REPUBLIC OF THE PHILIPPINES

FEASIBILITY STUDY REPORT ON MABINI AGRICULTURAL DEVELOPMENT PROJECT

(MAIN REPORT)

MARCH 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

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P R E F A C E

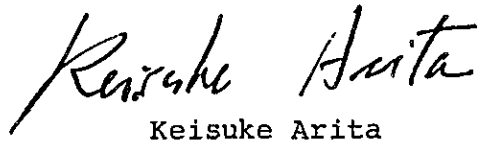
In response to the request of the Government of Republic of the Philippines, the Japanese Government decided to conduct a feasibility study on Mabini Agricultural Development Project and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to the Philippines a study team headed by Mr. Yoshimi Uchiyama from September 16 to December 15, 1981.

The team had a series of discussions with the officials concerned of the Government of the Philippines and conducted a field survey and study (in the Mabini Project area, Pangasinan Province). After the team returned to Japan, further studies were made and the final report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Philippines for their close cooperation extended to the team.

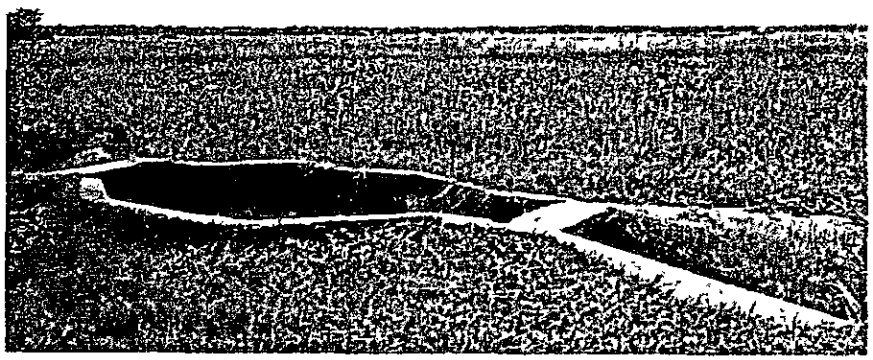
28, March, 1982



Keisuke Arita
President
Japan International Cooperation Agency

Seismic Test

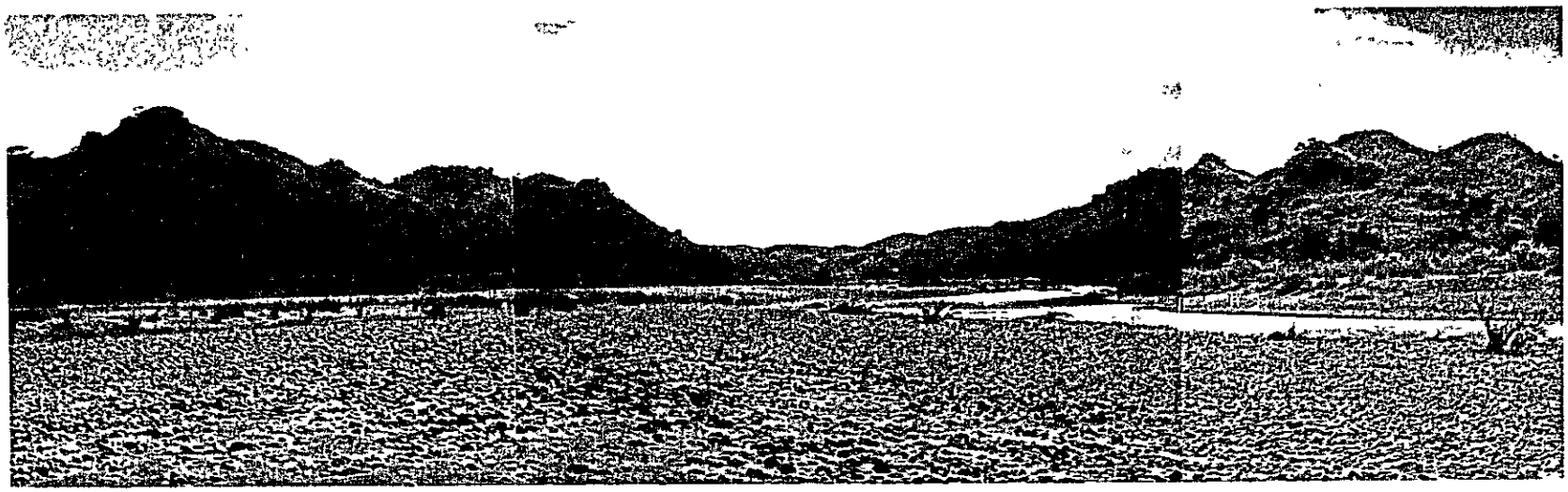
Seismic Test



Dam-site (View from Downstream)

Right Bank

Left Bank



GLOSSARY

Abbreviation

BAECON	Bureau of Agricultural Economics
BPI	Bureau of Plant Industry
GDP	Gross Domestic Product
IBRD	International Bank for Reconstruction and Development (World Bank)
JICA	Japan International Cooperation Agency
MPWTC	Ministry of Public Works, Transportation and Communication
NEDA	National Economic Development Authority
NFA	National Food Authority
NFAC	National Food and Agricultural Council
NIA	National Irrigation Administration
NPCC	National Polution Control Commission
F/S	Feasibility Study

Exchange Rate

1US$ = 8.00 pesos

0.125US$ = 1.00 peso

CONTENTS

Summary

1. The irrigation service area of the Mabini Agricultural Development Project (Refer to the Project hereafter) is located at the western half of the Pangasinan province, the north-western part of the Luzon Island, Republic of the Philippines. Major component of the project is the construction of rock fill dam and new irrigation systems including rehabilitation of the existing irrigation systems covering an irrigable area of 11,500ha, out of total paddy field of approximately 20,000ha extending the villages of Alaminos, Bani, Mabini and Sual. These irrigation facilities are aimed at supplying sufficient irrigation water to the service areas, in order to increase the production of paddy. Furthermore, this project will contribute to the stabilization of the people's livelihood, by increasing of employment oppotunity for the local labour force and improving the income distribution of the farmers and other people living in the area, through the provision of the relevant agricultural development facilities and system. (Refer to Chapter 2.)

2. Ensuring the source of irrigation water, a central core type rockfill dam with a storage capacity of approximately 300 million cubic meters will be constructed at upstream of the Balincaguin River, which is running along the southern boundary of the project area and flows in the western direction. Surplus water over the discharge amount required for river maintenance flow will be utilized to the project area for irrigation purpose. On the other hand, head of the discharge water from the dam will be used for hydroelectric power generation of which electricity can be supplied to the neighbouring areas.

3. Generally speaking, in case of studying an irrigation project, the service area, i.e., the area requiring

irrigation water and covered by the water supply network composed of irrigation canals, etc., is determined at the first step. Next step regarding the storage reservoir, irrigation canals, etc., are studied based upon the service area. However, in the case of the Project, a sufficiently accurate topographical map, which is indispensable for determination of the service area, was not available during the study and preparation of this report, in spite of the possible efforts of the National Irrigation Administration (Refer to NIA hereafter), which is the authority of the Philippines side in charge of the project study.

4. In view of the foregoing, a modified method of study different of the normal one, i.e., the determination of the storage capacity of the proposed reservoir is made before delineation of the irrigable vice area in the project. In other words, the study is set forth aiming at constructing the dam with the possible largest capacity allowed by the topographical and geological conditions of the damsite. As a result of such studies, the highest water level of the storage reservoir is determined at EL = 65.00m. (Refer to 5.6.(3) and 6.2.(1).)

5. On the other hand, the maximum flood discharge amount through the spillway structure, considering the surcharge effect of the reservoir, is studied to cope with the designed flood to be discharged at the dam construction site. For design of spillway capacity, the possible flood discharge of 4,000 m^3/s and the flood duration of 140 hours are estimated by applying the Probable Maximum Precipitation (PMP) normally used in Philippines. The study of spillway capacity resulted the maximum flood discharge of 3,100 m^3/s when the surcharge water depth is 2.00m. (Refer to 12.2.)

6. The normal water level of the proposed reservoir is taken as EL63.00m and its full storage capacity is computed at 303 million cubic meters including deadwater. (Refer to 6.4.)

7. It is decided that the proposed cropping pattern comprising two crops of paddy cultivation per year. It was studyed that recently the Philippines achieved self-sufficient in terms of Paddy since 1977, however a further increase of production of paddy seems to be preferable for the improvement of the living standard of the people. (Refer to 3.1.5 and 7.1.)

8. The basic drought year for irrigation scheme of the project is decided in the year of 1968 as the year of 1/5 in probability. For the purpose of water requirements study, the Penman method is adopted among others to estimate the evapotranspiration of the paddy cultivation. (Refer to 8.)

9. The river maintenance flow, which is water amount to be discharged to the downstream side from the proposed dam site is estimated at $2.3m^3/s$, by taking into consideration the existing right of water of $0.363m^3/s$ and other purpose prevailing in the downstream areas. (Refer to 4.6.)

10. The service area of the Project is examined by carrying out the water balance study of a storage capacity of 303 million cubic meters, based upon the proposed cropping pattern, the estimated water requirement for irrigation and the quantity of river maintenance flow.

    Namely, the water balance between the river inflow to the storage reservoir and the required quantity of irrigation water is calculated by assuming that the service area which ranges between 10,000ha and 13,000ha. The

service area is determined as 11,500ha and the intake water level of the dam is determined as EL38.00m as a result of the above calculation. Furhtermore, the effective storage capacity becomes 240 million cubic meters while the quantity of dead water becomes 63 million cubic meters. (Refer to 9.)

11. Elevation of the dam crest is designed at EL68.50m, by adding free board to the planned high water level EL65.00m of the storage reservoir. It is therefore 54.50m high above the original revierbed (EL14.00m) and 88.50m above the bedrock of which elevation is EL20.0m. (Refer to 11.1.)

    As for the type of dam to be constructed, it is decided to be a rockfill dam with center clay core as a result of the examination of the thickness of the alluvium layer of the foundation, and the qualitative and quantitative details of the possible embankment materials. The center core type rockfill dam is adopted as a result of the comparative study of the inclined core type and central core type rockfill dam. (Refer to 11.5.)

12. River deposit with approximately 32m thickness is sedimented at the proposed dam site above the foundation rock. It was decided to adopt the open cut type from the technical and economical points of view as a result of the comparative study of this method, concrete cut-off wall and the soletanche method for the possible foundation treatment.

13. The stability analysis of the dam embankment is carried out by using the results of the soil test of the embankment materials carried out during field survey. The seismic coefficient is assumed to be K = 0.2 and the analysis is carried out by means of the slip circule method.

14. As for the sipllway structure, it is decided to adopt the gated type spillway provided with 4 gates, as a result of the study mentioned above (5 of summary). This type of spillway is adopted in view of its technical and economical advantages when compared with other types of structures, like the side channel spillway, etc. (Refer to 12.)

15. The 1/20 flood is adopted for the design of the diversion tunnel, by taking into consideration the standards design criteria adopted in Philippines (1/50 through 1/20 of probable flood) and the foundation treatment method. It is decided to construct 2 tunnels with 8.5m diameter at the right bank of the dam site. In future, one of the said diversion tunnels will be used as the intake facilities, while the remaining one will be used as the emergency discharge channel. (Refer to 14.)

16. As mentioned above, the intake facilities will be constructed by using one of the diversion tunnels. The total intake discharge will be $25m^3/s$, which is composed of the maximum monthly discharge of irrigation water and the river maintenance flow purposes including the existing right of water. (Refer to 13.)

17. As for the planning of the irrigation canals, water coming from the intake facilities described above will be discharged in the driving canal and after diversion of water to the Mabini irrigation canal it bifurcates into the east and west main canals. The driving channel will be grouted masonry lining structures, but all other canals will be in principle earth lining canals.

    All other related structures will be in principle designed in compliance with the Design Criteria provided by NIA, Philippines. (Refer to 15.)

Roads for maintenance and operation purposes will be constructed along the irrigation canals.

18. As for the existing irrigation systems in the project area, they will be included in the service area of the project, by respecting their technical and social organizations. Irrigation water will be supplied from the new irrigation canals to the presently existing ones. The presently existing irrigation canals will be rehabilitated and expanded wherever required. (Refer to 15.3.3.)

19. The construction cost of the project is estimated to be 1,017.0 million PESOS (US$127.1 million). The aforesaid total cost consists of 571.5 million PESOS (US$71.4 million) of foreign currency and 445.5 million PESOS (US$55.7 million) of local currency portion. (Refer to 18.)

20. As for the production of paddy, it is expected to be 4.58 t/ha in the rainy season and 4.79 t/ha in the dry season, based upon data of areas presently provided with irrigation facilities and by assuming that the Masagana 99 system and technique is properly applied to the project area. The additional production costs required in the present case follows in principle the lines of the production costs required in the Masagana 99 system. (Refer to 7.2.)

