LOCAL WATER UTILITIES ADMINISTRATION

REPUBLIC OF THE PHILIPPINES

# GROUNDWATER DEVELOPMENT STUDY IN PANAY ISLAND IN THE REPUBLIC OF THE PHILIPPINES

# FINAL REPORT

NOVEMBER 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

Tokyo, Japan

LOCAL WATER UTILITIES ADMINISTRATION

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# PREFACE

In response to a request from the Government of the Republic of the Philippines, the Japanese Government decided to conduct a study on the Groundwater Development in Panay Island and entrusted the study to Japan International Cooperation Agency (JICA).

JICA sent to the Philippines a survey team headed by Mr. Toru Hayashi of Nippon Jogesuido Sekkei Co., Ltd. to conduct a series of survey, over the period from March 1988 to September 1989.

The team held the discussions with concerned officials of the Government of the Philippines, and conducted field surveys. After the team returned to Japan, further studies were made and the present report was prepared.

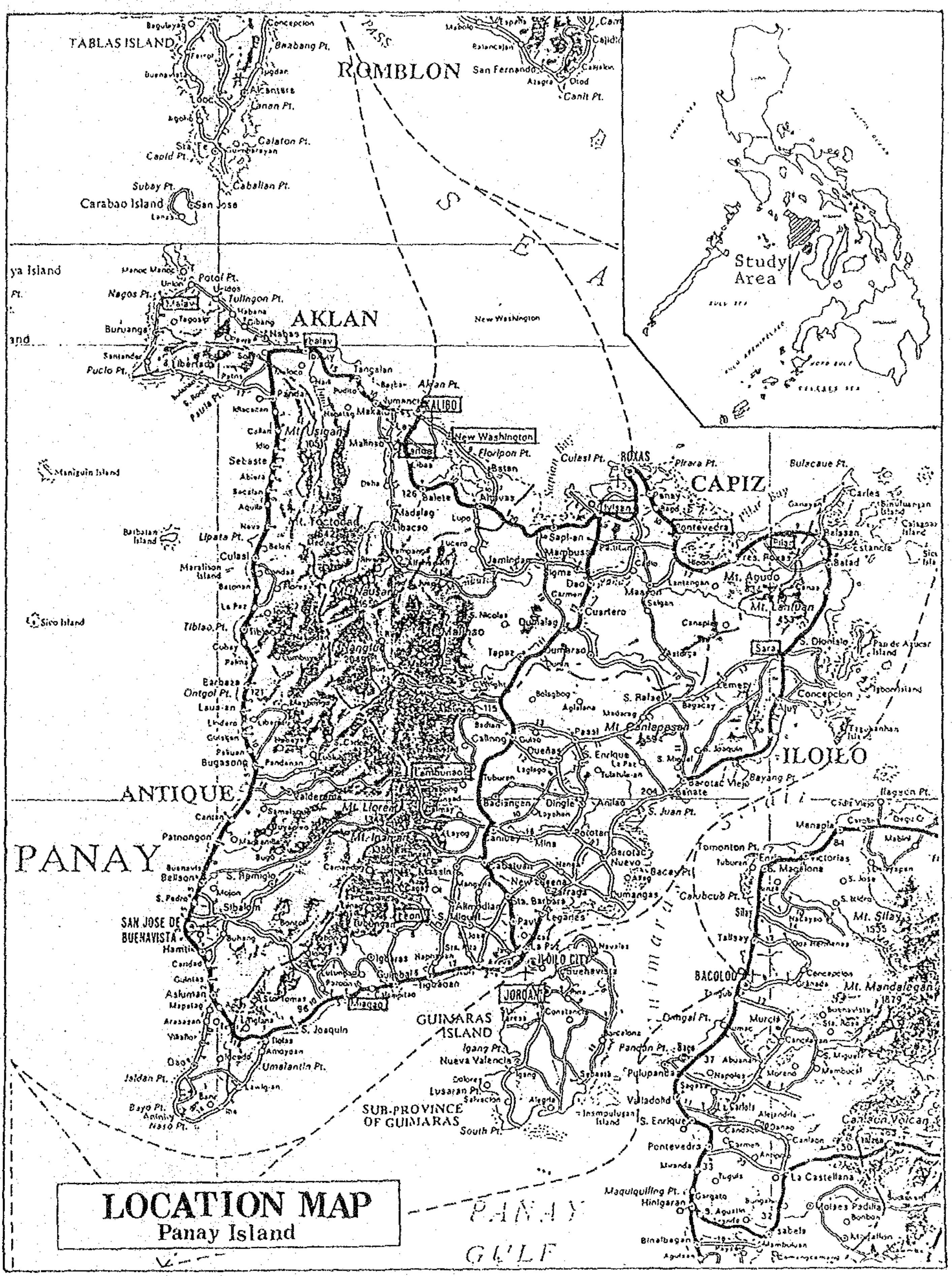
I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

