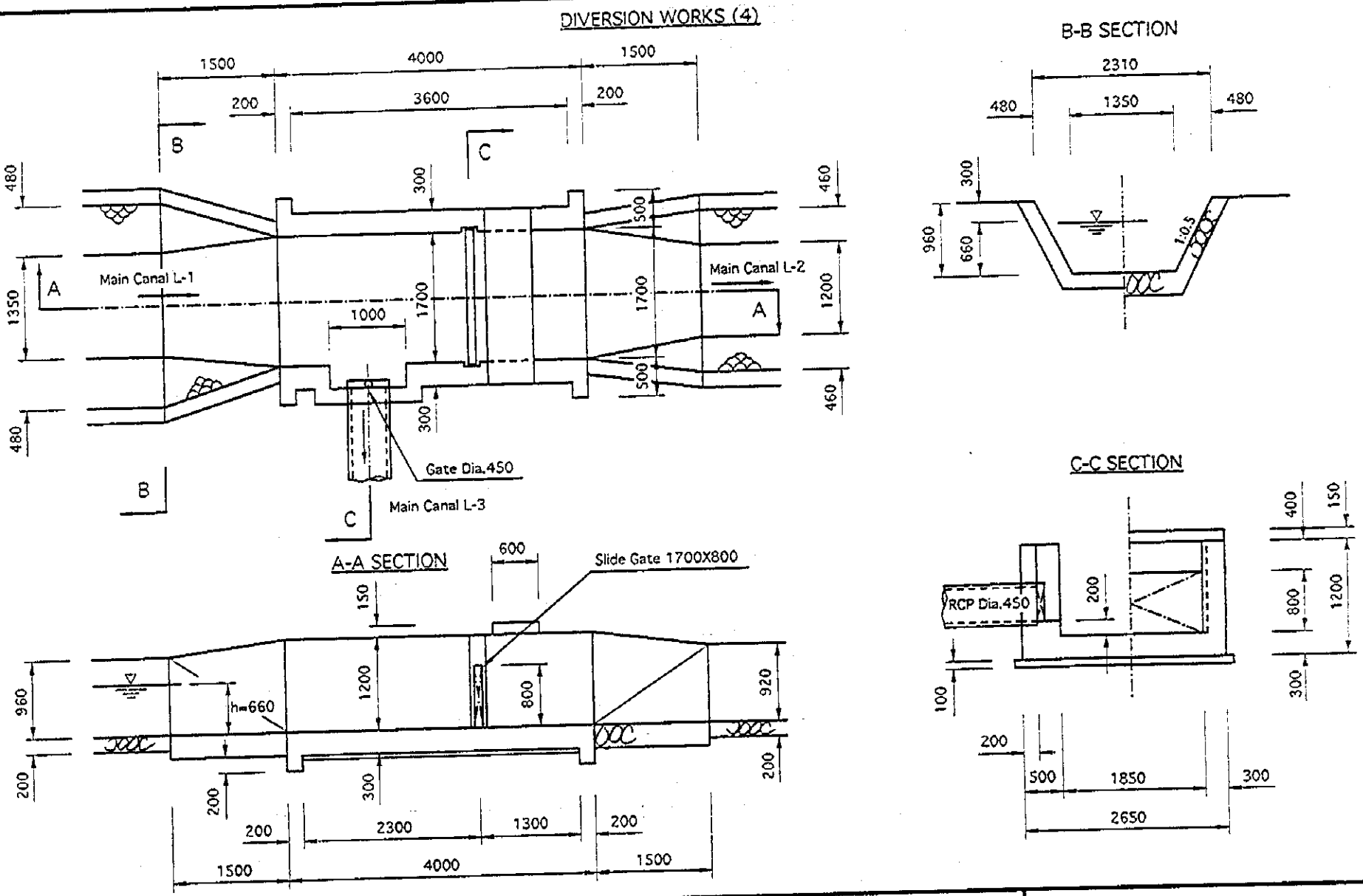
BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT	Fig. 2.3.2.1-6 DIVERSION WORKS (2)
JAPAN INTERNATIONAL COOPORATION AGENCY	



BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT

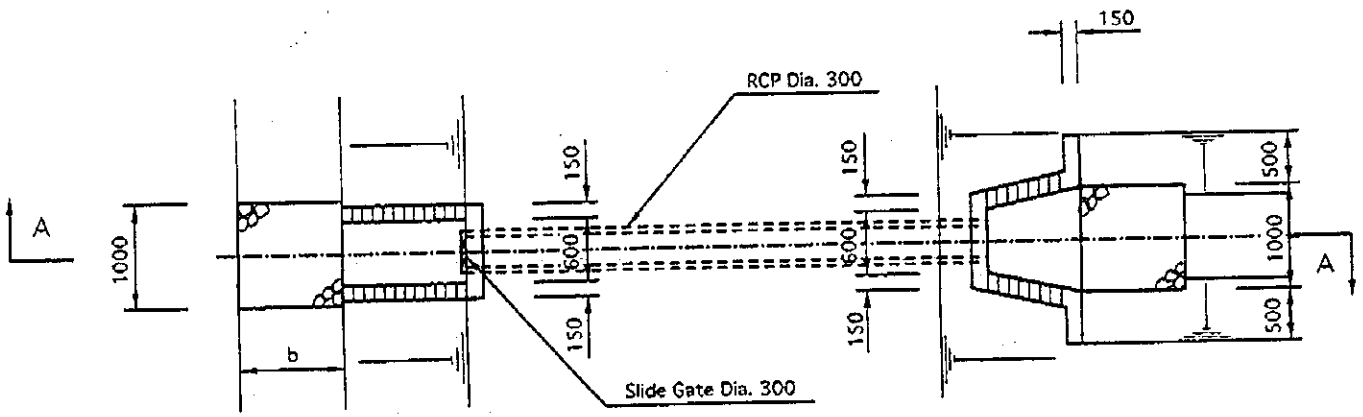
JAPAN INTERNATIONAL COOPORATION AGENCY

Fig. 2.3.2.1-7 DIVERSION WORKS (3)



BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT	Fig. 2.3.2.1-8 DIVERSION WORKS (4)
JAPAN INTERNATIONAL COOPORATION AGENCY	