21. The IRR calculated based upon the total project cost mentioned above and the benefit of the agricultural development results to be 12.8%.

22. A generator will be installed at the downstream end of the aforesaid diversion tunnel and will be used for hydroelectric power generation purposes. The power generating facilities will have a capacity of 7,000KW in

rainy season and 3,000KW in dry season and the annual generated hydropower will be about 25 million KWH. (Refer to Annex of Main Report.)

Recommendations

1. Data regarding aspects like irrigated zones of the existing irrigation systems, namely location of commanding area and the irrigation canals, etc., should be surveyed in detail.

2. The exact location and the geological conditions regarding the low velocity zone, parallel to the left bank of the river at the vicinity of EL=60.00m in the planned damsite should be surveyed in detail.

3. The study of dambody stability analysis was carried out based on the data and information of various kind of test and resulted the most preferable idea. However, further permeability tests and loading tests by means of vertical test pits will be required at the river deposits of the planned damsite, in order to collect the additional data for improving possibly foundation treatment and stability analysis of the dam body.

4. As for the embankment materials of the dam, soil tests of the sample will be requested to be carried out as many as possible.

   Rock materials which are being expected to be used presently are considered to contain large quantities of basalt in advanced state of weathering. Accordingly, tests regarding weathering and duration will be necessary to be carried out, to determine the strength and durability of the rock materials.

5. It is required to carry out overall field surveys regarding water leakage, landsliding, etc., within reservoir area.

6. As for the organization in charge of the implementation of this project, it is desirable to create an independent special project office as being establish presently by the National Irrigation Administration of Philippines, by taking into account the componenets of jobs and numbers of staff of the Region I Office of NIA presently in charge of the project and the scale of the project, etc.

7. As for the organization for maintenance and operation of the various facilities after completion of the project, it is recommendable to manage and operate the major structures (e.g. operation of the dam, spillway and intake facilities, major parts of the irrigation canals, etc.) under the responsibility of government organizations including the National Irrigation Administration and other minor facilities under the responsibility of farmers organizations or their federations. In this case, a close contact and communication between the government institutions and farmers organizations is required. Accordingly, the joint organization like a condinating committee, etc., might bring good results.

8. Sufficient irrigation water can be stored in the reservoir and supplied through canal systems in the project area after completion of the project. In addition to the irrigation, it is indispensable to make efforts to improve of the local agricultural technique based upon the Masagana 99 system in order to achieve the target yield of the paddy.

9. The service area proposed by NIA differs partially from that by this team, it would be, therefore, required to prepare additional topographical maps for the differed areas. (Refer to Fig. 15.3.3.)

CHAPTER 1

INTRODUCTION

1. Introduction

The National Water Resources Council (NWRC) was established in 1974 in the Philippines, to actively promote the development and planning of water resources.

On May 26, 1976, the Ministry of Public Works, Transportation and Communications (MPWTC) organized a Task Force in cooperation with the other ministries and government institutions concerned, and started the study for the development of the Small Scale Catchment Basins and Impounding Reservoirs. Results of the study were collected and were arranged by zone, and presented to the various ministers related to the NWRC on April 13, 1978 in the form of the Survey Inventory of Water Impounding Reservoirs. The water resource development programme is incorporated into the Five Year Development Plan of the Philippines (1977 - 1982) prepared in September, 1977.

On July 25, 1979, the Presidential Decree-LOI No. 898 was announced, aimed at implementing the recommended development programme by the NWRC, in an effective way and with perfect coordination between the related ministries and the government institutions. As a result, the Small Water Impunding Management (SWIM) Committee was created.

The Committee (SWIM) is headed by the Minister of MPWTC. Five other Ministries related to water are participating in the Committee. One of the institutions entitled to enforce this project, in accordance with the instructions issued by the Committee is the National Irrigation Administration (NIA).

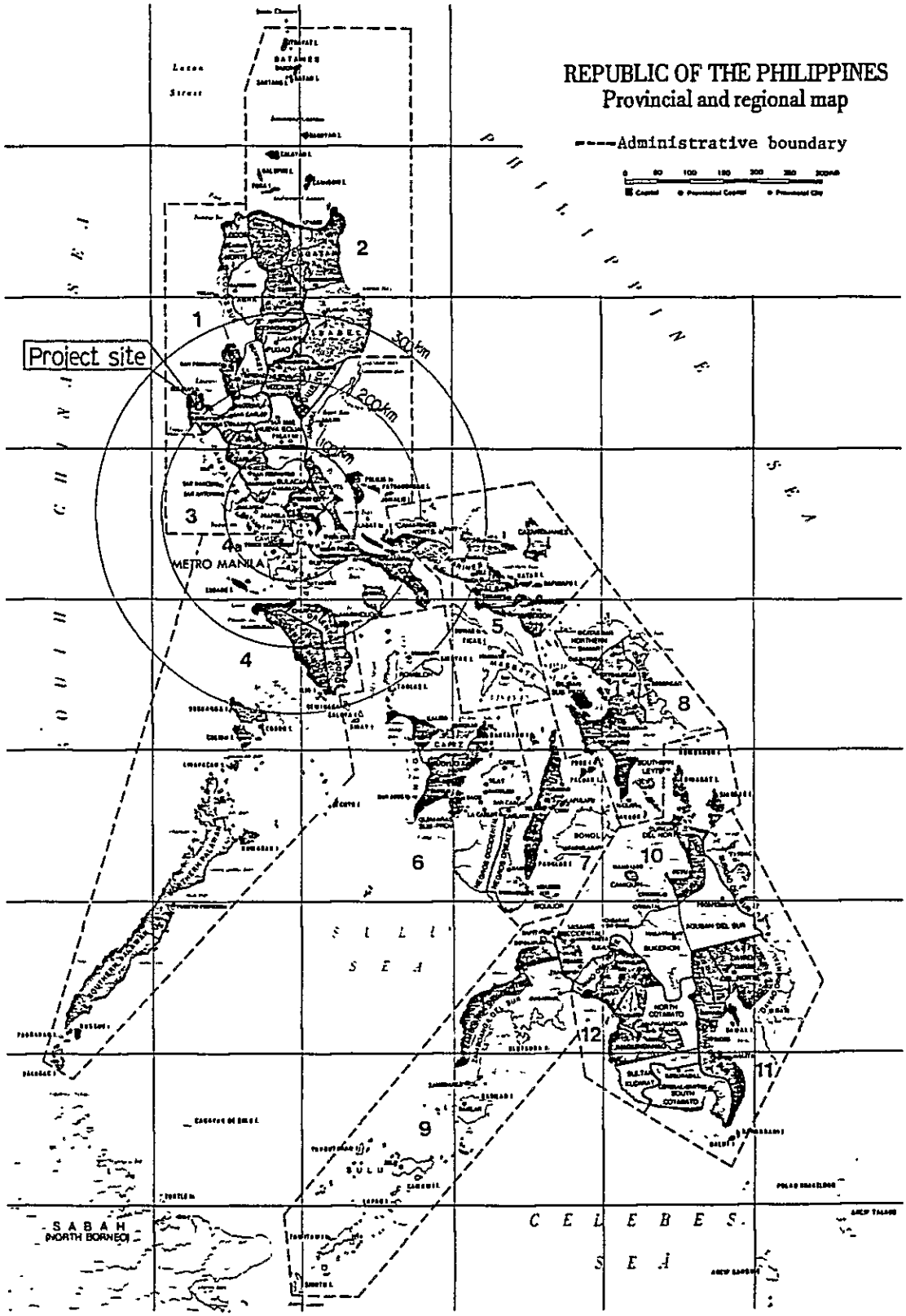
The NIA carried out studies for the projects under its jurisdiction, in accordance with the circumstances described above. Of the various areas listed in the NWRC report, the Committee agreed to authorize the NIA to act as an Executing

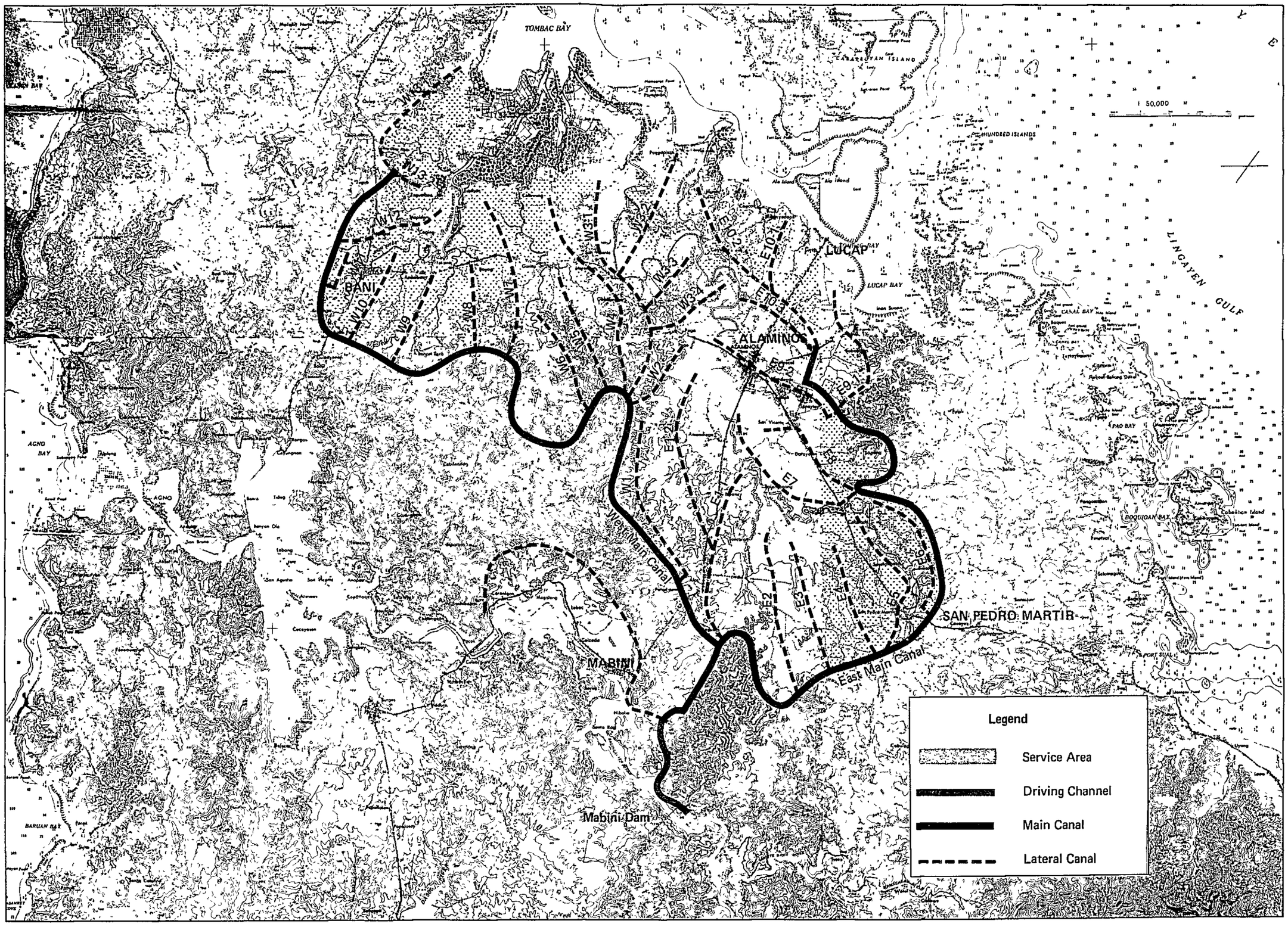
Agency of projects in 5 areas including the Mabini Area which belongs to the Region I of the NIA (its Regional Office is located in the city of Urdanata).

The Government of the Republic of the Philippines has given this project first priority and, in April, 1980, officially asked the Government of Japan to carry out the relevant Feasibility Study.

During the Annual Meeting in August, 1980, the governments of both countries agreed to carry out a feasibility study by restricting the subject to the Mabini Agricultural Development Project among the 5 areas mentioned above. In Janualy, 1981, a mission was sent to the Philippines, for the preliminary study. After discussions with authorities of the Government of the Philippines, the Mission confirmed the necessity of the feasibility study and determined the relevant scope of work. In compliance with the scope of work, the Feasibility Study is carryed out by the Consultants under the administration of the Japan International Cooperation Agency.