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

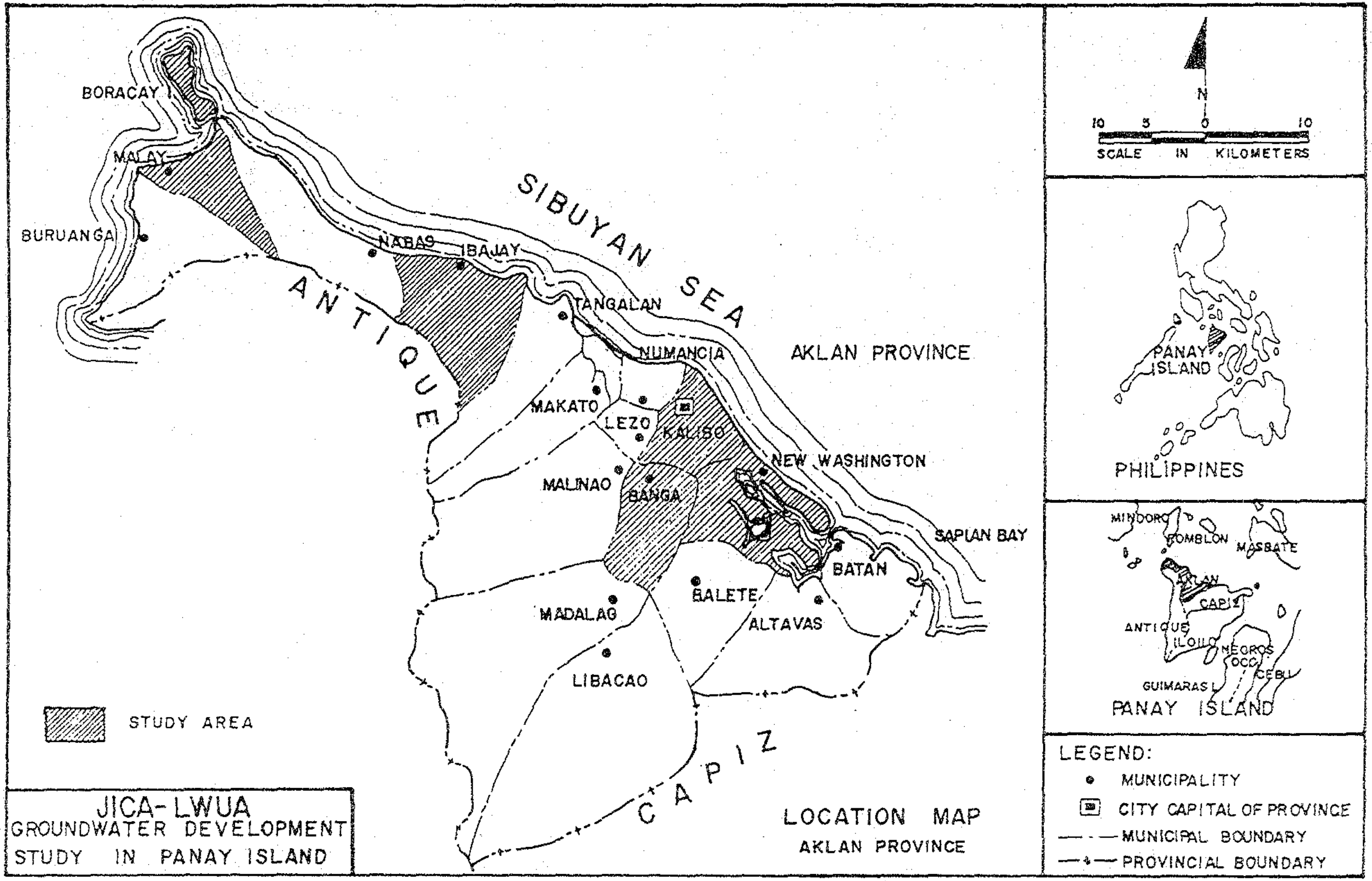
November, 1989

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

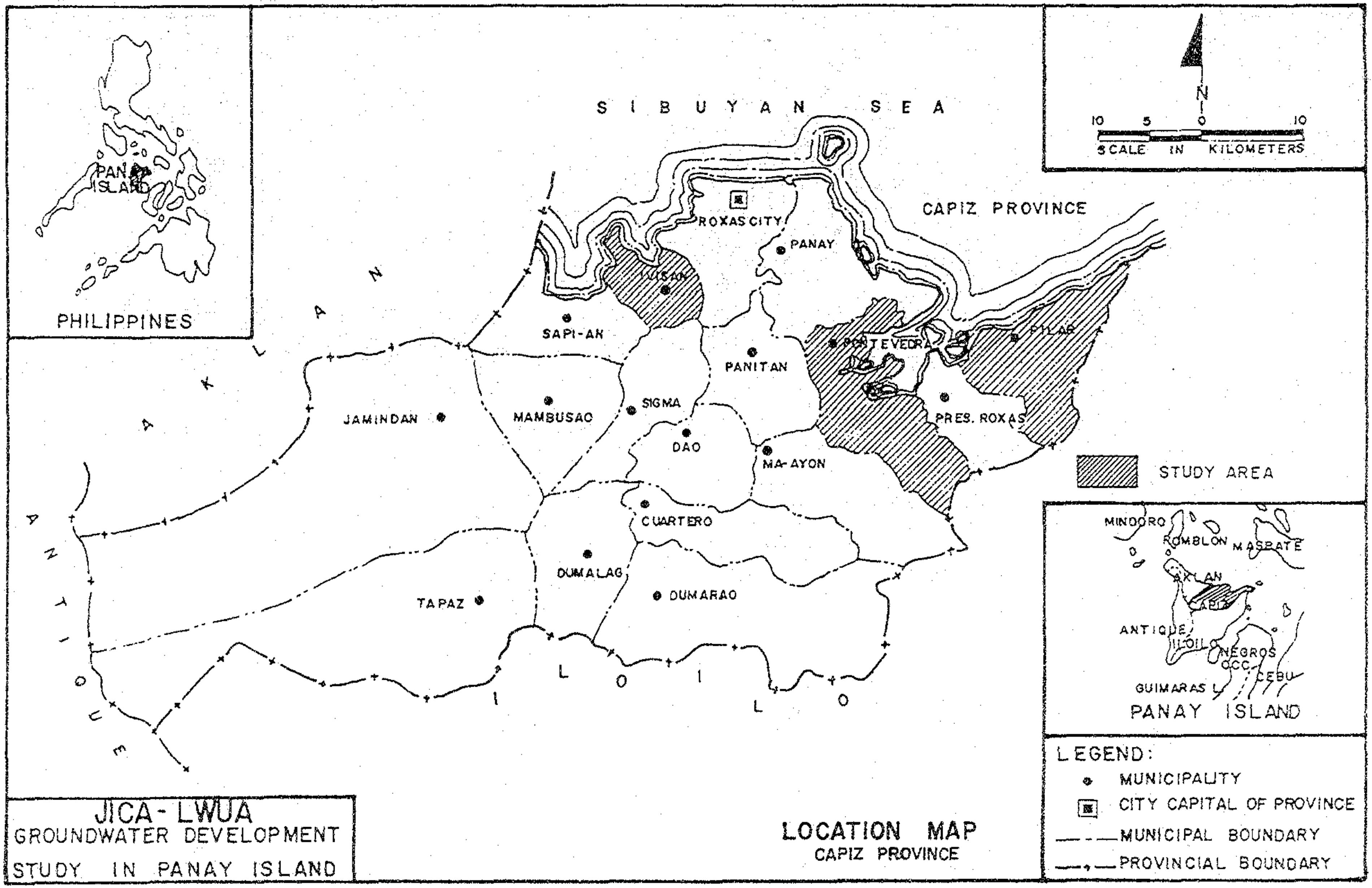



# LOCATION MAP
## Panay Island

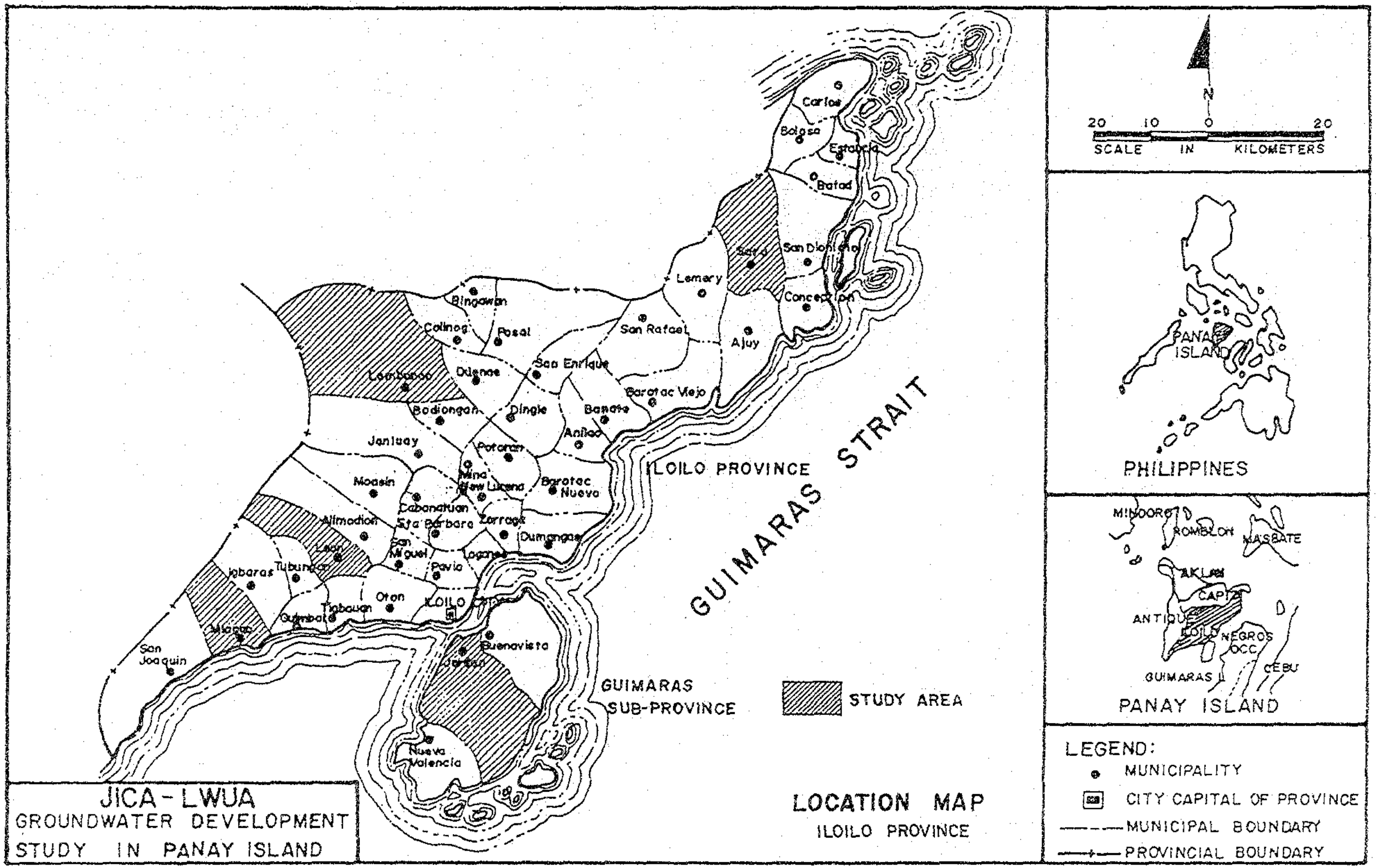



LOCATION MAP
AKLAN PROVINCE

JICA-LWUA
GROUNDWATER DEVELOPMENT
STUDY IN PANAY ISLAND




LOCATION MAP
CAPIZ PROVINCE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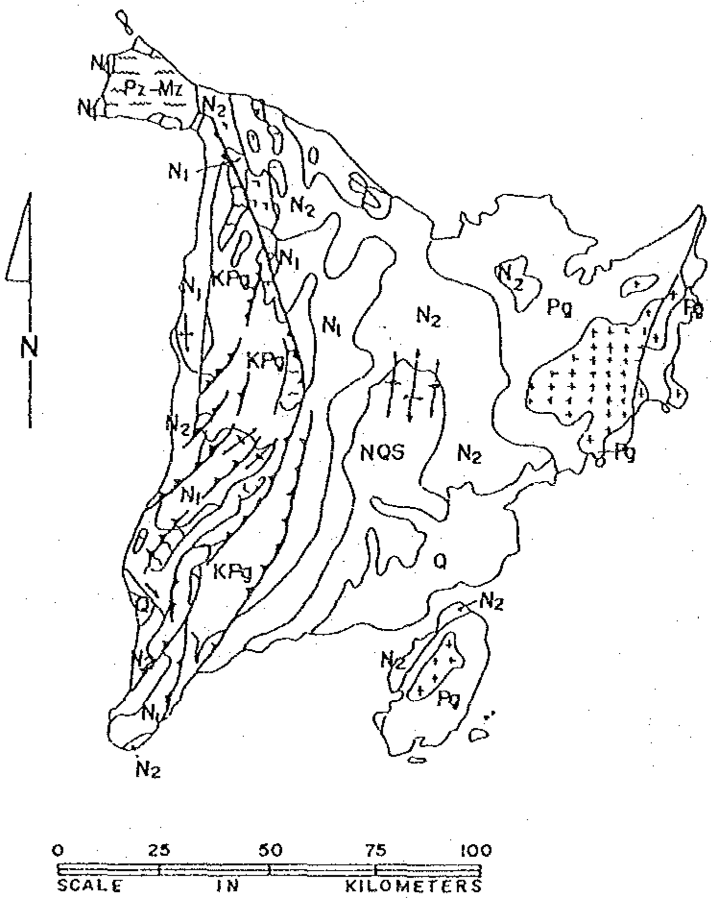
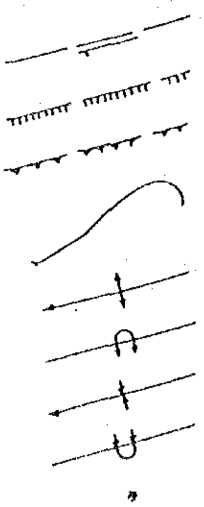
GUIMARAS
PANAY ISLAND
LEGEND:
MUNICIPALITY
CITY CAPITAL OF PROVINCE
MUNICIPAL BOUNDARY
PROVINCIAL BOUNDARY

# GEOLOGICAL MAP OF PANAY ISLAND




## STRUCTURAL SYMBOLS



High-angle fault, arrow shows relative direction of strike-slip movement

Normal fault, hachures on downthrown side, dashed where inferred

Thrust fault, saw-teeth on overriding side, dashed where inferred

Boundary of lithologic unit

Anticlinal axis with plunge

Overturned anticline

Synclinal axis with plunge

Overturned syncline

Quaternary volcanic center

# LEGEND

## STRATIGRAPHY

### STRATIFIED ROCKS:

| | |
|---|---|
| Q | Quaternary alluvial, lacustrine, beach and residual deposits. |
| NQV | Pliocene, Pleistocene and Recent volcanic deposits; mostly andesites and basalts with associated dacites.and rhyodacites in places, occurring manily as lava flows in volcanic centers and pyroclastics in their aprons; olivine-pyroxene basalt constitute largely the Lanao-Bukidnon volcanic plateau. |
| NQS | Pliocene to Pleistocene sediments both marine and terrestrial, includes extensive reef limestone and water-laid pyroclastics; also localized terrace gravel deposits. |
| $N_2$ | Upper Miocene sediments and volcanics; largely marine clastics, reef limestone and andesitic-basaltic pyroclastics and lavas. |
| $N_1$ | Late Oligocene to Middle Miocene sediments and volcanics; mainly marine sandstone, shale and reef limestone; some conglomerate, coal measure and marine andesitic-basaltic pyroclastics and lavas. |
| Pg | Paleocene to Oligocene sediments and volcanics; mainly marine sandstone, shale and limestone; dacite and andesite lavas and pyroclastics in Catanduanes, southern Sierra Madre and eastern Mindanao; mainly arkosic and quartzitic shales and sandstone in Mindoro and Palawan. |
| KPg | Undifferentiated Cretaceous to Paleogene strata; commonly mapped as metavolcanics and metasediments consisting mainly of spilites chert, pelagic to hemipelagic sediments and turbidites. |
| K | Cretaceous sediments and volcanics; mainly Upper Cretaceous spilitic to non-spilitic basalt, andesite, chert, pelagic to hemipelagic sediments, turbidites, limestone, sandstone and shale; Lower Cretaceous constitute the bulk of the Cretaceous in Cebu but has not been recorded in other areas. |
| J | Middle to Upper Jurassic arkose, subgraywacke, mudstone and conglomerate identified only in Mindoro (Mansalay Formation). |
| Pz-Mz | Carboniferous to Middle Jurassic radiolarite, sandstone, shale, limestone and conglomerate regionally metamorphosed to quartzite, slate, phyllite, marble and mica schist; limited to Mindoro, Romblon Island Group, Buruanga Peninsula, Cuyo Islands, Buruanga Island Group, northern Palawan and probably Zamboanga Peninsula. |

### INTRUSIVE AND PSEUDOSTRATIFIED ROCKS:

| | |
|---|---|
| | Intermediate to acid; mainly diorite, granodiorite, quarts diorite and monzonite; tonalite, adamellite, gabbro, syenite and granite are localized facies. |
| | Basic and ultrabasic; mainly peridotite, dunite and layered gabbro; peridotite and dunite are generally serpentinized; troctolite, norite, trondjhemite. |

### METAMORPHIC ROCKS:

| | |
|---|---|
| | Schist, phyllite, gneiss, marble and quartzite ranging from the greenschist to pyroxenite facies. (Color follows age of original rock) |

SOURCE: GEOLOGY AND MINERAL RESOURCES OF THE PHILIPPINES VOL. I
BUREAU OF MINES AND GEO-SCIENCES
MINISTRY OF NATURAL RESOURCES
1982

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**B. IBAJAY, AKLAN**



**C. NEW WASHINGTON, AKLAN**



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# S. SUMMARY

# SUMMARY

## A. INTRODUCTION

### 1. Background of the Project

Groundwater Development Study in Panay Island has been undertaken by the Japan International Cooperation Agency (JICA) together with the Local Water Utilities Administration (LWUA) as the counterpart agency. This study is made possible by the Government of Japan in response to the request of the Philippine Government for technical cooperation.

The implementing arrangement on the technical cooperation for the Study was agreed upon between JICA and LWUA in Notes Verbales signed in Manila, Philippines on 9 December 1987. Actual implementation started in the late March 1988.

Panay Island, located in the Western Visayas Region, is one of the priority areas for water supply improvement and development under the LWUA program because of the deficient supply of potable water in major municipalities of the Island. Pre-feasibility studies on water supply systems of the municipalities under the Study were conducted by LWUA since 1980. In some municipalities, a reconnaissance survey on water supply systems was likewise undertaken. This only shows LWUA's intention that something must be done to improve the water supply condition in said areas in Panay Island, even before this Study.

To make a reliable assessment of possible water sources, an extensive investigation with scientific and technical measures should be undertaken. Hence, comes this project to cope with pressing needs of the thirteen (13) municipalities all of which are waiting impatiently for alleviation of scarcity of water supply.

### 2. Study Area

The study area covers the thirteen (13) municipalities in the three (3) provinces of Panay Island enumerated as follows:

Aklan Province
- Malay, Ibajay, New Washington, Kalibo and Banga

Capiz Province
- Ivisan, Pontevedra and Pilar

Iloilo Province
- Sara, Lambunao, Leon, Miagao and Jordan

During meeting at the beginning of the Phase I Study between JICA Study Team and LWUA, the latter proposed that Jordan, Iloilo be included to replace Numancia, Aklan. Mainly for the reason of its urgency, JICA agreed to the proposal.

## 3. Objectives and Scope of the Study

Thus, the primary aim of this study is on how to find the most appropriate water source for each municipality, considering their physical and socio-economical condition, and how to realize the most appropriate water supply system strongly desired by the town respectively.

This Study involved extensive field surveys and investigations in the thirteen (13) municipalities of Panay Island. The scope of study may be summarized into two (2) categories: (a) investigation of potential water sources (Phase I Study) and (b) boring of test wells in the selected four (4) municipalities (Phase II Study).

Investigation of potential water sources (groundwater) was conducted using georesistivity meter in most of the municipalities except in the municipality of Malay, which may depend on spring water for future source.

Initially, the test well boring was planned to be conducted in the following four municipalities,
Viz:

Ibajay, Aklan
Kalibo, Aklan
Pontevedra, Capiz
Miagao, Iloilo

Eventually, Test wells in Kalibo, Aklan and Pontevedra, Capiz were successfully completed with much production of water more than expected.

On the contrary, in Ibajay, Aklan and in Miagao, Iloilo, geological formation were not favorable to produce groundwater. Consequently, in these two municipalities, only Observation Wells were constructed.

In addition to these predetermined four test well sites, an observation well drilling was conducted in Ivisan, Capiz.

Special mention should be made of that the LWUA staff who engaged in this project got direct experience how important to drill an observation well (pilot boring) prior to drill a test well (production well), in order to avoid a waste of time and waste of money. Because a test well (production well) is much larger than an observation well (pilot boring) in scale and it will take much longer time than to drill an observation well, it is too late if it is ascertained that the hydrogeological condition is unfavorable after the completion of the test well (production well).

In addition to construction of test wells in the Phase II Study, preparation of "conceptual" planning of water supply system and rough cost estimates of the system was carried out with each municipality.

## 4. Phases of the Study and the Composition of the Report

### Phasing of the Study

The study comprises two (2) phases, viz., Basic Study for Phase I, and Verification Study for Phase II. Each phase is subdivided into ten (10) terms totally. Phase I Study was conducted during the period of March 1988 through November 1988.

The main scope of work in Phase I Study is as follows:

- Collection of data
- Georesistivity survey - dry seasons
- Reconnaissance survey for existing water use conditions
- Population projection and demand projection (1995)

Phase II Study has been conducted since January 1989 and was completed in October 1989. The main scope of work in Phase II Study is as follows:

- Construction of observation/test wells
- Conceptional design and rough cost estimate of water supply system for each municipality

### Composition of the Final Report

This report consists of three parts: Summary, Part I and Part II. Part I is a detailed description of (a) the study area together with (b) hydrogeological analysis based on the results of field investigations on the water resources for the thirteen (13) municipalities, and on the results of observation/test wells for the selected sites in Panay Island.

Part II presents (a) a description relating to the water use condition of the existing water supply system and the water demand projection in 1995 for the proposed supply area, and (b) a description of conceptual design on the recommended water supply system for the thirteen (13) municipalities together with their rough cost estimate.

## 5. Hydrogeological Analysis

### Climate and Rainfall in Panay Island

The climatic conditions in the Philippines are varied due to the existence of mountains and plateaus in various parts of the country. The differences in climatic conditions depend mainly on the local air currents. The bases of climate classification in the country are the type of rainfall, the presence or absence of a dry season and the maximum rain period.

The first type has two pronounced seasons : a dry season from November to April and a wet one for the rest of the year. The second type has no dry season but a rainy season throughout the year with a very pronounced maximum rainfall from November to January. The third type has no distinct seasons but is fairly dry from November to April and wet during the rest of the year. The fourth type has precipitation during the year; however, the amount is not constant but more or less evenly distributed.

Type I covers the west side regions of the islands facing the South China Sea and the Sulu sea; type II, the east side of the islands facing the Pacific Ocean; type III, the islands which face the inland seas of the Sibuyan, Visayan and Mindanao Seas and also the inland area of Luzon; and type IV covers the rest of the area.

In the relation between the climate classification and rain distribution, the former does not necessarily accord to the latter completely, but has a relatively good correlation. FIGURE S-1 indicates the distribution of rainfall.

