Pangasinan Province
The Republic of the Philippines

No. 1

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

March 1997

Japan International Cooperation Agency
INA Cooperation
NAIGAI Engineering Co., Ltd.

Pangasinan Province
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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 Infant 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 from April 9 to 23 and from Octber 2 to November 15 in 1996 respectively.

The team held discussions with the officials concerned of the Philippines Government , and conducted a field study at the study area. After the team returned to Japan, further studies were made. A mission was sent again to the Philippinesfrom February 26 to March 10 in order to discuss a 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 relationship between the two countires.

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 1997

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 Infant Impounding Irrigation and Environmental Improvement in the Republic of the Philippines.

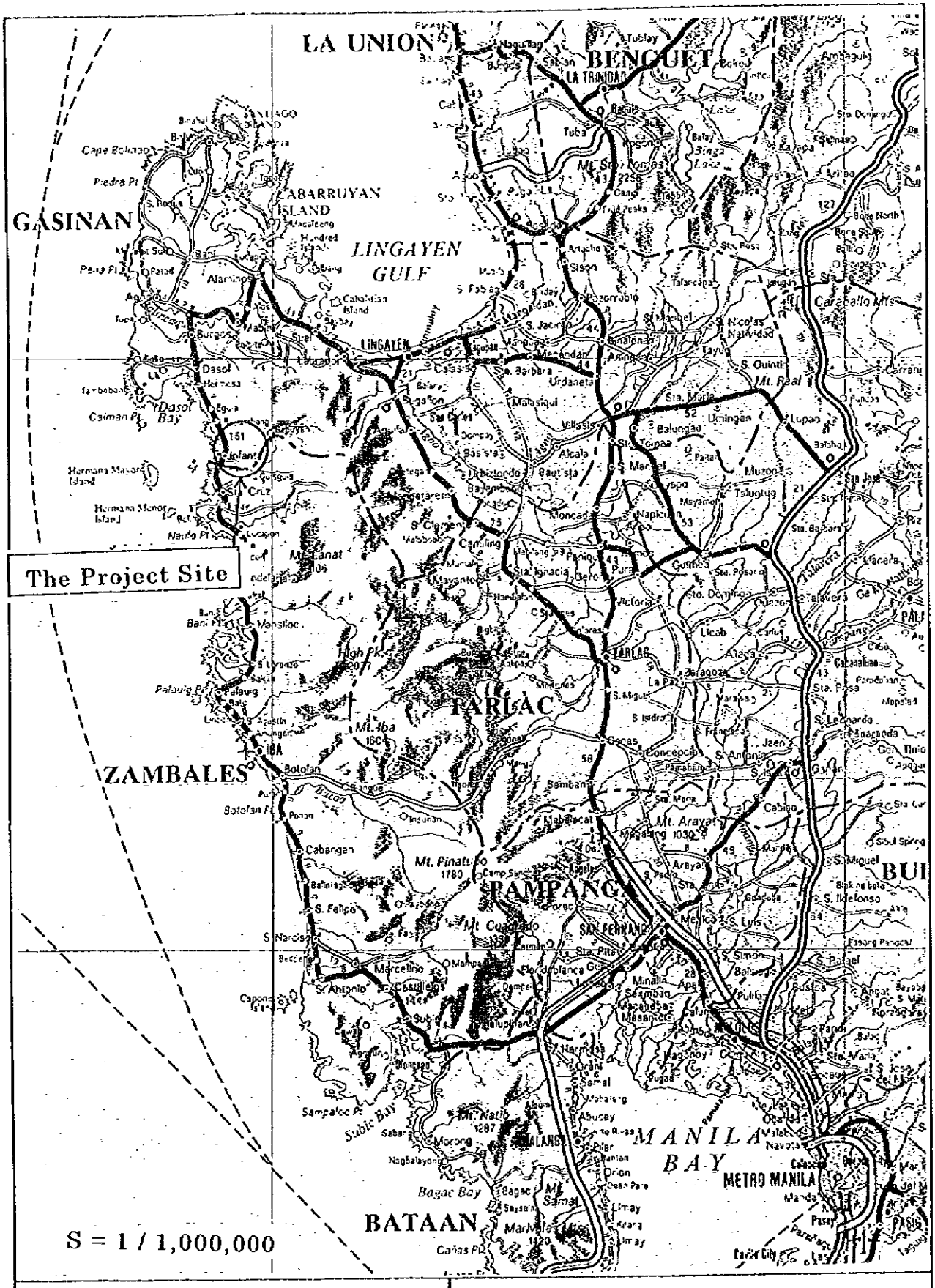
This study was conducted by Joint Venture of INA Corporation and Naigai Engineering Co., Ltd., under a contract to JICA, during the period from October 2, 1996 to March 31, 1997. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present 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

Joint Venture of INA Corporation and
Naigai Engineering Co., Ltd.

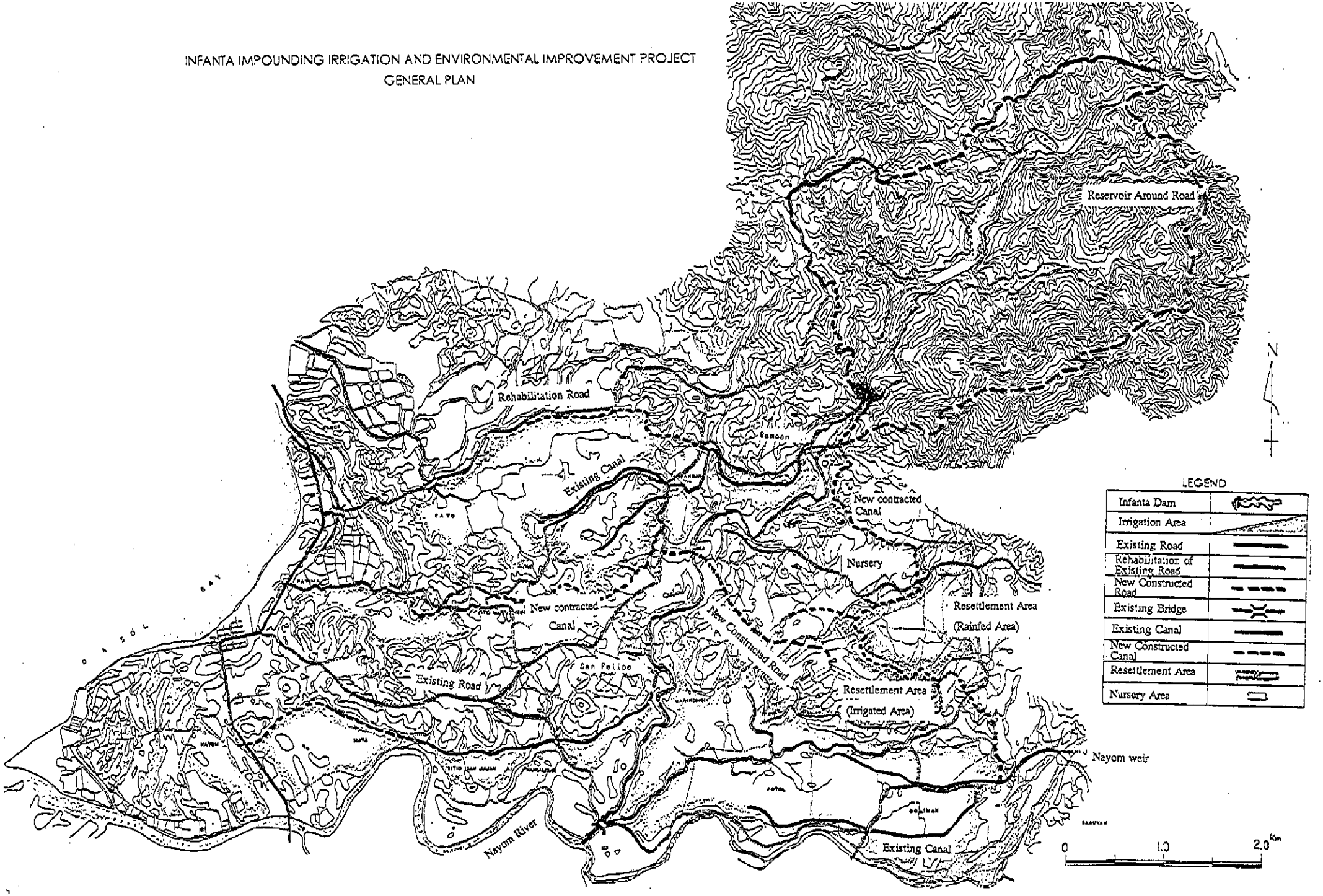


BASIC DESIGN FOR
INFANTA IMPOUNDING IRRIGATION AND
ENVIRONMENTAL IMPROVEMENT PROJECT

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

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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. I addition, the resettlement area is to be used for the smooth progress of the Project as it is used also for people who have to relocate due to the project implementation, especially in the proposed reservoir area.

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 1.2 times of a 200 year flood for the design, which is the standard condition in Japan, in consideration of insufficiency of the meteo-hydrological data. The design flood was decided basically by the unit-hydrograph method as the impounding effect can be expected to some extent. However, the appropriateness of peak discharge was checked by some other methods.

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 including the cases of Japan.

The reservoir capacity and the dam height were decided from a comprehensive viewpoints/study including the economic advantage and construction schedule in reference to the water balance calculation based on the irrigation plan, although the higher dam is advantageous in general from the point of only effective use of water resources in the river.

(B) Agriculture and Irrigation Plan

The irrigation area was decided at 1,280 ha in total (including 100 ha for the resettlement area) from the topographic conditions and the location of dam. Then the irrigation plan which makes complete (100%) irrigation in the rainy season and approx. 60% irrigation in the dry season, but all for paddy field, was prepared on the basis of economic advantage and construction suitability

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 3 routes with 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 appropriateness of resettlement area to be prepared by the Province was studied. And it was confirmed appropriate 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 farming for paddy (according to the results of soil tests). It was also confirmed that the area of approx. 220 ha would be reasonable in scale. The number of resettlers was tentatively decided at 70 families which consist of the Mt. Pinatubo victims coming from refugee camp, the Mt. Pinatubo victims already living in the Municipality, and the people living in and around the proposed reservoir area. It was also considered to give the resettlers the sufficient conditions for keeping an appropriate living standard in long term period.

The Japanese side will construct the main canal with some branch canals, road in the housing area, and water supply facility for the housing area. However, it was already agreed that the provincial side has to take responsibility for the further construction of housing, farm land preparation, power supply, and so on.

(E) Tree Nursery Plan

The location of 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	8,411,000m^3
	Effective Volume	8,000,000m^3
	Design Flood W. L.	EL 59.0m
	Normal High W. L.	EL 57.0m
	Low W. L.	EL 37.0m
Dam	Type	Center Core Fill Type Dam
	Dam Height	40.0m
	Crest Length	330.0m
	Crest Width	7.0m
	Dam Volume	423,000m^3
	Crest Elevation	EL 61.0m
Spillway	Type	Ungated side channel type
	Design Discharge	350m^3/s
Intake	Type	Inclined type
	Gate	Diameter 600mm, 4Nos.
	Energy Dissipater	Sluice Valve Diameter 600mm, 2 Nos.
	Conduit	Steel Pipe 1,800 mm in diameter

Irrigation Canal

Irrigation Area	1,280 ha (Including 100 ha of resettlement area)
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. 220 ha
(Irrigated area : 120 ha and Rainfed area : 100 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)
Canals (Diversion gate : 4 Nos., Canal : 3.25 km in total)

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

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

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 250 ha only is the irrigation area 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 60 % during the dry season. 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, 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.

(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.

(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 kinds of grouting 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 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 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 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. 4 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 rice paddies in the project area cover 1,385 ha. Irrigated area is 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 Pangasinan Province.

The proposed land use of the project area will be for paddy fields in the rainy season, and in the dry season that the irrigation water will be supplied, in consideration with present land use. 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 want rice production.

The benefited area of this project is the existing rice cropping area in the lowland around Infanta Municipality, Pangasinan Province. 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 for 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. Additionally, 100 ha of irrigation area are prepared for the farmers from the expected submerged area and the Pinatubo victims who are accepted by the Pangasinan Provincial Government. The entire benefited area covers 1,280 ha finally.

(B) Cropping pattern

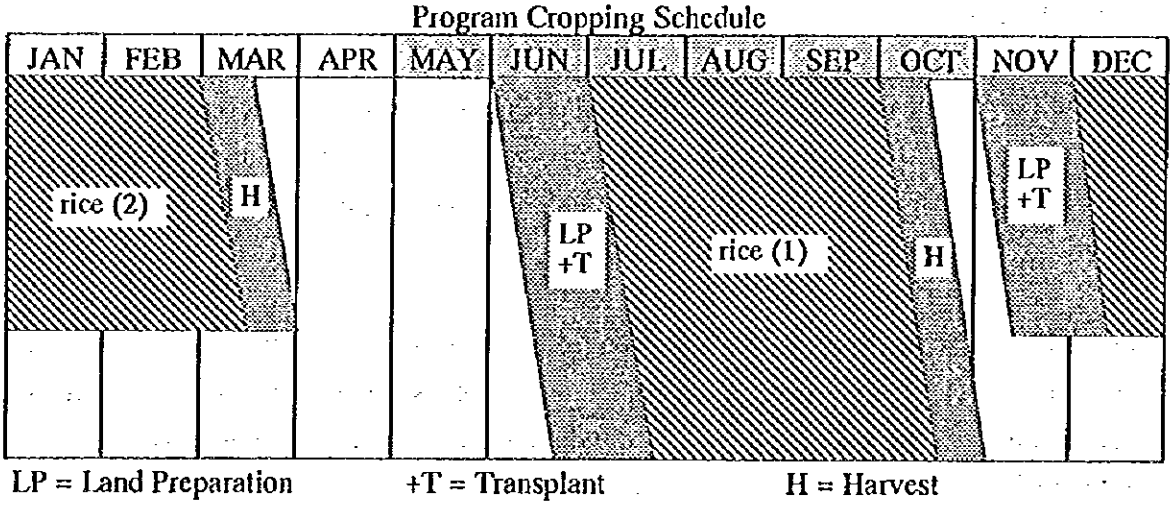
The irrigation plan is prepared as the cropping period is 120 days each for the rainy and the dry seasons. The water balance calculation was performed to estimate the irrigable area. As a result, the current cropping intensity of 123% is expected to be increased to 159%.

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	123
Post-project cultivation	1,280	760	0	2,040	159

*: 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 October, and the second November to mid March. The cropping schedule is shown in the following figure.



(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 February of the dry season, equivalent to 1,97 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 planed by the pan evaporation method as follows. Data of the evaporation is obtained at the San Manul 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 near the project site. The effective rainfall is calculated every 10 days. Daily rainfall of less than 5 mm is regarded as ineffective, and 180 mm in 10 days, which would exceed the height of the levee, is regarded as ineffective.

- 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 the following table.

IRRIGATION WATER REQUIREMENT

Month	①	②	③	④	⑤	⑥	⑦		⑧	⑨	⑩ 0.55
	Epan (mm)	Kp	ETo (mm)	Kc	Kh	ET (mm)	P (mm)	Total (mm)	mm/Month	mm/Month	mm/Month
Jan.	203	0.75	152.3	1.1	0	167	62	229	0	229	417
Feb.	250	0.75	187.5	1.1	0	206	56	262	0	262	477
Mar.	259	0.75	194.3	0.4	0	78		78	10	68	123
Apr.	230	0.75	172.5	0	0	0		0	34	0	0
May	147	0.75	110.3	0	0	0		0	160	0	0
Jun.	135	0.85	114.8	0.7	100	80	60	240	277	0	0
Jul.	119	0.85	101.2	1.1	50	111	62	223	339	0	0
Aug.	142	0.85	120.7	1.1	0	133	62	195	353	0	0
Sep.	139	0.85	118.2	0.683	0	81	60	141	304	0	0
Oct.	159	0.85	135.2	0	100	0		100	166	0	0
Nov.	137	0.75	102.8	0.6	50	62	60	172	54	118	214
Dec.	159	0.75	119.3	1.1	0	131	62	193	18	175	319

① Pan Evaporation ② Pan Coefficient ③ Crop Evapotranspiration
④ Crop Coefficient ⑤ Land Preparation Water ⑥ Crop Evaporation Transpiration
⑦ Percolation ⑧ Effective Rainfall ⑨ Crop Irrigation Requirement
⑩ Water Requirement

(B) Irrigation water requirement and irrigated area

If the entire 1,280 ha area (including 100 ha of the resettlement area) is taken for double-cropping, 15 million cubic meters of water is estimated as necessary for the irrigation. However, the optimum effective storage capacity is eight million cubic meters based on the natural and constructional conditions that are studied separately. This storage capacity can cover the complete 1,280 ha area with irrigation for paddy cropping during the rainy season. In the dry season the irrigated area is equivalent to 75% or 960 ha based on the average runoff of the San Felipe River for past 24 years. The irrigated area that may suffer from a shortage of water once in 4 - 5 years is approximately 65% or 760 ha. The result of calculation on water balance is shown in "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 8 million cubic meters. The existing 1,180 ha and the expected 100 ha for the farm land in the resettlement area, totaling 1,280 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	515	Dam
	Total	1,280	

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 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.