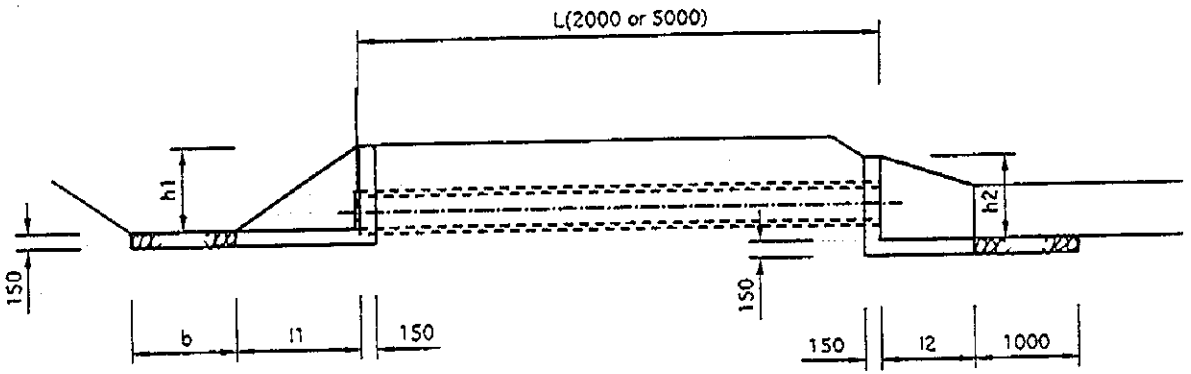
TURNOUT



Unit; m

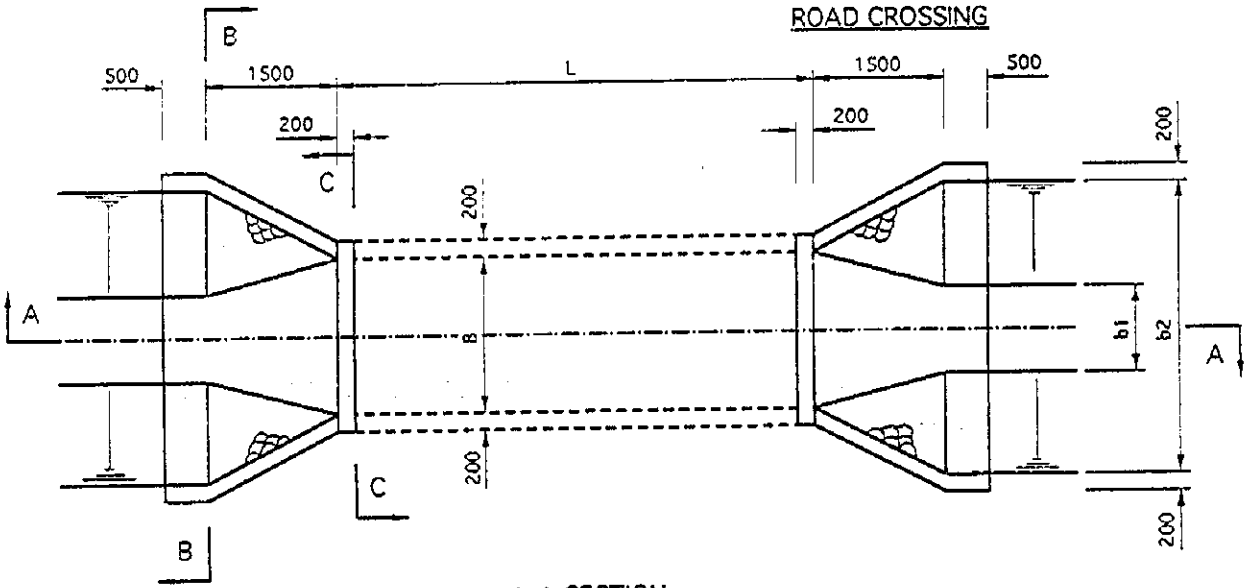
TYPE	b	h1	h2	l1	l2	Remarks
I	1.40	1.00	0.60	1.50	0.90	
II	1.10	0.90	0.60	1.35	0.90	
III	1.00	0.80	0.60	1.20	0.90	
IV	0.65	0.70	0.50	1.05	0.75	
V	0.60	0.65	0.50	0.98	0.75	
VI	1.35	1.00	0.60	0.50	0.90	
VII	1.20	0.90	0.60	0.45	0.90	
VIII	1.00	0.80	0.60	0.40	0.90	