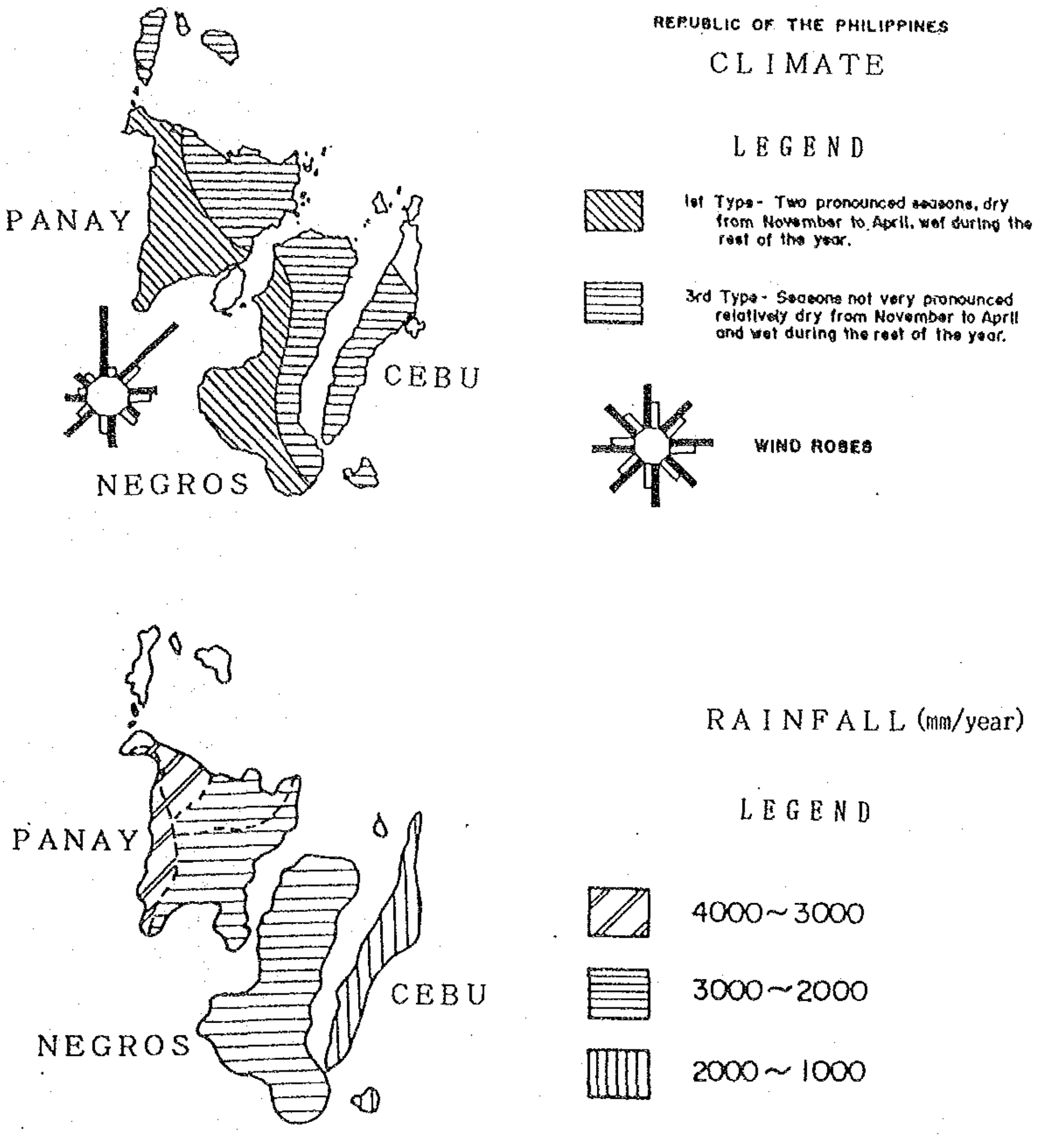
In general, the islands in the inland sea belonging to type III receive the least sum of precipitation at less than 2,000 mm. The area facing the Pacific Ocean, type II, has much rainfall, more than 3,000 mm.

The type I islands facing the South China Sea have relatively abundant rainfall but differ in regions (in the western part of Panay Island, over 3,000 mm).

<u>Water Resources in Panay Island</u>

It is often said that the Philippines is endowed by nature with abundant water resources. Two types of climate conditions prevail over the Island of Panay. The western half of Panay Island, together with the island sub-province of Guimaras, is under type I which is characterized by two pronounced seasons - dry from November to April and wet during the rest of the year. The northeastern half of Panay belongs type III. As a whole, the island has an average annual rain fall of about 2,500 mm. Temperature variation is minimal and the annual average temperature is 27.5°C. The island has an natural runoff of 24 MCM per day, half of which originating from its two major river basins, the Panay River Basin in Capiz and the Jalaud River Basin in Iloilo.

With a mean annual rainfall of 2,500 mm, the Panay Island seems to be assured of more than adequate water in its river as well as in its groundwater reservoirs to supply the requirements for irrigation and for domestic and industrial use in the future. These rivers also have great potentials for hydro-electric power generation.




JICA - LWUA
GROUNDWATER DEVELOPMENT STUDY IN PANAY ISLAND

FIGURE S-1
CLIMATE CLASSIFICATION AND RAINFALL IN THE WESTERN VISAYAS

According to the definition of National Water Resources Council (NWRC), principal river basins are defined as those with at least 40 sq.km of drainage area and river basins with areas of at least 1,400 sq.km are classified as major river basins.

Panay River Basin

The Panay River Basin encompasses almost entirely the province of Capiz. Its drainage area is 1,843 sq.km. It originates from the slopes of the hills near the Aklan-Capiz boundary and traverses the middle region of Capiz and ultimately discharges into Sibuyan Sea with an estimated average annual runoff of 2,344 MCM.

Jalaud River Basin

The Jalaud River Basin is located in the southwestern portion of the Island of Panay and its drainage area is 1,503 sq.km. The Jalaud River, the main drainage way of the basin, originates from the eastern slopes of Mount Baloy, the highest peak in the divide.

It has an estimated annual runoff of 1,912 MCM. From there, the river flows in an easterly direction through low rolling hills, and eventually flows southward until it empties into Iloilo Strait.

Groundwater Availability in Panay Island

In general, a large portion of water resources in the Philippines are found in rivers as surface water, and has so used since ancient times, especially for agricultural use. During the dry season, streamflows are mainly derived from ground reservoir.

The total drainage area of the principal river basins in the Panay Island is 6,984 sq.km, of which 3,346 sq.km is the drainage area of the major river basins i.e., Panay River Basin and Jalaud River Basin, while the total study area surveyed in this project is only 29 sq.km.

Therefore, it is difficult to explain any direct relationship between the volume of groundwater reservoir and the availability of groundwater in the specified thirteen (13) municipalities in this project. Anyhow, it seems that quite a enormous volume of groundwater is most likely reserved in subterranean reservoir.

On the other hand, the Groundwater Availability Map (FIGURE S-2) published by Bureau of Mines and Geo-Sciences shows that the most of the areas in Panay Island are, generally speaking, less extensive and less productive aquifers with limited potential for groundwater development, though annual precipitation is over 2,500 mm.

Water Use Conditions and the Result of Survey

Four (4) of the thirteen (13) municipalities surveyed, Banga, Sara, Lambunao and Leon are located inland, and remaining nine (9) municipalities are located in the coastal areas. Only the municipality of Kalibo uses groundwater as the source for water supply by deep well. In the other twelve (12) municipalities, spring, river-bed water and surface water are used as the sources of water supply systems, together with dug wells or shallow wells of the individual households.

Development of groundwater by drilling a deep well will usually be conducted through the following three steps; i.e., Surface investigations (geophysical exploration or georesistivity survey) as the first step, Subsurface investigation (test drilling of small diameter holes to ascertain geologic and groundwater conditions) as the second step and Well drilling as the final step, as illustrated in the flowchart in FIGURE S-3.

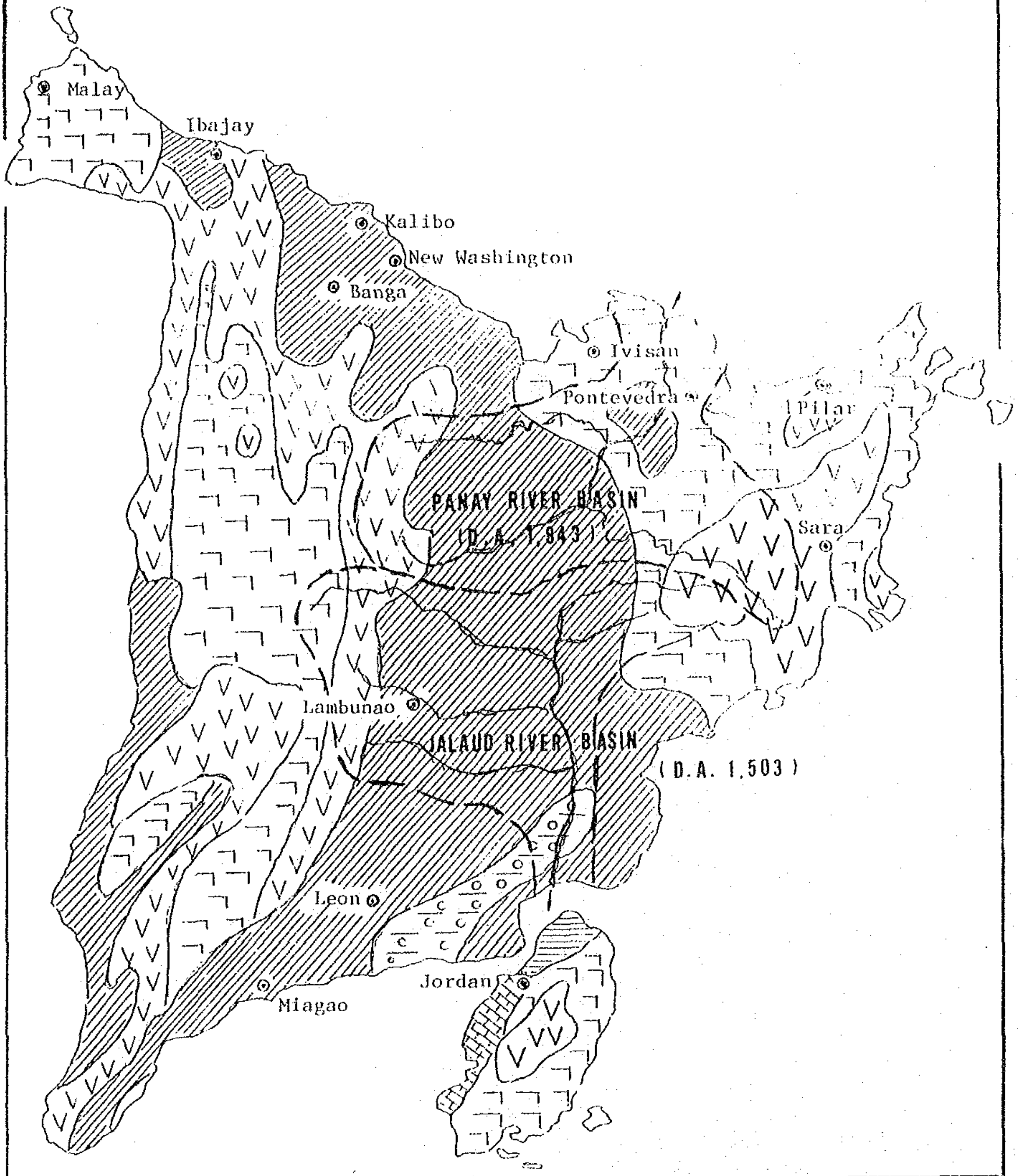
JICA-LWUA Survey Team performed a survey for groundwater potentiality of the selected thirteen (13) municipalities in Panay Island based on the procedures shown in FIGURE S-3. In this survey, the test drilling was called as "Observation well drilling" and the final well drilling was called as "Test well drilling". The first step, the surface investigation was performed in 1988, the second and the third steps were conducted in 1989. Eventually, the Survey Team hit the favorable aquifers in two municipalities, Kalibo, Aklan and Pontevedra, Capiz, and completed the "Test wells" which produce more than 2 cu.m/min of groundwater for the source of augmentation of their water supply systems respectively.

Usually in the Philippines, the test drilling of small diameter holes prior to drill a production well (pumping well) is omitted. This brings sometimes unfavorable results in the construction of pumping wells. Test drilling furnishes information on substrata in a vertical line from the surface. Logging techniques within a well can provide data on properties of the formation, water quality, size of well cavity, and rate of groundwater movement. Evaluation of these factors aids in proper location, construction, and development of production wells (pumping wells).

Test holes also serve as observation wells for measuring water levels or for conducting pumping tests. Thus, in this survey, test holes were called as "observation wells".

Technology Transfer

In compliance with the Implementing Arrangement on the technical cooperation for this project which was agreed upon between JICA and LWUA, December 9, 1987, "Technology Transfer" is one of the important objectives of this project. Therefore, in the course of the Study, JICA staff exerted themselves for pursuing such technology transfer to the LWUA counterpart personnels.




JICA - LWUA
GROUNDWATER DEVELOPMENT
STUDY IN PANAY ISLAND

FIGURE S - 2
GROUNDWATER AVAILABILITY/
MAJOR RIVER BASIN MAP
OF PANAY ISLAND

# EXPLANATION

## I ROCKS IN WHICH FLOW IS DOMINANTLY INTERGRANULAR

(A) EXTENSIVE AND HIGHLY PRODUCTIVE AQUIFERS

- with an average potential recharge of 0.5 to 1 meter, greater near influent rivers, with known production well yields between 50 to 100 L/s but as high as 150 L/s in some sites. High to very high permeability.

(B) FAIRLY EXTENSIVE AND PRODUCTIVE AQUIFERS

- with average annual potential recharge of 0.3 to 0.8 meters, greater near influent rivers, with known production well yields mostly about 20 L/s but as high as 60 L/s in somesites. Moderate to high permeability.

(C) LOCAL AND LESS PRODUCTIVE AQUIFER

- well yields mostly about 2 L/s but as high as 20 L/s in some sites. Very low to moderate permeability.

## II ROCKS IN WHICH FLOW IS DOMINANTLY THROUGH FRACTURES AND/OR SOLUTION OPENINGS

(A) FAIRLY EXTENSIVE AND PRODUCTIVE AQUIFERS WITH HIGH POTENTIAL RECHARGE

- with known production well yields of mostly 5 to 15 L/s and spring yields of up to 60 L/s.