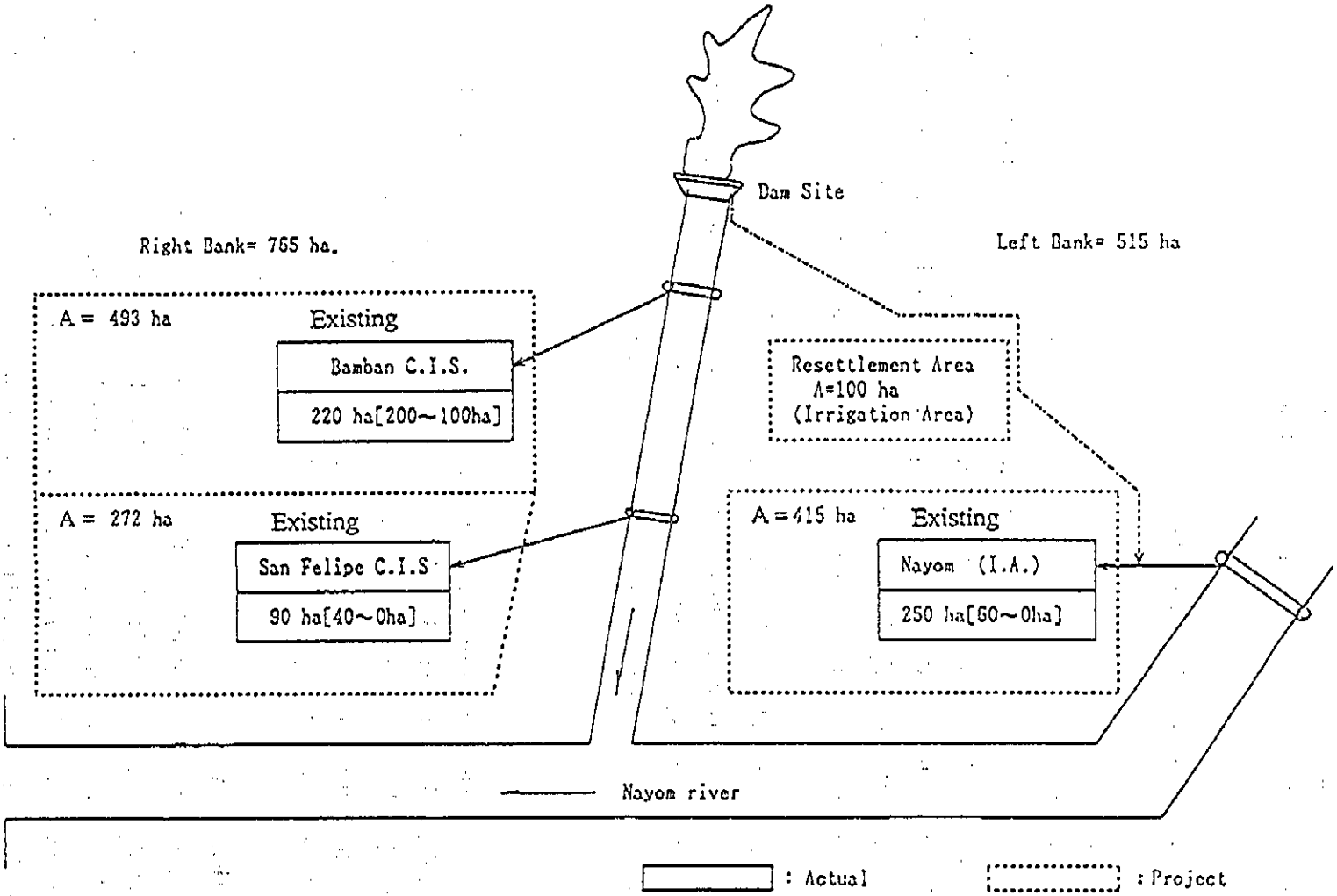
On the left river bank side of the San Felipe River, irrigation canals are newly constructed to take water directly from the dam and conduct it to the Nayom area. These canal are designed with the gentlest possible slope from the storage water level of the dam to be constructed so that they can irrigate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

(B) Design discharge

Since the seasonal maximum unit discharge is estimated 477 mm/month (February) 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 is 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 insufficient.



BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT

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FIG. 2.3.2.1-1 PLAN OF IRRIGATION SYSTEM AND BLOCK

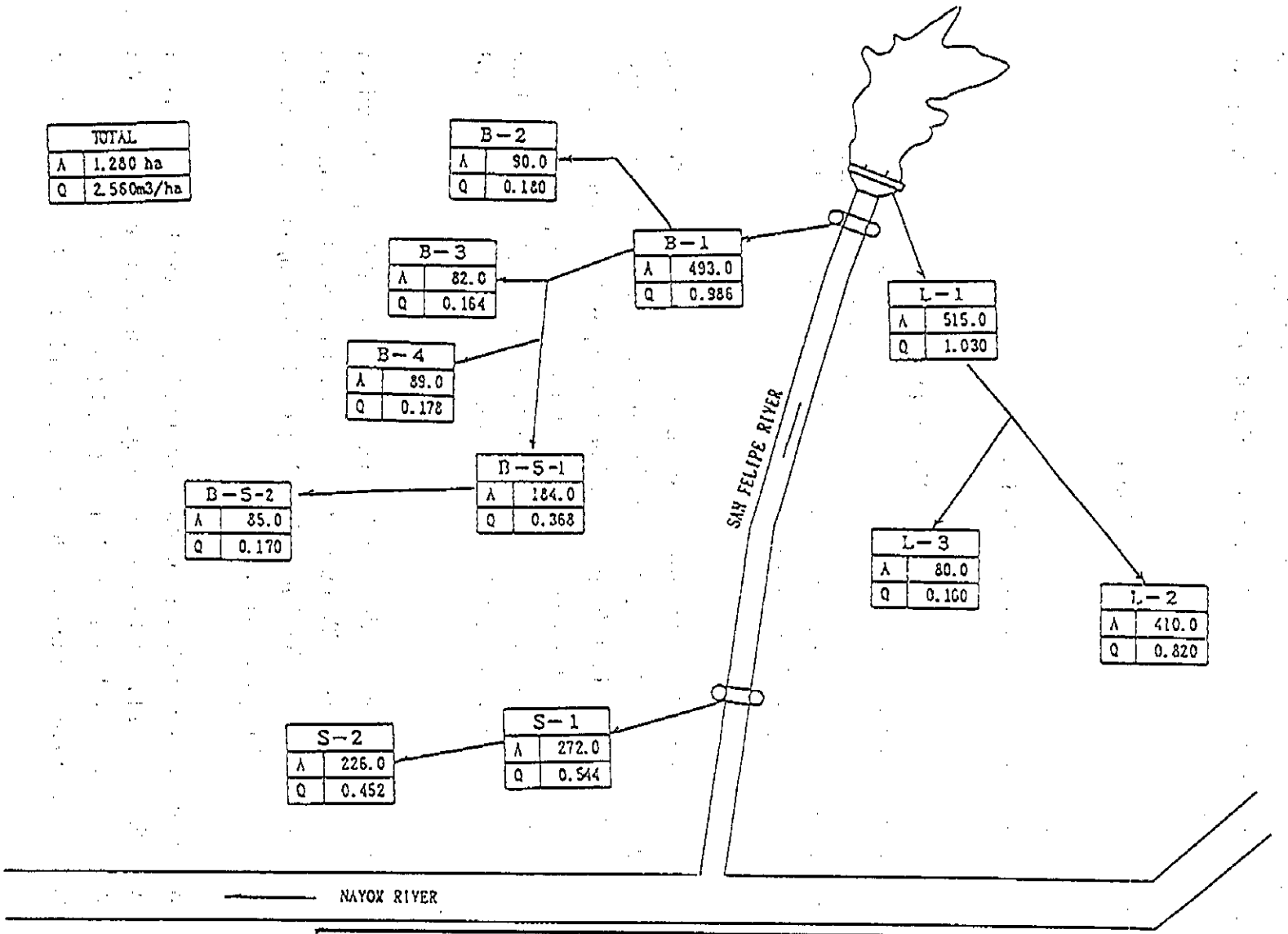

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FIG. 2.3.2.1-2 SCHEMATIC DIAGRAM OF IRRIGATION SYSTEM

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 the NIA design standards.

(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)

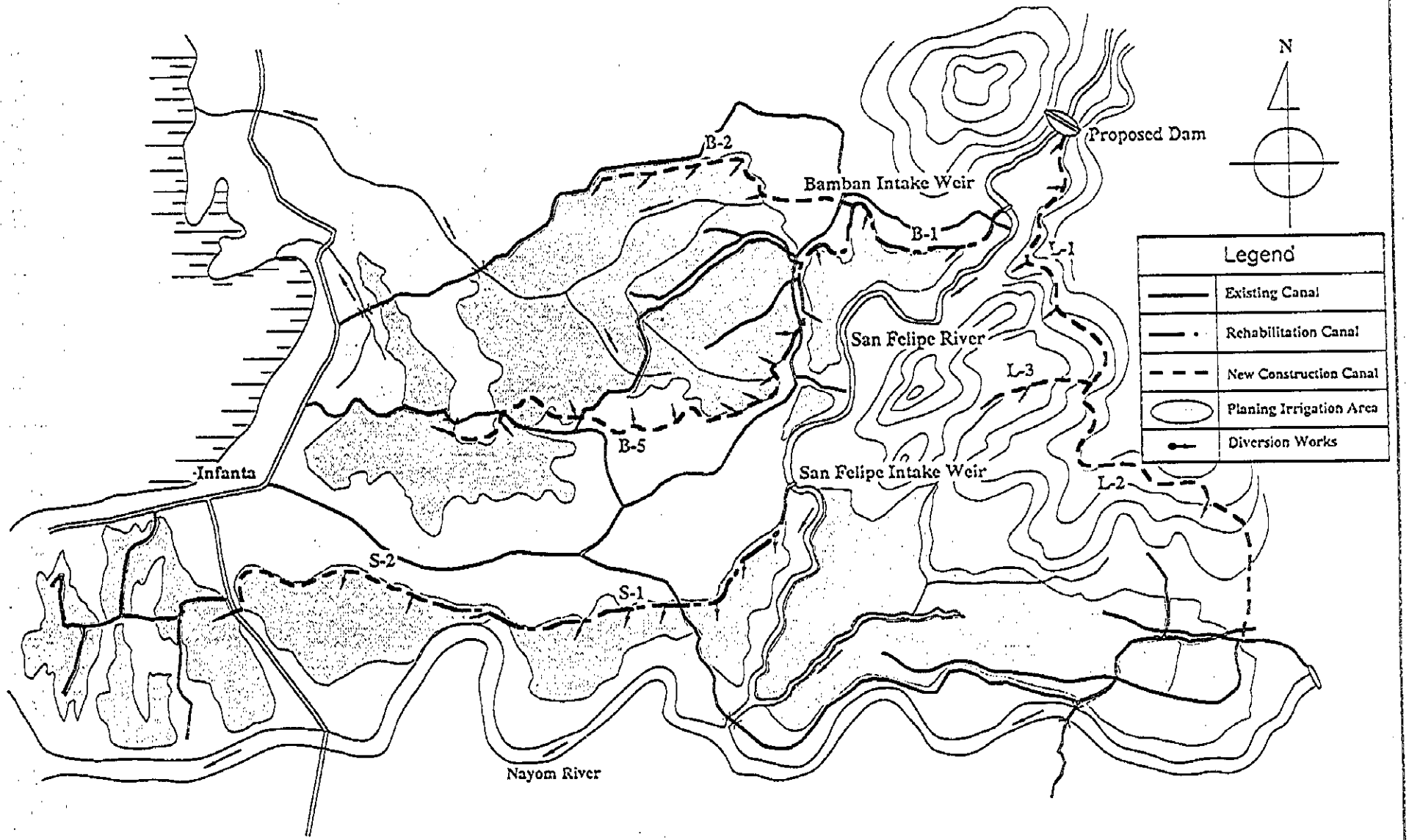
(E) Main irrigation canal

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.



BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT

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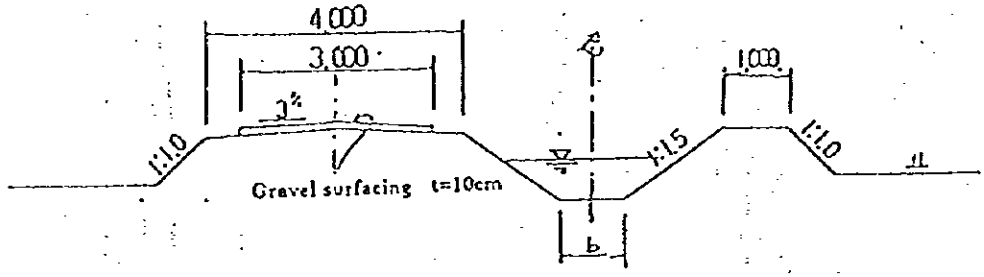
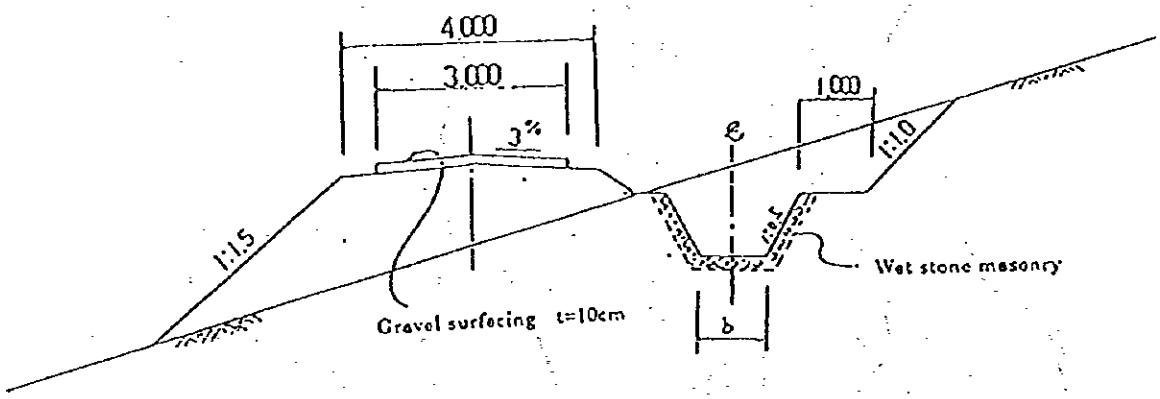
FIG. 2.3.2.1-3 PLAN OF IRRIGATION CANAL NETWORK

(1) Standard Section for Rehabilitation Canal



(2) Standard Section for New Counteraction Canal



BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT	FIG. 2.3.2.1-4 STANDARD SECTION OF MAIN CANAL
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Table 2.3.2.1-2 List of canal characteristic

Name of route	Beneficially area (ha)	Plan discharge(m³/s)	Length (m)	Construction category	Remarks
L-- 1	515	1.030	3,100	New construction	
L-- 2	410	0.820	3,230	〃	
L-- 3	80	0.160	600	〃	
B-- 1	493	0.986	2,720	Rehabilitation 〃)	
B-- 2	90	0.180	1,800	New construction	
B-- 3	82	0.164	(1,380)	Existing canal	Use of existing canal
B-- 4	89	0.178	(1,100)	Existing canal	Use of existing canal
B-- 5-1	184	0.368	3,880	Rehab. New const. 1,480+2,400	
B-- 5-2	85	0.170	900	New construction	
S-- 1	272	0.544	3,250	Rehabilitation 〃)	
S-- 2	226	0.452	2,230	New construction	
Total	(1,280)	(2.560)	21,710	New construction: 14,260m Rehabilitation: 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	

Name of Main Canal	Irrigated area (ha)	Number of Diversion Structures	Name of Main Canal	Irrigated area (ha)	Number of diversion Structures
L-1	515	5	B-5-1	184	5
L-2	410	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

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). Design will be made to complete the following canal network.

- The diversion structure connecting to the main canal will be located so that it can irrigate approximately 40 to 50 ha.

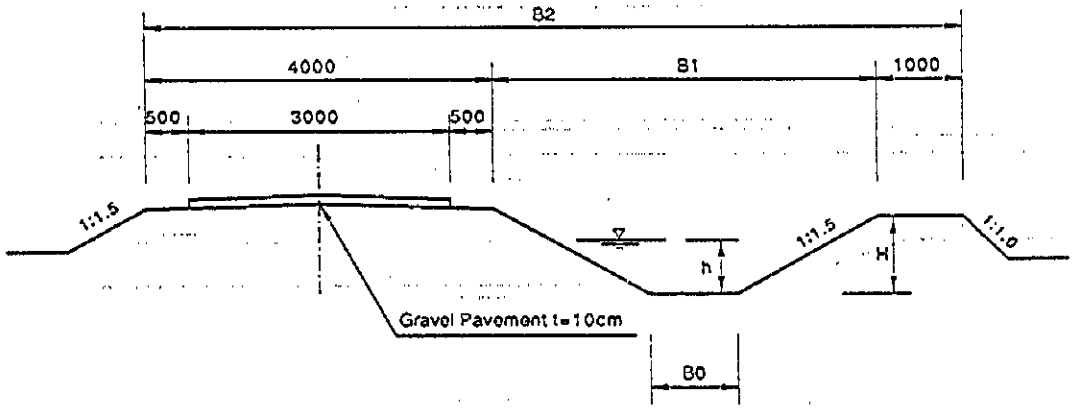
- Diversion is designed at a high-leveled location of each irrigation block so that secondary canals can easily be designed.

(3) Design of Canal

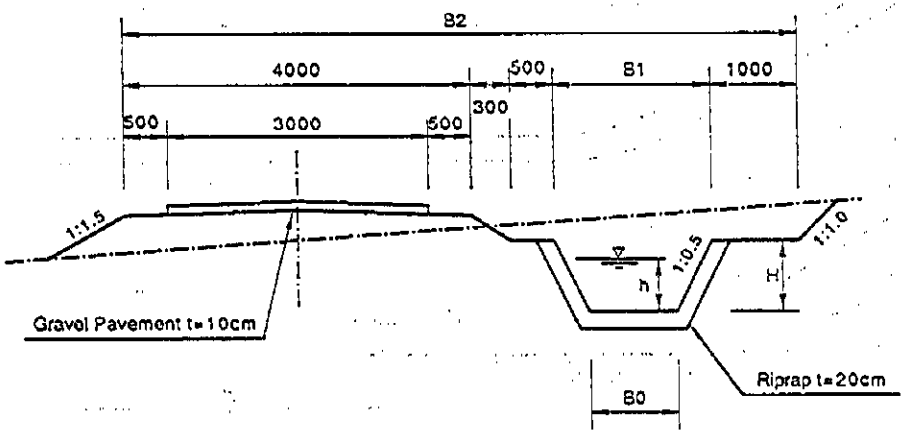
Canal and Related structures are shown in as follows. Longitudinal of canal also are shown in Technical reference.