A-A SECTION

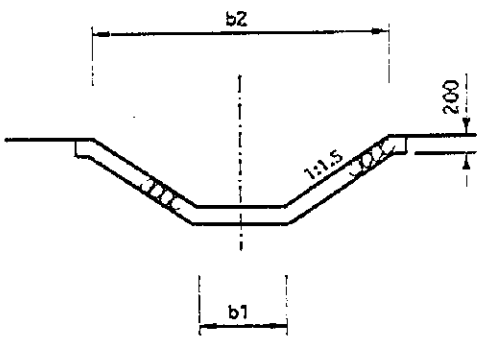


BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT	Fig. 2.3.2.1-9 TURNOUT
JAPAN INTERNATIONAL COOPORATION AGENCY	

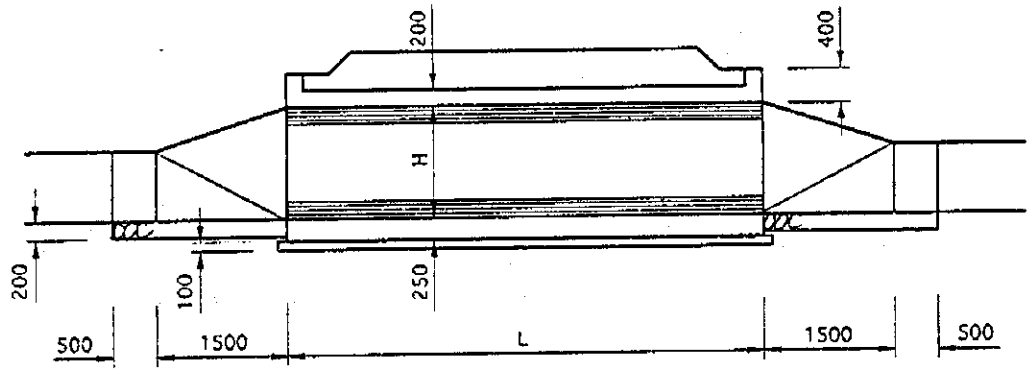
ROAD CROSSING



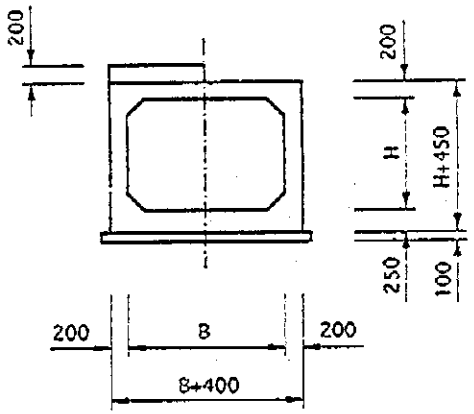
B-B SECTION



A-A SECTION



C-C SECTION



Unit: m

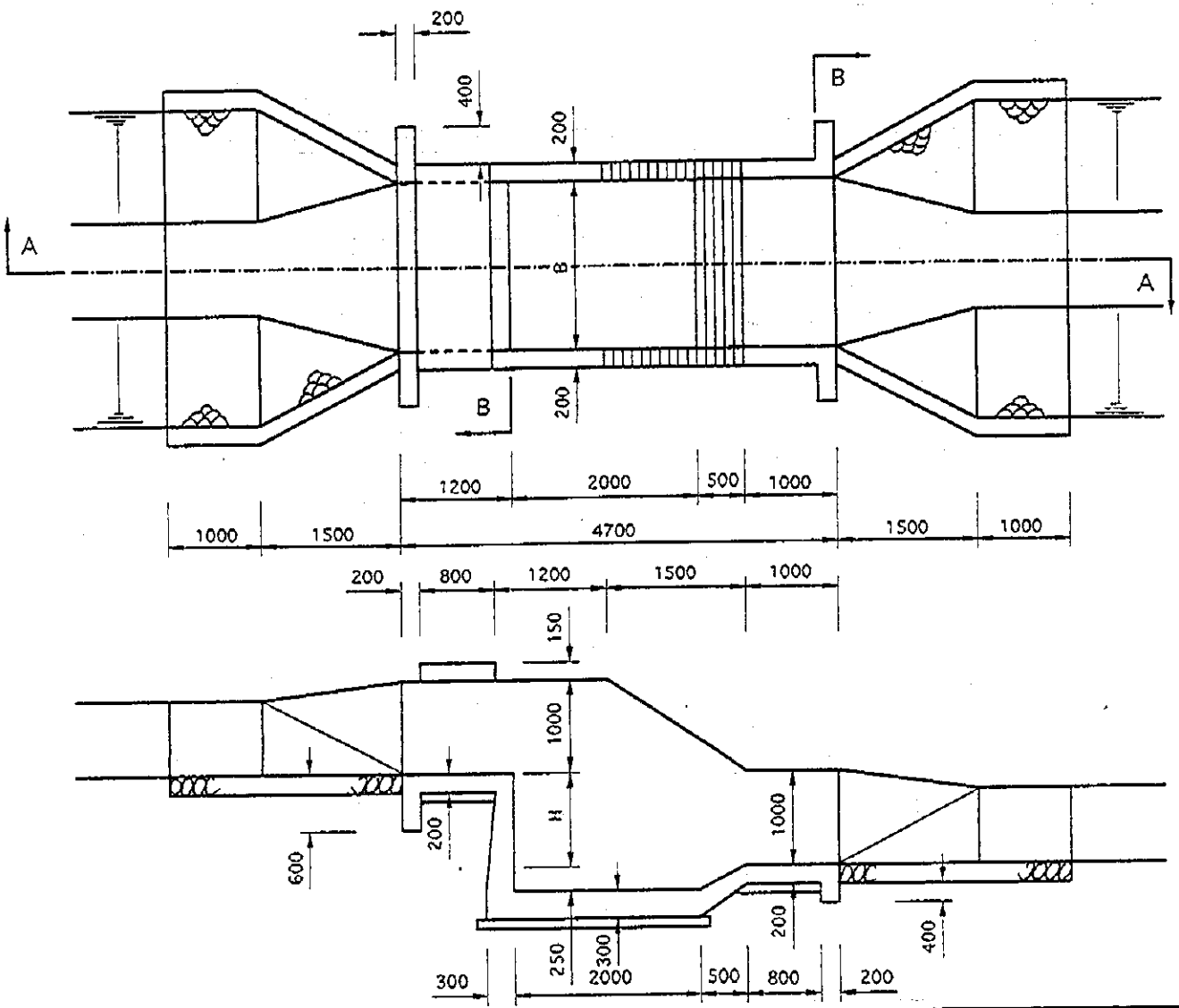
TYPE	b1	b2	B	H	Remarks
I	1.40	4.40	2.50	1.50	
II	1.10	3.80	1.90	1.40	
III	1.00	3.40	1.80	1.30	
IV	0.65	2.75	1.30	1.00	
V	0.60	2.55	1.20	1.00	
VI	1.35	2.35	1.70	1.30	
VII	1.20	2.10	1.50	1.20	
VIII	1.00	1.80	1.30	1.00	

BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT

JAPAN INTERNATIONAL COOPORATION AGENCY

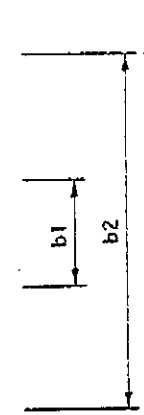
Fig. 2.3.2.1-10 ROAD CROSSING

DROP

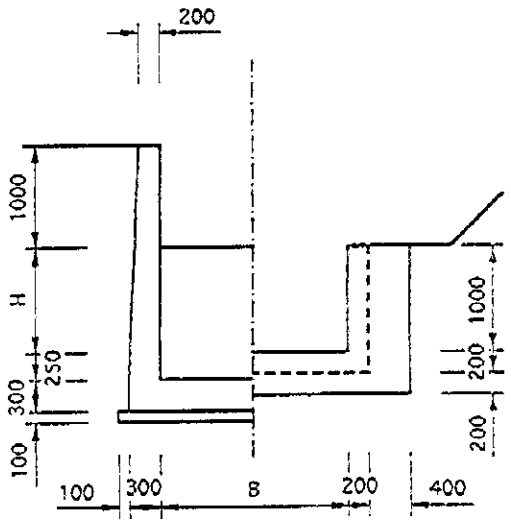


Unit: m

TYPE	b1	b2	B	H
I	1.40	4.40	2.50	1.00
II	1.10	3.80	1.90	1.00
III	1.00	3.40	1.80	1.00
IV	0.65	2.75	1.30	1.00
V	0.60	2.55	1.20	1.00
VI	1.20	2.10	1.50	1.00
VII	1.00	1.80	1.30	1.00