Fig. 1-1 Project Site




TOMBAC BAY
LINGAYEN GULF
LUCAP
LUCAP BAY
ALAMINOS
BANI
MABINI
SAN PEDRO MARTIR
Mabini Dam
West Main Canal
East Main Canal
HUNDRED ISLANDS
AGNO BAY
BOQUIOAN BAY
PAO BAY
CANAL BAY
W1
W2
W3
W4
W5
W6
W7
W8
W9
W10
W11
W12
W13
W14
E1
E2
E3
E4
E5
E6
E7
E8
E9
E10
E11
E12
Legend
Service Area
Driving Channel
Main Canal
Lateral Canal

CHAPTER 2

THE PROJECT

2. The Project

2.1. Project Area

The area of Mabini Agricultural Development Project is located in the Pangasinan Province, in the north-eastern part of the Luzon Island, Republic of the Philippines, which is one of the less-developed areas in the country. The service area is approximately 11,500ha of paddy field spreaded in the vicinities of Alaminos, Bani, Mabini and Sual. At present, the service area is composed of paddy fields mostly rain-fed and partially served by small scale irrigation facilities constructed by local farmers of their own expenses. Most of this area consists of a wide and low plains with elevations ranging from several meters to more than 30 meters, including wet lowlands in its northern part.

As for the meteorological conditions prevailing in the project area, the annual rainfall is 3,150 mm and most of the precipitation occurs during the rainy season from May to October. The rainfall during the dry season, extending from November to April of the next year, is negligible. The climate is a typically tropical one, with an average temperature of 27.9°C and an average humidity of 77%.

The production of crops is of the order of 2.0 t/ha in rain-fed paddy field and approximately 3.2 t/ha in irrigated paddy field, indicating a low productivity in spite of the introduction of high yielding varieties.

The proposed damsite is located at approximately 34Km upstream from the estuary of the Balincaguin River, and the elevation of the river bed is about 14m. The geology of the vicinity of the damsite is a volcanic zone with predominance of basalt partially capped by limestone at higher altitudes.

On the riverbed, there is deep sedimentation of river deposit.

The outline of the Mabini Agricultural Development Project consists of the construction of a dam in the Balincaguin River and supply of irrigation water from the dam to the service area of higher elevation through a diversion channel of approximately 7.7 Km in length,
The irrigation water will be distributed throughout paddy field of the service area by an irrigation system of main canals with a total length of approximately 50Km, which together with other irrigation canal and the drainage facilities, is expected to contribute to the boosting of agricultural production of the area of approximately 11,500ha extending over Alaminos, Mabini, Bani and Sual.

2.2. Outline of the Project Components

2.2.1. Storage Reservoir

Catchment basin area	225Km^2
Total storage capacity	303 million cubic meters
Effective storage capacity	240 million cubic meters
Deadwater	63 million cubic meters
Expected sedimentation	29 million cubic meters (For 100 years)
Area of normal water surface	12.2Km^2
High water level	EL65.00m
Normal water level	EL63.00m
Minimum water surface	EL38.00m

2.2.2. Dam

Type of dam	Center core clay type rockfill dam.
Crest elevation	EL68.50m
Elevation of foundation rock	EL(-)20.00m
Embankment height	88.50m (Above foundation rock)
Crest length	530.0m
Slope of upstream embankment	1:3.0
Slope of downstream embankment	1:2.2
Elevation of temporary cofferdam crest	EL36.00mm
Embankment volume	4,119,000 cubic meters
Excavation volume	1,093,000 cubic meters
Total length of grounting	30,600m

2.2.3. Spillway structure

Type of spillway	Gated type spillway
Design flood discharge	3,100m^3/sec
Gate size and number	9.5m(W)x10.5m(H)x4(units)

2.2.4. Diversion tunnels

Design discharge amount of diversion tunnel	1,500m^3/sec
Inner diameter of tunnel	8.5m of standard horse-shoe type

Tunnel length (2 tunnels)	700m and 750m

2.2.5. Irrigation

Maximum intake amount	$21.7m^3/sec$

Driving channel

- Maximum capacity	$21.7m^3/sec$
- Total length	4.8Km including 0.75Km of pipe line which is installed in a diversion tunnel.

Main irrigation canals

	Maximum capacity	Length
- Main canal (M_0)	$Q = 20.5m^3/sec$ (After diversion of water for Mabini area)	3.0Km
- West main canal	$Q = 10.4m^3/sec$	28.9Km
- East main canal	$Q = 10.1m^3/sec$	20.6Km
Lateral irrigation canals	26 lines	135.3Km

Structures

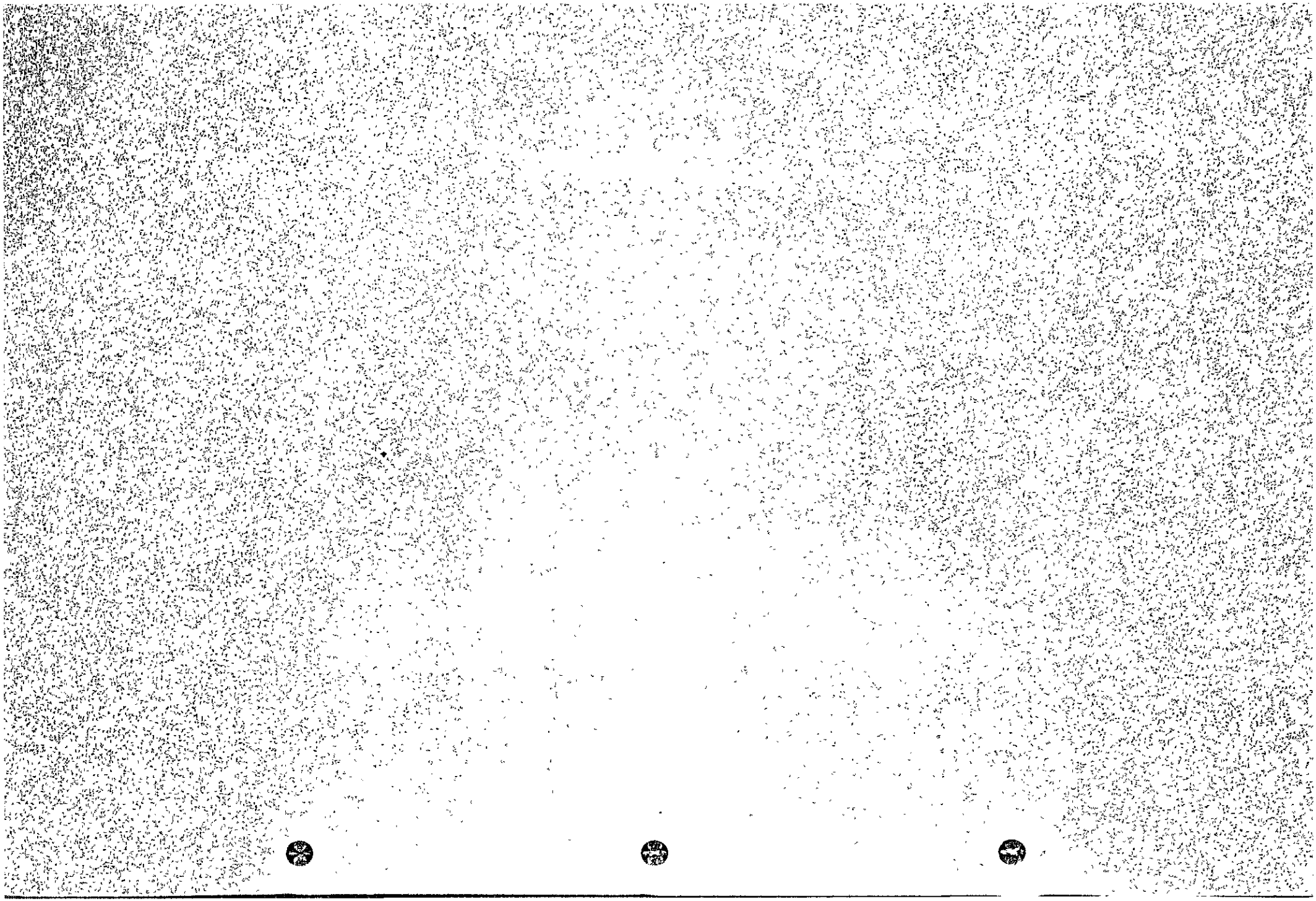
- Turnout structures	254 places
- Inverted siphon structures	13 places
- Culverts for under drain	17 places
- Bridges	28 places

2.2.6. Power Generation

Annual generation of power	25 MWH
Power station A. Installed capacity	3,000KW
Power station B. Installed capacity	7,000KW

CHAPTER 3

BACKGROUND



3. Background

3.1. National Economy

3.1.1. Population and National Territory

The total population of the Philippines in 1980 was 47,914,000, with 2.6% of the average annual growth rate of population from 1975 upto 1980. The total area of the national territory is about 300,000Km^2, with the population density of 159.7 persons/Km^2.

The country is composed of 47 provinces in 1980. In terms of administration, the country is consisted of 13 Regions, i.e., the National Capital Region (Metropolitan Manila) and the Regions 1 through 12. The Project area belongs to the Pangasinan Province, of the Region 1. The population of the Region 1 is 3,544,000, while it has an area of 21,568.4Km^2, resulting a population density of 164.3 persons/Km^2, which is almost same as the national average. Pangasinan Province has a population of 1,637,000 and an area of 5,368.2Km^2, which means approximately 47% of the population and 25% of the area of the Region 1, resulting the population density of 304.9 persons/Km^2, which is approximately 2 times as large as the average population density in the Region 1 and the whole Philippines.

Population, Land Area and Population Density in 1980

	Population (thousands)	Land Area (Sq. Km.)	Density (Persons/sq. Km.)
Philippines	47,914	300,000.0	159.7
Region I	3,544	21,568.4	164.3
Pangasinan	1,637	5,368.2	304.9

Source: 1981 Philippine Statistical Yearbook (NEDA)

3.1.2. Gross Domestic Product (GDP)

The Gross Domestic Product (GDP) of Philippines in 1980 is 268,167 million Pesos (91,947 million Pesos at constant 1972 price), i.e., 1.8 times as large as the GDP of 42,448 million Pesos (51,014 million Pesos at constant 1972 price) prevailing in 1970. Therefore, the annual average growth rate taking place during the said period is 6.1%.

The annual average growth rate taking place in the sectors of agriculture, forestry and fishery is 4.8%, lower than the overall average. The percentage of GDP shared by the sector in 1980 with regard to the total is approximately 25%, evidencing therefore a small decline compared with the 28.9% prevailing in 1970.

Gross Domestic Product (GDP)	Million Pesos (1972 Constant Price)					
Industry	1970		%	1980		%
Agriculture, Fishery and Forestry	11,782	(14,734)	28.9	62,487	(23,627)	25.7
Industrial sector	12,581	(15,048)	29.5	100,823	(33,354)	36.3
Service sector	18,085	(21,232)	41.6	104,857	(34,966)	38.0
Gross Domestic Product	42,448	(51,014)	100.0	268,167	(91,947)	100.0

Source: 1981 Philippine Statistic Yearbook (NEDA)

3.1.3. Labour Force

In 1978, the labour force of the country was 17,363,000, with 16,668,000 employed persons. The number of unemployed workers was 695,000 persons, with an unemployment rate of 4.0%. This indicates a trend of decrease in the unemployment rate, which was 5.2% in 1976.

Labor Force

Year	Total Labor Force	Labor Force by Employment Status			
		Employed		Unemployed	
		Number (thousands)	Percent	Number (thousands)	Percent
1975	15,161	14,517	95.8	643	4.2
1976	15,018	14,238	94.8	780	5.2
1977	14,994	14,323	95.5	671	4.5
1978	17,363	16,668	96.0	695	4.0

Source: 1981 Philippine Statistical Yearbook (NEDA)

The analysis of the number of employed persons by major industry group evidences that the sector of agriculture, fishery and forestry absorbs 8,702,000 of the work force, corresponding to approximately 52% of the total. The number of employed persons in the Region I is 1,240,000, with 749,000 absorbed by the same sector, corresponding to approximately 60% of the total of the region. In other words, the percentage of workers absorbed by this sector in this Region is higher than the national average, which means major industry of the Region I area is considered to be agriculture, fishery and forestry.

Employed Persons (in thousands) 1978

	Total	Agriculture Fisheries, Forestry	Others
Philippines	16,668	8,702	7,966
Region 1	1,240	749	491
%	7.4	8.6	6.2

Source: 1981 Philippine Statistical Yearbook (NEDA)

3.1.4. Agricultural Production

The harvested area of the country in 1980 comprising all kinds of crops was 12,134,400ha, and the harvested area of paddy was 3,503,000ha, i.e., the harvested area of paddy corresponds to 30% of the total. The production of paddy was 7,504,400 tons, corresponding to 25% of all kinds of crops. The value of the paddy production was 8,039.9 million Pesos, corresponding to 27% of the total value of all agricultural production.