(B) FAIRLY TO LESS EXTENSIVE AND PRODUCTIVE AQUIFERS WITH LOW TO MODERATE POTENTIAL RECHARGE

- with known domestic well yields of 3 L/s or less.

## III LOCAL GROUNDWATER-REGIONS UNDERLAIN BY IMPERMEABLE ROCKS GENERALLY WITHOUT SIGNIFICANT GROUNDWATER, EXCEPT IN RESIDUUM, SUFFICIENTLY LEACHED AND/OR FRACTURED ZONE

(A) ROCKS WITH LIMITED POTENTIAL, LOW TO MODERATE PERMEABILITY

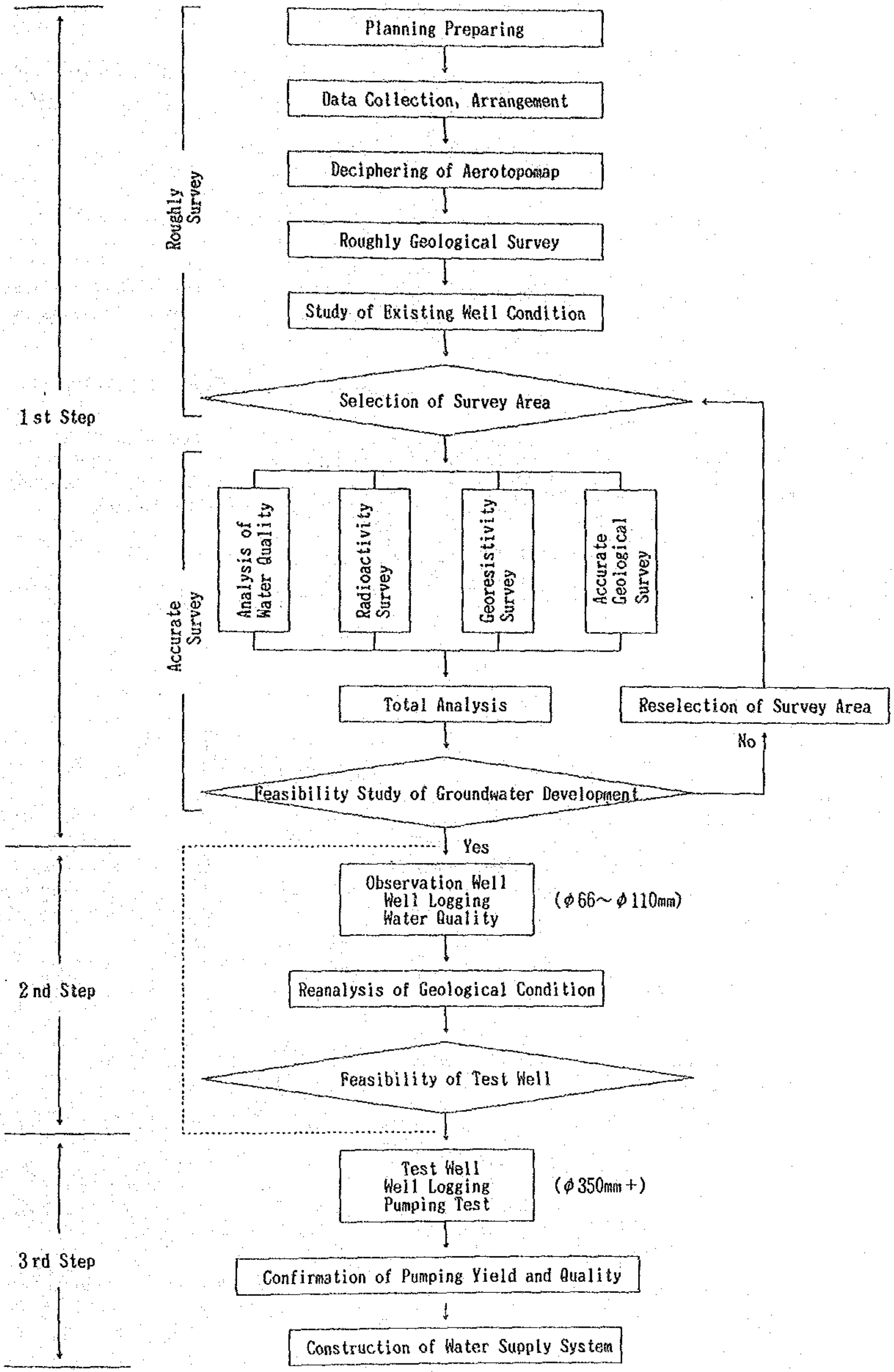
Quaternary lava flows, mostly andesite and basalt. Groundwater for domestic purposes locally obtainable in sufficiently fractured zones.

(B) ROCKS WITHOUT ANY KNOWN SIGNIFICANT GROUNDWATER OBTAINABLE THROUGH DRILLED WELLS, LARGELY UNTESTED

Quaternary lava flows, mostly andesite and basalt. Generally massive or slightly fractured but fractures are usually tight and not interconnected.

Republic of the Philippines
Ministry of Natural Resources
**BUREAU OF MINES AND GEO - SCIENCES**

FIGURE S-3 Flowchart of Groundwater Development Study



Various survey know-how as well as technique of drilling and development of wells were transferred to the counterpart personnels of LWUA with satisfaction.

## 6. Recommended Water Sources

Eventually, only two municipalities, Kalibo, Aklan and Pontevedra, Capiz will enjoy to use completed test wells as water source for the augmentation of their water supply systems. Other municipalities, some of them will have to use infiltrated river water which flows in the respective municipalities, and some of them are obliged to rehabilitate or augment the existing water sources.

## 7. Conceptual Water Supply Systems and the Rough Cost Estimate

Conceptual water supply systems have been designed aiming to grasp outline idea of the scale and the facilities of each municipality as well as the rough cost estimate. This may provide a useful information for the succeeding feasibility study in near future.

## B. STUDY AREA

The study area covers three (3) provinces in Panay Island, excluding the province of Antique. They are: Aklan, Capiz and Iloilo.

A total of thirteen (13) municipalities has been selected as priority areas for development of water resources. They are:

| PROVINCE | MUNICIPALITY |
|---|---|
| AKLAN | A. Malay |
| | B. Ibajay |
| | C. New Washington |
| | D. Kalibo |
| | E. Banga |
| CAPIZ | F. Ivisan |
| | G. Pontevedra |
| | H. Pilar |
| ILOILO | I. Sara |
| | J. Lambunao |
| | K. Leon |
| | L. Miagao |
| | M. Jordan |

The actual study areas are limited to the urban area of each municipality because of the great demand of adequate supply of water in urban area or in the Poblacion area, and in order to complete various studies within a very limited period. For these reasons, the total surveyed area for the study is approximately 2,900 ha, while the total land area of the thirteen municipalities is 176,000 ha.

Most of the municipalities under study are geographically located near the coastal lines except for some municipalities, viz., Sara, Province of Capiz and Lambunao and Leon, Province of Iloilo.

Not a few study areas of the municipalities located along the northern coast line of Panay Island, i.e., Ibajay, Kalibo, New Washington, Ivisan, Pontevedra and Pilar are swamps and marshes.

Based on records of the respective municipal treasurer's office of the areas under study, it was found out that only Kalibo is considered as a first class municipality, the rest are classified under the 3rd and 5th class based on their municipal income.

Considering their hard financial condition, forming a Water District for some of the municipalities is deemed to be less feasible at this moment.

Of the thirteen (13) municipalities, only seven (7) (Ibajay, Kalibo, Ivisan, Pilar, Sara, Miagao and Jordan) are running their water supply systems. The six (6) municipalities (Malay, New Washington, Banga, Pontevedra, Lambunao and Leon) have no water supply systems.

Thus, the primary aim of this study is on how to find the most appropriate water source for each municipality, considering their physical and socio-economical condition, and how to realize the most appropriate water supply system strongly desired by the town respectively.

## C. HYDROGEOLOGICAL ANALYSIS

### 1. Georesistivity Survey

Georesistivity survey was performed in the 12 municipalities except topographically steep Malay. The result is shown in TABLE S-1. It is difficult that each resistivity layer corresponds to the geology, because of few well data of which the geology was confirmed by core. Generally, in the area of bed rocks with volcanic rocks or limestones, resistivity value of layer presumed rock mass increases, but in the area of the Tertiary and Quaternary deposit, each layer value remarkably decreases. Strata and resistivity are shown in TABLE S-2. The equipment used for georesistivity and hydrological survey are as follows.

| | | |
|---|---|---|
| Georesistivity Survey | -- Model 2115 McOHM (Oyo) | 1 unit |
| Hydrological Survey | -- Model WQC-2A Water Quality Checker | 1 unit |
| | Water Sampler | 1 unit |
| | Model NP 50 Portable Water Level Meter | 1 unit |
| | Model ADR-104WP Water Level Recorder | 3 sets |

### 2. Observation/Test Well Drilling

<u>Observation Well Drilling</u>

The location, date, depth and result of each observation well are summarized as follows:

| Municipality | Date | Depth of Well | Result |
|---|---|---|---|
| B. Ibajay | 20 - 30 May, 1989 | 70.35 m | no G.W. |
| D. Kalibo No.1 | 8 Apr. - 4 May, 1989 | 120.00 | plenty G.W. |
| D. " No.2 | 2 - 14 Jun. 1989 | 63.25 | small G.W. |
| F. Ivisan | 16 - 26 Jun. 1989 | 36.00 | no G.W. |
| L. Miagao | 10 - 31 Mar. 1989 | 182.50 | no G.W. |
| TOTAL | | 472.10 | |

TABLE S-1 Results of Resistivity Survey

| | MUNICI-PALITY | TOPOGRAPHY | GEOLOGY OF BED ROCK | No | SOUND-ING DEPTH | 1st LAYER $\rho_1$ Ω-m | 1st LAYER $D_1$ m | 2nd LAYER $\rho_2$ Ω-m | 2nd LAYER $D_2$ m | 3rd LAYER $\rho_3$ Ω-m | 3rd LAYER $D_3$ m | 4th LAYER $\rho_4$ Ω-m | 4th LAYER $D_4$ m | 5th LAYER $\rho_5$ Ω-m | 5th LAYER $D_5$ m | 6th LAYER $\rho_6$ Ω-m | 6th LAYER $D_6$ m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B | Ibajay | Alluvial plain | Tertiary sediments and Volcanics | 1 | 150 | 10 | 2.0 | 7 | 3.4 | 13 | 32 | 25 | - | | | | |
| | | | | 2 | 100 | 10 | 4.2 | 25 | - | | | | | | | | |
| | | | | 3 | 150 | 20 | 0.5 | 13 | 4 | 27 | 25 | 44 | - | | | | |
| | | | | 4 | 150 | 34 | 2.2 | 102 | 8 | 18 | 42 | 34 | 62 | 13 | - | | |
| | | | | 5 | 150 | 28 | 1.2 | 19 | 3 | 126 | 7 | 31 | 17.5 | 73 | 32 | | |
| | | | | 6 | 100 | 170 | 4.2 | 17 | 40 | 27 | - | | | | | | |
| C | New Washington | Sandbank | ? | 1 | 40 | 250 | 1.1 | 625 | 3.8 | <<9 | - | | | | | | |
| | | Alluvial plain | | 2 | 44 | 780 | 3 | << 16 | - | | | | | | | | |
| | | | | 3 | 40 | 460 | 4.4 | <<9 | - | | | | | | | | |
| | | | | 4 | 150 | 16 | 1.3 | 11 | 2.2 | 20 | 7 | 11 | 25 | 37 | 36 | 6 | - |
| | | | | 5 | 130 | 7 | 1.3 | 11 | 10 | 7 | 36 | 3 | - | | | | |
| D | Kalibo | Alluvial plain | ? | 1 | 150 | 42 | 1.1 | 8 | 1.8 | 98 | 9 | 60 | 16 | 23 | - | | |
| | | | | 2 | 150 | 12 | 2.4 | 62 | 25 | 12 | 58 | 21 | - | | | | |
| | | | | 3 | 150 | 240 | 0.4 | 12 | 3 | 67 | 39 | 29 | - | | | | |
| | | | | 4 | 140 | 140 | 0.3 | 23 | 4.3 | 172 | 11.5 | 27 | 56 | 47 | - | | |
| | | | | 5 | 150 | 16 | 2.8 | 66 | 18 | 16 | - | | | | | | |
| | | | | 6 | 150 | 13 | 0.5 | 9 | 3.4 | 23 | 36 | 9 | - | | | | |
| | | | | 7 | 150 | 9 | 3.3 | 14 | 30 | 2 | - | | | | | | |
| | | | | 8 | 150 | 87 | 0.8 | 9 | 8 | 14 | 56 | 6 | - | | | | |
| | | | | 9 | 150 | 150 | 1.0 | 8 | 9 | 13 | 40 | 7 | - | | | | |
| | | | | 10 | 150 | 100 | 1.0 | 13 | 7 | 21 | 16 | 10 | 84 | 16 | - | | |
| | | | | 11 | 150 | 94 | 0.6 | 9 | 6.4 | 26 | 50 | 14 | - | | | | |
| | | | | 12 | 100 | 26 | 0.6 | 7 | 2 | 11 | 76 | 6 | - | | | | |
| | | | | 13 | 100 | 11 | 2.8 | 17 | 6.8 | 5 | - | | | | | | |
| | | | | 14 | 150 | 7 | 1.0 | 19 | 12 | 2 | - | | | | | | |
| | | | | 15 | 150 | 14 | 1.1 | 42 | 10 | 10 | 72 | 3 | - | | | | |
| | | | | 16 | 150 | 8 | 4.0 | 21 | 10 | 11 | 60 | 4 | 80 | 16 | - | | |
| | | | | 17 | 150 | 9 | 2.6 | 13 | 16 | 2 | - | | | | | | |
| | | | | 18 | 150 | 32 | 13.0 | 12 | 3 | | - | | | | | | |
| | | | | 19 | 120 | 12 | 3.8 | 61 | 24 | 20 | - | | | | | | |
| | | | | 20 | 100 | 74 | 0.6 | 10 | 3 | 120 | 19 | 53 | 38 | 21 | 58 | 48 | - |
| | | | | 21 | 150 | 23 | 0.5 | 15 | 4 | 112 | 14 | 56 | 36 | 16 | - | | |
| | | | | 22 | 150 | 175 | 0.5 | 18 | 4 | 120 | 24 | 25 | - | | | | |
| E | Banga | Terrace | Volcanics | 1 | 150 | 10 | 1.3 | 103 | 17 | 8 | 75 | 168 | - | | | | |
| | | | | 2 | 150 | 24 | 2.5 | 192 | 14 | 55 | 120 | 216 | - | | | | |
| | | | | 3 | 150 | 34 | 1.5 | 170 | 14 | 49 | 76 | 78 | - | | | | |
| | | | | 4 | 150 | 18 | 2.1 | 144 | 24 | 26 | 76 | 88 | - | | | | |
| | | | | 5 | 150 | 56 | 0.8 | 224 | 25 | 8 | 60 | 73 | - | | | | |
| | | | | 6 | 150 | 68 | 1.0 | 136 | 9.8 | 21 | 75 | 132 | - | | | | |
| | | | | 7 | 150 | 32 | 2.3 | 130 | 6.2 | 31 | 14 | 60 | 25 | 16 | 70 | 80 | - |
| | | | | 8 | 150 | 30 | 1.2 | 8 | 2.3 | 63 | 26 | 1 | 80 | 108 | - | | |
| F | Ivisan | Alluvial plain | Andesite and Tertiary sediments | 1 | 100 | 56 | 2.5 | 28 | 10 | 300 | - | | | | | | |
| | | | | 2 | 100 | 50 | 0.6 | 25 | 5 | 144 | 25 | 28 | 52 | 102 | 64 | 27 | - |
| | | | | 3 | 100 | 130 | 1.2 | 43 | 9 | 96 | 46 | 144 | - | | | | |
| | | | | 4 | 100 | 60 | 1.0 | 15 | 3 | 50 | 24 | 132 | - | | | | |
| | (Malocloc) | Mountain foot | | 1 | 100 | 19-285-3 | 3.3 | 165 | - | | | | | | | | |
| | | | | 2 | 150 | 30 | 2.3 | 450-165 | 57.7 | 100 | - | | | | | | |