TYPICAL CANAL SECTION

(Main Canal TYPE I)



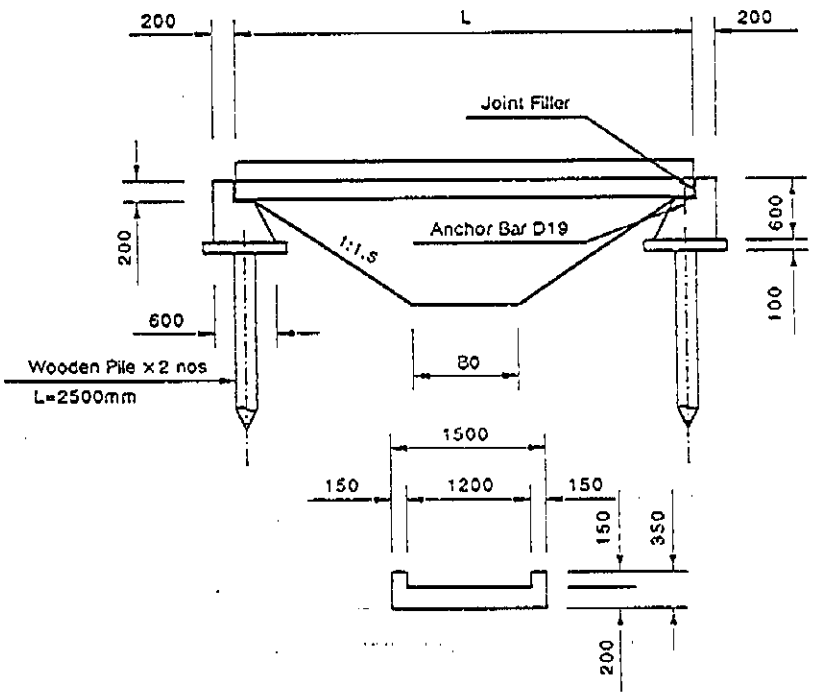
(Main Canal TYPE II)



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

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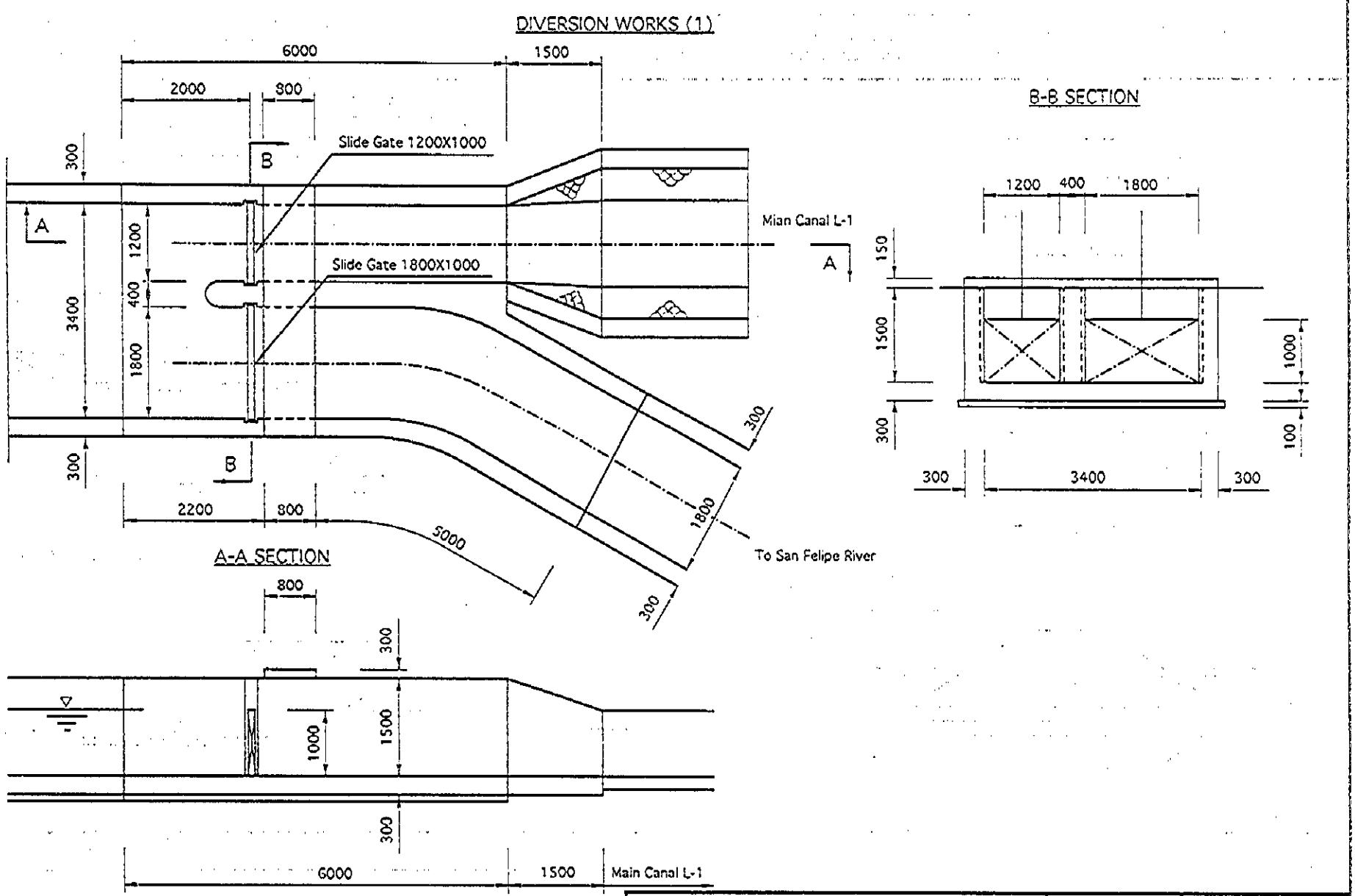
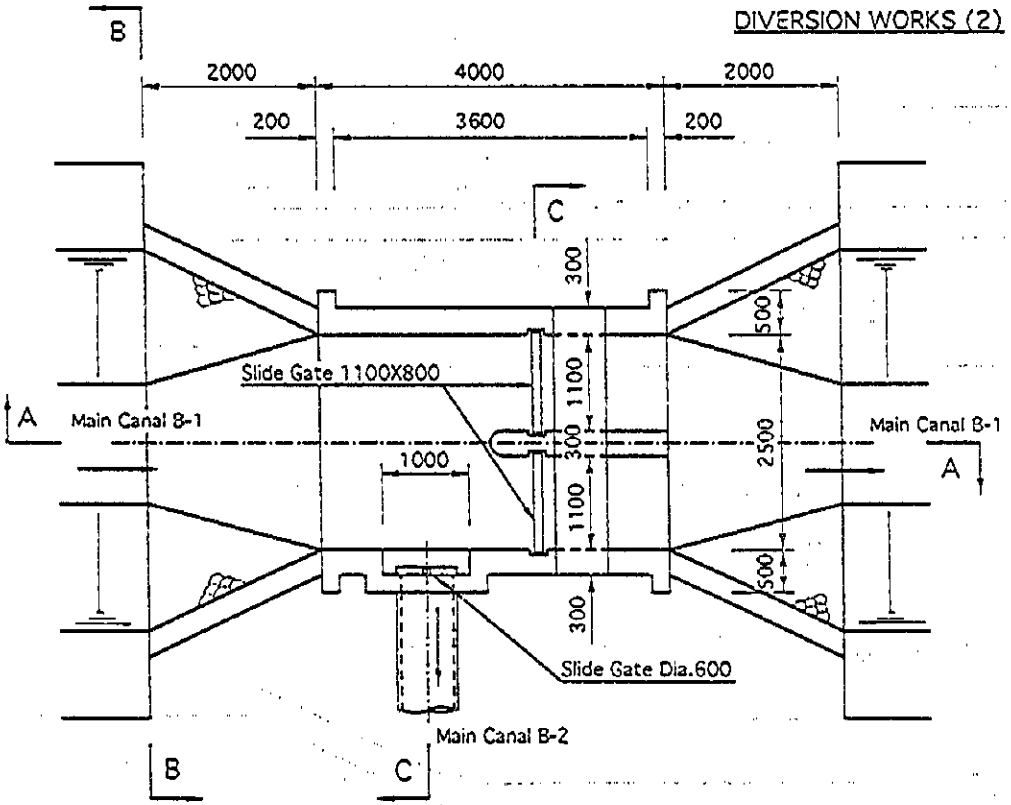
FIG. 2.3.2.1-5 TYPICAL CANAL SECTION

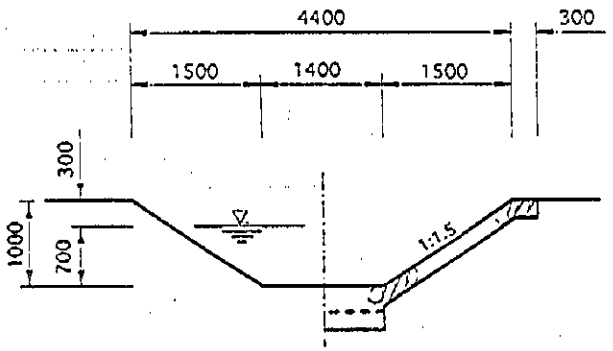


BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT	FIG. 2.3.2.1-6 DIVERSION WORKS (1)
JAPAN INTERNATIONAL COOPORATION AGENCY	

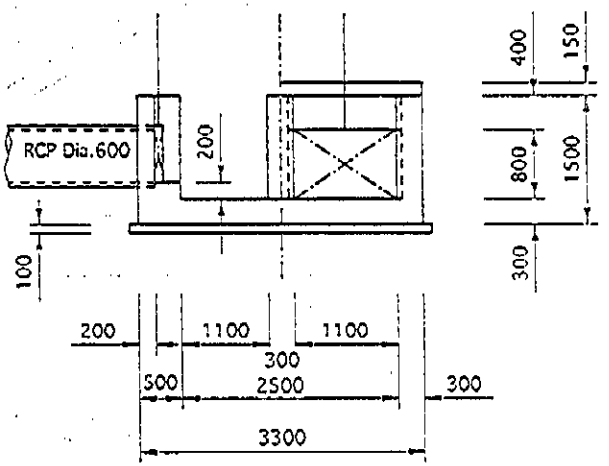
DIVERSION WORKS (2)



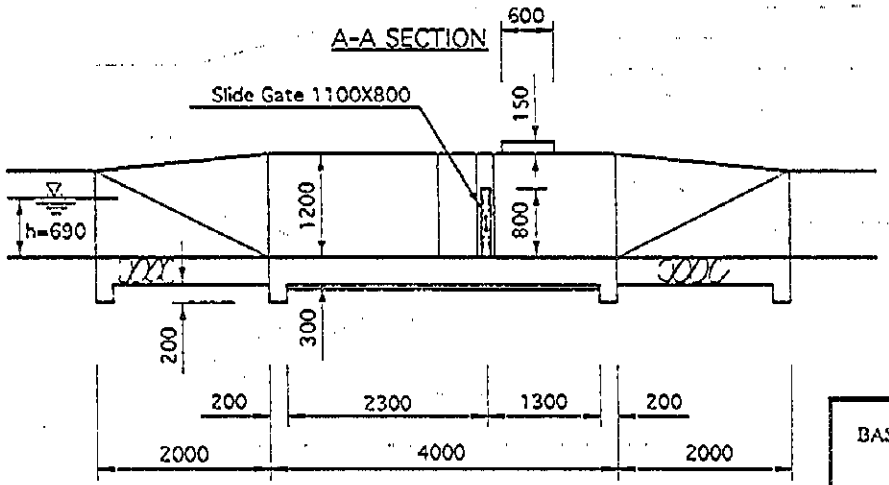
B-B SECTION



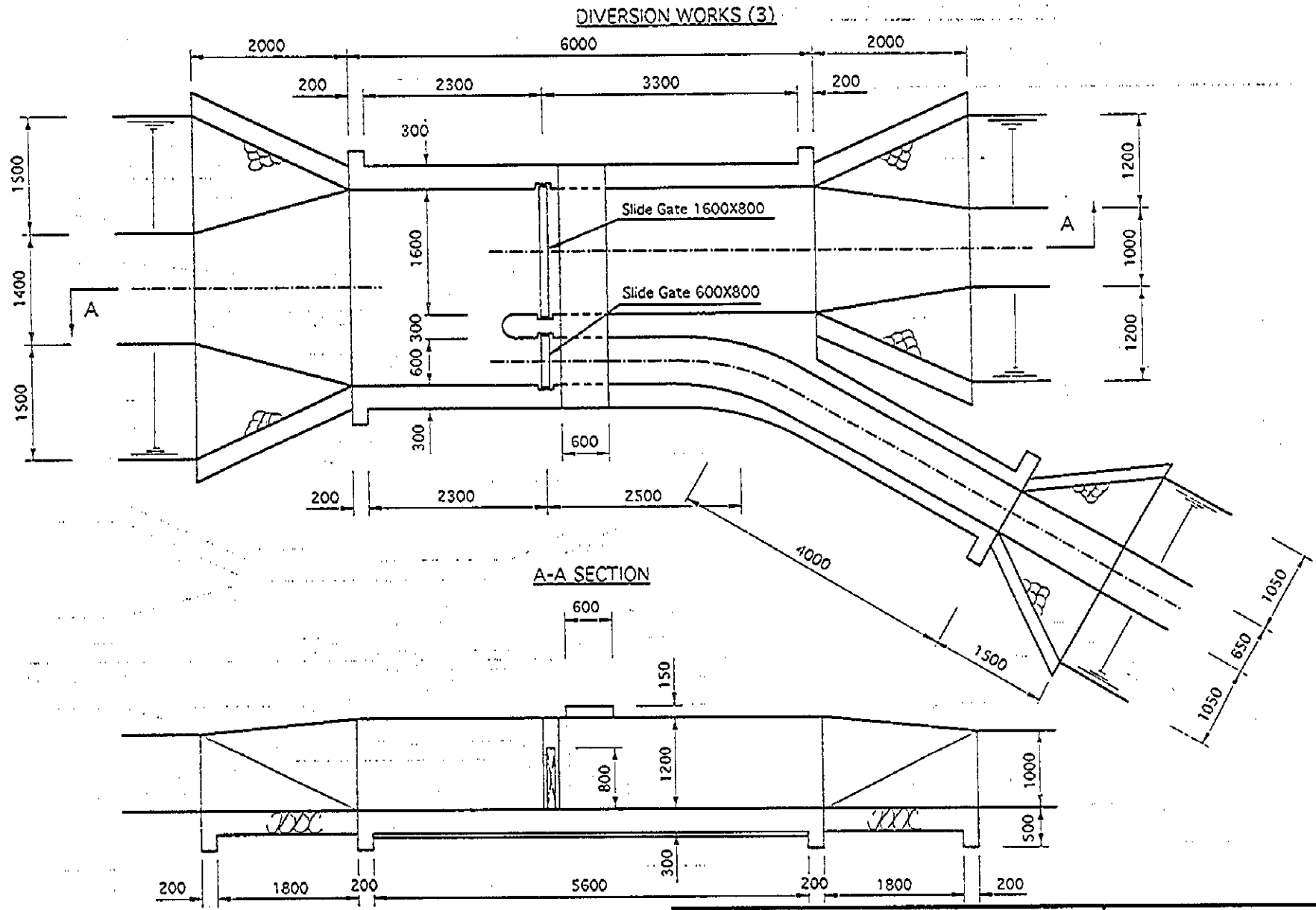
C-C SECTION



A-A SECTION



BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT	FIG. 3.3.2.1-7 DIVERSION WORKS (2)
JAPAN INTERNATIONAL COOPORATION AGENCY	



BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT	FIG. 2.3.2.1-8 DIVERSION WORKS (3)
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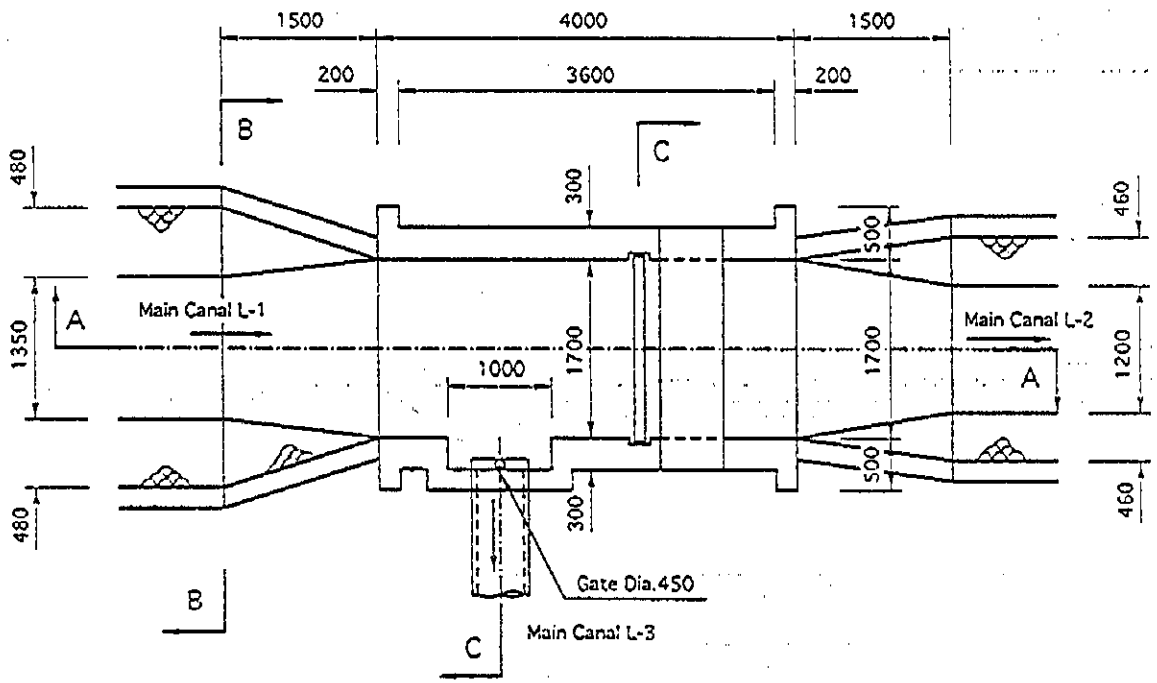
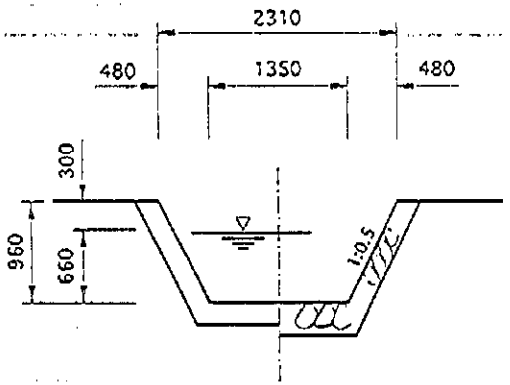
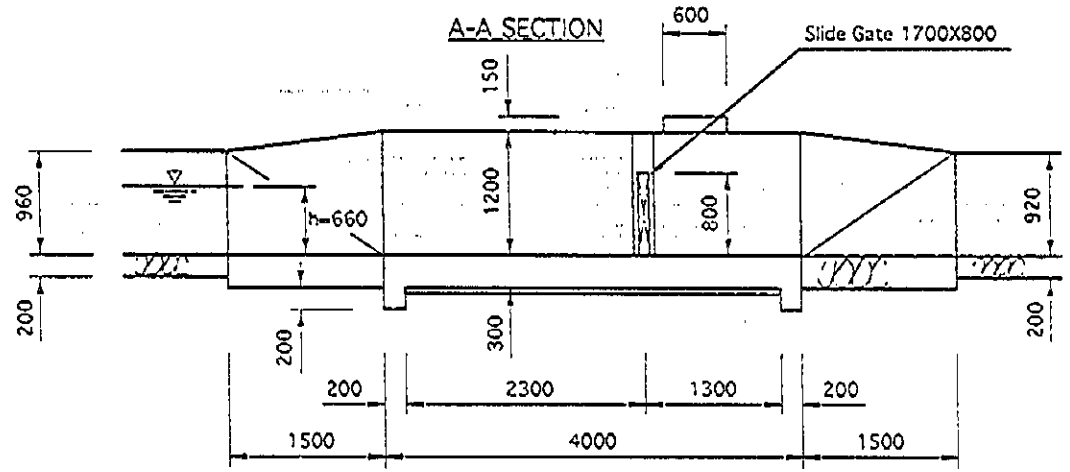
DIVERSION WORKS (4)