Agricultural Area Harvested, Quantity and Value of Agricultural Production in 1980

	Area Harvested (1,000ha)	Quantity (1,000 ton)	Value (1,000,000₱)
Total	12,134.4	29,566.2	37,609.4
Paddy	3,503.0	7,504.4	8,030.9
Other Food Crops	4,714.5	14,081.0	8,657.4
Commercial Crops	3,905.9	7,981.7	14,476.0

Source: 1981 Philippine Statistical Yearbook (NEDA)

The production of paddy in 1970 was 5,233,400 tons, with an average yield of 1.681 tons/ha. The total production and the yield presented fluctuations during the first half of the '70s, but from 1975, these two parameters present a trend of constant increase. In 1980, the total production of paddy in the country was 7,504,400 tons, while the average yield was 2.142 tons/ha.

Area Harvested, Production and
Mean Yield of Paddy

Crop Year	Area Harvested (1,000ha)	Production (1,000 ton)	Average Yield (ton/ha)
1970	3,133.4	5,233.4	1.681
1975	3,538.8	5,660.1	1.599
1976	3,579.3	6,159.5	1.721
1977	3,547.5	6,456.1	1.820
1978	3,508.9	6,894.9	1.965
1979	3,468.9	7,197.6	2.075
1980	3,503.0	7,504.4	2.142

Source: 1981 Philippine Statistical Yearbook (NEDA)

The statistical data regarding the production of paddy in the various regions indicates that in 1980 the harvested area of the Region I was 311,410ha, with a production of 647,150 tons. The average yield is 2.078tons/ha, which is practically same as the average yield prevailing in the country as a whole.

Area Harvested, Production and
Average Yield of Paddy in 1980

	Area Harvested (1,000ha)	Production (1,000 ton)	Average Yield (ton/ha)
Total	3,503.0	7,504.4	2.142
Region 1	311.4	647.2	2.078
Others	3,191.6	6,857.2	2.149

Source: Bureau of Agricultural Economics

3.1.5. Demand and Supply of Food

In the early '60s, the situation of food supply in the Philippines evidenced critical situation, which is so-called the "Rice Crisis". In the period ranging from 1963 through 1965, the annual imports of rice increased from 250,000 tons to 570,000 tons. After this period, technical renovation like the development and extension of high yielding varieties, applying fertilizers, etc., was introduced in the agricultural sector. No import of rice was required in 1968.

In the early stage of '70s, the production of paddy in the Philippines declined due to a consequence of unfavourable meteorological conditions and spreading of deseases and insects and the import of rice increased once again. The annual quantity of imported rice in the period of 1973 through 1975 ranged from 360,000 tons to 460,000 tons. However, in the late '70s the agricultural production of the country stabilized, and in 1976 the production of paddy surpassed the domestic consumption. The quantity of imported rice was only 24,000 tons, and the surplus was stored as reserved rice.

The national average production of paddy in 1980 was 156.6Kg/person. The conversion ratio from paddy to edible rice is 63%, and the quantity of edible rice supplied per capita in 1980 was 98.7Kg.

In the Five Year Development Plan of the Philippines (1978 through 1982), the future consumption of rice per capita is assumed to be 89.4Kg. However, the production and consumption of rice present some fluctuation in each region and the consumption tends to be higher in rice producing regions. In the Pangasinan Province, the said Plan assumes that the consumption of paddy per capita is 239Kg (150.6Kg in terms of polished rice). <1

<1 Source; Office of Provincial Agriculturist, Province of Pangasina.

According to the Five Year Development Plan of the Philippines (1978 - 1982), the population of the country is estimated at 52,036,000 persons in 1982 and 59,903,000 persons in 1987, assuming an annual average population growth of 2.9% during the period. If the tendency of population growth rate remains unchanged, the population of the country in 1990 will be 65,191,000 persons, and a production of 5,828 through 9,818 thousand tons of rice will be required (9,251 through 15,584 thousand tons of paddy) in order to feed the said population.

On the other hand, the Five Year Plan assumes a production of 7,999 thousand tons of paddy in 1982 and 9,870 thousand tons in 1987, with an average growth rate of 4.5%/year. This growth rate surpasses the expected population growth rate. If this growth rate of paddy remains unchanged until 1990, the production expected in that year will be 11,197 thousand tons.

The Philippines is presently self-sufficient in terms of rice, but further increase in the production is required to improve the living standards of the people.

3.1.6. Economic Planning

The Government of the Philippines has prepared the "Five-Year Development Plan, 1978 - 1982", which sets up the following national development goals.

1) Promotion of the social development and the social justice through:

   - creation of the productive employment opportunities;
   - reduction of the income disparties;
   - improvement of living standard of the poor; and
   - enrichment of the social and cultural values;

2) Attainment of the self-sufficiency in food and greater self reliance in energy;

3) Attainment of a high and sustained economic growth;

4) Maintenance of an acceptable price level and improvement in domestic resource mobilization and balance of payments position;

5) Expedited development of lagging regions, especially rural areas;

6) Improvement of habitat through the development of human settlement and proper management of environment; and

7) Maintenance of internal security and harmonious international relations.

The strategies and policies required in the agricultural sector in order to materialize the goals are as follows.

1) Promotion of the agrarian reform through the reinforcement of the modernization plans:

   - Compact farming;
   - Resettlement program;

2) Development and strengthening of farmer organizations;

3) Improvement of the production efficiency:

   - Expansion of irrigated areas
   - Introduction of high yielding varieties (HYV)
   - Effecient use of fertilizers and pesticides
   - Improvement of the agricultural methods, through the agricultural extension service system and farm population education.
   - Development of better farming systems in rainfed areas
   - Land expansion in relatively unexplored frontiers.
   - Improvement of productivity of the fishing industry, through the modernization of fishing facilities.
   - Improvement of productivity of livestock industry through the improvement of both breeds and techniques.

4) Improvement in marketing system and post-harvest operation:

   - Stabilization of prices, expansion of buffer stock and grains storage facilities.
   - Improvement of the efficiency in inter island movement of grains through the construction of grains terminal silos.

- Prevention of post-harvest losses, through the improvement of the rice processing efficiency at the farms and improvement of storage efficiency of polished rice.
- Consolidation of the infrastructure, like roads from the farms to the market, fishing ports, etc.

5) Management of the pricing of farm inputs and outputs.

6) Extension of the agricultural credit system.

Among the items listed above, top priority is given to upkeep the stable and sufficient food supply, being considered indispensable the storage of paddy to ensure its self-supply.

It is necessary to increase the production of rice from 6.7 million tons in 1978 to 8.0 million tons in 1982, with an annual average of 4.4%, with a further increase to 9.9 million tons in 1987.

In order to achieve the target, it is necessary to increase the harvesting area of high yielding varieties from 2.5 million hectares to 2.9 million hectares during the period of implementation of the Five Year Plan, followed by a further increase to 3.4 million hectares in 1987. The percentage of high yielding variety harvesting areas with regard to the total harvesting area of paddy will increase from 69.6% in 1978 to 80.8% in 1982. The percentage of irrigated areas in the high yielding variety harvesting areas will increase from 57.3% to 65.1% during the 1978-1982 period, and in 1987 the entire irrigated areas will be cultivated with high yield varieties.

The stable supply of water to the arable lands is a very effective means to expand the agricultural production, to

improve the productivity of the land and to absorb the labour force. Therefore, the irrigation projects contribute to achieve the self-sufficience in terms of food, which is one of most important national policies, and is also closely related with the stabilization of the prices of food through the improvement of productivity. Presently, the shortage of irrigated areas is of the order of 770,000ha. This shortage will become more rigorous as a consequence of the increase in the demand of rice, being therefore required a further irrigation projects.

The Ten Year Plan (1978-1987) expects to carry out the improvement of existing irrigation facilities in 254,903ha of harvesting areas, besides the development of 1.4 million hectares of new irrigated areas. By 1987, the total irrigated area will reach 2.57 million hectares, which corresponds to 73% of the irrigable areas.

3.2. Present Profile of the Agriculture in the Project Area

3.2.1. Population and Area of the Project

In 1980, the population of the four municipalities namely, Alaminos, Bani, Mabini and Sual was 108,529 persons, corresponding to 6.6% of the total population of the Pangasinan Province. On the other hand, the area of the four municipalities is 698.4 Km^2, i.e., 13.0% of the total area of the Pangasinan Province, resulting the population density of 155.4 persons/Km^2. The population density corresponds to approximately 1/2 of the average value prevailing in the Pangasinan Province, but it is practically equivalent ot the national average population density.

Among the four municipalities located in the project area, Alaminos has the largest population of 47,710 persons. It has also the highest population density of 299.7 persons/Km^2 and is the most important municipality of the project area.

The estimation of the number of families of each town, based upon the results of the survey of number of families carried out in 1975 showed that the total number of families in the four towns was 16,587. According to the agricultural census of 1971, the number of farmers families in the four towns was 7,379, corresponding to 56% of the whole number families living in the area. Particularly in the towns of Bani and Sual, the percentage of farmers' families exceeds 60%, evidencing agriculture sector is the major industry in the project area.

3.2.2. Labour Force

In 1975, the population aged 10 or more in the Pangasinan Province was 1,063,647, of which 391,557 persons, corresponding to 36.8% is actually employed. The analysis of the number of persons employed in the various economic sectors evidences that the agriculture, forestry and fishery sector employs the largest number of persons, i.e., 212,360 persons, corresponding to 54.2% of all economic sectors.

In 1970, the population aged 10 or more of the four towns of the project area was 55,833 persons, of which 27,248 of that total composing the labour force. The total of employed workers was 23,562 persons, presenting therefore an unemployment rate of 13.5%. In the Pangasinan Province as a whole, the labour force consists of 402,972 workers, with 356,308 of that total actually employed. Therefore, the rate of unemployment in the whole province is 11.6% and the rate in the four towns exceeds that of the whole Pangasinan Province.

3.2.3. Utilization of Land

According to the agricultural census of 1971, the agricultural land existing in the four towns related to the project area is 21,758ha, which the arable land is 17,334ha. The area of short-duration crops mainly composed of paddy is 15,927ha, corresponding to 73% of the total agricultural area, and there are 9,934 farmers cultivating therein.

According to the land use survey, carried out by the NIA, the arable area is 12,146ha, and 5,104ha is non-arable.

3.2.4. Land Hold

According to the agricultural census in 1971 on the condition of land hold surveyed, the percentage of tenancy (sharecropping) of Alaminos and Sual is higher than the average of the Pangasinan Province, while the percentage in Mabini and Bani is lower than the average of the Province. In the comparison of the data collected by the abovementioned agricultural census with those ones collected by the agricultural economy survey carried out by the NIA in 1979, the percentage of tenants (sharecropping) tends to increase. The tendency of sharecropping tends to decrease, while the percentage of fixed amount of tenants tends to increase.

3.2.5. Soil

The NIA carried out soil survey at 16 points in the project area, to clarify the characteristics of the soil. During the present study, additional 11 holes were drilled, totaling 27 points.

The Alaminos soil existing in the eastern part of the Alaminos town and in the northern part of the Mabini town presents a relatively high productivity, and its drainage characteristics are also satisfactory. This kind of soil occupies 36% of the total area. The Bani Clayey Soil is found in the town of Bani and in the western part of the town of Alaminos. This is a soil with poor drainage characteristics in addition to a low productivity and corresponds to 25% of the total area. The BaASIL and BaBCL of the western part of the town of Mabini occupies 14% of the total, and its productivity can be increased by improveming the drainage system. Alaminos BCL, CCL and DCL are found everywhere in the remaining area.

3.2.6. Agricultural Production

In 1975, the paddy harvesting area of the four towns was 26,300ha, corresponding to 89% of the total harvesting area of all kinds of crops. The production was 73,758 ton, corresponding to 92% of the total production of all kinds of crops. The data evidences that this is an area where the agriculture is concentrated mainly on the cultivation of paddy.

According to the data provided by the Alaminos Office of the BAECON, the production of paddy during the period of 5 years extending from 1977 to 1981 presented decline, both in terms of two season cropping and single season cropping, with exception of Alaminos in 1980.

Furthermore, the same data of the Alaminos Office of the Bureau of Agricultural Economics (BAECON) evidence that in terms of relation between cultivation area and cropping area of paddy in 1980, there is a slight reduction of cropping area. The fact is attributable to the delays in the rainfall and to influence of typhoons.