TABLE S-1 Results of Resistivity Survey (Cont'd)

| | MUNICIPALITY | TOPOGRAPHY | GEOLOGY OF BED ROCK | No. | SOUNDING DEPTH | 1st LAYER $\rho_1$ Ω-m | $D_1$ m | 2nd LAYER $\rho_2$ Ω-m | $D_2$ m | 3rd LAYER $\rho_3$ Ω-m | $D_3$ m | 4th LAYER $\rho_4$ Ω-m | $D_4$ m | 5th LAYER $\rho_5$ Ω-m | $D_5$ m | 6th LAYER $\rho_6$ Ω-m | $D_6$ m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F | (Malocloc) | Mountain foot | Andesite and Tertiary sediments | 3 | 100 | 15 | 1.6 | 150 | 18.4 | 57-96 | – | | | | | | |
| | | | | 4 | 100 | 30-15 | 5.5 | 247 | – | | | | | | | | |
| | | | | 5 | 100 | 16-10 | 2.8 | 125 | 41 | 54-140 | – | | | | | | |
| | | | | 6 | 100 | 25-17 | 3.0 | 180 | – | | | | | | | | |
| G | Pontevedra | Alluvial plain | Andesite | 1 | 100 | 28 | 0.9 | 19 | 7 | 76 | 28 | 19 | 50 | 100 | – | | |
| | | | | 2 | 100 | 86 | 1.8 | 22 | 11 | 46 | – | | | | | | |
| | | | | 3 | 150 | 4 | 2.3 | 66 | – | | | | | | | | |
| | | | | 4 | 150 | 140 | 0.4 | 28 | 4 | 200 | 64 | 73 | 86 | 147 | 110 | 73 | – |
| | | | | 5 | 150 | 18 | 3.0 | 90 | 26 | 44 | 44 | 135 | 120 | 57 | – | | |
| | | | | 6 | 150 | 126 | 1.8 | 25 | 18 | 81 | – | | | | | | |
| | | | | 7 | 110 | 124 | 1.0 | 248 | 2.6 | 19 | 10 | 77 | – | | | | |
| | | | | 8 | 150 | 16 | 1.0 | 8 | 3 | 99 | 80 | 45 | | | | | |
| | | | | 9 | 150 | 27 | 0.7 | 18 | 2.5 | 76 | 22 | 32 | 30 | 2,100 | 62 | | |
| | | | | 10 | 100 | 82 | 1.0 | 27 | 7 | 90 | – | | | | | | |
| | | | | 11 | 150 | 66 | 2.1 | 13 | 5.4 | 60 | 84 | 106 | – | | | | |
| | | | | 12 | 150 | 78 | 0.7 | 5 | 1.4 | 21 | 30 | 78 | – | | | | |
| | | | | 13 | 150 | 21 | 1.2 | 14 | 3 | 77 | – | | | | | | |
| | | | | 14 | 150 | 150 | 1.1 | 3 | 1.8 | 19 | 22 | 171 | 110 | 30 | – | | |
| | | | | 15 | 150 | 7 | 0.8 | 105 | 6.5 | 21 | 9 | 85 | 64 | 53 | 90 | 130 | – |
| H | Pilar | - do - | - do - | 1 | 100 | 26 | 1.9 | 78 | – | | | | | | | | |
| | | | | 2 | 100 | 100 | 0.9 | 13 | 2.1 | 84 | 52 | 76 | – | | | | |
| I | Sara | - do - | Diorite | 1 | 100 | 27 | 0.8 | 41 | 10 | 780 | – | | | | | | |
| | | | | 2 | 100 | 58 | 0.6 | 19 | 4 | 630 | – | | | | | | |
| J | Lambunao | Terrace and Flood plain | Tertiary sediments | 1 | 100 | 12 | 0.7 | 60 | 2.2 | 7 | 30 | 3 | 56 | 8 | – | | |
| | | | | 2 | 100 | 60 | 0.5 | 15 | 3.8 | 4 | 34 | 2 | – | | | | |
| | | | | 3 | 150 | 19 | 0.9 | 48 | 5.4 | 1 | 21 | 15 | – | | | | |
| | | | | 4 | 150 | 5 | 1.0 | 11 | 20 | 4 | – | | | | | | |
| | | | | 5 | 100 | 45 | 1.0 | 180 | 4.2 | <2 | – | | | | | | |
| | | | | 6 | 150 | 7 | 1.0 | 29 | 11 | 3 | – | | | | | | |
| K | Leon | - do - | - do - | 1 | 100 | 130 | 1.2 | 195 | 2.7 | 8 | 43 | 4 | – | | | | |
| | | | | 2 | 150 | 32 | 0.8 | 48 | 5 | 15 | 40 | 1 | – | | | | |
| | | | | 3 | 100 | 6 | 0.5 | 37 | 12 | 2 | – | | | | | | |
| | | | | 4 | 150 | 35 | 0.5 | 7 | 12 | 2 | – | | | | | | |
| | | | | 5 | 100 | 100 | 0.7 | 7 | 5.4 | 12 | 8.4 | 6 | 36 | 0.3 | – | | |
| L | Miagao | - do - | - do - | 1 | 100 | 27 | 5.4 | 11 | 11 | 2 | 2.5 | 138 | 65 | 7 | – | | |
| | | | | 2 | 150 | 9 | 1.0 | 4 | 2.2 | 13 | 7 | 10 | 20 | 1 | – | | |
| | | | | 3 | 150 | 8 | 2.2 | 24 | 8 | 8 | 48 | 2 | – | | | | |
| | | | | 4 | 150 | 34 | 1.1 | 23 | 7 | 2 | – | | | | | | |
| | | | | 5 | 100 | 9 | 1.1 | 4 | 7 | 2 | – | | | | | | |
| | | | | 6 | 150 | 42 | 0.4 | 8 | 16 | 6 | 26 | 20 | 63 | 1 | – | | |
| | | | | 7 | 150 | 5 | 1.3 | 7 | 7 | 14 | 55 | 2 | – | | | | |
| M | Jordan | Terrace | Limestone and Volcanics | 1 | 150 | 94 | 1.9 | 19 | 11 | 33 | 16 | 17 | 21 | 32 | 46 | 18 | – |
| | | | | 2 | 150 | 4 | 0.6 | 13 | 10 | 48 | 100 | 34 | – | | | | |
| | | | | 3 | 150 | 220 | 0.8 | 550 | 7.5 | 160 | 20 | 650 | 30 | 88 | – | | |
| | | | | 4 | 150 | 13 | 0.8 | 390 | 2.3 | 17 | 76 | 51 | – | | | | |
| | | | | 5 | 150 | 24 | 2.2 | 16 | 11 | 9 | 22 | 17 | – | | | | |

TABLE S-2 **Resistivity of Permeable and Impervious Rocks**

| | Rocks | Resistivity in Ohm-m | |
|---|---|---|---|
| | | Dry | Moistured |
| Aquifer | Gravel | 1,000 - 15,000 | 200 - 10,000 |
| | Sand and gravel | 1,000 - 7,000 | 200 - 5,000 |
| | Sand | 300 - 7,000 | 100 - 700 |
| | Conglomerate | 300 - 1,800 | 100 - 500 |
| | Sandstone | 2,000 - 2,500 | 100 - 500 |
| Aquitard | Loam | 500 - 5,000 | 100 - 1,000 |
| | Tuff | 100 - 1,000 | |
| Aquitard | Silt | | less than 100 |
| | Clay | | less than 100 |
| | Shale | | less than 100 |
| Aquiclude | Granite | 1,000 - 10,000 | |
| | Andesite | 200 - 10,000 | |
| | Basalt | 20,000 | |
| | Crystalline | 200 - 20,000 | |
| | Schist | | |
| | Gneiss | 200 - 20,000 | |
| | Volcanic lava | 1,000 - 20,000 | |
| | Limestone | 60 - 500,000 | |
| | Fresh Water | 10,000 - 1,000 | |
| | Sea Water | 0.3 | |
| | Rain Water | 1,000 - 1,500 | |

Specifications of drilling machine and logging equipment of observation well are as follows.

| | | |
|---|---|---|
| KOKEN Rotary Spindle Type Core Drill | Model OE-8L2 | 1 unit |
| KOKEN Boring Pump | Model MG-10 | 1 unit |
| KOKEN Mud Mixer | Model HM-250 | 1 unit |
| OYO Logging Equipment | Model 3030 | 1 set |

<u>Test Well Drilling</u>

Test wells were drilled at Kalibo and Pontevedra one each.

| Municipality | Date | Depth of Well | Result of Pumping Test |
|---|---|---|---|
| D. Kalibo | Apr. 7 - May 13, 1989 | 85.0 m | drawdown 1.12 m ($2.0m^3$/min x 72 H continue) |
| G. Pontevedra | June 3 - July 22, 1989 | 47.0 m | drawdown 3.70 m ($2.0m^3$/min x 72 H continue) |

The existing water source well of Kalibo Water District yields approximately 2,600 $m^3$/d of water (in 23 hours operation per day). Therefore, the newly constructed test well of which yield is expected to be 2,000 - 3,000 $m^3$/d can double the supply capacity of Kalibo Waterworks when it join into the line.

Also the successful completion of the test well in Pontevedra enlightens the water supply system of Pontevedra which has suffered from the lack of an appropriate water source since long time.

Water quality analysis was made for the water produced from the newly constructed test wells both in the municipalities of Kalibo and Pontevedra respectively.

The result of analysis for major water quality items of water from the respective wells are shown below. Judging the value of the items, the quality of both wells a fairly well.

Some simple facility may be provided to reduce the iron content for Pontevedra well.

| | Kalibo | Pontevedra |
|---|---|---|
| Tot. Fe | < 0.2 ppm | 1.0 ppm |
| $NO_2$ | 0 | 0 |
| $NH_4$ | 0.5 - 0.6 | 0 |
| Mn | 0 | 0 |
| pH | 6.3 | 6.7 |
| EC | 370 μS/cm | 550 μS/cm |

3. Recommended Water Sources

Through this survey, it has become clear that in the most of municipalities hydrogeological conditions are not favorable to develop deep wells for the sources of their water supply systems.

The recommended water sources for the 13 municipalities are as follows:

A. Malay, Aklan
To maximize the collection of existing spring water is the only solution for the source.

B. Ibajay, Aklan
Infiltrated river bed water of the Ibajay River will be recommended for the source.

C. New Washington, Aklan
Considering sea water intrusion, there is no possibility of getting groundwater within the administrative boundary of the town itself. Therefore, it is recommended to develop a deep well at an appropriate site within the administrative boundary of the municipality of Kalibo, on the premise of a well-disposed understanding of the next-door municipality of Kalibo.

D. Kalibo, Aklan
The test well which was constructed in the course of this study proejct is recommended as a source for augmentation of the system.

E. Banga, Aklan
Rehabilitation of the existing deep well or construction of a new deep well is recommended.

F. Ivisan, Capiz
Use of Cabugao spring as well as new construction of an intake dam at an appropriate site downstream Tularo spring.

G. Pontevedra, Capiz

The test well which was constructed in the course of this study will be the most recommendable source.

H. Pilar, Capiz

An additional spring source located at the hilly area near Bgy. Yating, 16 km southwest to the poblacion will be recommended.

I. Sara, Iloilo

In addition to the improvement of the existing water sources, a new exploitation of Alibayog creek will be recommended.

J. Lambunao, Iloilo

Exploitation of river-bed water from Ulian River will be recommended.

K. Leon, Iloilo

Exploitation of river-bed water from Sibalom River will be recommended.