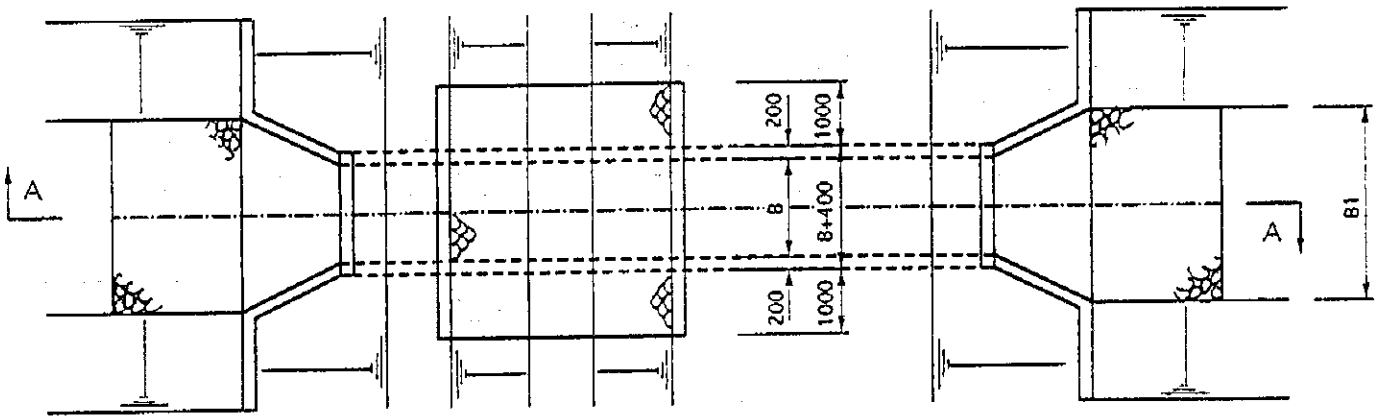
B-B SECTION



A-A SECTION

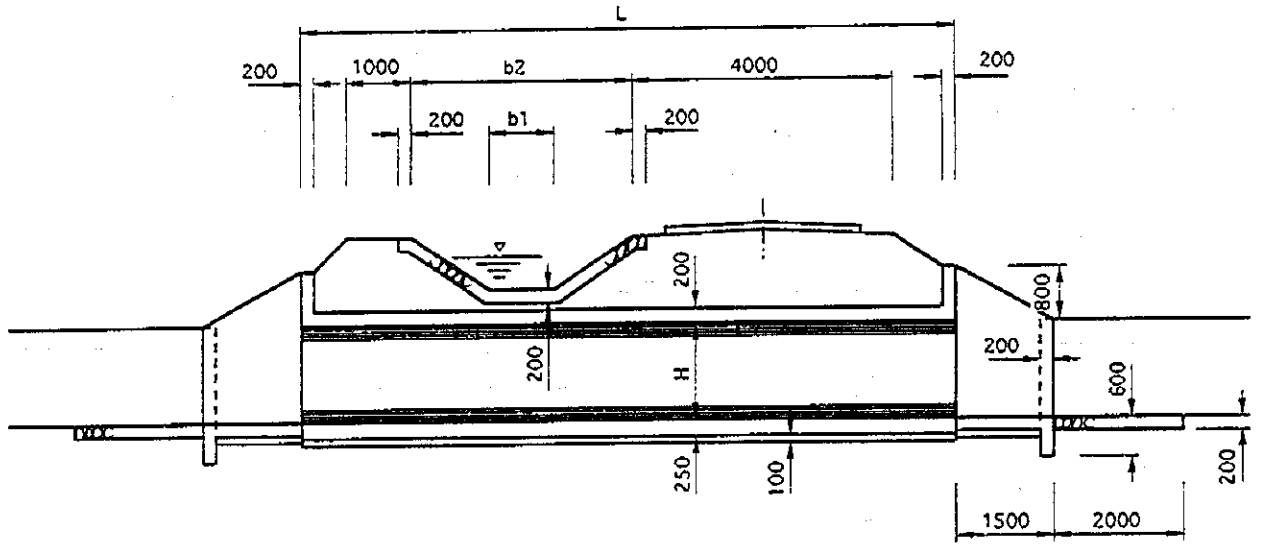
BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT	Fig. 2.3.2.1-11 DROP
JAPAN INTERNATIONAL COOPORATION AGENCY	

DRAINAGE BOX CULVERT



TYPE	H	B	B1	Remarks
I	1.00	1.00	2.00	
II	1.00	1.50	3.00	
III	1.50	1.50	3.00	
IV	1.50	2.00	3.50	
V	1.50	3.00	4.00	