Table 3.2.1 PADDY: Area Harvested and Production in Four Municipalities of Western Pangasinan

Municipality	Crop Year	IRRIGATED (1st crop) Area	IRRIGATED (1st crop) Production	RAINFED Area	RAINFED Production	UPLAND Area	UPLAND Production	(2nd crop) Area	(2nd crop) Production
Alaminos	1977	1693	111,280	7794	319,436	281	8,704	408	2,704
	1978	1472	117,276	7548	310,770	271	8,672	532	35,644
	1979	1472	110,114	7548	345,260	271	9,405	532	35,112
	1980	1442	109,592	7397	369,850	266	9,044	1,194	116,541
	1981	1176	71,736	5983	227,354	178	4,014	643	30,221
Bani	1977	181	8,289	4969	177,337	501	13,954	381	1,890
	1978	157	6,877	4810	176,360	492	16,236	44	2,420
	1979	157	7,744	4810	181,960	492	15,744	44	2,376
	1980	153	7,803	4714	179,132	482	14,942	87	4,895
	1981	317	13,631	4403	162,911	163	3,260	29	1,044
Mabini	1977	266	12,000	2182	37,950	288	6,600	222	12,210
	1978	381	22,686	1575	45,528	245	5,145	281	16,184
	1979	381	22,692	1572	59,760	245	5,880	289	16,473
	1980	373	22,753	1541	50,853	240	5,760	65	3,705
	1981	224	13,440	1983	53,541	90	1,530	0	0
Sual	1977	2000	154,000	2469	108,750	519	18,268	670	43,550
	1978	1050	84,000	2743	117,949	578	20,808	876	60,444
	1979	1050	80,850	2743	115,205	577	20,772	874	61,180
	1980	1050	73,500	2688	120,960	569	16,950	710	52,578
	1981	842	50,520	2513	82,929	134	2,546	364	14,924
Total	1977	4140	285,569	17414	643,473	1589	47,606	1681	60,354
	1978	3060	230,839	16,673	650,407	1586	50,861	1733	114,692
	1979	3060	221,400	16,673	702,185	1585	51,881	1730	114,160
	1980	3018	213,648	16,340	720,795	1557	46,696	2056	177.719
	1981	2559	149,327	14,882	526,735	565	11,350	1036	46,189

Unit: Area — hectares harvested.

Production — cavans in sack of 50 kgm.

Note : These are preliminary estimates.

(i) 1981 IRRIGATED: July-December 1980, 1981 RAINFED: July-December 1980. 1981 UPLAND: July-December 1980, 1981 2ND CROP: January-June 1980.

(ii) Decreased in area harvested and production is due to late rainfall and typhoon.

Source: Ministry of Agriculture, Bureau of Agricultural Economics, Alaminos, Pangasinan.

3.2.7. Paddy Yield

The average yield of paddy is selected from the period of 5 years extending from 1977 to 1981, by excluding years with pronounced reduction of harvest due to special calamities, etc. (in 1981, the harvested quantity of rice presented a considerable reduction due to drought) is presented in the table below.

Paddy Yield (ton/ha)

Municipality	Wet Season			Dry Season
	Irrigated	Rainfed	Upland	Irrigated
Alaminos	3.84	2.28	1.68	4.15
Bani	2.40	1.87	1.60	2.77
Mabini	3.00	1.67	1.15	2.86
Sual	3.78	2.17	1.70	3.54

(Weighted average of harvesting area)

The yield of paddy per unit area in the irrigated paddies is 2.40 through 3.84 ton/ha in the wet season, and 2.77 through 4.15 ton/ha in the dry season, while in the rain-fed areas, the yield is of the order of 1.67 through 2.28 ton/ha.

3.2.8. Operation of Farms

(1) Farming Scale

In terms of farming area per farmer, the size of 1.0 ha through 3.0 ha per farmer corresponded to 57% of the total number of farmers surveyed in 1971 and 71% in 1979

which is considered to be almost same as 1971. However, the percentage of farmers of which farm size is less than 1.0ha increased from 10% in 1971 to 25% in 1979, which means the number of small scale farmers increased considerably.

The peak labor will be developed in course of the transplantation of paddy and the harvesting. These peaks are the factors which contribute decisively to restrict the expansion of the farming size. Accordingly, the introduction of agricultural machinery will be indispensable in the project.

(2) Grade of Dispersion of Arable Land

Number of patches cultivating by each farmer is ranged in 1 through 3 parts, located relatively close to their dwellings. Therefore, dispersion of cultivating land is in a relatively satisfactory situation in the project area.

(3) Masagana 99 Project

The Masagana 99 Project was established to increase the yield of paddy in the Philippines. The Masagana 99 project is under the administration of the National Food and Agricultural Council (NFAC) and is aimed at providing the seeds of high yielding varieties, fertilizers, insecticides and extension service.

The Masagana 99 Project also provides financing to its members. The limit of such financing is presented in the table below and the required interest is 1% per month.

∘ plowing and other land preparation	525	₱/ha
∘ transplanting work	350	
∘ weeding	165	
∘ Sub-total	1,040	(paid in cash)
∘ seed	60	
∘ agricultural chemicals	200	
∘ fertilizer	300	
∘ Sub-total	560	(paid in coupon which is convertible into the above items)
Total	1,600	

After the completion of the Mabini Agricultural Development Project, the farmers cultivating in the project area will be entitled to participate in the Masagana 99 Project as members, being therefore possible to be financed at low interest rates.

(4) High Yielding Varieties

The cultivation of high yielding varieties, consisting mainly of IR-36, 42 and 50 have widely prevailed in the project area, and the farmers are cultivating the variety with best manners suited to each case. The varieties recommended to select by the Masagana 99 Project in 1978 was of virus resistance capability.

3.2.9. Existing Irrigation Facilities

Presently, there are 17 areas provided by irrigation facilities within the project area. The irrigable area covered by the facilities is surveyed at about 3,000ha. (Table 3.2.13 of supporting report) However, as a matter of fact, only 1/2 through 1/3 of the total irrigable area is actually irrigated during the dry season, due to high oil price and insufficiency of the water resources. Most of the existing irrigation facilities consist of weirs and pumps. Gravity irrigation from rivers is very rare.

The weirs are provided with gates and stoplogs, but it is impossible to increase the weir height because this kind of weir should not be an obstacle to the river flow at the occasion of floods. Even in case of pumping-up irrigation, the used machines are mostly submersible pumps or centrifugal pumps tentatively installed, and such facilities are frequently clogged at suction portion with sand.

Furthermore, pumping facilities are often not in operation due to soaring costs of electricity and fuel.

In view of the circumstances, the presently existing irrigation facilities seem to be temporary facilities.

Nevertheless, the service areas covered by such irrigation facilities were taken into account and means to improve such irrigation practices were studied.

3.2.10. Forecast of Demand and Supply of Paddy

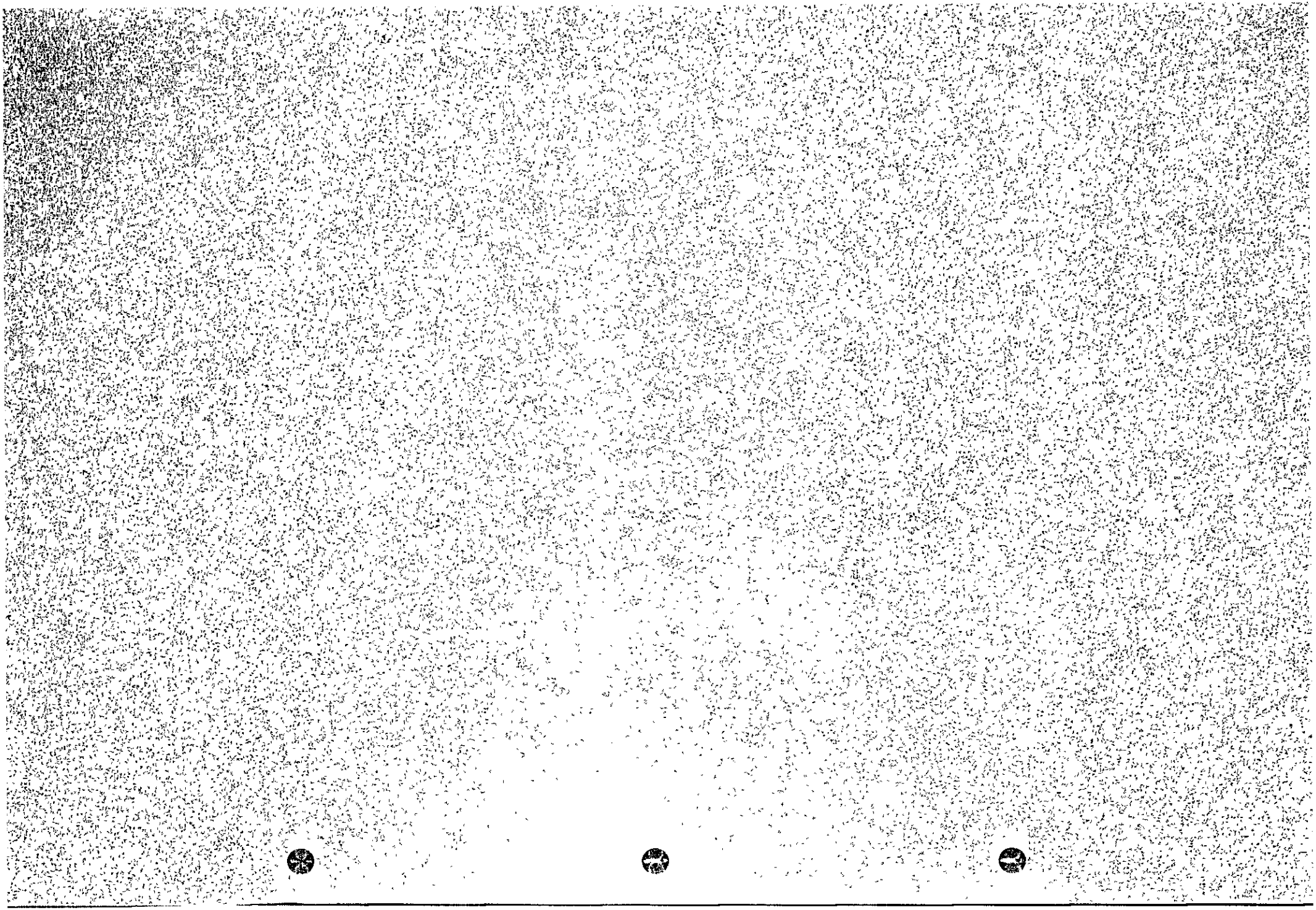
The Pangasinan Province and the project area presented a practically linear population growth from 1960 through 1980. If the tendency remains unchanged in the future, the population of the Pangasinan Province in 1990 will be 1,900,000, while in the 4 towns of the project area it is expected to be 125,800.

Assuming an annual consumption of paddy of 239Kg per capita (Socio-Economic Profile of Pangasinan), the Pangasinan Province will require 454,100 tons, and 30,066 tons of paddy in the project area per year in order to feed the respective populations.

However, the production of paddy within the project area was 733,601 tons in 1981, being therefore perfectly self-sustained in terms of rice. Accordingly, the increase of production of paddy in the project area will contribute to supply rice to the other areas where paddy production is insufficient, increment of reserved rice and earning of foreign currency through exportation.

CHAPTER 4

METEOROLOGY & HYDROLOGY



4. Meteorology & Hydrology

4.1. Meteorology

The project area belongs to the tropical zone and suffers from the influence of the monsoon. The temperature presents minor seasonal variations, within the limits of approximately 26.0°C through 29.6°C (monthly average).

The rainfall data presents considerable seasonal and annual variations. A year can be divided into two seasons, namely the rainy season from May to October and the dry season from November to April. In rainy season, rain falls approximately 94% of the total annual amount, and in December rainfall is normaly very scare.

As for the annual variation of the rainfall, according to data collected at the Mabini Meteorological Station located nearby the planned dam site, the maximum rainfall observed during the period of 1956 to 1980 was 4651.6mm (1972), the minimum was 1966.7mm (1959) while the average was 3134.7mm, with a quite pronounced variation annual rainfall in the project area.

The evaporation in the project area is very large. The annual amount of evaporation exceeds 2,000mm. Collected data shows that the evaporation in the dry season is higher than in the rainy season.

Wind blows from SSE in January and February, from NNW in March and April and from SE during the period from May to December.

4.2. Available Data of Water Resources

The runoff records of the Balincaguin River are abailable from 2 gauging stations: one is operted by the BPW during the period of 1959 through 1974 and another is observed by the NIA from 1979 to date. The BPW station is located approximately 6.5Km downstream, while the NIA gauging station is located approximately 50m upstream of the proposed dam-site.

Data recorded by the BPW is partially missing. However, they were recorded with the automatic water level recorders provided in the observation stations and the obtained results are arranged in a systematic way. Unfortunately the gauging station was lost at the occasion of a flood in 1974 and presently there is no vestige of it.

On the other hand, data collected by the NIA present a short period of time and are obtained by using staff gauge, measuring water level twice a day.

Taking the above facts into considerations, data collected by the BPW were used for the hydrological study of the Balincaguin River.

Inflow to the reservoir is estimated by multiplying the discharge measured at the Balincaguin Observation Station of the BPW with the rate of the catchment area, i.e., 225/242. Here 225Km^2 expresses the catchment area of the proposed dam-site, while 242Km^2 expresses the catchment area at the site where the BPW Gauging Station is located.