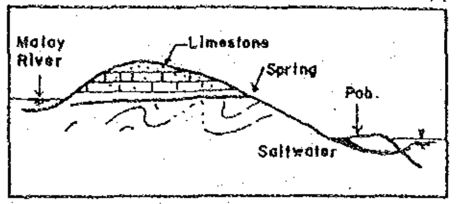
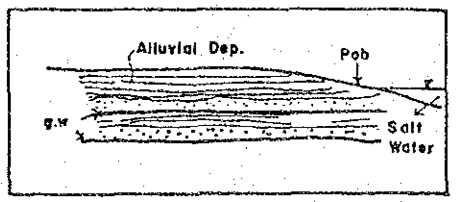
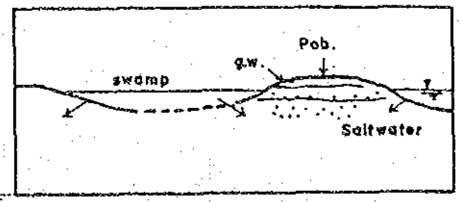
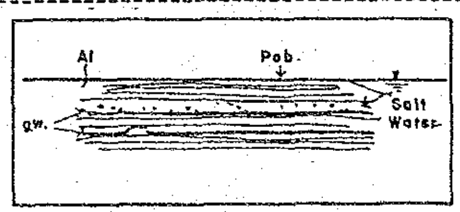
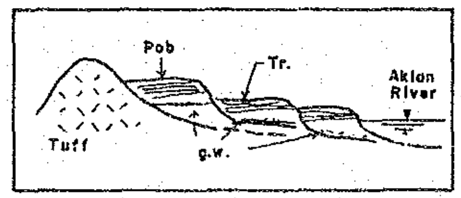
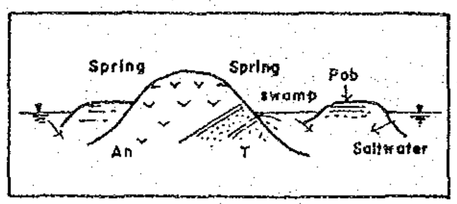
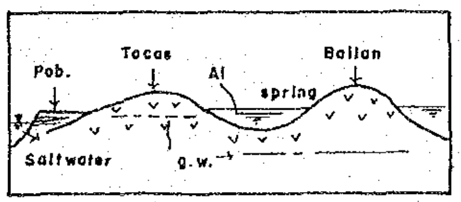
L. Miagao, Iloilo

As it was disclosed that the geological formation at the proposed well site is not favorable to produce groundwater, an augmentation of the existing infiltration gallery at the intake site of Tumagboc River will be recommended.

M. Jordan, Iloilo

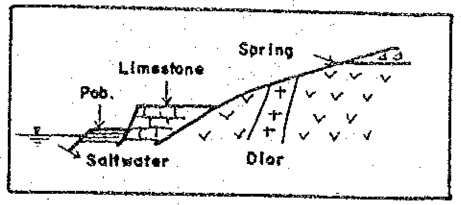
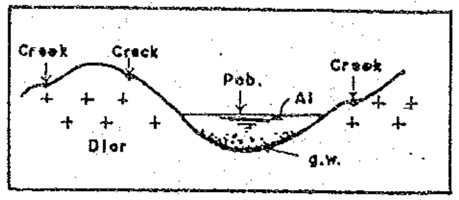
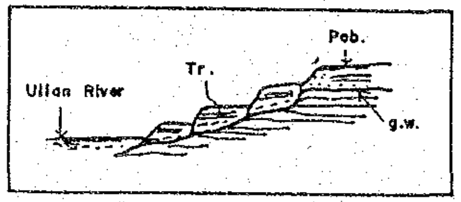
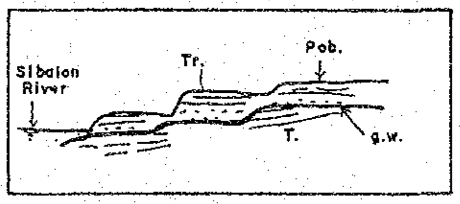
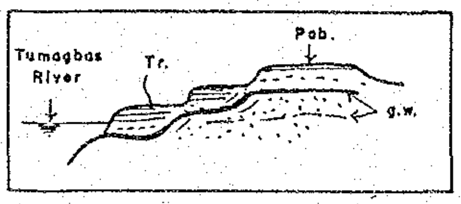
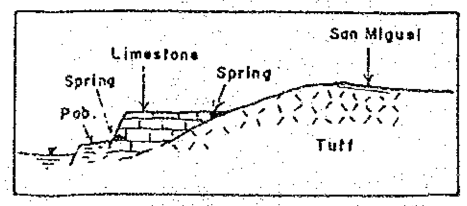
In addition to the rehabilitation and improvement of the existing springs, new development of Teodoro deep well, Biri spring and M-2 spring will be recommended.

TABLE S - 3  ABSTRACTS OF POTENTIAL WATER RESOURCES ANALYSIS

| MUNICIPALITY | TOPOGRAPHY | GEOLOGY | OUTLINE OF GEOLOGICAL STRUCTURE | WATER SUPPLY SYSTEM | OPERATION | PRESENT WATER SOURCE | POSSIBLE WATER SOURCE: SHALLOW WELL | DEEP WELL | SURFACE WATER | RIVERBED WATER | SPRING |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A. Malay | mainly mountainous: narrow coastal plain | Pre-Jurasic, Metamorphic Rock, Pliocene, Limestone, Alluvial Deposit |  | Level III | not functioning | Spring (surface water) | X | X | O | X | O |
| B. Ibajay | wide alluvial plain; westward hilly; eastwards mountain | Miocene, alt. of cg, ss Pliocene, ss, sh, cg. Alluvial Deposits |  | Level III | operating | Deep Well | X | O | X | O | O |
| C. New Washington | narrow sandbank | Alluvial Deposits |  | Level II | not functioning | Shallow well | O | X | X | X | X |
| D. Kalibo | wide alluvial plain | Alluvial Deposits |  | Level III | operating | Deep well | X | O | X | O | X |
| E. Banga | mainly alluvial east and south-east; parts of Poblacion is hilly | Miocene, Pyroclastic (Tuff); Terrace Deposits; Alluvial Deposits |  | Level III | not functioning | Deep well | X | O | X | O | X |
| F. Ivisan | mountainous coastal plain | Paleocne, ss, sh, andesitic to basaltic lava; Alluvial Deposits |  | Level III | operating | Surface Water | X | X | O | X | X |
| G. Pontevedra | rolling hill; coastal plain | Paleone, Basaltic andesite lava; Alluvial Deposits |  | --- | ------ | Shallow Well: Deep well | X | O | X | X | X |

REMARKS : X = not available  O = high  Δ = low

TABLE S – 3 ABSTRACTS OF POTENTIAL WATER RESOURCES ANALYSIS (Cont'd)

| MUNICIPALITY | TOPOGRAPHY | GEOLOGY | OUTLINE OF GEOLOGICAL STRUCTURE | WATER SUPPLY SYSTEM | OPERATION | PRESENT WATER SOURCE | POSSIBLE WATER SOURCE: SHALLOW WELL | DEEP WELL | SURFACE WATER | RIVERBED WATER | SPRING |
|---|---|---|---|---|---|---|---|---|---|---|---|
| H. Pilar | rolling hill; coastal plain | Paleocene, Basaltic andesite; Sara Diorite; Miocene, Limestone; Miocene, Basaltic andesite; Alluvial Dep. |   | Level III | operating | Surface Water | X | Δ | O | X | X |
| I. Sara | mountain area surrounging alluvial plain | Paleocene, Sara Diorite; Alluvial Deposits |   | Level III | operating | Surface Water | X | Δ | O | X | X |
| J. Lambunao | rolling hill | Pliocene, Siltstone; Terrace Deposits; Alluvial Deposits |   | Level II | not operating | Surface Water | X | X | X | O | X |
| K. Leon | rolling hill | Pliocne, Siltstone with sandstone; Terrace Deposits; Alluvial Deposits |   | --- | ---- | Shallow Well | X | X | X | O | X |
| L. Miagao | rolling hill | Pliocene, Sandstone; Terrace Deposits; Alluvial Deposits |   | Level III | operating | Infilt. Water | X | O | X | O | X |
| M. Jordan | inland is plateau cliffs along the coast | Miocene, Limestone; Paleocene, Pyroclastic rock (Tuff); Alluvial Deposits |   | Level III | operating | spring | X | X | X | X | O |

REMARKS : X = not available O = high Δ = low

## D. CONCEPTUAL WATER SUPPLY SYSTEM

### 1. Target Year, Service Area and per Capita Consumption

The target year for water supply planning is set for the year 1995 as an intermediate water supply development/improvement. In this regard, the planned service area of this target year is determined to be the densely populated area and some priority areas as poblacion and adjacent barangays.

Service area of each municipality are as follow.

| | | |
|---|---|---|
| Malay | : | Poblacion, Dumlog |
| Ibajay | : | Poblacion |
| New Washington | : | Poblacion |
| Kalibo | : | Poblacion, Andagaw, Bacho Sur, New Buswang, Old Buswang, Estancia, Pook |
| Banga | : | Poblacion |
| Ivisan | : | Poblacion (Norte & Sur), Agmalobo |
| Pontebedra | : | Ilawod, Ilaya, Tacas |
| Pilar | : | Poblacion |
| Sara | : | Poblacion |
| Lambunao | : | Poblacion |
| Leon | : | Poblacion |
| Migao | : | Poblacion |
| Jordan | : | Poblacion, Rizal, Hoskyn |

Unit Water Consumption

Per capita potential water demand is assumed at 90 to 115 lpcd based on the LWUA Methodology Manual and on the experience in similar water supply feasibility study, "Municipal Water Supply Project" conducted by JICA in 1987.

Design unit water consumption is also estimated in accordance with the said Manual for domestic, commercial and institutional purposes, respectively:

- Domestic unit water consumption is estimated at 100 to 130 lpcd for the year 1995 with an annual increase ratio of 2% from 1988 to 1990 and 1.5% from 1990 to 1995 against 90 to 115 lpcd in 1988.

- Commercial unit water consumption is estimated at 1.4 cu.m/connection/day in 1995 with its connection density ratio of 1.2 per 100 inhabitants.

- Institutional unit water consumption is estimated at 5.2 cu.m/connection/day in 1995 with its connection density ratio of 1.0 per 2,000 inhabitants in the service area.

Following domestic unit water consumptions are used for municipalities.

100 lpcd -- Malay, Pontevedra, Pilar, Lambunao, Leon, Jordan
112 lpcd -- Ibajay, New Washington, Banga, Ivisan, Sara, Miagao
130 lpcd -- Kalibo

## 2. Basic Concept of Planning of Water Supply System

The basic concept in the "Conceptual Design" of the water supply systems in this project is to satisfy the requirement of each municipality in the target year, 1995. To cope with this aim, the planing of the water supply facilities has been conducted on the basis as mentioned hereunder.

### Water Source

In the case that the existing water source cannot satisfy the demand of the community in the target year, development of groundwater will be given the first priority to supplement the existing source. When the result of subsurface investigation was favorable, deep wells were recommended as the supplemental/new sources. If not, spring water or river-bed water were recommended as supplemental sources. Also, rehabilitation and improvement of the intake facilities and transmission facilities were carried out as well as their augmentation and/or additional construction.

For New Washington, a proposed new deep well in the administrative boundary of Kalibo deems as the water source to supply it.

Municipalities and their corresponding water sources are categorized as follows;

Deep Well : New Washington, Kalibo, Banga, Pontevedra
River-bed Water : Ibajay, Lambunao, Leon, Miagao
Spring/Creek Water : Malay, Ivisan, Pilar, Jordan, Sara

### Transmission/Distribution Facilities

For the municipalities which have no existing water supply system, all the facilities should be newly constructed. For the municipalities which have existing water supply systems, consideration paid on their capacities and the degrees of deterioration that they could meet the requirement in the target year of the municipalities.

As for distribution pipes, only the distribution main which forms simple loop has been taken in the planning. Branch pipeline and service pipes which connect to individual housing were omitted in this project.

## 3. Rough Cost Estimate of Major Water Supply Facilities

Unit Construction Cost

Unit Construction cost of required facilities is based on the "In-Place Cost of Waterworks Materials" (as of January 1989) of LWUA. Any unit cost not shown in this list is referred to "Unit Price Manual - Water Supply Feasibility Studies" (July 1983) upon consideration of price escalation that 15% per annum up to 1987 and 7% per annum from 1987 as adopted by LWUA.

All construction costs are estimated in Philippine Pesos and the total cost is only converted into U.S. Dollars and Japanese Yen based on the following exchange rate as of September 1989.

U.S. $1.00 = Yen 145.70 = Peso 20.78

Unit costs used in rough cost estimate are attached in Appendix-5.

Rough Construction Cost (Thousand Pesos)

| | | |
|---|---|---|
| Malay | : | 2,244.8 |
| Ibajay | : | 5,825.8 |
| New Washington | : | 8,217.0 |
| Kalibo | : | 21,188.9 |
| Banga | : | 2,274.8 |
| Ivisan | : | 8,976.7 |
| Pontevedra | : | 2,924.7 |
| Pilar | : | 15,617.4 |
| Sara | : | 9,702.3 |
| Lambunao | : | 5,908.0 |
| Leon | : | 3,542.7 |
| Miagao | : | 4,730.9 |
| Jordan | : | 11,820.7 |
| Total | | 102,974.9 (Thousand Pesos) |

(722.0 million Yen or 4.96 million U.S. Dollar)

# A. MALAY, AKLAN

# A. MALAY, AKLAN

# I. STUDY AREA AND HYDROGEOLOGICAL ANALYSIS

## 1. Description of the Study Area

### 1.1 Physical Description

#### 1.1.1 Geographical Location and Area

The municipality of Malay is located at the northwestern tip of Aklan or at the "pan handle" of Panay Island bordered by the Sibuyan and Sulu Sea on the north, the municipality of Buruanga on the west, the municipality of Nabas on the east, and the province of Antique on the south. It lies between 121°52'00" and 121°59'00" E longitude and 11°50'00 and 12°00'00" N latitude. It is about 96 km from the municipality of Kalibo, the provincial capital.

It has a land area of 6,814 ha covering about 4% of the total land area of the province. It includes the island of Boracay. Location map is shown in FIGURE A-1.

#### 1.1.2 Climate

Malay has a Type I climate, with very pronounced wet and dry seasons. The dry season extends from January to April, registering an average of only 100 mm of rain due to dry winds blowing off the Asia mainland. The southwestern monsoons arrive in June causing the gradual increase in rainfall which is at its peak (500 mm on the average) in the month of August. Temperature varies slightly, averaging 26°C in January and 29°C in May.

#### 1.1.3 Terrain/Topography

Malay is generally mountainous and hilly as it is located on the so-called "northern knot" which is composed of four large mountains belonging to two ranges, the Duyang and Tanag-tacan. This rugged profile is found in the southern inaccessible barangays of Malay while lowland and gently sloping areas are located near the shoreline. Its land slope classification therefore are as follows: 19.5% slope; 22.7% with 8-18% slope; 37.3% with 18-30% slope; 0.2% with slope 30% and over.