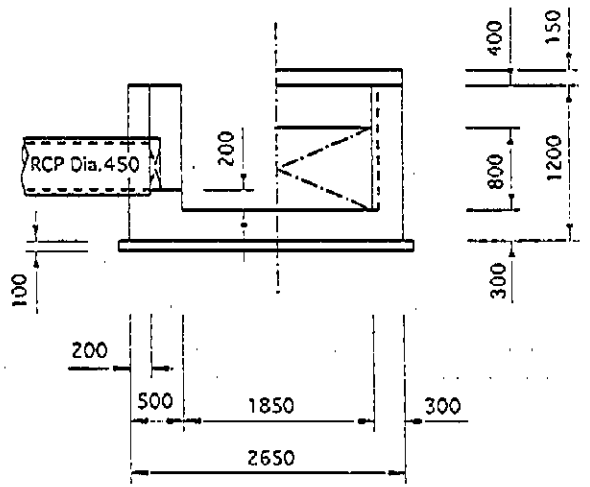
B-B SECTION



A-A SECTION

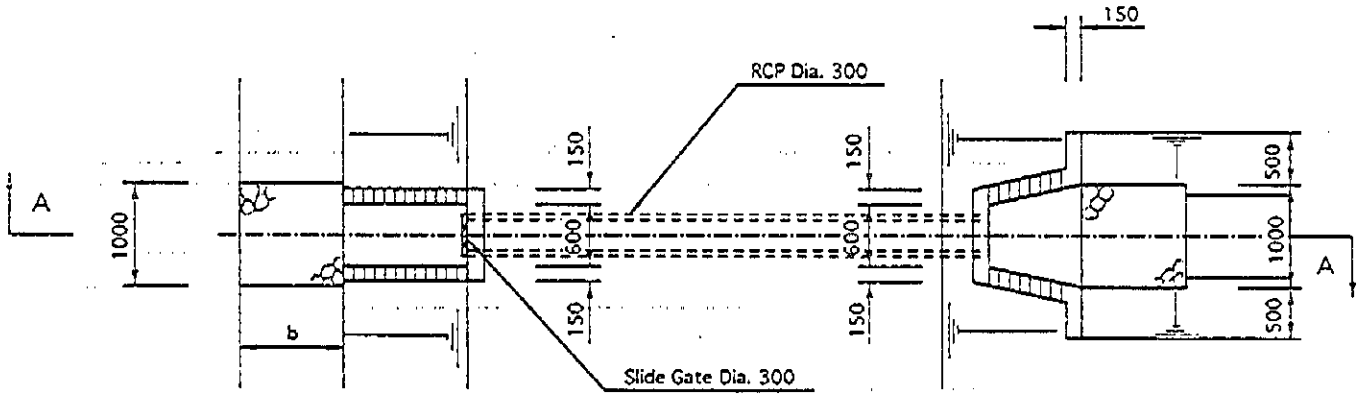


C-C SECTION



BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT	FIG. 2.3.2.1-9 DIVERSION WORKS (4)
JAPAN INTERNATIONAL COOPORATION AGENCY	

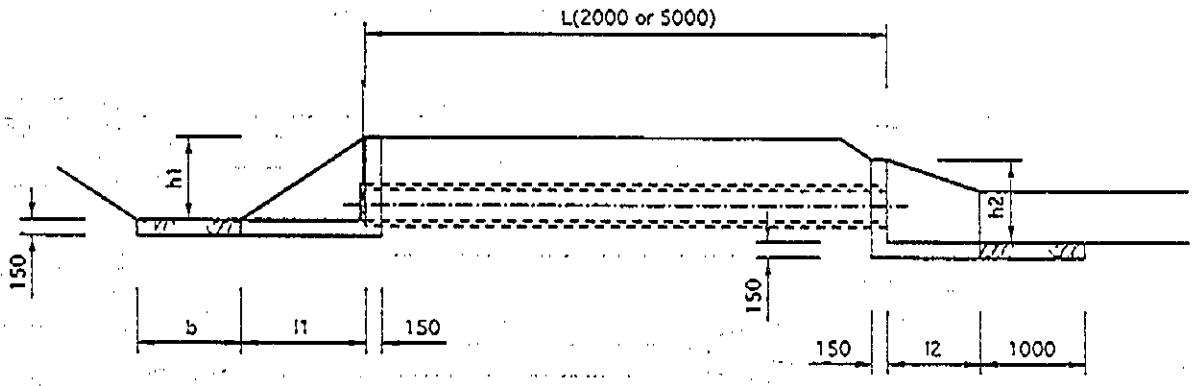
TURNOUT



Unit; m

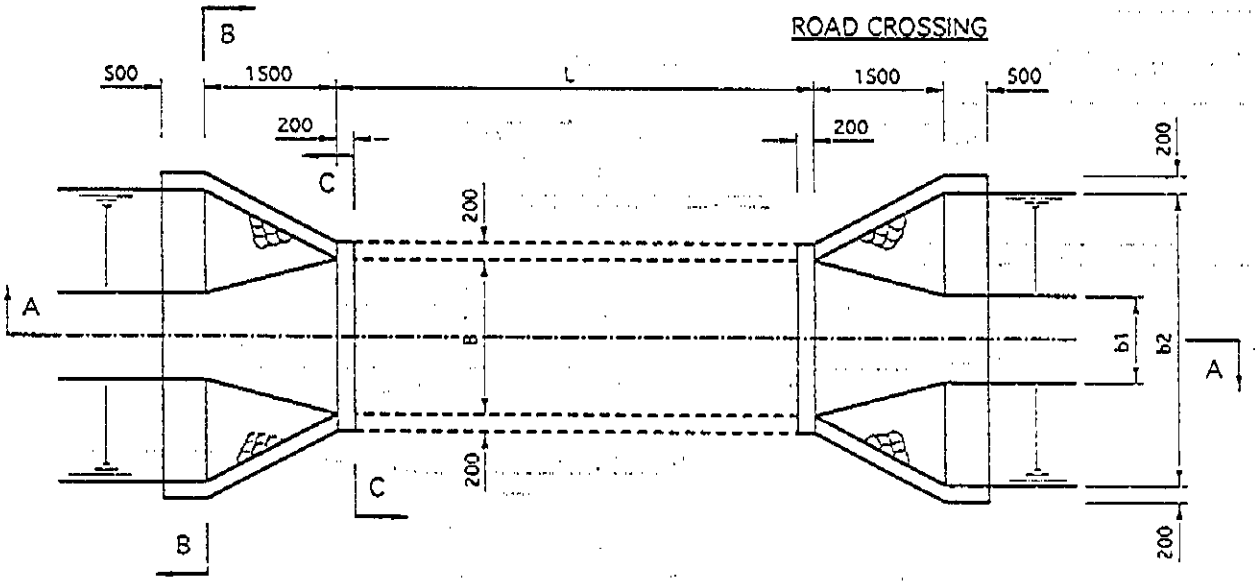
TYPE	b	h1	h2	l1	l2	Remarks
I	1.40	1.00	0.60	1.50	0.90	
II	1.10	0.90	0.60	1.35	0.90	
III	1.00	0.80	0.60	1.20	0.90	
IV	0.65	0.70	0.50	1.05	0.75	
V	0.60	0.65	0.50	0.98	0.75	
VI	1.35	1.00	0.60	0.50	0.90	
VII	1.20	0.90	0.60	0.45	0.90	
VIII	1.00	0.80	0.60	0.40	0.90	

A-A SECTION

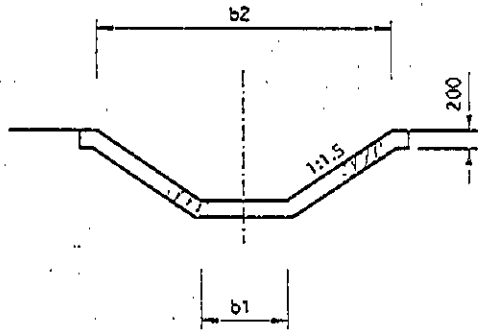


BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT	FIG. 2.3.2.1-10 TURNOUT
JAPAN INTERNATIONAL COOPORATION AGENCY	

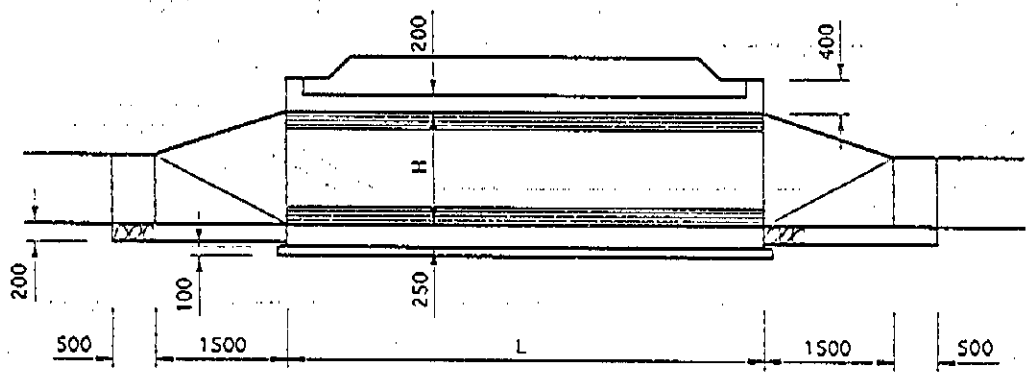
ROAD CROSSING



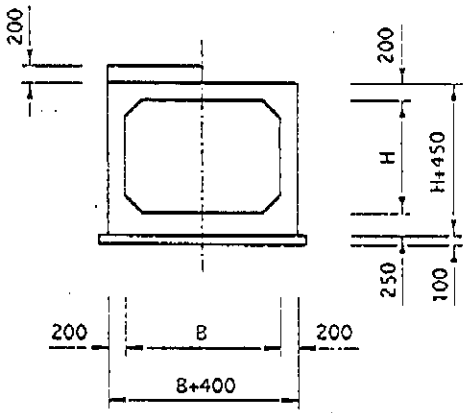
B-B SECTION



A-A SECTION



C-C SECTION



Unit: m

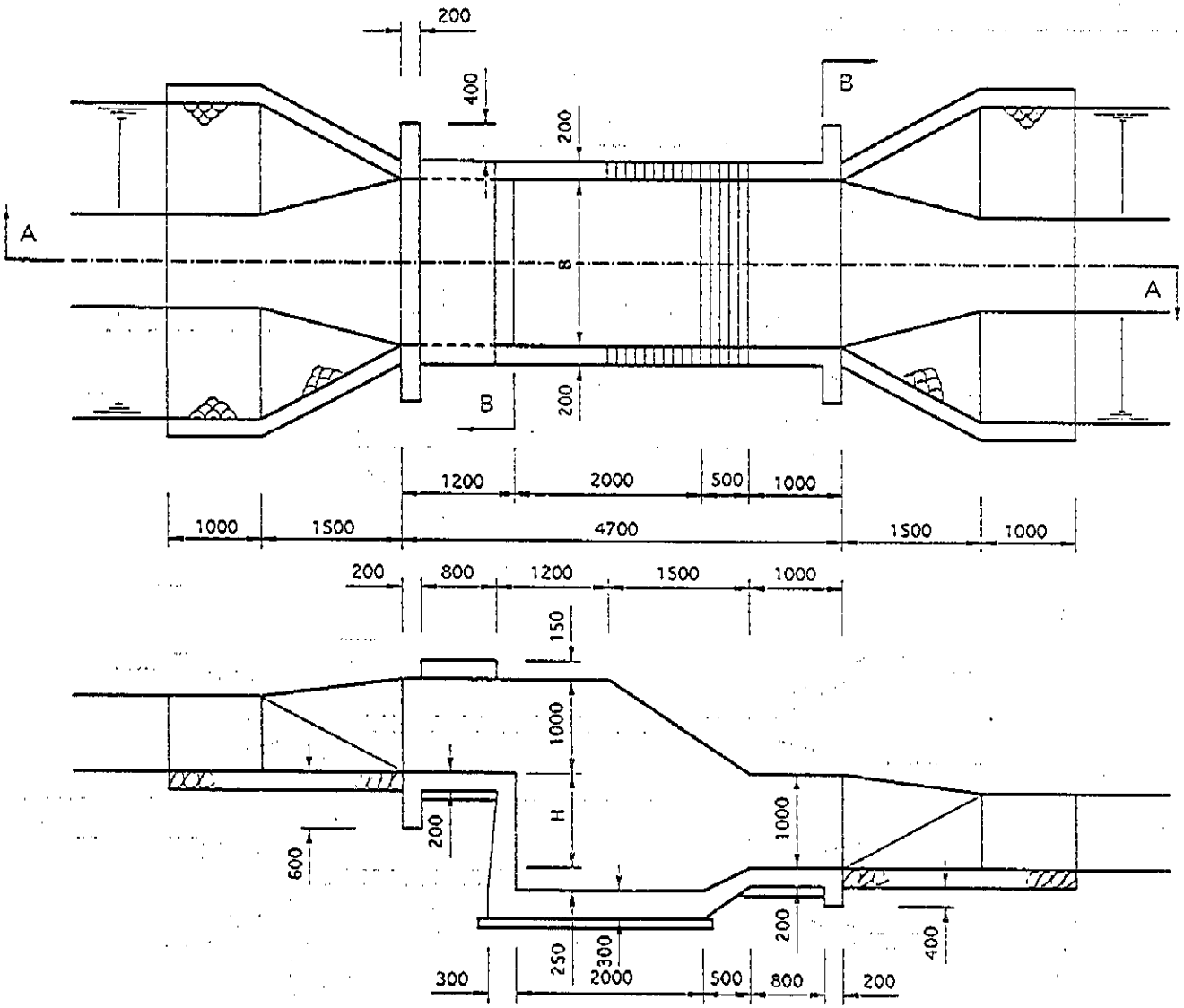
TYPE	b1	b2	B	H	Remarks
I	1.40	4.40	2.50	1.50	
II	1.10	3.80	1.90	1.40	
III	1.00	3.40	1.80	1.30	
IV	0.65	2.75	1.30	1.00	
V	0.60	2.55	1.20	1.00	
VI	1.35	2.35	1.70	1.30	
VII	1.20	2.10	1.50	1.20	
VIII	1.00	1.80	1.30	1.00	

BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT

JAPAN INTERNATIONAL COOPORATION AGENCY

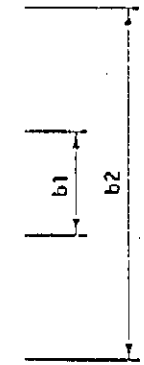
FIG. 2.3.2.1-11 ROAD CROSSING

DROP

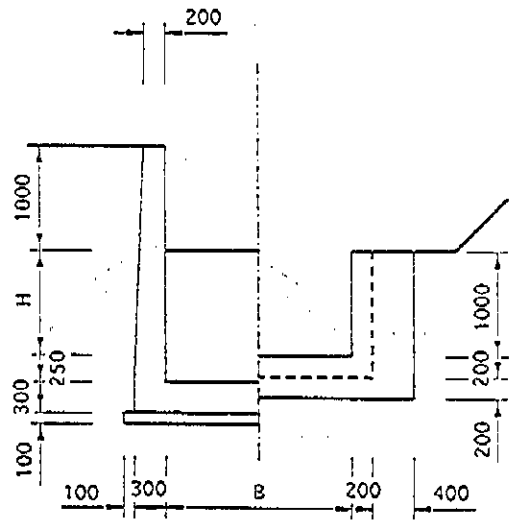


Unit: m

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



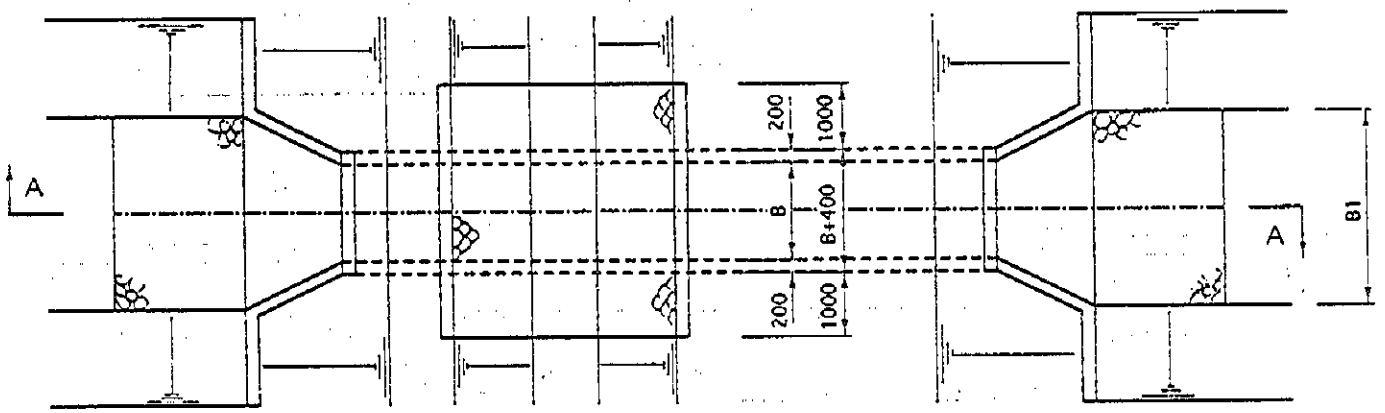
A-A SECTION

BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT

JAPAN INTERNATIONAL COOPORATION AGENCY

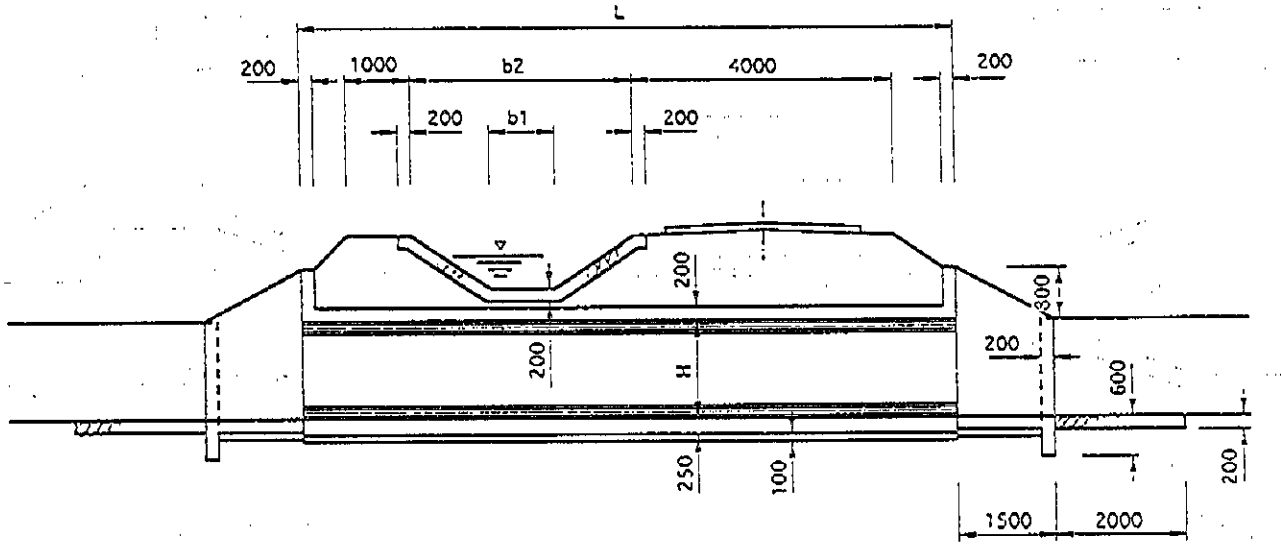
FIG. 2.3.2.1-12 DROP WORK

DRAINAGE BOX CULVERT



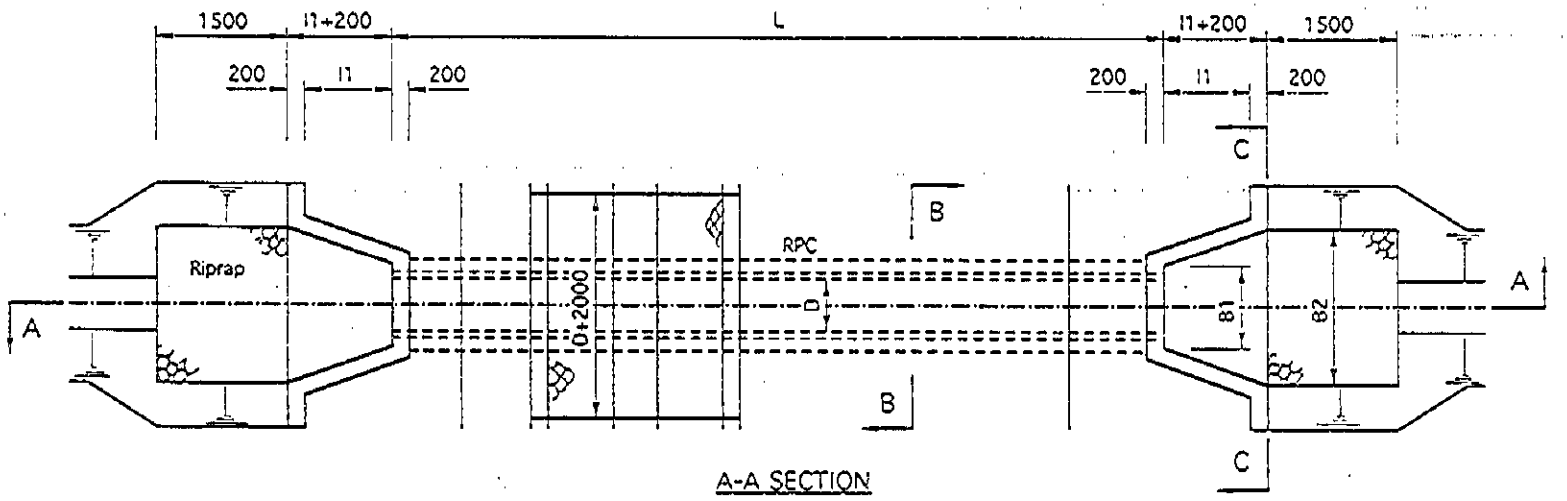
TYPE	H	B	B1	Remarks
I	1.00	1.00	2.00	
II	1.00	1.50	3.00	
III	1.50	1.50	3.00	
IV	1.50	2.00	3.50	
V	1.50	3.00	4.00	

A-A SECTION

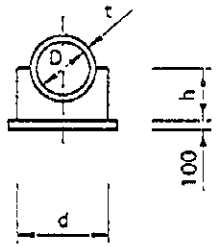


BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT	FIG. 2.3.2.1-13 DRAINAGE BOX CULVERT
JAPAN INTERNATIONAL COOPORATION AGENCY	

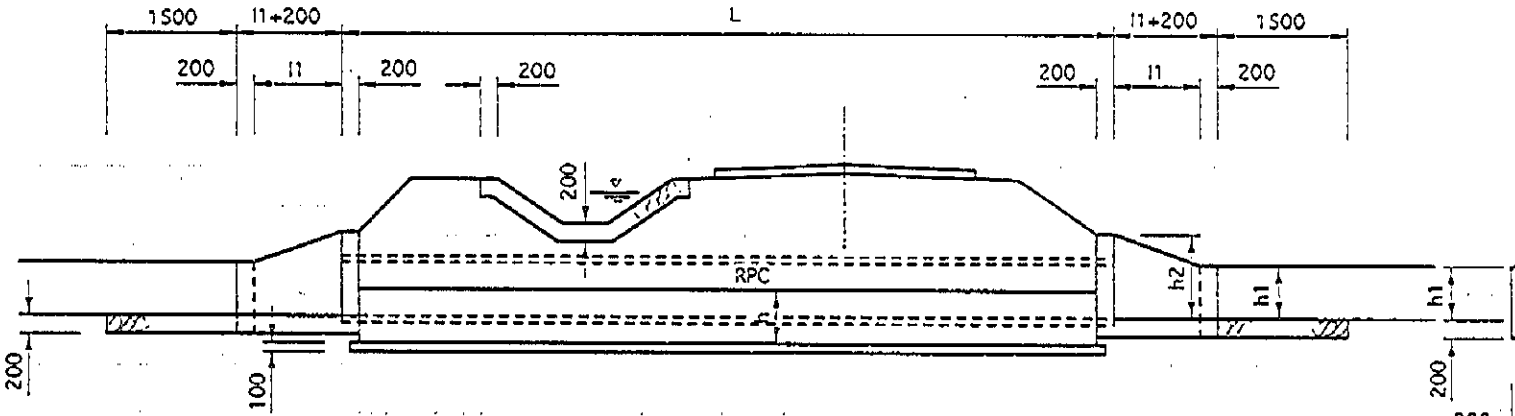
DRAINAGE PIPE CULVERT



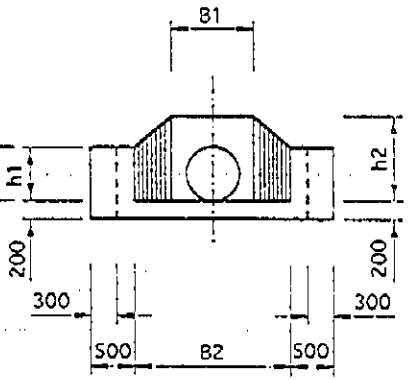
B-B SECTION



A-A SECTION



C-C SECTION



Unit: cm

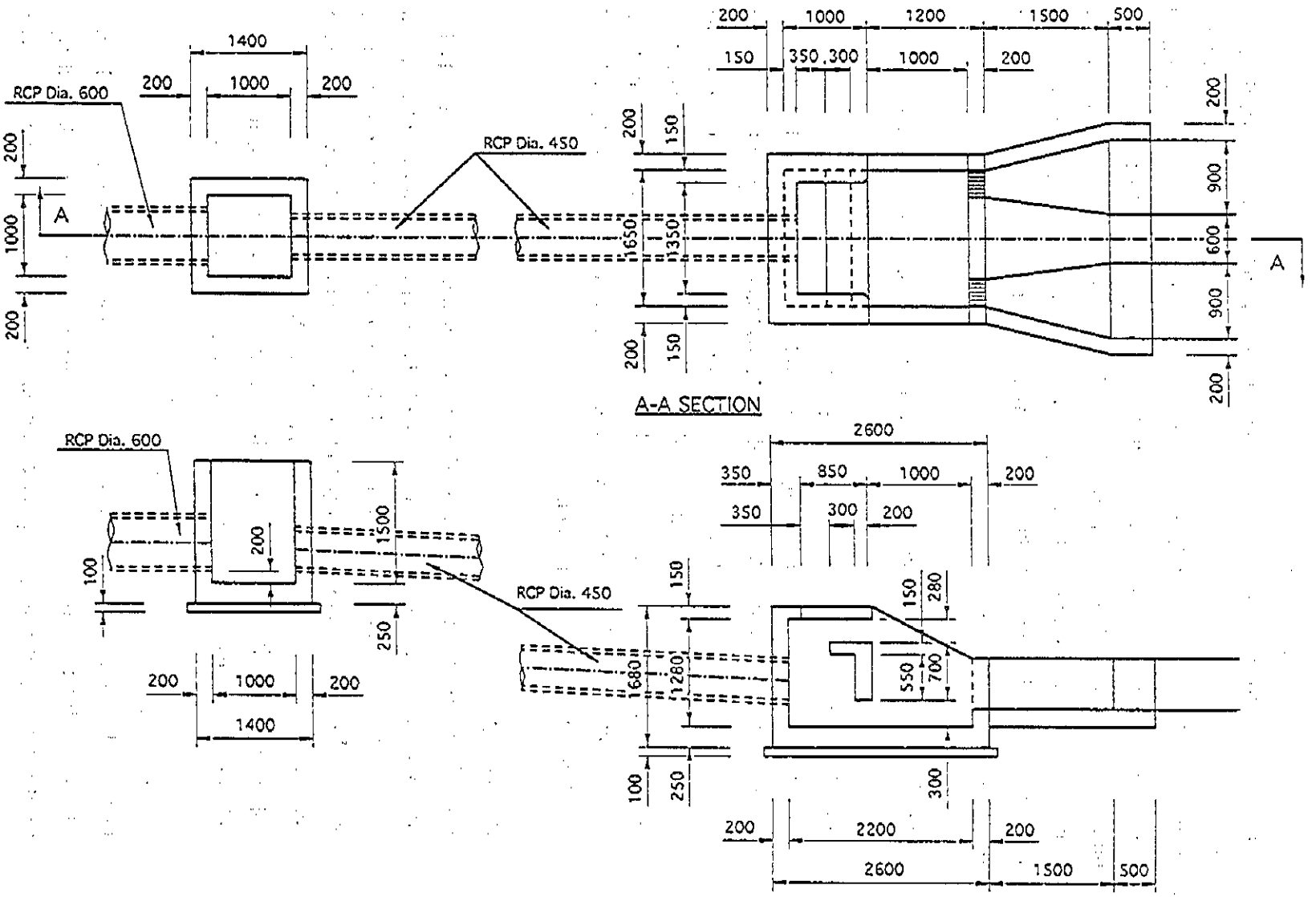
TYPE	D(cm)	t	h	d	h1	h2	l1	B1	B2	Remarks
I	46(18")	6	50	90	80	60	100	80	150	
II	61(24")	7	60	105	95	60	100	95	180	
III	76(30")	8	70	125	110	60	120	110	200	
IV	107(42")	11	85	160	140	60	150	140	250	

BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT

JAPAN INTERNATIONAL COOPORATION AGENCY

FIG. 2.3.2.1-14 DRENAGE PIPE CURVERT

CHUTE-IMPACT BOX



BASIC DESIGN FOR INFANTA IMPOUNDING IRRIGATION AND ENVIRONMENTAL IMPROVEMENT PROJECT	FIG. 2.3.2.1-15 CHUTE - IMPACT BOX
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. 1,280 ha in total which consists of 1,180 ha of the existing paddy fields and an additional 100 ha in the proposed resettlement area. The reservoir should have a capacity of approxi. 15 MCM to ensure the complete double cropping in the whole service area. On the other hand, it is considered to be desirable to have a relatively small dam due to local conditions such as rainfall, earthquake intensity and other natural conditions, and limitation of construction period due to rainfall.

(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.

(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) Dam Volume

The proposed project area falls on the first type of the climate and it has two pronounced seasons, the rainy & dry seasons. It is considered to be impossible to carry out the dam embankment within one dry season and it is 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) . Acordingly, it is considered to be reasonable to carry out the embankment works only during the six months period of the dry season, with small scale diversion facility. 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.

(E) Reservoir Sedimentation Volume

There are many factors to estimete 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.

According to the comprehesive study on the sedimentation, it is decided to estimate the volume based on 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. 355,000 m^3 (300.0 $m^3/km^2/year$) in consideration of safety factor.

The study on dam & reservoir plan is to be carried out in two stages, as follows:

(1.1) Preliminary Study (Comparison and Determination of Alternative Scheme)

The data used in the study are the feasibility study report, a 1:1000 scale topographic map of the damsite, the geological report, the hydrological data of Nayom gauging station, and 1:5000 topographic maps of the project area which were prepared by the JICA study team in 1996. That is, the results of geological survey for the basic design are not yet obtained in this preliminary study.

The preliminary study is carried out for two alternatives of dam axis, the upper axis and lower axis, in which the upper axis becomes the middle axis in the study on the optimum scheme. The dam volume and reservoir capacity of these alternatives at normal high water level are calculated as shown in Table 2.3.2-1 and Table 2.3.3.2-1.

Table 2.3.2.2-1 Upper Axis Plan

HWL m	Reservoir Capacity MCM (A)	Dam Volume m^3 (B)	(A)/(B)
53	5.67	270,000	21.00
54	6.28	300,000	20.90
55	6.96	330,000	21.10
56	7.72	370,000	20.90
57	8.57	400,000	19.90
58	9.66	450,000	21.50
59	10.59	450,000	23.00
60	11.65	500,000	23.30
61	12.44	530,000	27.50

Note: This axis becomes the middle one of three alternatives in the optimum scale study.

Table 2.3.2.2-2 Lower Axis Plan

HWL m	Reservoir Capacity MCM (A)	Dam Volume m^3 (B)	(A)/(B)
53	6.24	280,000	22.30
54	6.88	310,000	20.40
55	7.60	320,000	23.80
56	8.39	360,000	24.00
57	9.28	380,000	24.40
58	10.50	410,000	25.60
59	11.48	440,000	26.00
60	12.50	480,000	26.00
61	14.51	570,000	25.60

According to Table 2.3.2.2-1 and Table 2.3.2.2-2, the dam volume is 570,000 m^3 at N.H.W.L El. 61.0 m if it is required to have capacity for 100% two cropping of rice production for the whole irrigable area (1,280 ha). And if the dam volume is assumed to

be approx. 400,000 m^3 , N.H.W.L becomes approx. El. 57.0 m at the upper axis and approx. El. 58.0 m at the lower axis. On the other hand, the ratio of reservoir capacity over dam volume shows that the higher dam is more or less economical than the lower dam. And it shows that the lower axis has more effective ratio and consequently be economical in comparison with the upper axis.

Based on the preliminary study, it is decide carry out the study to obtain the optimum reservoir capacity based on the field survey (especially the geological survey) for the damsite and to secure more reservoir capacity on the condition to carry out the dam embankment (approx. 400,000 m^3) only during one dry season.

(1.2) Study on the Optimum Scheme of Dam

In addition to the data used in the preliminary study, the results of geological and the materials survey were obtained in the field survey. According to the new data, it was found that the river deposits at the both axes are deeper than the expectation and the deposits-depth at the lower axis is more or less deeper than that of the upper axis. It is considered that the cost of foundation treatment and dam embankment in case of the lower axis would be more costly than the upper axis. Therefore it is decided to carry out the alternative study by adding an additional alternative axis to be located in the further upstream side of the upper axis for the preliminary study. The upper axis also would have deep foundation at the river bed portion , however it is expected that the depth is 1-3 m less than those at the middle and lower axes and further the excavation & embankment volume at the upper axis would be comparatively smaller due to narrower river valley width.

That is, it is decided to carry out the alternative study by three axes, that is, upper, middle, and lower dam axis. Table 2.3.2.2-3 shows the results of the study for three alternatives.

Table 2.3.2.2-3 Salient Features of Three Alternative Axises

Dam Axis	HWL m	Elev. of Dam m	Height of Dam m	Length of Dam m	Dam Volume m^3	Reservoir Capacity MCM	Reservoir Capacity/ Dam Volume
Upper Axis	57	61	40	310	420,000 (310,000)	8.41	20.00
Middle Axis	56	60	38	370	450,000 (330,000)	7.72	17.20
Lower Axis	56	60	41	305	500,000 (370,000)	8.39	17.80

Note : ( ) shows dam volume above the original ground level. The upper axis is a new one and the middle axis is the same as the upper axis for the preliminary study.

According to Table 2.3.2.2-3, the dam volume at the upper axis is smaller than the volume of the other axes in case of the same reservoir capacity of 8×10^5 m^3 and the the impounding efficiency ratio (reservoir capacity/dam volume) is also the highest in the upper axis. Furthermore, the dam axis of the middle or lower site has more disadvantages in connection with the care of river during the construction period due to the necessity of treatment against small valley located on the right bank of damsite and a large gully located on the left bank. Accordingly, the upper axis is chosen as the most favorable one.

On the other hand, the construction cost of dam including the diversion tunnen is estimated to be approx. 1,100 million yen in case of 100 % cropping intensity even in the dry season, which is almost double of the cost (approx. 530 million yen in case of dam with 60 % cropping intensity . In this case, the rice production is approx. 8,960 t for the 100 % cropping intensity and approx. 7,000 t for the 60 % cropping intensity, that is , only 13 % increase against the high cost increase of dam construction. It is decide to prepare the design of dam with a scale which does not need the diversion tunnel for the rainy season, that is , approx. 4×10^5 m^3 in dam emvankment volume.

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

Height of Dam	: 40m
Crest Length	: 310m
NHWL	: Elev. 57.00 m
LWL	: Elev. 37.00 m
Total Reservoir Capacity	: 8.410 MCM
Total Effective Capacity	: 8.000 MCM

Note: LWL is decided based on the design volume of reservoir sedimentation, but adding some additional height. The reservoir has a capacity of approx. 400,000m^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 1,280 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 8.41 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, the inflow data is estimated for the 24-year period from 1956 through 1979 by low-water discharge analysis is used.