4.3. Basic Drought Year

The water balance of the reservoir is studied based upon the basic drought year. The basic drought year is

determined from the frequency analysis regarding the annual rainfall data (Mabini Observation Station of PAGASA, Period: 1956 through 1980) and annual runoff data (Balincaguin Gauging Station of BPW, Period: 1959 through 1974), by taking 1/5 in the non-exceedance probability for formulation of the irrigation project. Results of the frequency analysis is as follows.

Probability of non-exceedance	Rainfall (mm)	Runoff (MCM)
2 year	2138.9	494.4
3 year	2881.7	464.0
5 year	2650.0	400.0
20 year	2259.4	371.8

The annual rainfall of 2668.2mm occurred in 1968 and the annual runoff of 429.37MCM occurred in 1970 correspond respectively to once every approximately 5 years. Accordingly, 1968 is selected as basic drought year. The study of the water balance of the reservoir is carried out for 3 years from May of 1967 to April of 1970, by eliminating the influence of the initial values as well as by subsequent calculation steps (in units of months) before and after the basic drought year aiming at checking the conditions of reservoir operation of the dam.

4.4. Flood Runoff

The flood analysis of Balincaguin River is carried out by taking into consideration the concept of Probable Maximum Precipitation (PMP) (refer to Fig. 4.3.2 in Supporting Report), which is prepared by the rainfall data observed at the Baguio Meteorological Station of the Luzon Island, and the concept of the unit hydrograph method regarding the major floods observed at the Balincaguin River Gauging Station of the BPW.

The Mabini Meteorological Station of the PAGASA, located near the proposed dam-site is of the ordinary type, and has a complete record of daily rainfall. The observation stations located nearby are equipped with automatic rainfall recorder, but do not have complete data to make possible the study of the rainfall intensity for a short interval of time. Therefore, the design rainfall based upon the data collected in Baguio is used for the purpose of the flood study and adjusted with the inflow design flood data of other dam projects.

The maximum design flood discharge is estimated that the peak flow is 4,000m^3/s, and its frequency is equivalent to approximately 1/5,500, according to the results of frequency analysis based upon the annual maximum flood flow of the Balincaguin River Gauging Station of the BPW. Regarding the comparative study of the specific discharge, it is calculated at 17.8$m^3/s/Km^2$ at the proposed dam-site of Balincaguin River. The specific discharges of other dam projects suggests that the specific discharge of 17.8$m^3/s/Km^2$ in the Mabini Project appears to be reasonable.

The tentative flood discharge during the construction work is assumed to be the flood discharge equivalent to 1/20 in the probability. Frequency analysis based upon the maximum annual flood discharge of the Balincaguin River Gauging Station of the BPW resulted that the design flood discharge during construction period is 1,500m^3/s.

4.5. Sedimentation

There are not sufficient data enough to find out a relationship between the quantity of sedimentation load and the discharge amount of Balincaguin River.

A sufficient complete study for the purpose was carried out in the Central Luzon Development Project, and the results of the study indicate that the unit sedimentation is 1,670 tons/Km^2/year. As for the other projects, the value of 2,075 tons/Km^2/year is adopted in the Magat River Multipurpose Project, 1,711 tons/Km^2/year in the UPRP (Upper Pampanga River Project) and 1,949 tons/Km^2/year in the Jalur River Multipurpose Project.

Among them, the design sedimentation of the Mabini Project is determined to be the value of 1,670 tons/Km^2/year of sediment obtained in the Central Luzon Development Project.

The total sedimentation of the reservoir thus is calculated to be 29 million cubic meters for a period of 100 years and the catchment area of 225 Km^2.

4.6 Existing Water Right

As shown in Figure 4.6.1 and Table 4.6.1, the water rights along the Balincaguin River for mostly irrigation purpose have been granted and all of them are located at the downstream of the planned dam-site.

The total amount of the granted water rights is $0.362 m^3/s$.

Fig. 4.6.1 Established Water Rights
(Surface Water)

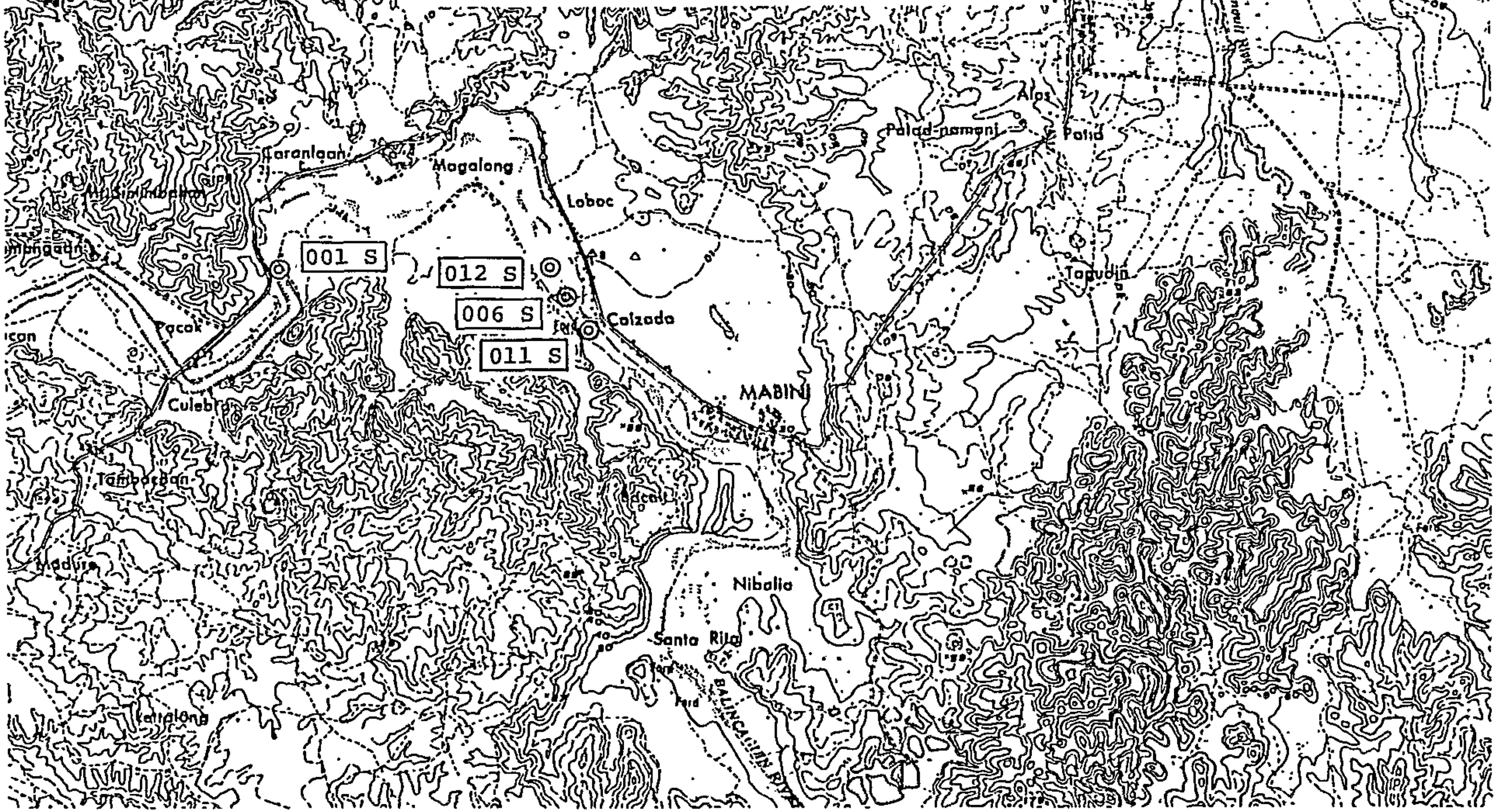


Table 4.6.1 Existing Water Rights

Balincaguin River

No.	Serial No.	Permit No.	Name	Date Granted	Source	Q (l/s)	Remarks
1	001S/1	2223	FSDC/2	Jan.13,1977	Balincaguin River	40	Approved
2	006S	3617	FSDC	Mar.13,1978	Mabini/3 River	50	Approved
3	011S	5198	FSDC	Apr.23,1979	Balincaguin River	125	Approved
4	012S	7810	FSDC	Oct. 3,1980	Balincaguin River	147	Approved
Total	-	-	-	-	-	362	-

NOTE: Data Source; NWRC

/1 S ; Surface Water

/2 FSDC ; Farm System Development Corporation

/3 Mabini River ; Balincaguin River

4.7 Water Quality

The water quality analysis was carried out with the water samples collected from the Balincaguin River.

Results of the analysis of the collected water samples are presented in Table 4.7.1, while the allowable contents of the various elements provided by the National Pollution Control Commission (NPCC) regarding irrigation purpose are shown in Table 4.7.2.

Compared with the standard provided by the NPPC, with exception it is clear that the chemical elements contained in the collected water sample are less than the NPCC standards except one sample collected on March 16, 1981. Therefore, it is considered that utilizing water of the Balincaguin River for irrigation purpose does not present any problem.

As for the influence of the copper mine located which will be inundated by the Mabini reservoir (It was informed that the said mine stopped operation in December, , 1981), it is presumed to be negligible in terms of the water quality.

However, it is considered that further more survey of the abandoned copper mine located in the reservoir area should be carried out for future treatment of the mining and disposed materials, if necessary. For example, plugging of the remained mining shaft by concrete or other materials like clay, and dumping water material of the mining into a pit and covered by earth material are preferable treatment of the abandoned mining when further actions would be necessary.

TABLE 4.7.1 RESULTS OF WATER QUALITY
BALINCAGUIN RIVER, NIBARIW MABINI, PANGASINAN

Date Collected	E.C.x10^6 mm hos/CM 25°C	T.D.S. PPM	Ca + Mg mg/l	No. mg/l	K mg/l	CL mg/l	SO_4 mg/l	CO_3 mg/l	HCO_3 mg/l	SAR	pH	REMARKS
11-27-79	203	132	2.138	0.240	0	0.121	0.225	0.250	2.000	0.232	8.0	
4-20-80	219	142	2.499	0.300	0.020	0.194	0.621	0.375	1.413	0.268	7.4	
1- 81	222	-	2.550	0.222	0	0.091	0.202	0.101	2.626	0.197	7.4	Very low pH high EC high SO_4 - sample maybe contaminated with sulfuric acid
2- 5-81	207		2.091	0.222	0	0.091	0.210	0.101	2.323	0.217	7.4	
3-16-81	9.186		2.346	0.220	0.01	0.242	62.50	0	0	0.203	1.9	
6-26-81	185		1.485	0.400	0.02	0.091	0.192	0	1.667	0.464	7.3	

Table 4.7.2
Standard requirements of the National Polution Control Commission for Irrigation Water.

Quality Parameter		Specification
1.	Temparature	The maximum rise above natural Temperature shall not exceed 3°C outside the mixing zone as determined by the Commission
2.	Dissolved oxygen	Not less than 3 Mg./l
3.	pH	Not less than 6 nor greater than 8.5
4.	Total dissolved solids	Not more than 1000 Mg/l
5.	Sodium absorption ratio	Not less than 8 nor more than 18
6.	Trace elements	Not to exceed the following concentration:
	Aluminum	5.0 mg/l
	Arsenic	0.1 mg/l
	Beryllium	0.1 mg/l
	Boron	0.75 mg/l
	Cadmium	0.01 mg/l
	Chromium	0.1 mg/l
	Cobalt	0.05 mg/l
	Copper	0.2 mg/l
	Fluoride	1.0 mg/l
	Iron	5.0 mg/l
	lead	5.0 mg/l
	Lithium	2.5 mg/l
	Manganese	0.2 mg/l
	Molybdenum	0.01 mg/l
	Nickel	0.2 mg/l
	Salenium	0.02 mg/l
	Vanadium	0.1 mg/l

CHAPTER 5

TOPOGRAPHY & GEOLOGY

5. Topography & Geology

5.1. Topography

The proposed dam-site of the Mabini Agricaltural Development Project is located at upstream of the Balincaguin River, which originates from the mountain ranges of the NNW part of the Zambales-Pangasinan Range and approximately 5Km southeast ward from the center of Mabini.

The mountain mass adjacent to the dam-site is composed of ridgelines with altitudes of the order of EL150m. The altitude increases gradually to the upstream direction, and composes a mountainous area with the elevation of the order of several hundred meters. On the other hand, at the downstream side, the project area is the alluvial plains along the river and the low hilly area with altitudes not exceeding EL100m, in contrast to the upstream areas.

A Karst topography with slight undulations develops throughout the hilly area extending to the downstream side of the mountain area (altitudes exceeding 100m) located in the vicinity of the dam-site. Peculiar topography like doline*, etc., can be observed in the area.

At approximately 4Km upstream from the dam-site, the Balite Basit River, which is a tributary of the Balincaguin River, branches off the main stream. The basin of the Balincaguin River is located mostly at the south of the dam-site, while the basin of the Balite Basit River is located mostly in the mountain masses at the NE side of the dam-site. The total basin area is approximately 225Km^2.