#### 1.1.4 Soil

There are four (4) types of soils found in the municipality, the most predominant of which is San Manuel sandy clay loam. Other types include San Manuel clay loam, Alimodian clay loam and Sara sandy loam.

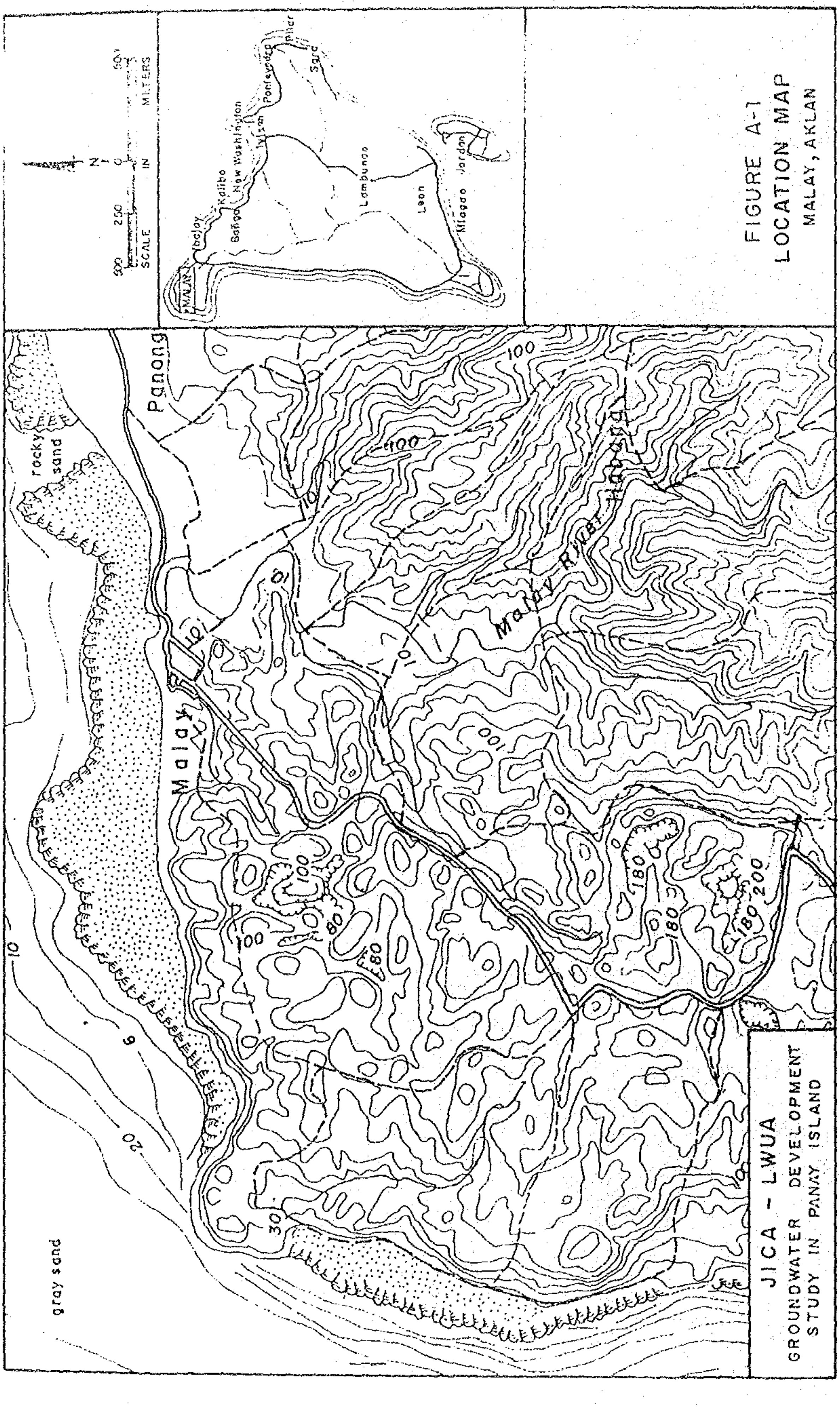



FIGURE A-1
LOCATION MAP
MALAY, AKLAN

### 1.1.5 Administrative Composition and Land Use

The municipality is headed by the Mayor and Vice-Mayor with eight (8) members of the Sangguniang Bayan as the local legislative body. Under the municipality are the barangays, the smallest political subdivision, which are headed by the barangay captains/chairmen with the Sangguniang Barangay as the lawmaking body. All these local officials are selected by the people through popular election.

Municipalities are classified according to the annual revenues from taxes. This classification serves as a major indication of the socio-economic situation of the population in the municipalities. The municipality of Malay belongs to the fifth class.

The municipality of Malay covers 17 barangays namely:

1. Argao
2. Balabag
3. Balusbus
4. Cabulihan
5. Caticlan
6. Cogon
7. Cubay Norte
8. Cubay Sur
9. Dumlog
10. Manoc-manoc
11. Naasog
12. Nabaoy
13. Napaan
14. Poblacion
15. San Viray
16. Yapak
17. Mutag (newly created formerly part of Balusbus)

As of December 1983, about 38% of the municipality's total land area of 6,814 ha. were being used as agricultural lands. Forests composed the greater portion, about 46% of the total land area while grasslands accounted for 7%. Swamps, marshes and fishponds, residential areas and others accounted for the remaining 9%.

### 1.1.6 Transportation

Buses, jeepneys/jitneys, tricycles and cars-for- hire connect all poblacions in the province. Pumpboats are the primary coastal transportation particularly to and from Boracay Island.

### 1.1.7 Infrastructure

As of 1988, Malay had a total road network of 63.326 km. consisting of 7.321 km of national road (gravel), 1.00 km provincial (gravel), 1.325 km municipal (71.3% gravel and 28.7% concrete), and 53.68 km. of gravel barangay roads. Bridges are of the bailey type except for Caticlan Bridge which is of the concrete type.

Malay has one small port suitable for light vessels such as the motorized bancas plying between the province and Romblon, Masbate and Mindoro, and fishing boats. It also has an airport, Caticlan airport, which is classified as a feeder airport and covers 800 m of gravel runway. With the increased small plane traffic in this airport due to the popularity of Boracay Island, there is a need to improve and expand this airport.

The National Power Corporation (NPC) provides electricity through the Aklan Electric Cooperative, Inc. (AKELCO). As of 1986, only 34.81% of the municipality's 1,742 households were served. In 1987, the number of connections totaled 502 covering 477 residential connections, 16 commercial, 2 industrial and 7 public buildings and government offices.

## 1.2 Population and Living Conditions

### 1.2.1 Population Trend from the Past

As of 1980, Malay, which covers 16 barangays and 1,742 households, had a total population of 9,120 reflecting an increase of only 350 over the 1975 population or a geometric annual growth rate of 0.79%, which is much lower than the provincial average of 2.04%. Compared with the other municipalities of the province, it had the least population, accounting for only 2.8% of the provincial population.

Its population density increased from 112 persons per square kilometer in 1970 to 129 persons per square kilometer in 1975 and then to 134 persons per square kilometer in 1980.

Sex ratio of the town's population (101.3 males for every 100 females) showed a predominance of males in 1980. Rural population also registered the greater proportion, 92 percent of the municipal population, over the population claimed by urban areas.

**TABLE A-1 Population and Number of Households by Barangay, Malay, Aklan 1980**

| Barangay* | Population | No. of Households |
|---|---|---|
| Argao | 405 | 72 |
| Balabag | 1,108 | 193 |
| Balusbus | 1,127 | 200 |
| Cabulihan | 355 | 70 |
| Caticlan | 990 | 174 |
| Cogon | 249 | 51 |
| Cubay Norte | 117 | 30 |
| Cubay Sur | 315 | 75 |
| Dumlog | 404 | 75 |
| Manoc-manoc | 1,056 | 204 |
| Naasog | 421 | 82 |
| Nabaoy | 528 | 108 |
| Napaan | 344 | 61 |
| Poblacion | 709 | 144 |
| San Viray | 271 | 54 |
| Yapak | 721 | 149 |
| Total | 9,120 | 1,742 |

* Excluding Mutag, a newly created barangay and formerly part of Balusbus.

### 1.2.2 Age Distribution

Persons under 15 years of age comprised 41% of the total population of the municipality. The productive population, those with ages ranging from 15 to 64 years old, accounted for 53%. Adults 65 years old and above made up only 6% of the municipal population. With this age distribution, dependency rate was recorded at 86.7%.

### 1.2.3 Morbidity/Mortality

Leading causes of sickness and deaths are respiratory diseases such as upper respiratory tract infection, bronchitis and influenza. Secondary to respiratory diseases are gastrointestinal diseases and nutrition-based diseases.

Malnutrition is a major factor behind the morbidity and mortality cases. Of the 1,800 preschool children weighed in 1987, only 28.3% were normal in weight. More than two- thirds, 68.3%, were malnourished while the rest were overweight.

### 1.2.4 Sanitation

As of 1984, water-sealed with septic tank was the most common type of toilet facility in Malay with 90.5% of the 1,742 households using it. Other households, about 1.8%, were using the flush with septic tank type of waste disposal. There were still about 7.7% of the total households without waste disposal systems.

### 1.2.5 Public Services

Health facilities include one private hospital with a 20-bed capacity, one public clinic, one private clinic and 4 barangay health centers. Public health personnel servicing the area include one doctor, one dentist, 2 nurses and 5 midwives.

Existing facilities in 11 schools show total area of 14.59 ha. occupied by public elementary and secondary schools in Malay. There were 6 Bagong Lipunan type school buildings, 15 pre-fabricted and 2 others.

The number of elementary classrooms totaled 100 of which 46% are dilapidated but repairable and 21% are condemned.

The number of teachers reached a total of 62 during school year 1987-1988 reflecting a teacher-pupil ratio of 1:36 in public elementary schools. In public secondary schools, the teacher-student ratio was 1:29.

## 1.3 Economy and Industry

### 1.3.1 Agriculture

As is true for the entire province, agriculture continues to dominate the economy with rice as the major crop. As of 1980, the total number of farms reached 733 covering an aggregate area of 1,916.51 ha. and with sizes averaging at 2.61 ha.

The dominant crop in the municipality is coconut, which produced 32,066 metric tons in 1980 or 96.70% of total agricultural production in that year. This was followed by palay, which produced 730 metric tons or 2.2% of total production and fruits and vegetables with 336 metric tons or 1.00% of total. Some minor crops included corn and other cereals, coffee, cacao and fiber crops.

The livestock population of the municipality as reported in the 1980 census of Agriculture totaled 23,054 heads consisting of 394 carabaos, 226 cattle, 220 goats, 909 pigs and 21,303 fowls, mostly chickens and ducks.

### 1.3.2 Other Industries

Fishing is also a major industry in Malay and provides a leading export product for the local economy and a basic diet staple for the local people. Fishpond operation is composed of bangus and prawn raising with crab raising on the side. As of 1983, Malay registered a total fishpond area of 523.30 hectares. Marine fishing on the other hand, registered an annual production of 108.864 MT. As of December 1986, there were 100 full time and 15 part-time fishermen with 104 bancas of which 44 are motorized.

Minor forest products such as nito, ungali, pari-pari, bulan, sagacap, hipgid, kagay and hagnay abound in Malay. These can be used for handicraft and furniture production.

Classification of industries in the municipality falls into cottage and home industries having less than ₱100,000.00 capital upon registration; employment size is small scale with less than 30 employees; family-oriented (work mostly or solely done by family members); and products are generally marketed locally.

The number of industrial establishments/operators totaling 268 in 1981 may not be all encompassing since many activities are carried out in homes of entrepreneurs. Majority of these establishments are engaged in rice milling, fiber-craft, woodcraft, ceramics, shell-craft and hollow-block making.

Tourism has also become a major source of income and foreign exchange owing to the increasing popularity of Boracay Island.

## 2. Analysis of Potential Water Source

### 2.1 Topography and Geology

Located on the north western tip of Panay Island, the municipality of Malay has mainly mountainous and hilly topographical feature. Its narrow coastal plain which faces the Sibuyan Sea, stretches for miles eastward.

The municipality exhibits geological features, some of which are different from the rest of the island, with its mountain area occupied by basement rocks and its low land composed of alluvial deposits. Geological map is shown in FIGURE A-2.

Basement Rocks (Pre-Jurrasic)

The geological characteristics of this study area is different from the rest of the area in Panay Island. Metamorphic rocks of Carboniferous to Jurrasic which are the oldest in Panay exist predominantly. The most common basement rocks are chart and black slate and the strike and the dip show N30 E, 40 SE, respectively.

Pliocene Sediments (Tertiary)

In the westward of the study area, limestone forms cliffs which are highly karstified massive reef.

Alluvial Deposits (Quaternary)

This unit is found down- stream of the Malay River and forms a coastal plain along its estuary and mainly composed of sand, clay and gravel.