(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 10 days unit. Daily rainfall of less than 5 mm is regarded as ineffective to paddy fields, and the excess over 180 mm in 10 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

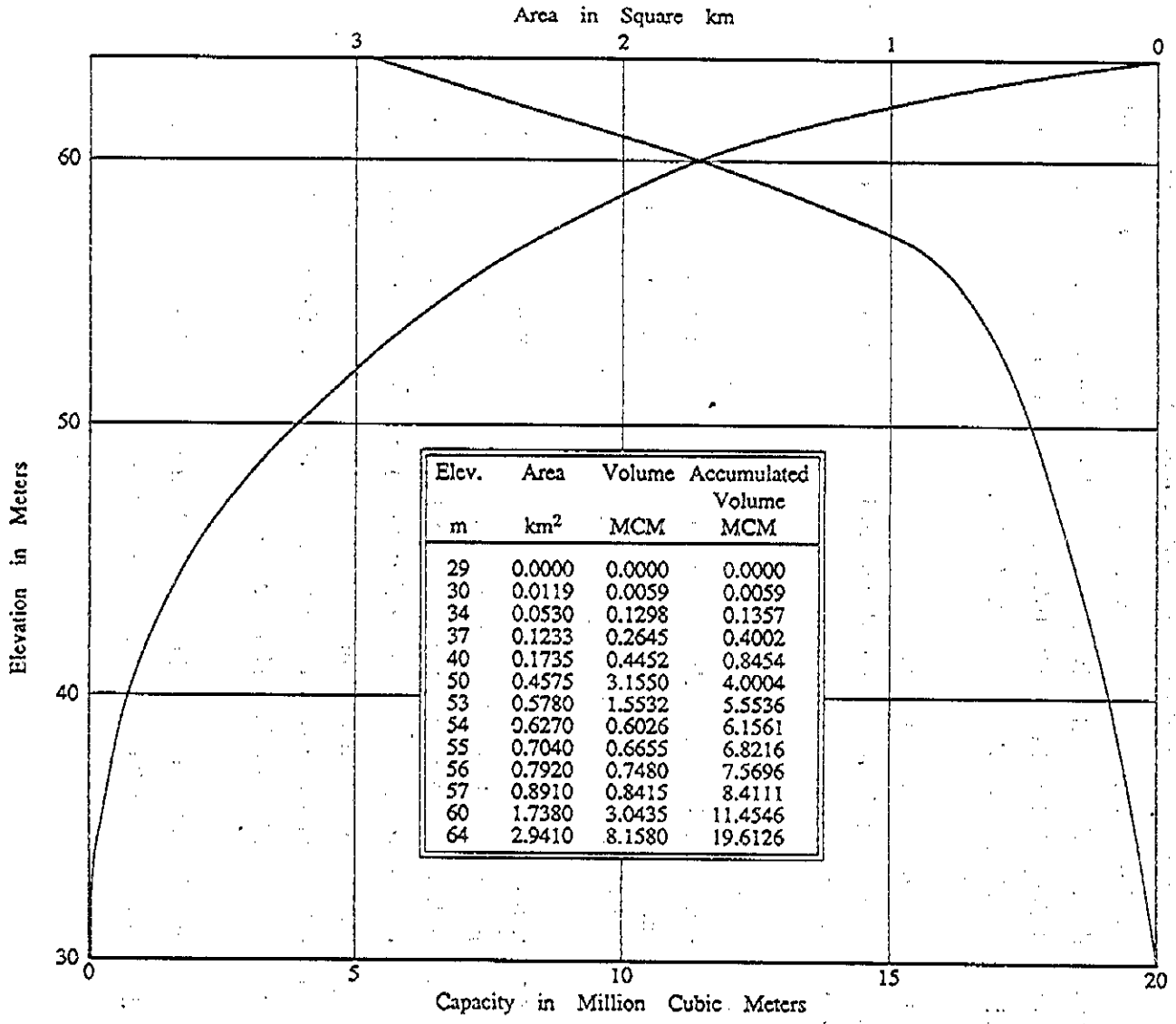
The rating curve of the reservior is drawn up based on the topographical map of 1/5,000 in scale . (See Fig.2.3.2.2-1)

(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 1,280 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 60% or 760 ha. Approx. 70% (900 ha) of irrigated area (1,280ha) will suffer from a shortage of water once in two years. In accordance with the result of water balance calculation based on the average runoff of the river for past 24 years, irrigable area is 75% (960 ha) of the total irrigated area.

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



Elev. m	Area km²	Volume MCM	Accumulated Volume MCM
29	0.0000	0.0000	0.0000
30	0.0119	0.0059	0.0059
34	0.0530	0.1298	0.1357
37	0.1233	0.2645	0.4002
40	0.1735	0.4452	0.8454
50	0.4575	3.1550	4.0004
53	0.5780	1.5532	5.5536
54	0.6270	0.6026	6.1561
55	0.7040	0.6655	6.8216
56	0.7920	0.7480	7.5696
57	0.8910	0.8415	8.4111
60	1.7380	3.0435	11.4546
64	2.9410	8.1580	19.6126

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Fig2.3.22-1

AREA－CAPACITY－ELEVATION CURVE

2.3.2.3 Design of Dam Structure

(1) Design Concept

The design concept for dam structure is summarized as follows:

(a) The dam, spillway and intake structures are designed in consideration of the sufficient safety/stability against external forces, long-term durability of structure, easy & reliable operation, economic advantages, and so on.

(b) The annual rainfall in the region ranges from 2,900 mm to 3,000 mm of which more than 90% is distributed during the rainy season, from May to October. The spillway is designed with enough capacity to release the flood flow during the rainy season in order to prevent the overtopping from the dam. It is planned to construct the dam within the period of only two dry seasons (the foundation works in the first dry season and embankment in the second dry season).

(c) The geological investigation found that the river deposit is deep ranging from 8 m to 10 m. These deposits will be excavated and replaced by core materials to prevent the seepage through the dam foundation. The excavation line of the dam abutment will be determined, because of deep overburden, in consideration of bearing capacity and seepage rate from the foundation. For the design of foundation, the grouting is necessary due to the results of the geological survey with permeability test. The grouting range is determined in consideration of the distribution of weatherd rock layer with relatively high permeability.

(2) Design Conditions

The design conditions for dam in connection with geology, hydrology, embankment materials, and reservoir water level are as follows:

(2.1) Geology

The drilling survey with the permeability test was carried out at the damsite. The geological conditions are obtained as summarized as follows:

- The abutment slopes on the left and right banks are approximately 20° and 10° respectively. According to the results of the geological investigation at the dam foundation, the solid rock is covered with deep weathered soil and weathered rock. The depth of soil is approxi. 12 m deep on the left bank and approxi. 13.60 m deep on the right bank. And the depth of weathered

rock underneath is 6 m to 7 m.

- The permeability coefficient of the weathered rock is 5.3 Lugion and the solid rock 1.6 Lugion.
- The width of the river bed is approxi. 30 m and covered with about 10 m depth of deposits composed of sands and gravels.

(2.2) Embankment Materials

The material investigation was carried out by boring, test pitting, and laboratory test. As the results of investigation, the locations of for the embankment materials are tentatively selected as follows:

Core materials	:	Back side hill of PSU (TP-7)
		Resettlement area (TP-8, TR-11)
		Right bank abutment (TP-3)
		Leftbank abutment (TP-5 ; for blend material)
Filter materials	:	River deposits (TP-6)
Random materials	:	River deposits (Nayom river) and near the resettlement area (MBH-1)

Note : There are the other alternative material sites, however the quantity from the above sites would be sufficient .

(2.3) Water Level of Reservoir

In consideration of the required volume of water for irrigation, and the estimated sedimentation volume in the reservoir, the normal high water level and the low water level are determined as follows:

Normal high water level	:El. 57.00 m
Low water level	:El. 37.00 m

(2.4) Design Flood

According to the design criteria of NIA, 50 years or 100 years return period of flood is adopted for the design flood of small reservoir. However, it is decided to adopt the value of 1.2 times of 200 years probability flood for the design inflow in consideration of the reliable safety. A flood with 200 years return period is calculated to be a flood with peak inflow of 446 m^3/sec at the proposed dam site. And 120% of the 200 years flood is regulated by the storage function and the design discharge of spillway is obtained at 350 m^3/sec.

(3) Basic Design

(3.1) Dam Axis

The upper dam axis is selected from the three alternatives in consideration of the geological and topographical conditions of the dam site. This axis has an advantages of easier works for river diversion during construction and also less volume of the dam due to the narrow width of the river valley. (See : Section 2.3.2.2)

(3.2) Dam Type

The type of dam is generally selected based on the syntetic study from the viewpoints of the conditions of topography, geology, spillway capacity, quality of embankment materials, quantity of works, and construction cost. The topography at the damsite is gentle. There are relatively thick weatherd soil layer and weatered rock layer underneath. The riverbed has approx. 10 m deep garavel sedimentation.

The fill type dam is selected to be suitable for the geological conditions at dam site and the availability of embankment materials from the nearby areas. And the zoned fill type with center core is adopted to make sure of its safety and also to use the local materials effectively.

(3.3) Design of Dam

(3.3.1) Dam Height

The dam height is determined from the study on some aspects such as reservoir capacity, sedimentation volume, and the design flood. In addition, the wave height and some allowances are added as a surplus height. The wave hight of the reservoir is estimated from the combination of SWB method and Saville method on the following conditions:

- Fetch	:1,400 m
- Slope of dam embankment	:1:3.0
- Slope material of slope	:Rock
- Wind velocity	:30 m/sec
- Height of wave by wind	:0.55 m (< 1.0 m)

An ungated type of spillway is designed for the simple operation & maintenance of the dam. In consideration of 2 m surplus height, including the wave height the crest elevation is determined at El. 61.00 m. The height of dam is thus 40 m from the river

bed foundation.

(3.3.2) Foundation Excavation Line

The excavation line for core zone foundation is determined to be a foundation layer with sufficient bearing capacity and permeability condition which can be improved by cement grouting to a sufficient level as the foundation of fill-type dam , after removing the highly weatered zone and the river bed gravels. The excavation depth for foundation is determined at approx. 12 m on the left abutment, approx. 11 m on the right abutment, and approx. 10 m on the riverbed. On the other hand, the foundation for the randum zone is determined at a layer with a certain level of bearing capacity and shearing strength (A layer with N value over 30, in general).

(3.3.3) Embankment Materials

The embankment materials are composed of soil, gravels and rocks. These materials are obtained from the nearby sites of which locations are tenatively decided as shown in a figure attached in the Appendices. The design criteria of soil materials are determined in reference to the results of laboratory test. And those for randum materials are basically determined in referece to the examples of the existing dam. (Refer to the Appendixes for the deign values)

(3.3.4) Zoning for Dam

The zoning of dam is composed of impervious zone, semi-pervious zone, and pervious zone. These zones are arranged adequately to prevent the movement of embankment materials. The zoned type is adopted for this dam, as it is confirmed from the material survey that there are not sufficient volume of economically acceptable and physically sound rock materials for a rockfill type dam.

(3.3.4.1) Width of Dam Crest

The width of dam crest is generally determined on the basis of synthetical considerations on the safety of the dam from the points of wave and seepage and also the utilization of crest area for construction works and traffic. The crest width of 7 m is decided in reference to the examples of the existing dam of which width is generally 6 - 9 m.

(3.3.4.2) Impervious Zone (Core Zone)

(a) The thickness of core generally corresponds to 30 - 50 % of the water depth of the reservoir. Therefore, 50% of the water depth is adopted for the thickness of

the core zone considering the safety side against the seepage. While the top width of the core zone is 4.0 m and the gradient of upstream and downstream slopes are 1: 0.25 respectively.

(b) The permeability coefficient for core materials is decided to be less than $1x10^{-5}$ cm/sec.

(c) The core materials is decided to be blended by soils and riverbed sands as the soils/silt materials contain too much fine particles. The blend-ratio may be decided after the laboratory tests during the supplementary survey, however the soil material would be blended with one - two times of sands materials in volume. The grain size curves of materials from test pits and the appropriate one (range) by USBR (together with examples in Japan) are shown in the figures in the next two pages for a reference.

(3.3.4.3) Semi-Pervious Zone (Filter Zone)

(a) The filter zone is provided to prevent the runoff of core materials and to safely drain the seepage water.

(b) The materials are selected based on the standard for filter zone.

(c) The thickness of filter zone is 2 m considering the working conditions.

(d) The sand and gravel from river deposit are to be used for the filter zone.

(3.3.4.4) Pervious Zone (Random Materials)

The rock and gravel materials with enough shear strength is used for the random zone to keep the stability against the sliding. The design values are decided to be more or less safety side at present.

(3.3.4.5) Slope Protection

(a) Riprap is placed on the upstream slope of the dam from the crest to 1 m below LWL. These materials are used to prevent the upstream surface of the embankment from erosion against the wave action.

(b) Gravels from the river deposit are used for riprap.

(c) Downstream slope protection is covered with grasses for the beautification and also to prevent from soil erosion due to rain.

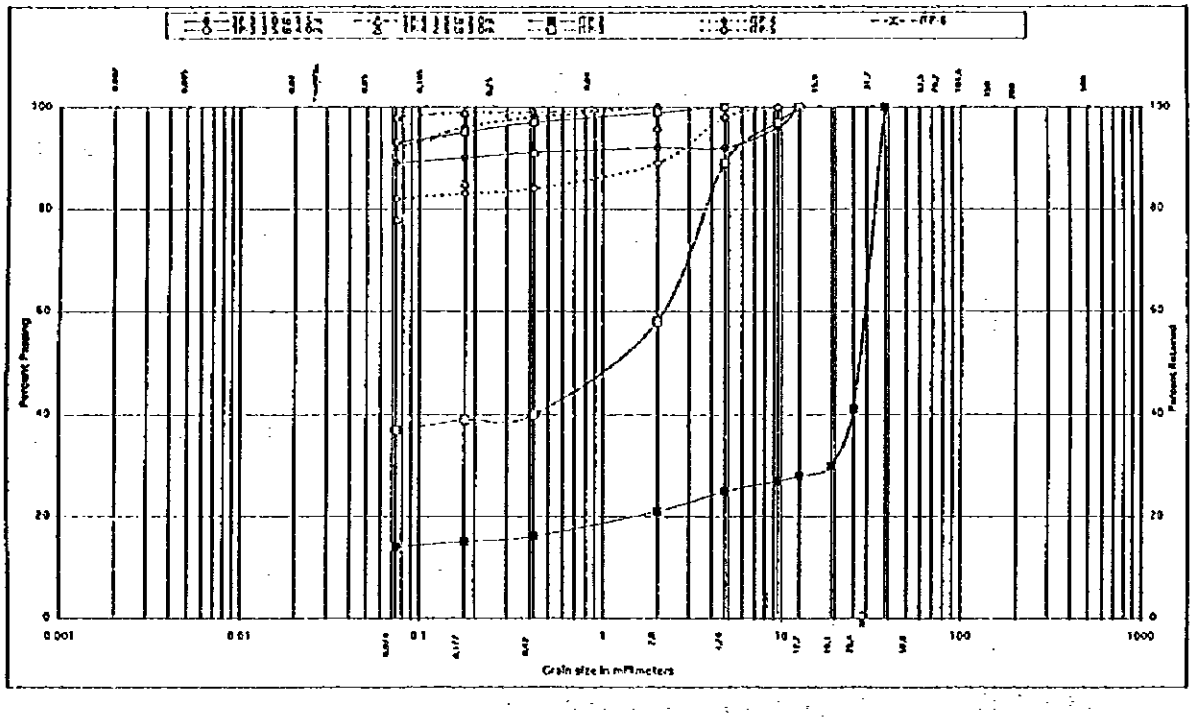


Fig. (1) Grain size curve for core materials from test pits near the damsite

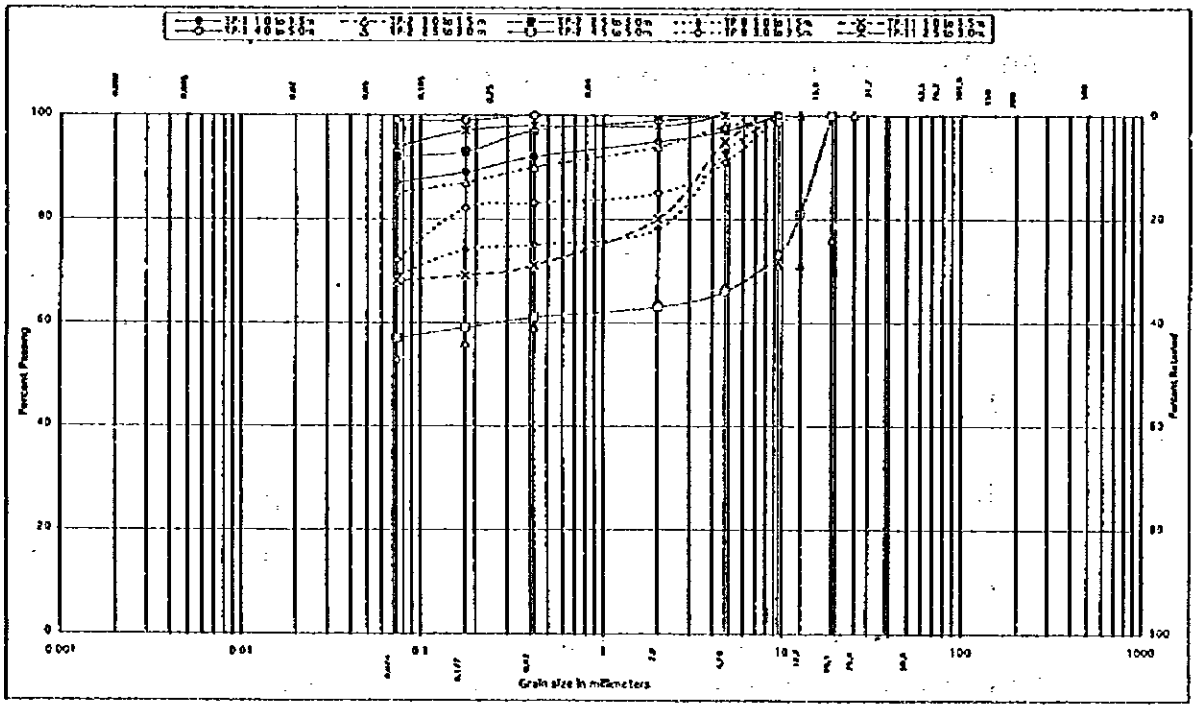


Fig. (2) Grain size curve for core materials from test pits of the other areas

Figure attached to Section 3.3.2.3 Grain Size Curve for Core Materials (1/2)