In the vicinity of the dam-site, the river bed with the elevation of approximately 14m above the mean sea level has a width of about 150m. The slopes of the mountainsides at both abutments of the dam-site are of the order of 15 through 30 degree. The dam-site was selected at the narrowest river bed located at the downstream of the confluence of the Balincaguin River with the Balite Basit River.

* Doline: Karst depressions with elliptical shape.

5.2. Geology

5.2.1. General

The foundation rock in the vicinity of the dam-site and reservoir area can be classified into basalt, andesite, quartz-diorite and limestone layers. On the other hand, river bed material consisting mainly of sand and gravel are found as new deposits overlying the foundation rocks.

The project areas are formed at the downstream side of the dam-site, being observed the distribution of alluvium consisting of sandy and clayey soil.

Layer of basalt which can be seen at the dam-site is observed up to distances of 5Km in the SE direction and 10Km to the south, or upstream direction of the dam-site. Andesite and quartz-diorite areas are found, by going further upstream from the aforesaid basalt area. It is considered that the andesite was found as a result of the magmatic differentiation of the intrusions of quartz-diorite, and accordingly, the relationship between the andesite and the quartz-diorite is of gradation type. Limestone is capping the basalt layer

at the downstream side of the dam-site. The limestone layer is distributed in the vicinity of the dam-site at an elevation higher than EL.100m, while the boundary with the basalt layer presents a gentle inclination of the NW direction. Accordingly, limestone is generally distributed at the downstream side, and no basalt is observed therein.

From the lithological point of view, basalt is observed in the form of pillow lava, lava, volcanic breccia, etc., but generally speaking it is characterized by the fact of containing very frequently veins of calcite and quartz. In the vicinity of the dam-site, this layer presents weathering, and very often its surface presents argilization.

5.2.2. Geological Structure

The Philippines is part of the circum-pacific seismic zone, and belongs to an area with relatively active diastrophism. The Luzon Island itself is composed of the geological structure divided by several fualts and foldings which extend approximately in the N-S direction, and this is applicable to the western area of Pangasinan. The project area is located in the vicinity of major tectonic lines extending in the N-S direction, like the Philippines Rift Fault, Zambales Fault, etc., and is presumed to be an area with relatively active orogenic movements.

Accordingly, several lineaments having the same directional characteristics mentioned above are also observed in the vicinity of the project area. However, it is not possible to recognize the existence of major tectonic lines corssing the dam-site and the reservoir area, from the currently available geological data.

5.3. Geological Characteristics of the Dam-site

The geological structure of the dam-site consists of a base layer of basalt, capped by limestone at the mountain masses located at both abutments, at the altitudes exceeding approximately EL.100m. At the river bed, there is a thick layer of river deposite which has not solidified yet. In the river basin, a flood plain is formed, with a difference of level of 3m through 5m compared with the river bed, with a thin alluvium sedimentation.

5.3.1. Basalt Layer

The basalt layer can be divided into 4 velocity layers listed below, according to the results of analysis of the seismic exploration. The layer corresponding to the unweathered 4th speed layer presents low elastic wave velocities of the order of V=2.8 through 4.0 Km/sec as basalt. It is considered that the low velocity is attributable to the fact that the layer in question consists chiefly of pillow lave, etc., where joint of rock is prone to develop at the occasion of the cooling down. The presence of veins is predominant in the layer.

This classification in terms of velocity layers expresses with relatively good fidelity the conditions of weathering of basalt when the said type of rock (basalt) is distributed from the surface. In other words, the basalt layers classified as 1st, and the 2nd velocity layers present argilization and/or a pronounced developments of irregular cracks. This weathered layer presents a comparatively large thickness, of the order of 10m through 25m at the right bank side, while at the left bank side, it is of the order of 5m through 15m.

Velocity Layer	Elastic Wave Velocity (Km/sec.)
1st velocity layer	0.3 through 0.8
2nd velocity layer	0.8 through 1.4
3rd velocity layer	1.4 through 2.2
4th velocity layer	2.8 through 4.0

The thickness of the weathered basalt layer is very small with values of the order of 1m. The value of the elastic wave velocity at the sand and gravel layer located above the basalt layer is approximately V=2Km/sec, and the boundary with the base basalt layer can be traced at depths of the order of 30 through 35m.

5.3.2. Limestone Layer

The limestone layer can be divided in 2 horizons, namely, limestone located at the upper portion and sandstone (partially siltstone) located at the lower portion. The sandstone layer located at the lower portion is distributed with thickness ranging from 5m through 10m. This is a soft rock layer with weak resistance against weathering. Once exposed at the surface, it is prone to be weathered and converted into soil. Therefore, it is difficult to find cases of exposure of this layer at the ground surface.

On the other hand, the limestone layer located at the upper portion forms sheer cliffs, etc., being ease to recognize its distribution in view of such topographical peculiarities. Each individual lump of this limestone layer is hard, but it is also subject to weathering, resulting into formation of Karst topography dotted with doline and other formations peculiar to limestone formations. Accordingly,

the occurrence of spring water coming from the bottom of the limestone layer, limestone caverns, etc., is remarkable.

5.3.3. River Deposit

It is observed that river deposits are distributed at depths ranging from 31.0m through 31.8m.

Generally speaking, this layer is composed of sand and gravel. There are minor variations in the gravel size and percentage, but the absolute majority is composed of gravel. The major part of the gravel is hard type round gravel like quartz-diorite, etc., and the maximum diameter of gravel particles is measured to be of the order of 30cm. The layer condition of this river deposit is shown in the log chart of the Figure 5.3.1 of the supporting report. The study team selected places where the percentage of gravel components is deemed to be relatively low, and carried out the standard penetration test. The results of the test showed extremely large values, ranging from N=50 strokes/2.5cm to 50 strokes/1.5cm.

The matrix contains silt and clay at some parts, but the observation prevailing during the drilling showed the frequent occurrence of complete leakage in case of boring with water. Accordingly, it is considered that the matrix is generally composed of a kind of material ranging from fine sand to coarse sand.

5.4. Low Velocity Zone

The occurrence of low velocity zone is observed at 5 places, as a result of the seismic exploration. The said

zone extends practically in the straight line along the mountainside located at the left bank side of the dam-site and it is presumed that a fault is located therein.

Besides the case mentioned above, there are also 2 cases of low velocity zones observed at the right bank side. However, it is not possible to conclude that they are symptoms of a fracture zone with continuity like a fault, because these low velocity zones do not present an evident correlation with low velocity zones of other seismic exploration line.

5.5. Permeability

The permeability test of basalt was carried out by means of the pressure test using packer method. The results of the test are presented in the Table 5.4.1 of the supporting report. The permeability coefficient of the basalt layer presents values of the order of $K = \alpha \times 10^{-5}$ through 10^{-6} cm/sec. at the riverbed of dam-site. Making the conversion into Lugeon coefficient, the most observed permeability coefficient are below Lu=1(Lugeon).

At the mountainside, the coefficients of permeability have relatively larger values, and are generally within the range of $K = \alpha \times 10^{-5}$ through 10^{-6} cm/sec. As for the Lugeon coefficient, values of Lu is less than 1 in the most cases.

The permeability test of the river deposit is carried out at DH-11 hole. The results obtained so far are presented in Table 5.4.2 of the Supporting Report. The river deposit presents extremely large permeability coefficients of the order of $K = 10^{-1}$ through 10^{-2} cm/sec, because it is composed mostly of gravel. Besides the surface water stream flowing in the rivers, it is considered that a large quantity of water would flow under ground.

5.6. Summary

The topographical and geological characteristics of the dam-site described above can be summarized as follows in terms of engineering geology.

(1) At the upstream of the dam-site, the Balincaguin River joins with the Balite Basit River, its tributary, and at the downstream of confluence there is a narrowest topographical configuration where the proposed dam-site is selected. Accordingly, the proposed dam-site seems to be appropriate in terms of topographical conditions.

(2) As a result of the seismic exploration, it is presumed that a possible fault extends at the left bank side, forming an oblique angle with the dam axis. It is desirable to arrange the dam axis at the upstream side, where the extension of this possible fault escapes to the mountainside (west side), aiming at minimizing the influence of the fault in question on the dam embankment.

(3) It is desirable to restrict the full water level of the dam at the altituded below EL.65m, aiming at avoiding the limestone and the weathered basalt which present poor inpervious conditions.

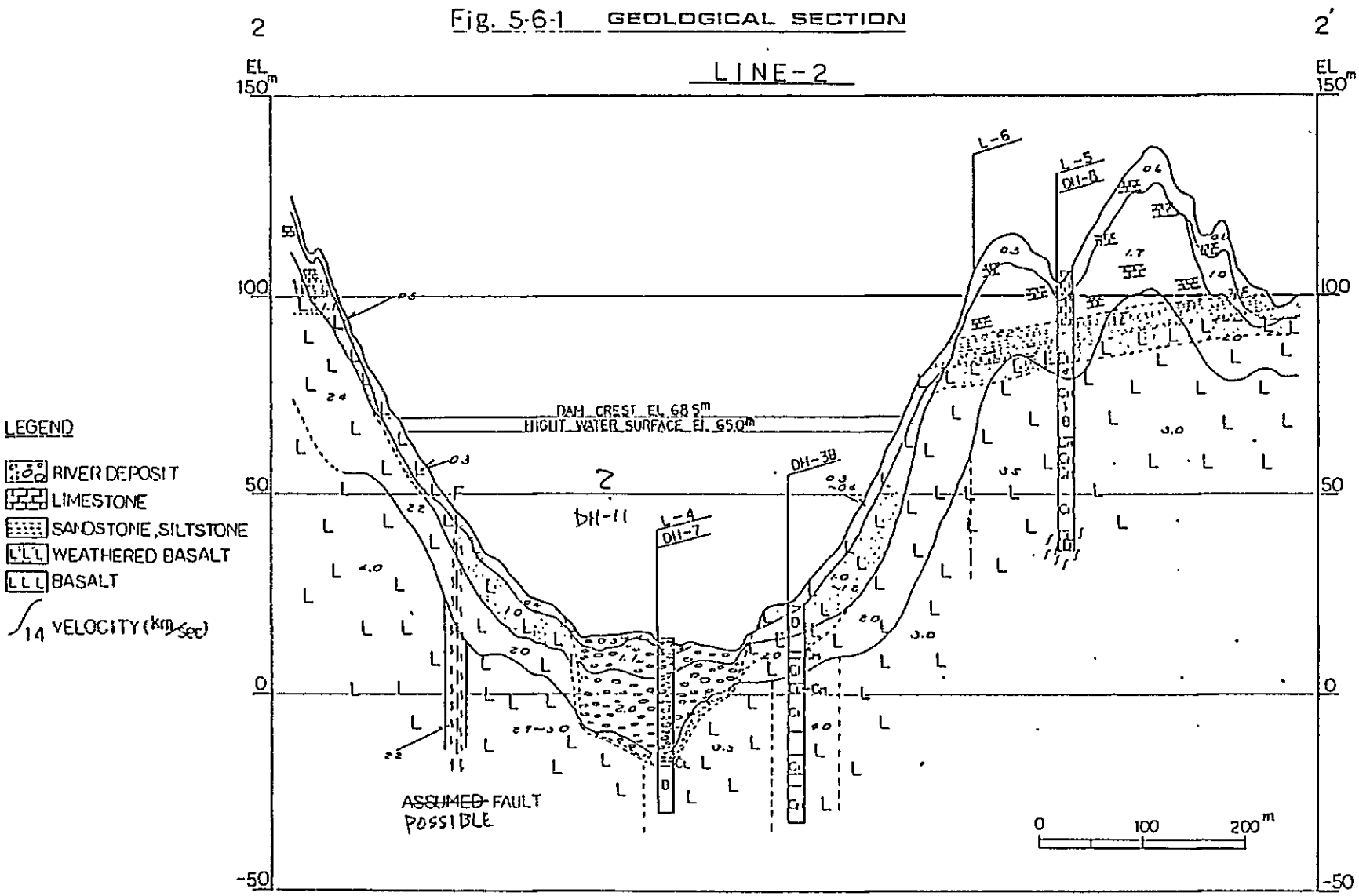
(4) It is estimated that values of the order of 10m through 25m at the right bank side and 5 through 15m at the left bank side are appropriate for excavation at both abutment of the dam axis, where basalt outerup is distributed.

(5) Layers composed chiefly of sand and gravel, with coefficient of permeability of the order of $K = 10^{-1}$ through 10^{-2} cm/sec are sedimented on the riverbed. It is considered that the cut-off measures regarding these sedimentation which are not consolidated yet will be the most important problem during the construction of the dam.