A-A SECTION

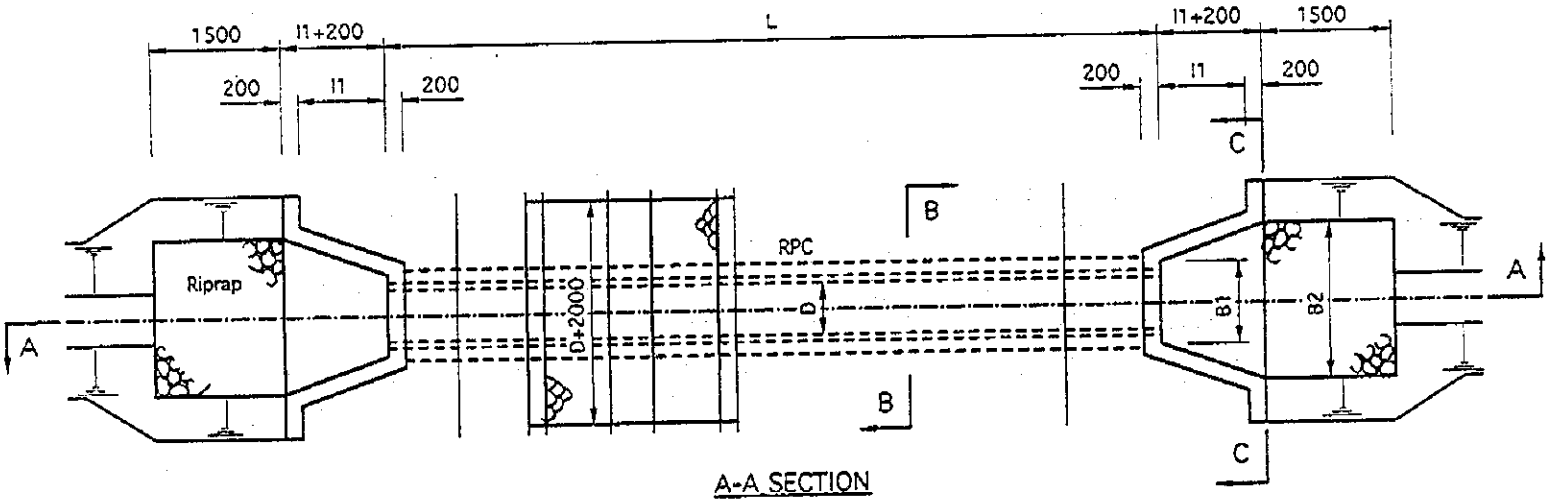


BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT

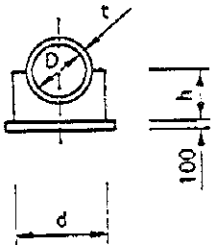
JAPAN INTERNATIONAL COOPORATION AGENCY

Fig. 2.3.2.1-12 DRAINAGE BOX CULVERT

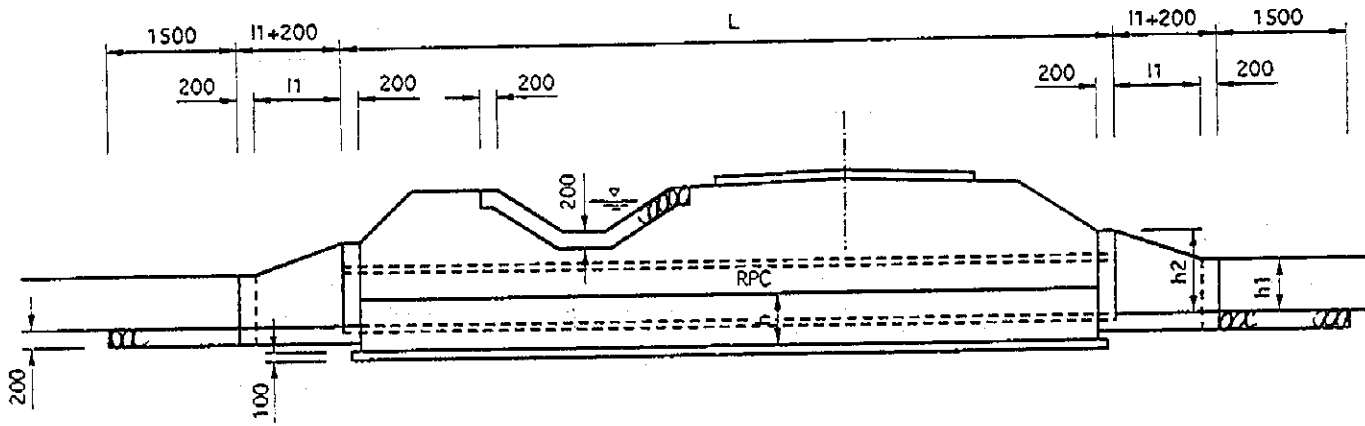
DRAINAGE PIPE CULVERT



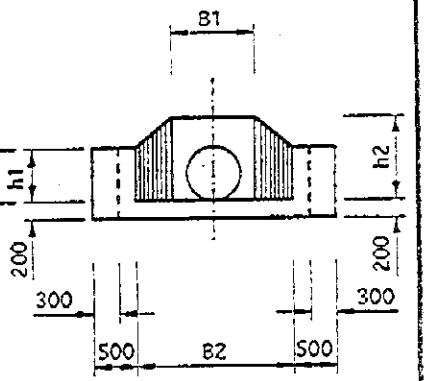
B-B SECTION



A-A SECTION



C-C SECTION



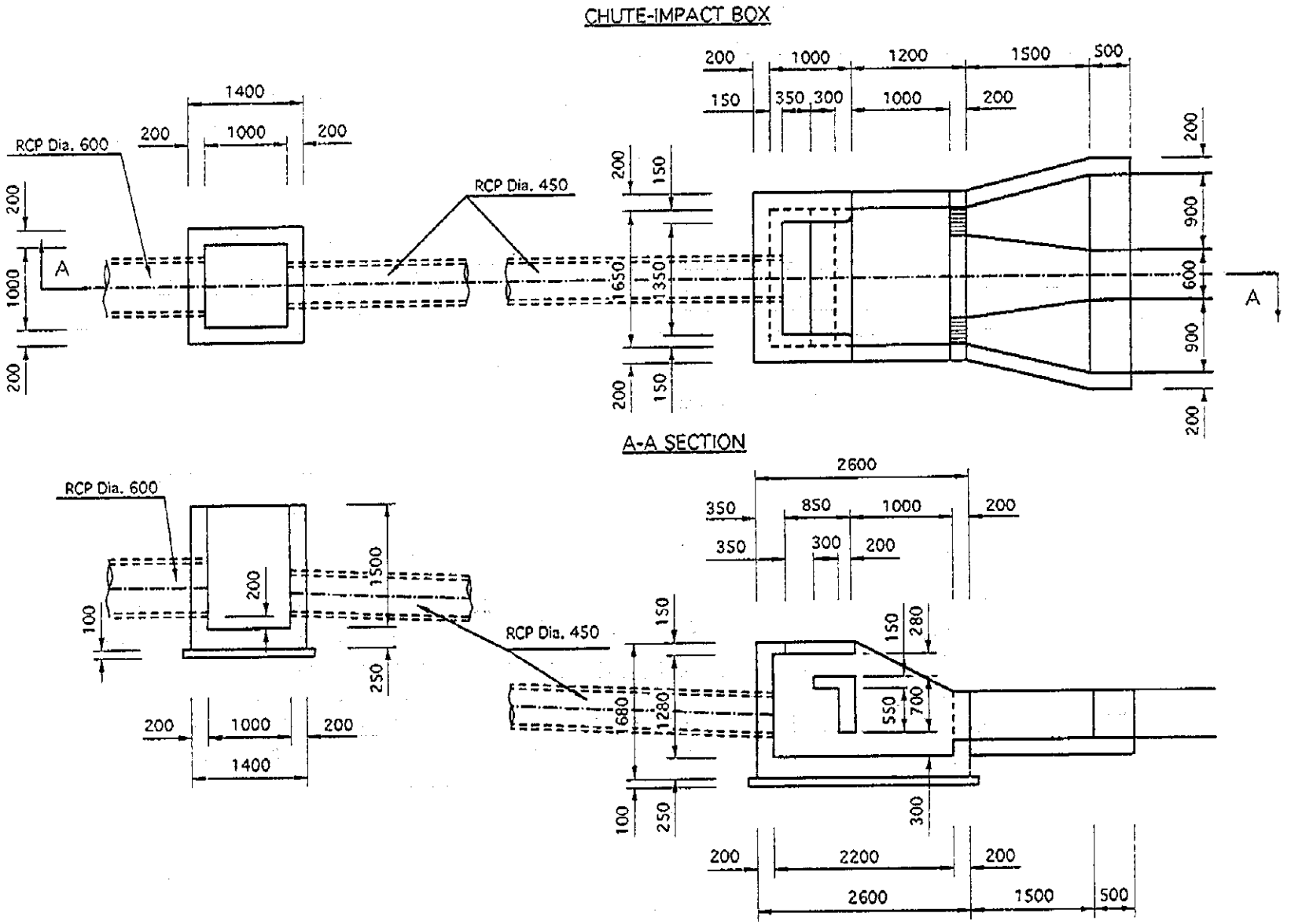
Unit; cm

TYPE	D(cm)	t	h	d	h1	h2	l1	B1	B2	Remarks
I	46(18")	6	50	90	80	60	100	80	150	
II	61(24")	7	60	105	95	60	100	95	180	
III	76(30")	8	70	125	110	60	120	110	200	
IV	107(42")	11	85	160	140	60	150	140	250	

BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT

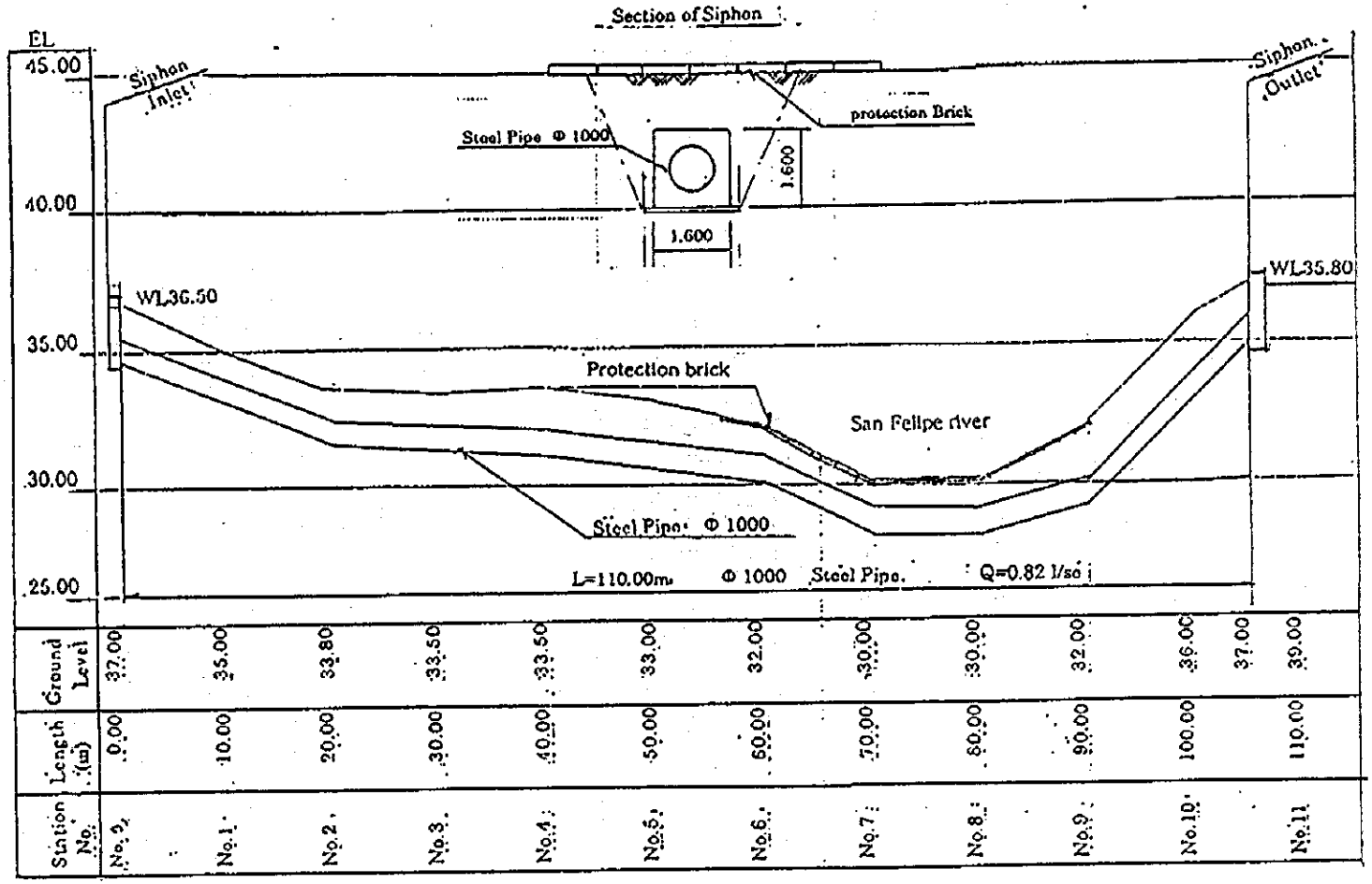
JAPAN INTERNATIONAL COOPORATION AGENCY

Fig. 2.3.2.1-13 DRAINAGE PIPE CULVERT



BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT	Fig. 2.3.2.1-14 CHUTE-IMPACT BOX
JAPAN INTERNATIONAL COOPORATION AGENCY	

SIPHON STRUCTURE



BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT	Fig. 2.3.2.1-15 SIPHON CANAL
JAPAN INTERNATIONAL COOPORATION AGENCY	

2.3.2.2 Dam & Reservoir Plan

(1) Determine Dam Scheme

The climatological condition in the project area is characterized by two seasons, the rainy season from May to October and the dry season from November to April. About 90% of annual rainfall is concentrated during the rainy season. On the other hand, the local farmers expect double cropping of rice production every year in order to increase their income. The proposed reservoir will become the main source of water for accommodating the expectation. It is necessary to have a reservoir plan to store the surface water as much as possible during the rainy season and release it effectively to the service area during the dry season.