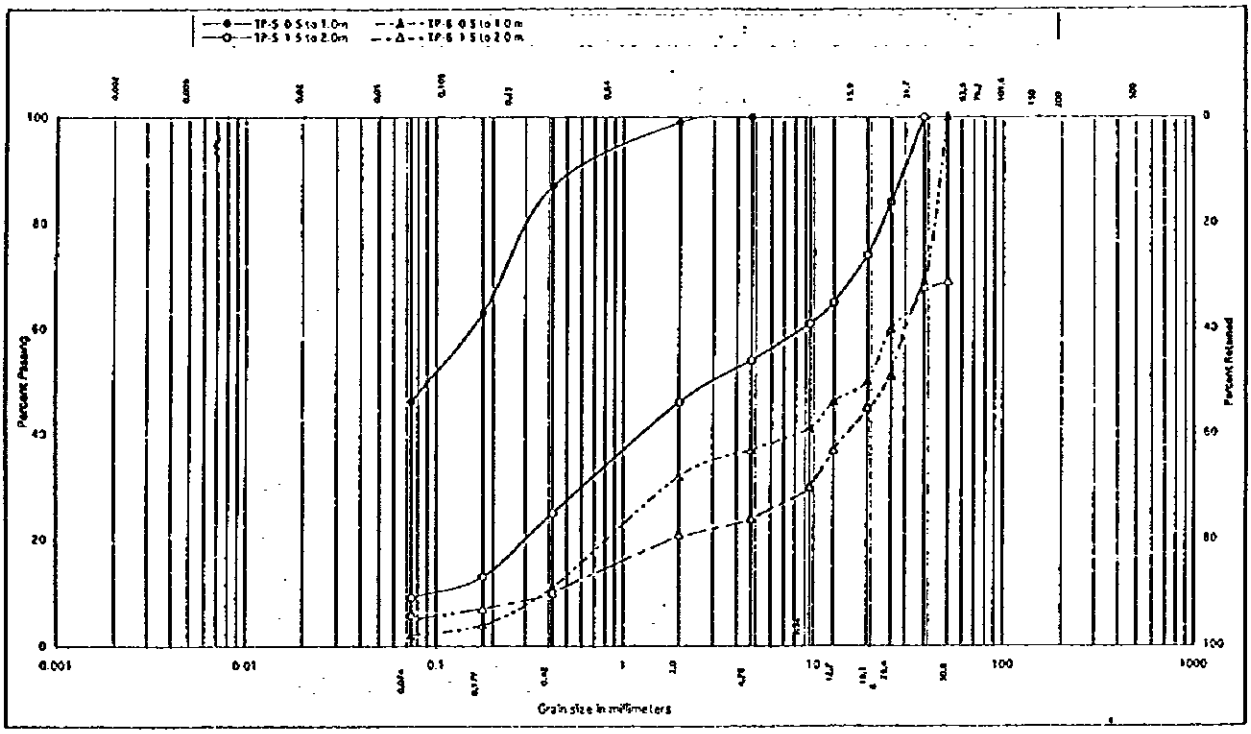


Fig. (3) Grain size curve for materials to be blended with core materials

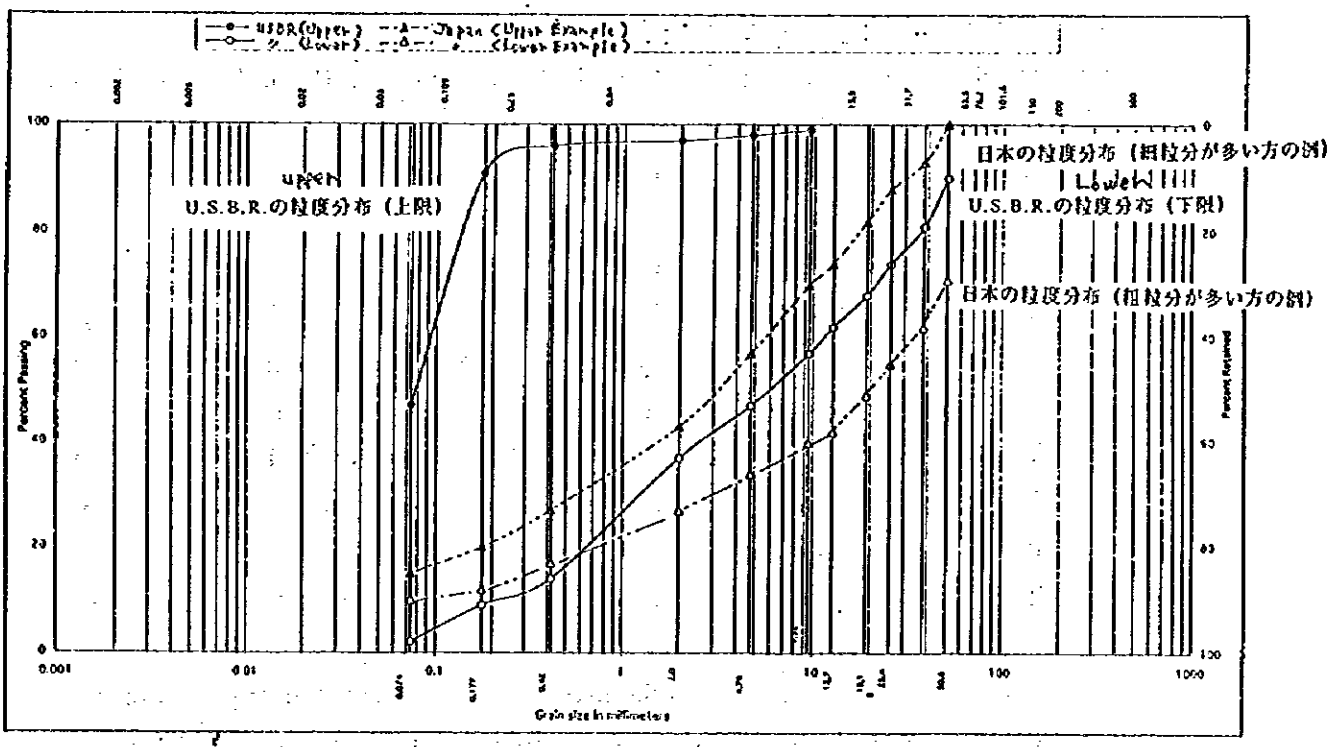
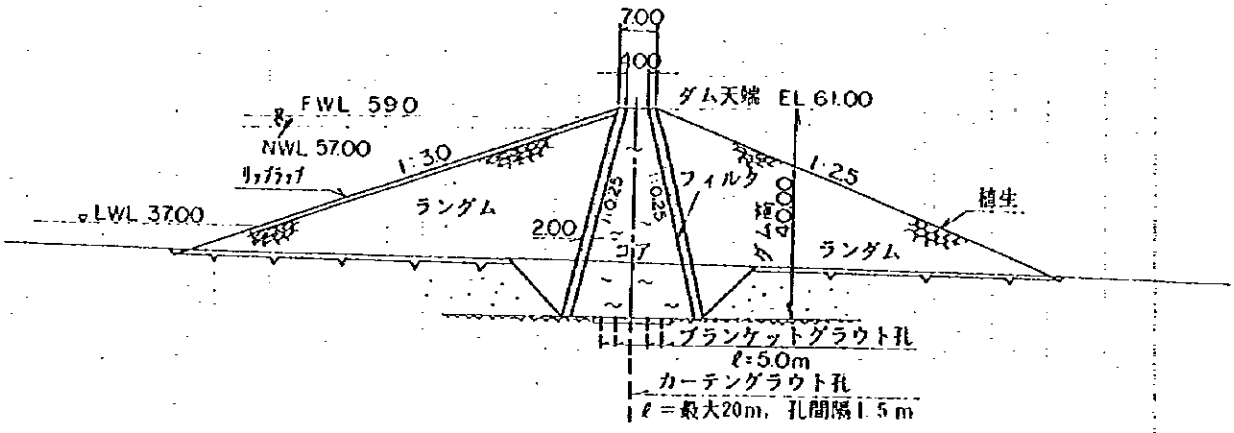


Fig. (4) Grain size curve for core materials (after blended), USBR standards & Japanese examples

Figure attached to Section 3.3.2.3 Grain Size Curve for Core Materials (2/2)

The standard cross section of the dam is shown below.



(3.3.5) Foundation Treatment (Foundation Grouting)

The permeability coefficient of gabbro from the foundation is 1.40 - 5.30 lugeon for the weathered rock layer and 0.30 - 1.60 lugeon for solid rock layer. Grouting is necessary to improve the permeability of weathered rock with cracks.

The considerations for foundation treatment are made as follows:

(a) The surface crack of the foundation is filled with cement by blanket grouting to strengthen the bearing capacity and to unite the foundation layer. Blanket grouting also has effect to strengthen the function of curtain grouting.

(b) The blanket grouting is arranged to have 4 lines on the river bed, 2 lines on the lower abutment, and 1 line on the upper abutment. The grouting hole is 3 m deep with the interval of 5 m.

(c) The curtain grouting is designed to form the water tight curtain in the rock foundation. The lugeon value of solid rock layer is quite low, but the grouting is planned to be 20 m long at the maximum, equivalent to nearly 50% of water depth in consideration of not-uniform foundation sturucture. And 5 m long grouting is also planned for the abutment. While the arrangement of curtain grouting is 5 m interval.

(d) Grouting is carried out by the staging method which will be performed from the top to bottom of the rock foundation to make sure the successful grouting. The blanket grouting is carried out in advance of curtain grouting.

The grouting plan is shown in Fig.2.3.2.3-4.

(3.3.6) Stability of Dam

The circular arc or slip circle method is applied for the stability analyses of the dam as well as the foundation.

The analyes are carried out for the following cases:

(a) Immediately after completion

(b) Normal high water level

The applied values for the stability analysis are shown in the data of Appendices and the safety factors obtained from the stability analysis are shown below. Seismic coefficient of 0.15 is applied for the case of normal high water level and 0.075 for the case of immediately after the completion respectively.

Slope	Immediately After Completion		Normal High Water Level	
	Normal	Earthquake	Normal	Earthquake
Upstream Slope	2.45	1.94	2.3	1.22
Downstream Slope	2.04	1.66	2.04	1.39

(3.3.7) Seepage Analysis

The following items are studied for the seepage of dam body.

(a) Estimate of seepage discharge through dambody and foundation.

(b) Stability of dam body and foundation affected by seepage (piping).

Grouting is provided to reduce the seepage from foundation. The results of seepage calculation are as follows:

(a) Seepage through dam body

The seepage through impervious zone is calculated by the flow nets method indicated

in the following formula.

$$Q = \Sigma \Delta q = \Sigma \cdot k \cdot H / L \cdot \Delta x$$

Where : Q = seepage quantity (m^3/s)
Δ q = seepage quantity per unit width (m^3/sec)
k = coefficient of permeability (m/s)
H = Total head (m)
L = Flow length (m)

The results of calculation are shown as follows:

Normal High Water Level (m)	Coefficient of Permeability (m)	Seepage Quantity (m^3/day)
57	1×10^{-7}	63

(b) Seepage through Foundation

The seepage through the foundation/ground of which conditions are already improved by the grouting is calculated by the flownets method as shown below:

Normal High Water Level (m)	Water Level at Downstream side (m)	Coefficient of Permeability (m)	Seepage Quantity (m)
57	30.00	5 x 10-7	29

Total seepage quantity Q = 63 + 29 = 92 m^3/day

0.05 % of the reservoir capacity = 840,000,000 m^3 x 0.0005 = 4,200 m^3/day

Generally 0.05% of the reservoir capacity is allowed for the irrigation dam in terms of storage efficiency. The total volume of seepage, 92 m^3/day, is very small amount so that it may not cause any problem to the stability of the dam body.

(3.4) Design of Spillway

The points of spillway design are summarized below:

- The spillway is a designed as a structure to have enough capacity to outflow the design flood.
- The ungated type of spillway is selected in consideration of the small catchment area of the reservoir
- The spillway is constructed at the right bank of the dam to prevent the complicated construction works as the diversion (outlet) facities are located on the left bank.
- In consideration of the topographical, geological, and hydrological conditions, a side spillway of ungated type is selected due to the topographic of condition with comparatively steep slope
- The spillway is arranged to keep away from the small valley located downstream of the dam axis and to shorten the length of the spillway.
- The whole structure is placed on the foundation with more than 30 of N values to have sufficient bearing capacity.
- The stilling basin is provided at the end of the chute way to control the energy of outflow and to keep the steady flow to the downstream river. The USBR type II is adopted for effective energy disspation.
- The side spillway is 60 m long with 2.0 m depth of overflow and the chuteway width is 15 m.

(3.5) Features of Dam and Reservoir

The Salient Features of Dam and Reservoir are as follows:

Type of dam	:	Center core rockfill dam
Height of dam	:	40 m
Crest length	:	330 m
Crest width	:	7 m
Dam volume	:	423,000 m^3
Dam crest elevation	:	Elev. 61.00 m
Type of spillway	:	Ungated side spillway
Design flood	:	350 m^3/sec

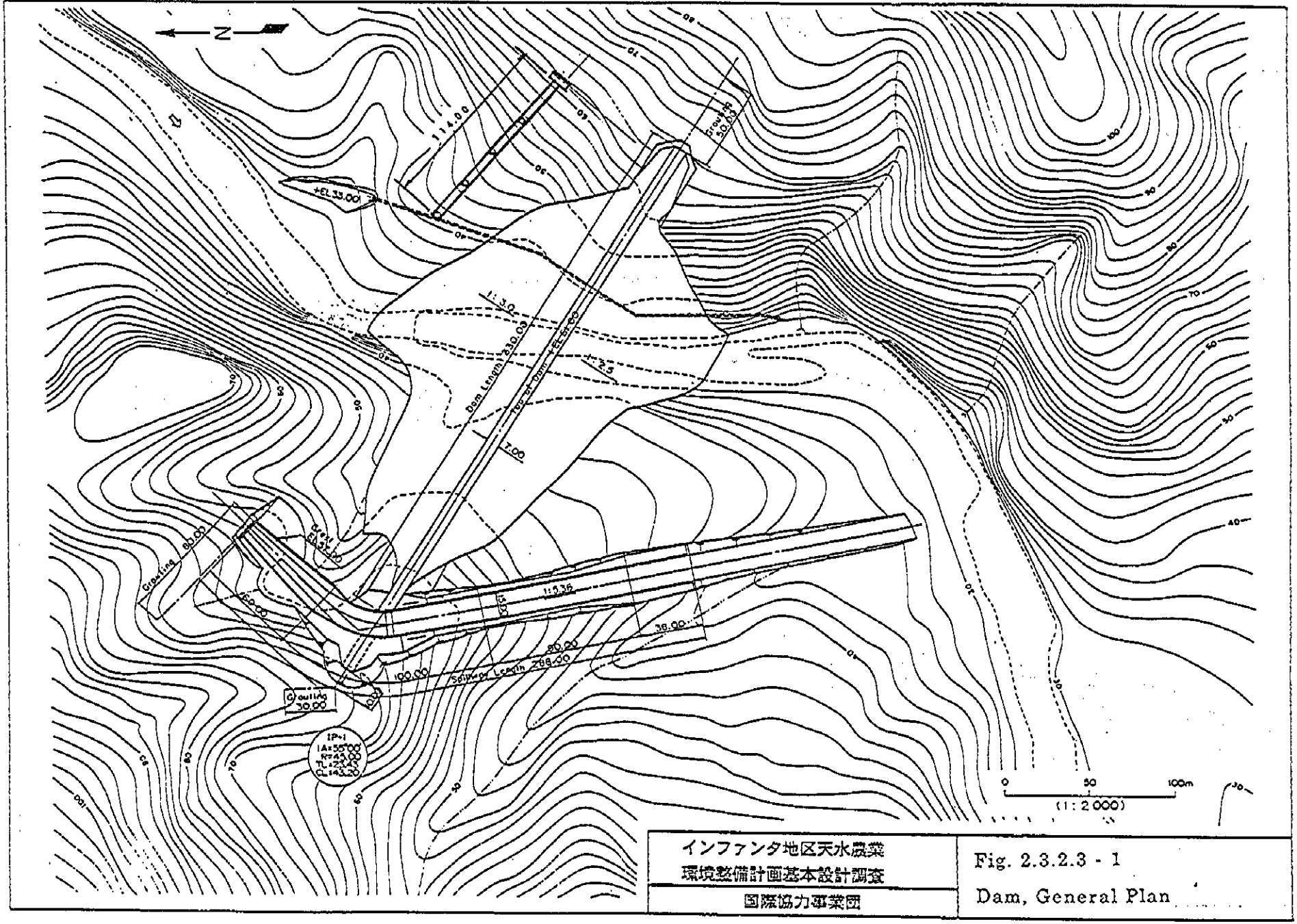
Catchment area	:	23.68 km^2
Total capacity of reservoir	:	8.411 MCM
Effective capacity of reservoir	:	8.000 MCM
Design flood elevation	:	Elev. 59.00 m
NHWL	:	Elev. 57.00 m
LWL	:	Elev. 37.00 m

(3.6) Design of Intake Structures

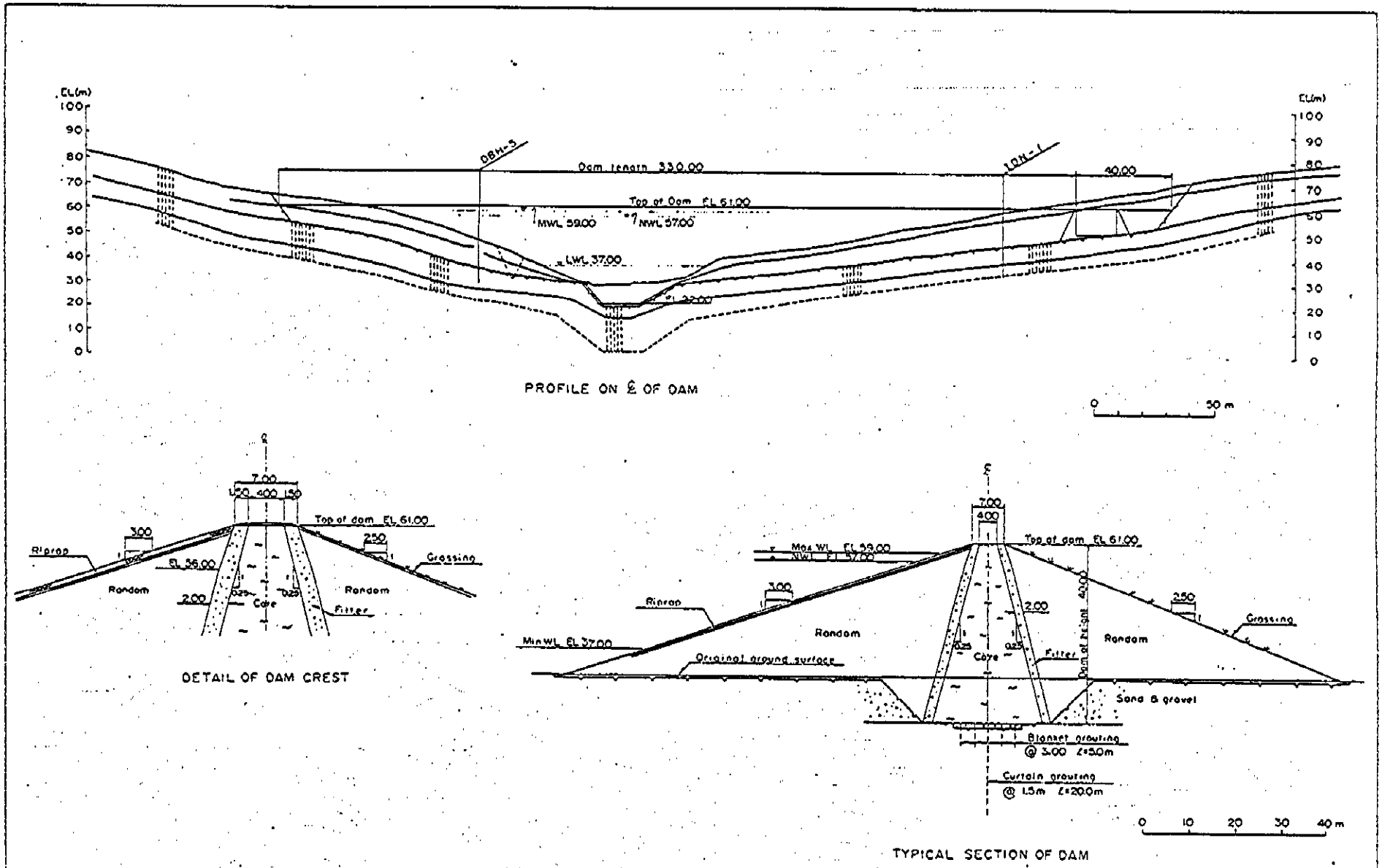
An inclined-type conduit is adopted as the intake facility in consideration of the intake volume, purpose of use, management system and also the economic viewpoint. The inclined conduit gate is to be set up on the natural ground for stability and on the left abutment. A 1,800 mm dia. steel pipe for the temporary drainage pipe will be used for the bottom outlet. Steel pipes will be held in the bedrock in order to avoid leakage. The inclined conduit gate is designed with four gates of 600 mm dia. each so that the planned maximum intake discharge of 2.5 m^3/sec can be controlled. Two sets of 600 mm dia. sluice valves will be installed as energy dissipating valves after intake.