(6) It is presumed that a possible fault is located at the left bank side. Therefore, it is desirable to locate the various facilities related to the dam (spillway, diversion channel, headrace tunnel, etc.) at the right bank side.

(7) The geology of the reservoir area consists of igneous rocks like basalt, andesite, quartz-diorite, etc., and cases of major tectonic lines and topography of sliding nature are not observed therein. Accordingly, the influence of impounding water is considered to be negligible.

Fig. 5-6-1 GEOLOGICAL SECTION



CHAPTER 6

PROPOSED RESERVOIR

6. Proposed Reservoir

6.1. Site Selection

The site of the Mabini Agricultural Development Project is selected at approximately 34Km upstream from the estuary of the Balincaguin River. The longitude and the latitude of the damsite are approximately 119°57'30"E and 16°01'50"N, respectively.

The Damsite-B, located in the Namacalan River approximately 3.3Km upstream from the confluence of the Balincaguin River and the Namacalan River (the confluence is located approximately 5Km upstream from the proposed damsite) and the Damsite-C, located in the main stream side (Balincaguin River) approximately 5.2Km upstream from the point of confluence were selected as alternative sites. A comparison study of these damsites were carried out by using topographical maps of 1:4,000 and of 1:50,000 in scale. The Proposed Damsite (Damsite-A) is concluded to be the most advantageous conditions as a result of the aforesaid comparative study. The advantages of the Proposed Damsite (Damsite-A) are as follows.
(Refer to Supporting Report 6.1)

(1) The Damsite-A has the disadvantage of requiring higher construction cost due to the necessity of the treatment of the river deposit (approximately 30m thick), but, nevertheless, it is the most economical dam-site among other alternatives.

(2) From the point of view of the storage capacity, Damsite-B cannot ensure the supply of irrigation water required to cover 11,500ha (240 million cubic meters) even if ponding the total annual

runoff (134 million cubic meters) is stored because of the small catchment area. In this alternative, there are no rivers of other basins located nearby, from which supplemented water can be taken to supply the deficit.

(3) Also at the Damsite-C, the annual run-off of the river (261 million cubic meters) is not sufficient to ensure the quantity of water required for the irrigation of 11,500ha, because the catchment basin is small. In addition, there are no rivers located nearby, which might supply additional water for irrigation purpose.

Accordingly, it is not required to carry out a detailed study of the alternatives.

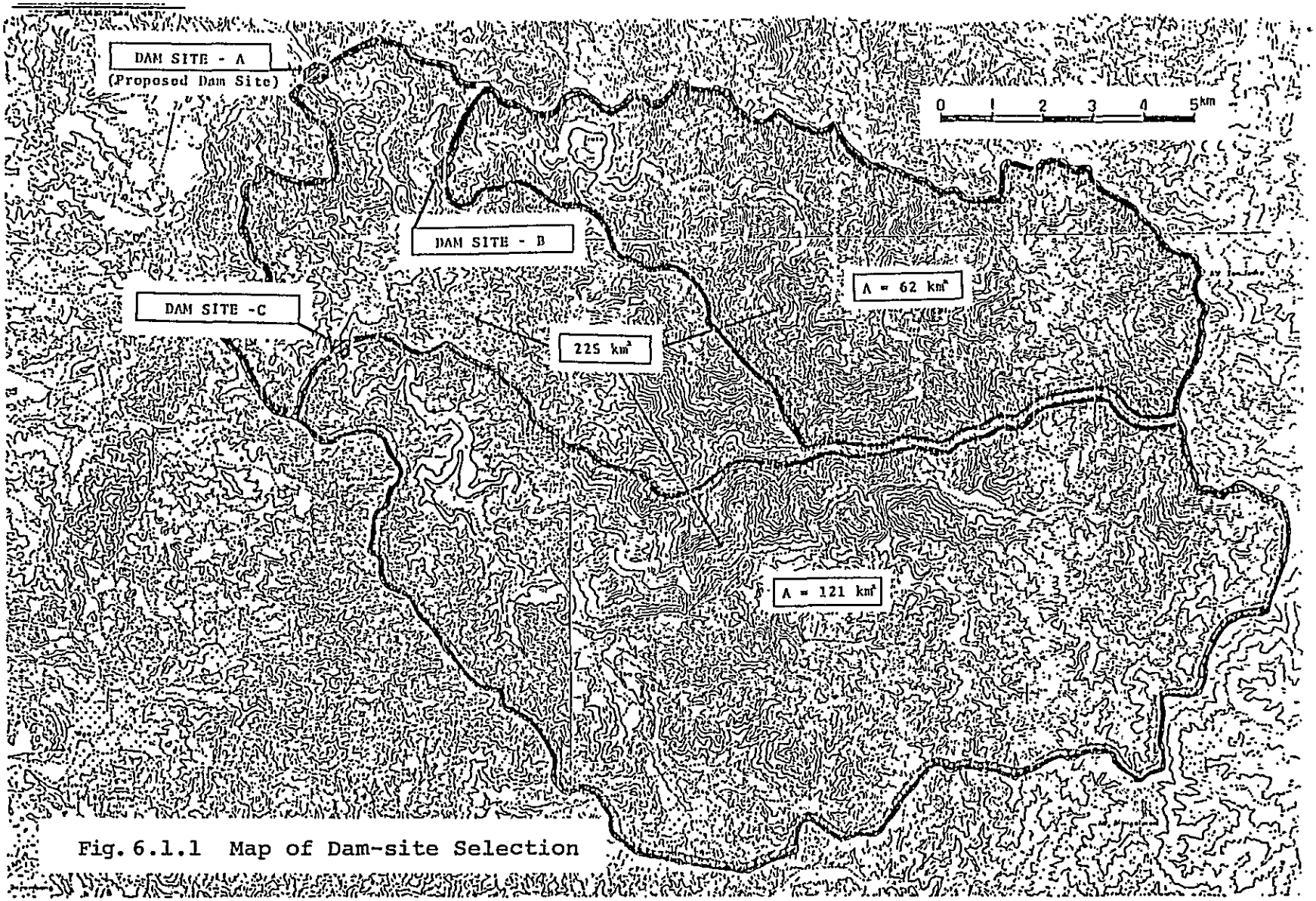


Fig. 6.1.1 Map of Dam-site Selection

6.2. Maximum Water Surface

The discussion of the maximum water surface at the proposed dam-site is presented in the followings.

(1) The sandstone layer and limestone layer overlying the basalt layers of both abutments of the dam-site have a considerably high permeability, because they normally contain caves and open cracks.

Taking into consideration the upper portion of the basalt strata at both abutments of the dam-site seems to be relatively weathered, it is recommended to restrict the high water level of the reservoir at elevation not exceeding EL65.00m.

(2) From the points of view of economy, the construction cost of the Mabini Dam contains cost of the spilway, and the foundation treatment remains practically almost unchanged, in different to the height of the dam. The height of the dam should therefore be made as high as possible, in order to reduce the unit cost per cubic meter of both the possible stored water amount and the dam embankment volume.

(3) It is advantageous, from the point of view of the national economy, to utilize the valuable water resources as much as possible.

The normal water level and the effective storage capacity of the reservoir are decided to be EL63.00m and 240 million cubic meters, by providing 2.00m depth of reservoir for a surcharge as a result of the discussion presented above and the study of the design flood described later in this report. (Refer to 12.2 of spillway structure.)

6.3. Dam Axis Selection

The dam axis should be selected at the most adequate position, by taking into consideration factors like topography, geology, type of dam, types of the pertinent structures and their layout, etc. It was decided to locate the dam axis of the Mabini Dam at a position shifted paralelly by 50m upstream from the original dam axis planned by the NIA. The aforesaid position was selected due to the following reasons.

(1) The existence of a low velocity zone was presumed at the left bank of the dam-site, as a result of the seismic exploration. The direction of this low velocity zone shifts to the mountain side as it goes to the upstream direction. It is therefore better to shift the dam axis to upstream in order to reduce the influence of the hydrostatic pressure working on the probable faults.

(2) The length of the approach waterway of the spillway can be made shorter, by shifting the dam axis by 50m to upstream. Such shift contributes to cut-down the excavation cost of the approach waterway because it requires a considerably deep excavation.

(3) This dam axis makes possible a better balance in the overall layout of the dam and its related structures like the spillway, the diversion tunnels, etc.

6.4. Proposed Reservoir

The reservoir capacity will be 345 million cubic meters and a reservoir area of 15.0Km^2 at the high water

surface (HWS = 65.00m) with inflow of the designed maximum flood (Qmax = 4,000 m^3/sec). However the peak discharge coming out from the spillway with the high water level due to the function of the surcharge capacity is 3,100m^3/sec. (Refer to Hydrology 4.3.4 and Spillway structure 12.2). In this case, the normal water surface of the reservoir is EL 63.00m, the reservoir area 14.2Km^2 and the storage capacity 303 million cubic meters.

The low water surface is EL38.00m and the capacity for dead water is 63 million cubic meters. Accordingly, the quantity of water stored between these (EL38.00m and EL63.00m) is 240 million cubic meters while the effective storage capacity can be utilized for the purposes of irrigation and hydro-power generation. The estimated volume of sedimentation is 29 million cubic meters (Refer to Hydrology 4.5) and this quantity corresponds to the capacity of the reservoir up to the altitude of EL=31.00m. The above considerations are diagramatically summarized in Figure 6.4.1. The V-H curve and the A-H curve of the reservoir are presented in Figure 6.4.2.

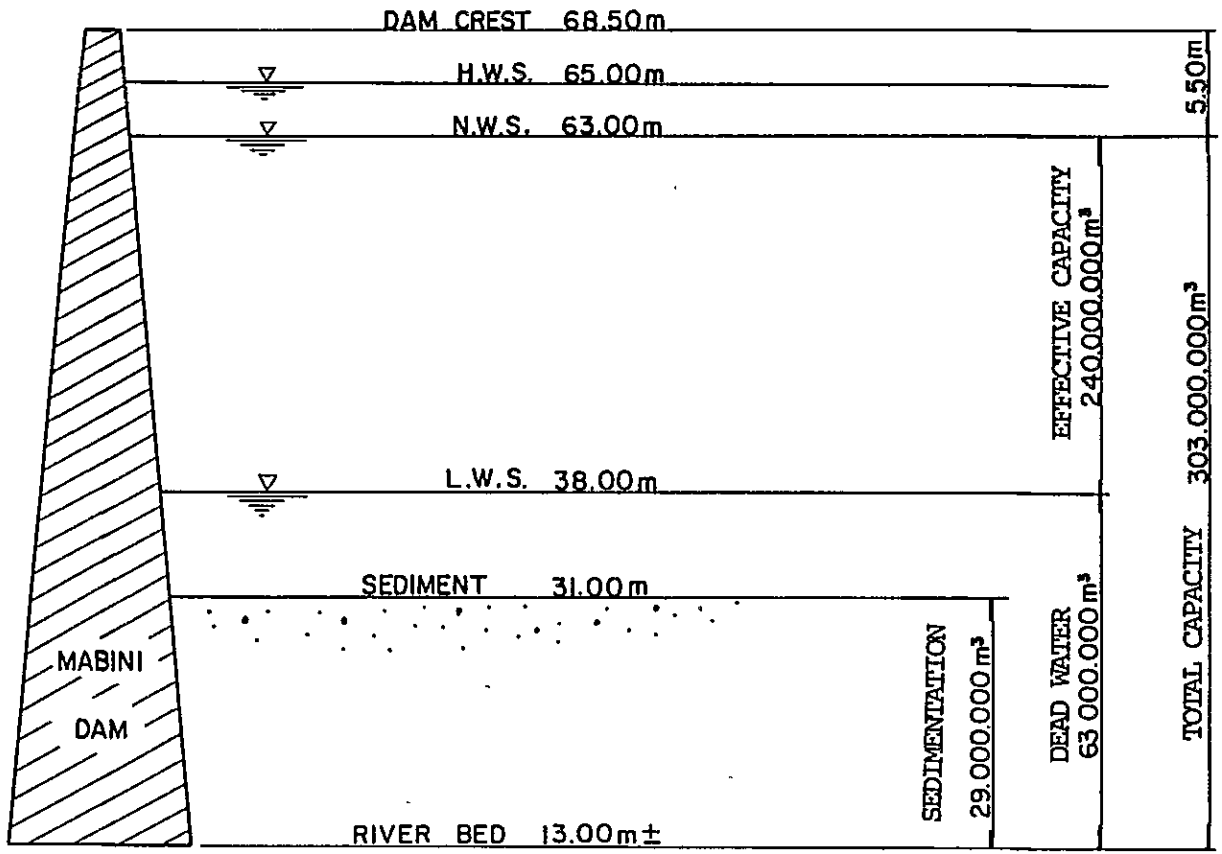


Fig.6.4.1 DIAGRAM OF DAM AND RESERVOIR

Fig.6.4.2 Storage Capacity & Surface Area Curve