The study for sizing of dam and reservoir is carried out in consideration of the following:

(A) Water Requirement and Reservoir Capacity

The service area of the project is approxi. 1,180 ha in total. The reservoir should have a capacity of approxi. 14 MCM to ensure the complete double cropping in the whole service area. However, as already explained in the previous section 2.3.2.1, it is decided that the required irrigation water is approx. 450 MCM which becomes the effective capacity of reservoir. The dam volume in this case becomes approx. 300 thousands m^3.

On the other hand, it is considered to be desirable to have a dam with the embankment volume of approx. 300 thousands m^3 from the viewpoints of economy and construction difficulties. The proposed project area falls on the first type of the climate zone and it has two pronounced seasons, the rainy & dry seasons. It is considered to be too costly to have a diversion tunnel or canal to divert the river flow for the construction during the rainy season. The cost increase would be approx. 350 - 400 million yen to construct a diversion tunnel with a capacity against a flood of 10 year return period (250m^3/s). Based on the construction schedule of the Western Barrios Impounding Irrigation Project and the preliminary study of the construction methods and schedule of the dam, it is considered to be reasonable to limit the dam embankment volume within approx. 400,000 m^3. But, it would be more appropriate to have a limit of dam scale within 30 - 35 million m^3 in consideration of unexpected accident as well as unusual weather/climate. In this case, it is possible to complete the embankment

works during a six months period of the dry season with a comparatively small scale diversion channel/structures.

(B) Dam Axis

It would be effective to set the dam axis in the downstream stretch of the San Felipe river valley, outlet to the low land areas with the service area. In case of upstream side, the inflow to the reservoir is reduced due to smaller catchment area and some additional works such as waterway and access road to the outlet of valley become necessary. In addition, the dam height has to be higher to secure the same impounding capacity. That is, it would be advantageous to have the dam axis at the valley outlet stretch from the viewpoints of construction plan as well as cost.

The alternative study , based on the dam volume & reservoir capacity curves, was carried out between the selected dam axis located in the river valley outlet and a representative axis located approx. 1 km upstream. It was comfirmed that the selected axis is superior to the upstream axis from the viewpoints of effective impounding as well as the construction cost.

Then the alternative study of dam axis was carried out among three axis in the river valley outlet stretch ; the upper, middle and lower axes. The upper axis is the selected one , the middle axis is the original site where the geological investigation was carried out by the Philippiness side a few years ago, and the lower axis is considered to have a priority from the topographic view. The interval between each axis is approx. 150 - 180 m.

As a result of geological investigation, it was found in the lower axis that the foundation rock in the river bed section is much deeper than the information from the F/S report. And consequently, it was anticipated that the cost for the excavation, foundation treatment and embankment is remarkably increased in the lower axis. On the other hand, the middle axis has also deeper foundation although approx. 2 m shallower than the lower axis. The upper axis has also deeper foundation although appro. 1 - 4 m shallower than the middle axis and the valley section is comparatively narrow in the upper section. In addition, it is expected to have some difficulties in the middle and lower axes to take countermeasures against a large scale gully located on the right bank side of the middle axis and the lower axis respectvely. It was decided from the comprehensive study that the upper axis

would be the best among the three alternative axes.

(C) Dam Type

In general, a fill type dam and a concrete type dam are considered to be the alternatives for the project. However, it is definitely suitable to built a fill type from the viewpoints of geological condition and availability of materials. The concrete type dam would have some adverse points in economy and safety. The cost & volume for the excavation, concrete, and foundation treatment would be remarkably increased to construct a concrete gravity dam on the foundation with deep foundation rock which is overburdened with the gravel layer (river bed) or weathered rocks (abutment). The fill-type dam has more flexibility for such foundation conditions and the construction materials are available from the nearby area.

(D) Reservoir Sedimentation Volume

There are many factors to estimate the reservoir sedimentation volume such as rainfall intensity, vegetation, soil erosion, slope garadient, and so on. The investigation was made for the actual records in some reservoirs in the Phillipines and also for the natural conditions in and around the reservoir area. However, no useful and reliable sedimentation records in a reservoir were found.

According to the comprehesive study on the sedimentation, it is decided to estimate the volume in reference to the estimated volume used in the Western Barrios irrigation project which is located in the similar natural conditions and in the nearby region. The estimated volume based on the project is 150,000 m^3 (126.2 $m^3/km^2/year$), however the design volume of sedimentation is decided to be approx. 500,000 m^3 (420.0 $m^3/km^2/year$) in consideration of safety factor. In Japan, where the sedimentation rate is generrally high due to mountains of younger age with steeper slopes, the average rate is approx. 380 $m^3/km^2/year$. Accordingly it is considered that the estimated design sedimentation volume is safer side as the age of mountain in the project area is old with gentle slopes.

(E) Basic Features of Dam & Reservoir

The basic features of dam & reservoir are decided to be as follows:

Height of Dam : 34 m

Crest Length	: 270m
NHWL	: Elev. 52.00 m
LWL	: Elev. 37.00 m
Total Reservoir Capacity	: 5.0 MCM
Total Effective Capacity	: 4.5 MCM

Note: LWL is decided based on the design volume of reservoir sedimentation. The reservoir has a capacity of approx. 500,000m^3 at LWL.

(2) Reservoir operation plan

The dam & reservoir has its objective to control the natural flow into the reservoir and to ensure timely discharge for the purpose of water supply for the irrigation system of 1,180 ha paddies located below the dam, the nursery of 2.35 ha, and the resettlement village with approx. 70 families , as sufficiently as possible. The spillway can serve to cut down the flood peak naturally, since the spillway will be constructed without gates in order to avoid artificial floods caused by erroneous gate operation. As stated in (1), the maximum storage of the reservoir is 5.0 million m^3. The annual average inflow into the reservoir is 43.6 million m^3, and a little more than 80% out of this flows in for the six months during rainy season. Therefore, it is not possible to control the entire inflow. However, based on the fundamental rule that the dam is filled up to the maximum at the end of the rainy season and reserved water is discharged during the dry season, the reservoir operation plan was examined to find the reliability of the reservoir for the irrigation plan and to calculate the irrigable area in the rainy season and that of the dry season.

The data used for the examination are as follows.

(A) Inflow to the reservoir

To calculate the inflow into the reservoir in the Sanfelipe river, the inflow data in the Nayom river for the 20-year period from 1960 through 1979 were converted by a proportional rate of the catchment areas of both rivers for the low-water discharge analysis.