(4) Design Drawings of Dams

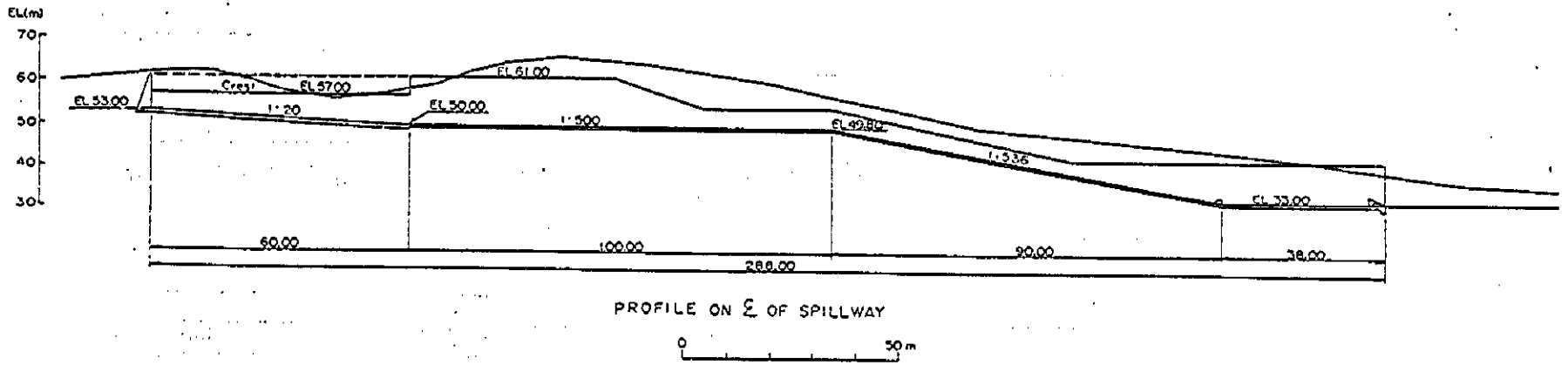
The basic design drawings of dam and appartment structures and attached in the following pages.



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. 2.3.2.3 - 1 Dam, General Plan

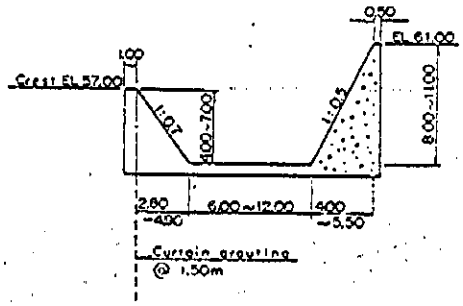


インファンタ地区天水農業 環境整備計画基本設計調査	Fig. 2.3.2.3 - 2 Dam, Profile and Standard Cross Section
国際協力事業団	

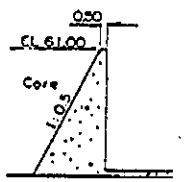


PROFILE ON ℄ OF SPILLWAY

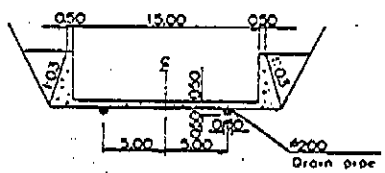
0 50 m



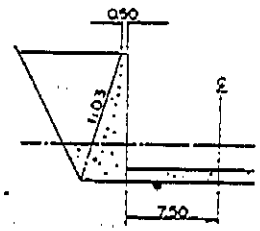
WEIR SECTION



CONTACT OF DAM SECTION



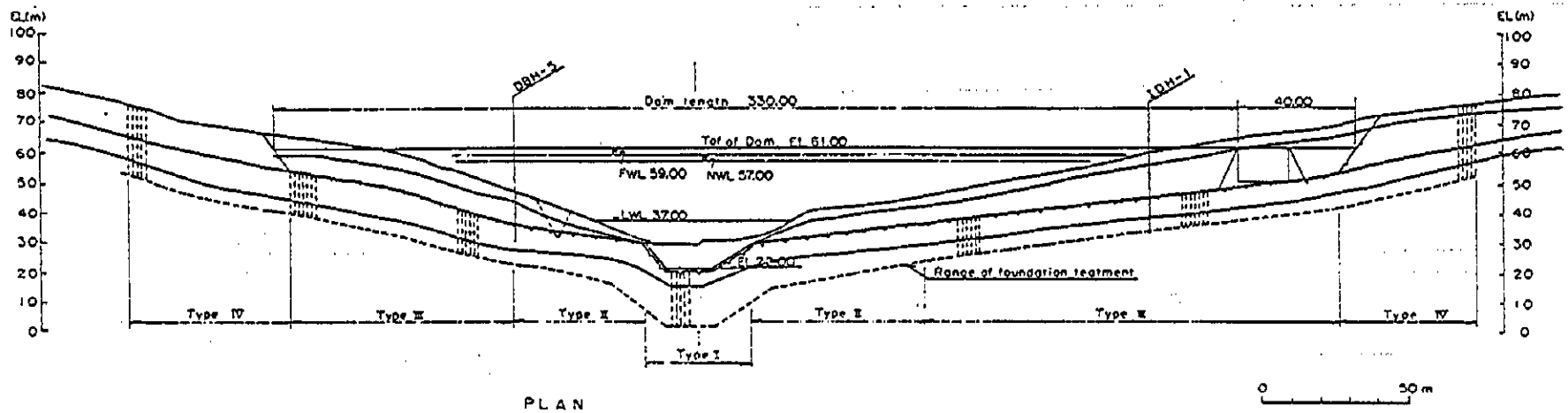
CHUTE SECTION



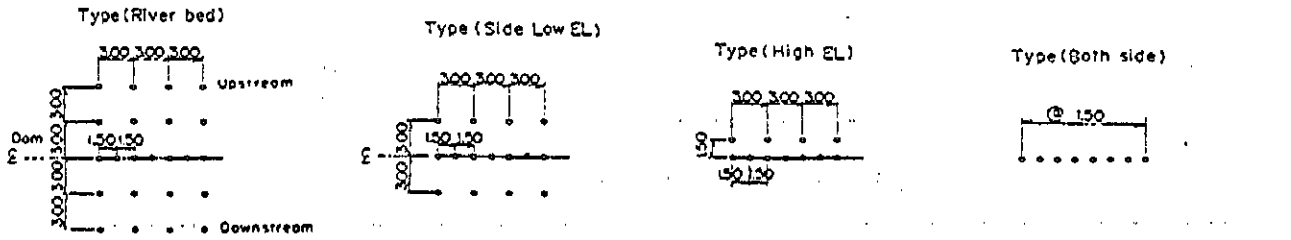
STILLING BASIN SECTION

0 10 20 m

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. 2.3.2.3 - 3 Spillway, Profile and Cross Sections



PLAN



SECTION

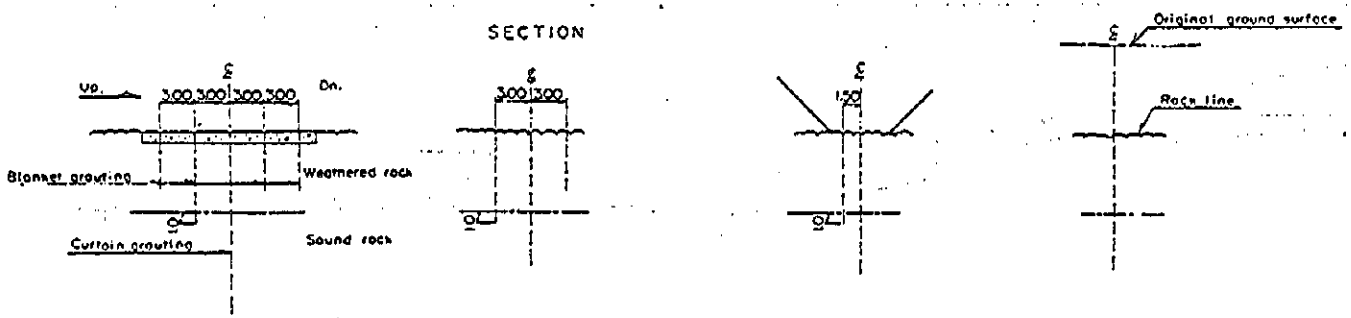


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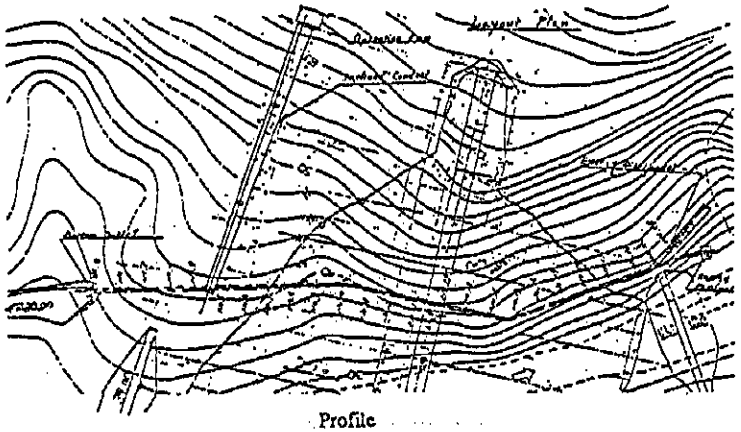
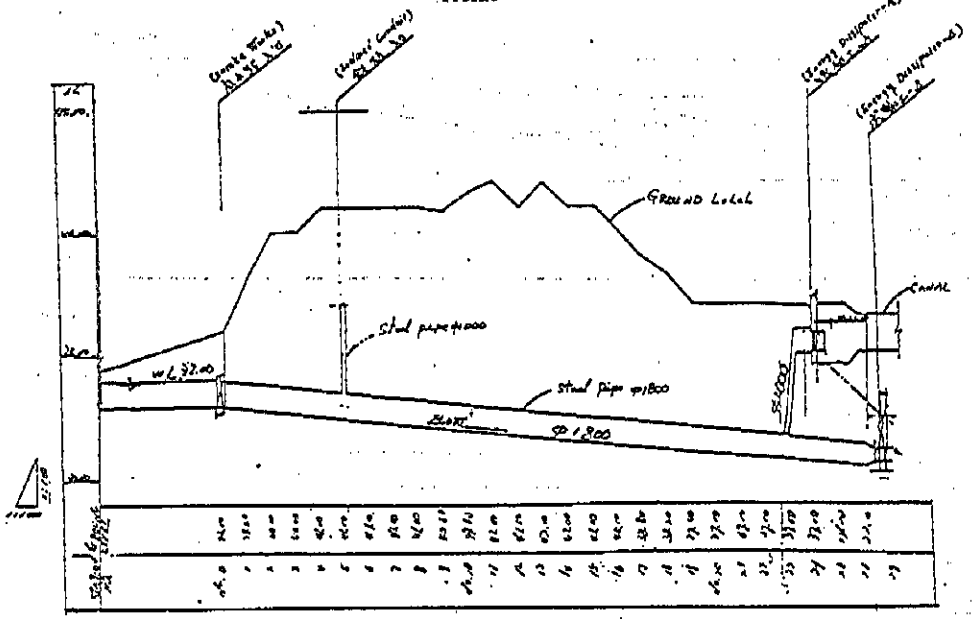
Fig. 2.3.2.3 - 4
Dam Foundation Treatment
(Grouting Plan)

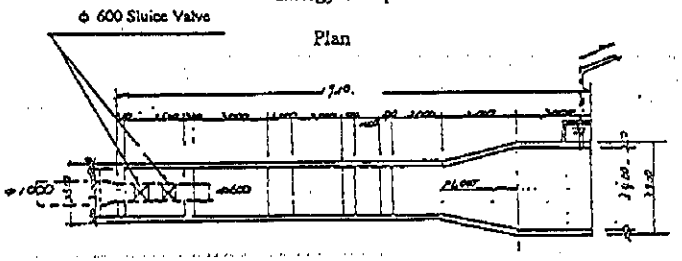


Profile

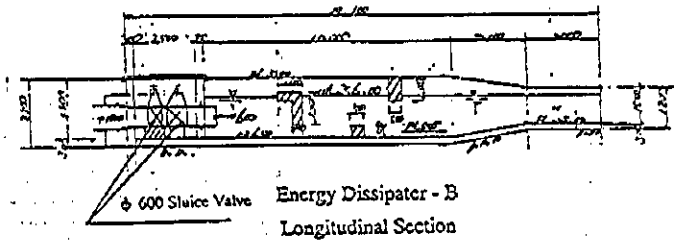


Energy Dissipater - A

Plan

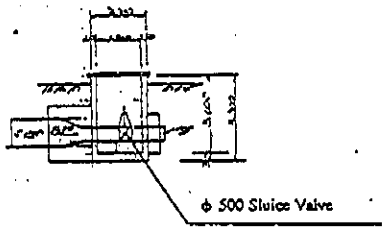


Longitudinal Section



Energy Dissipater - B

Longitudinal Section



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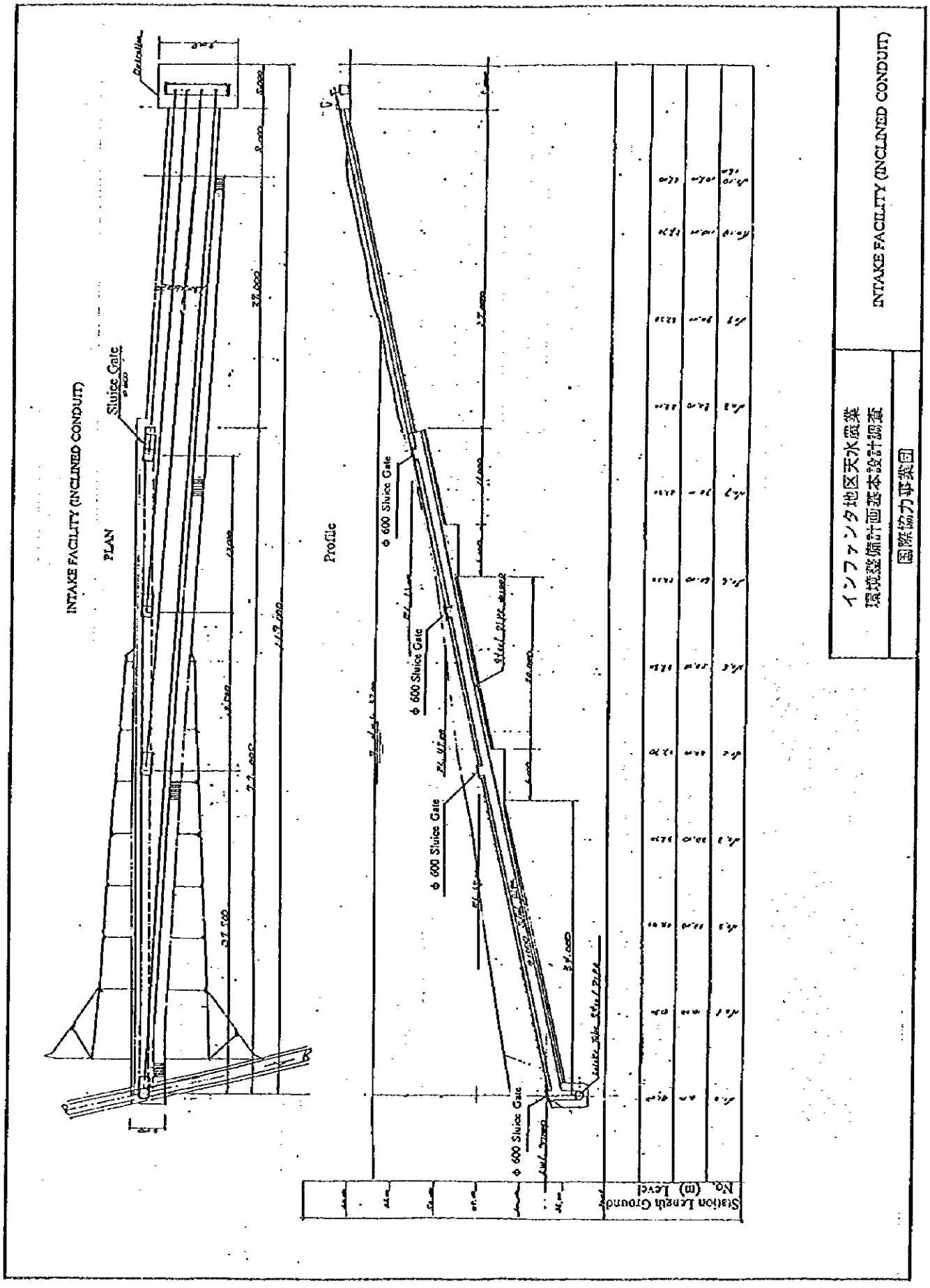
INTAKE FACILITY (INCLINED CONDUIT)
PLAN
Sluice Gate
Profile
φ 600 Sluice Gate
φ 600 Sluice Gate
φ 600 Sluice Gate
φ 600 Sluice Gate
Station Length Ground No. (m) Level
インファンタ地区灌水農業
環境整備計画基本設計調査
国際協力事業団
INTAKE FACILITY (INCLINED CONDUIT)