(B) Evaporation loss

The evaporation loss of the reservoir is estimated at 70% of the evaporation record in the nearby observatory as the actual evaporation rate is higher than that of observatory. The pan evaporation data collected by the San Manul Observatory (with relatively long-term period and a few lacking records) in Pangasinan Province was used.

(C) Rainfall

The effective rainfall is calculated every 5 days unit. Daily rainfall of less than 5 mm is regarded as ineffective to paddy fields, and the excess over 150 mm in 5 days is also regarded as ineffective discharge. Under this condition, the average rainfall of the period 1956 through 1995 was calculated, and the irrigation water volume was planned based on the result of calculation.

(D) Rating curve of reservior

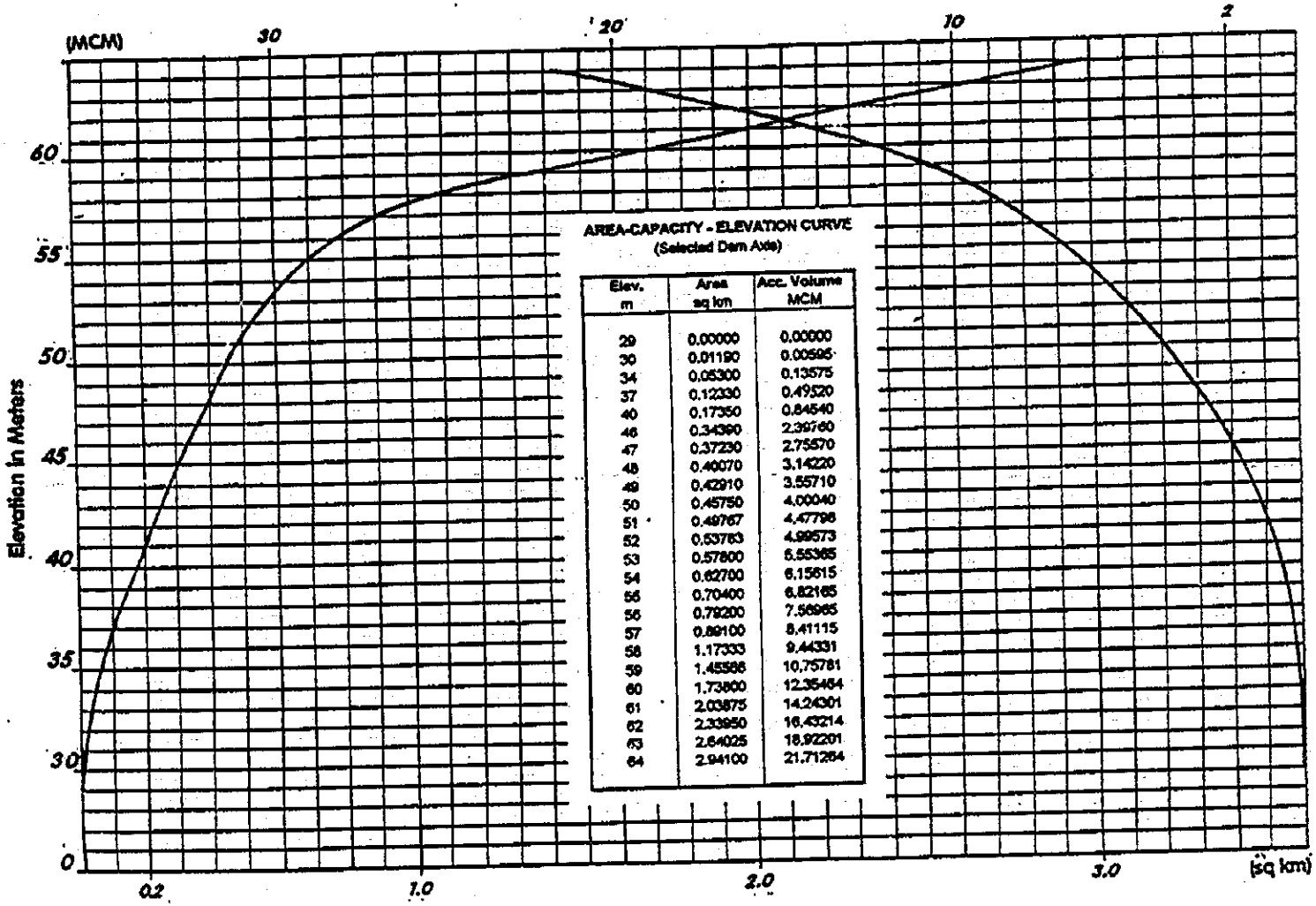
The rating curve of the reservior is drawn up based on the topographical map of 1/5,000 in scale . (See Fig.2.3.2.2-1)

(E) Water balance plan based on reservoir operation

Water balance calculation is performed based on the above mentioned conditions such as the storage capacity, river inflow, evaporation loss and irrigation water volume. The result of calculation is shown in Appendices.

According to the result, it is confirmed to be possible to supply supplemental water to the 1,180 ha of irrigation area (100%) in the rainy season. In the dry season, the irrigated area that may suffer from a shortage of water in February once in 4 to 5 years is approximately 53% or 620 ha. If the effective storage capacity is more than 1 million m^3 at the end of February, the third crop/irrigation for the areas of 150 - 200 ha will be possible.

However, it is noted that the substantial operation (the irrigabl area) is expected to vary depending on the actual rainfall of each corresponding year.



Elev. m	Area sq km	Acc. Volume MCM
29	0.00000	0.00000
30	0.01190	0.00595
34	0.05300	0.13575
37	0.12330	0.49520
40	0.17350	0.84540
46	0.34390	2.39760
47	0.37230	2.75570
48	0.40070	3.14220
49	0.42910	3.55710
50	0.45750	4.00040
51	0.49767	4.47798
52	0.53783	4.99573
53	0.57800	5.55365
54	0.62700	6.15615
55	0.70400	6.82165
56	0.79200	7.56965
57	0.89100	8.41115
58	1.17333	9.44331
59	1.45566	10.75781
60	1.73800	12.35464
61	2.03875	14.24301
62	2.33950	16.43214
63	2.64025	18.92201
64	2.94100	21.71264

インファンタ地区天水農業 環境整備計画基本設計調査 国際協力事業団	Fig. 2.3.2.2 - 1 Rating curve of reservoir