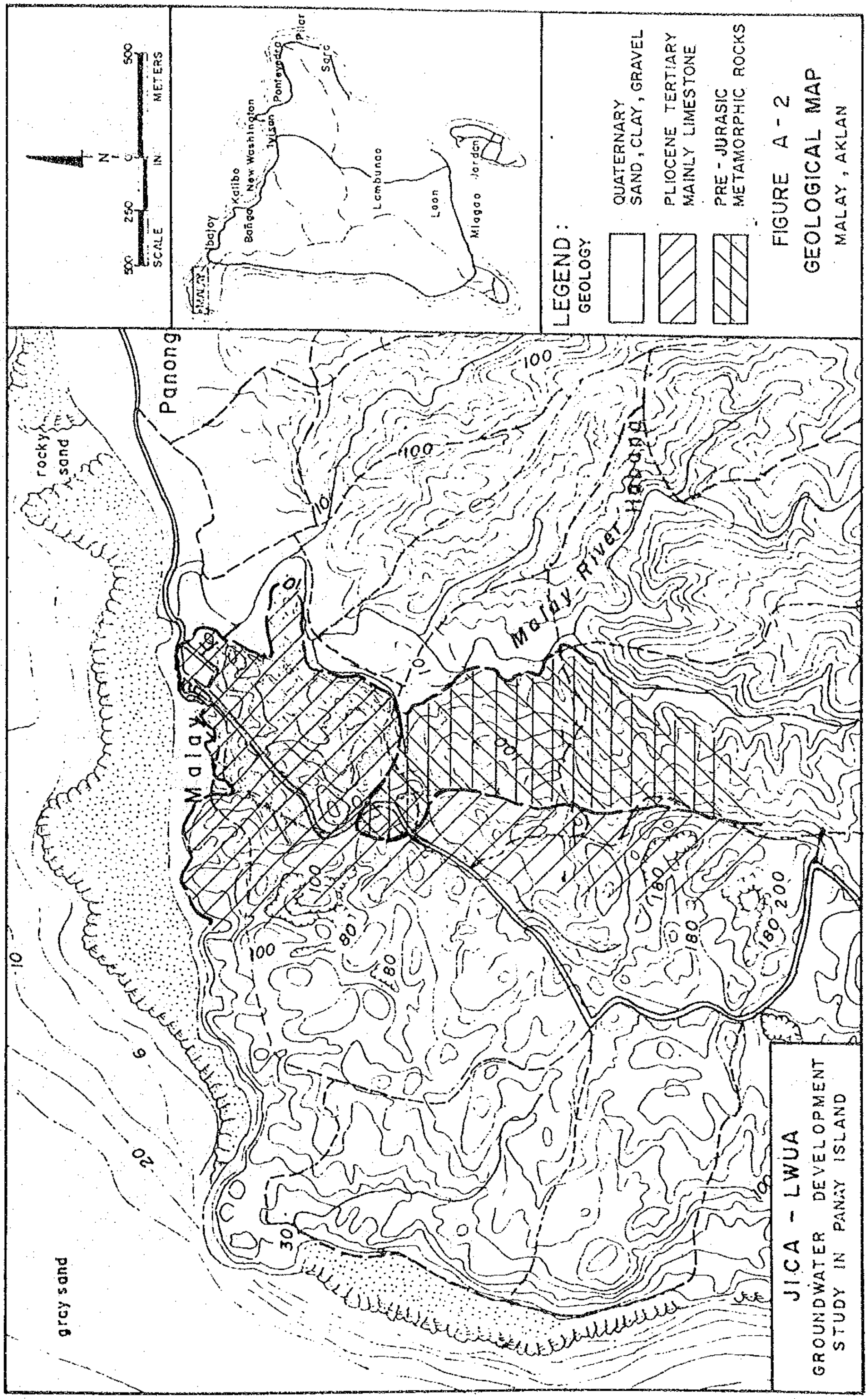
### 2.2 Existing Water Source

Springs and Surface Water

There exist three springs in the mountainous area of the municipality near the Poblacion.

One is located about 2.5 km southwest of the town proper, with 1.9 mW x 2.2 mL x 1.0 mH concrete collection box, from which collected water is conveyed through 4" GI pipe to a ground reservoir 6.5 mW x 4.4 mL x 2.4 mH about 300 m far away from the spring. From this ground reservoir, a 4" GI transmission pipeline stretches to a point approximately 600 m downwards from the reservoir. Up to this point, no connection was observed.

The second spring is located beside the above-mentioned ground reservoir and downstream of the first spring. Inhabitants in the vicinity use this spring as their source of water.



SCALE IN METERS
500 250 0 500
N
Bajay
Kalibo
Bañga
New Washington
Tyisan
Pontevedra
Pilar
Sara
Lambunao
Loon
Miagao
Jordan
LEGEND :
GEOLOGY
QUATERNARY SAND , CLAY , GRAVEL
PLIOCENE TERTIARY MAINLY LIMESTONE
PRE - JURASIC METAMORPHIC ROCKS
FIGURE A - 2
GEOLOGICAL MAP
MALAY , AKLAN
Panong
rocky sand
Malay River
Malay
gray sand
JICA - LWUA
GROUNDWATER DEVELOPMENT STUDY IN PANAY ISLAND

The third spring is located at the opposite side of the hill and is used by a few residents in its vicinity. However, the yield of this spring is very low.

Flow measurements of the first two springs were conducted on April 25 and September 16 to assess the yield during the dry season and rainy season, respectively. Measurement results are summarized in TABLE A-2.

TABLE A-2 **Spring Yield Measurement**

| | | Flow Rate | |
|---|---|---|---|
| JICA-LWUA Source No. | Location | Dry Season (April 25) | Rainy Season (September 18) |
| A-9 | First Spring (upper) | 280 cu.m/day (3.28 liter/sec) | 850 cu.m/day (9.86 liter/sec) |
| A-8 | Second Spring (lower) | 370 cu.m.day (4.32 liter/sec) | 560 cu.m/day (6.56 liter/sec) |
| Total | | 650 cu.m/day (7.60 liter/sec) | 1,410 cu.m/day (16.4 liter/sec) |

During the dry season, the flow amount from the upper spring was measured at approximately 280 cu.m/day, and the downstream of the second (lower) spring was measured at approximately 370 cu.m/day. Thus, the total flow amount of 650 cu.m/day is being considered as the minimum potential discharge from the two springs. On the other hand, a total flow amount of 1,410 cu.m/day was measured during the dry season.

The Malay River flows into the Sulu Sea beside the town proper of Malay with a basin area of about 16 sq.km. The river flow, however, was not measured at the river mouth both in dry and rainy season, because it is located at the downstream of swampy area and being influenced by tidal movement.

Wells

Well inventory survey was conducted within the Poblacion of Malay (as shown in FIGURE A-3) in order to assess the present groundwater conditions. However, useful well log data, including well lithologic log, were not available at the various official agencies, i.e. LWUA, DPWH and NIA. Two deep wells constructed by DPWH (formerly MPWH) were found in the Poblacion. In addition, many private shallow wells with pitcher pump or jetmatic pump had been used by residents. Among those wells, three wells including one DPWH well were surveyed for their static water levels and total depths. The collected data are presented in TABLE A-3.

TABLE A-3 Well Data Summary

| JICA-LWUA Source Number | Well Depth (M) | Ground Level (MAMSL) | Static Water Level Dry Season (MBGL) | Dry Season (MAMSL) | Rainy Season (MBGL) | Rainy Season (MAMSL) |
|---|---|---|---|---|---|---|
| A-1 | 5.28 | 1.6 | -0.87 | 0.7 | -1.51 | 0.1 |
| A-2 | 2.16 | 2.5 | -0.46 | 2.0 | -1.50 | 1.0 |
| A-3 | 4.79 | 2.0 | -1.17 | 0.8 | -1.32 | 0.7 |

The results are summarized as follows:

i) Depth of the wells did not exceed 5.5 m below ground surface.

ii) Groundwater table is considered as free declined from the inland part to sea shore.

iii) Groundwater table approaches nearly at sea water level at the time survey was conducted (MSL +1.06 m). Those levels range between +0.73 m and +1.96 m above mean sea water levels during the dry season.

iv) On the other hand, groundwater levels during the rainy season range between +0.09 m and +1.00 m. These values are lower than those during the dry season. It seems to be caused by the low tide level at the survey time (MSL -0.44 m). Therefore, the shallow groundwater aquifer is strongly influenced by the tidal movement, and the groundwater development in the Poblacion has a high possibility of saline water intrusion.

## 2.3 Survey for Potential Water Source

### 2.3.1 Evaluation of Georesistivity Survey

It is very difficult to develop groundwater resources in this area due to steepness of the terrain. Considering the condition of the area, the georesistivity survey was not conducted.

## 2.4 Water Quality Analysis

A total of 9 existing water sources (2 springs and 7 wells) was surveyed and on-site analysis was carried out. Water samples collected from the undeveloped spring No. 2 were brought to LWUA for laboratory analysis.

The following are the field analysis data of existing water sources performed in dry and rainy seasons. Location of these water sources are pinpointed on FIGURE A-3.

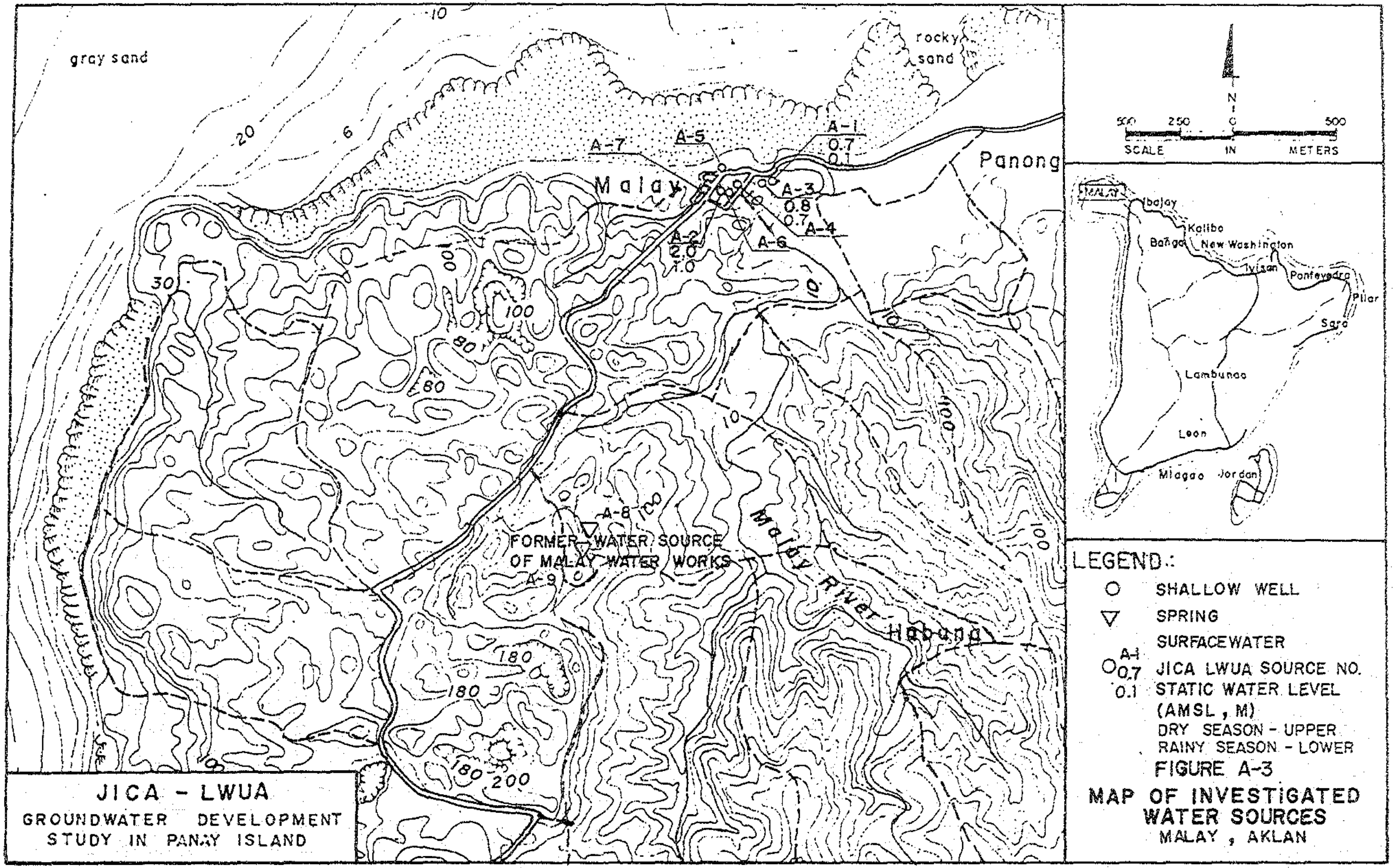



FIGURE A-3
MAP OF INVESTIGATED WATER SOURCES
MALAY, AKLAN

TABLE A-4 Water Quality Analysis Results

| Sample | WT (°C) | pH (-) | EC (μS/cm) | T-Fe (ppm) | Mn (ppm) | $NH_4$-N (ppm) |
|---|---|---|---|---|---|---|
| **Dry Season** | | | | | | |
| A-1 DPWH Well 01-1-87-06 | 27.2 | 7.0 | 234 | nil | nil | nil |
| A-4 DPWH Well 3-60-9 | 28.6 | 7.7 | 540 | nil | nil | nil |
| A-5 Private Shallow Well No. 1 | 28.0 | 7.5 | 580 | nil | nil | nil |
| A-6 Private Shallow Well No. 2 | 32.8 | 7.8 | 900 | nil | nil | nil |
| A-7 Private Shallow Well No. 3 | 29.0 | 7.7 | 760 | nil | nil | nil |
| A-8 Lower Spring No. 2 | 27.0 | 7.6 | 500 | nil | nil | nil |
| **Rainy Season** | | | | | | |
| A-1 DPWH Well 0-1-1-87-06 | 27.6 | 7.2 | 755 | 2.0 | - | nil |
| A-2 Private Shallow Well | 30.4 | 8.1 | 420 | 0.5 | - | 0.4 |
| A-3 Private Shallow Well | 29.2 | 7.2 | 750 | 0.2 | - | nil |
| A-4 DPWH Well | 28.6 | 7.5 | 460 | - | - | - |
| A-5 Private Shallow Well No. 1 | 30.5 | 7.9 | 1,000 | nil | - | 0.4 |
| A-6 Private Shallow Well No. 2 | 28.5 | 7.3 | 500 | - | - | - |

TABLE A-4 **Water Quality Analysis Results (Cont'd)**

| Sample | | WT (°C) | pH (-) | EC (μS/cm) | T-Fe (ppm) | Mn (ppm) | $NH_4$-N (ppm) |
|---|---|---|---|---|---|---|---|
| A-7 | Private Shallow Well No. 3 | 28.6 | 7.4 | 750 | - | - | - |
| A-8 | Lower Spring | 26.5 | 7.6 | 400 | 0.4 | - | nil |
| A-9 | Upper Spring | 26.3 | 7.2 | 420 | nil | - | 1.2 |

Generally, existing water sources have fair quality with regard to pH, Total Iron, Manganese. Electric conductivity shown non presence of salt water intrusion, but is relatively high resultant from absorption of chemical constituents.

The following data are laboratory analysis results for samples collected at Lower Spring (A-8):

| | Dry Season | Rainy Season |
|---|---|---|
| Date of Sampling | 6.07.88 | 9.18.88 |
| Turbidity (FTU) | 1 | 0.7 |
| Color (UNIT) | nil | 22 |
| TDS (mg/l) | 307 | 255 |
| pH (-) | 7.4 | 8.1 |
| EC (μS/cm) | 480 | 450 |
| Alkalinity as $CaCO_3$ (mg/l) | 199 | 180 |
| Hardness as $CaCO_3$ (mg/l) | 225 | 210 |
| Major Cations | (meq/l) | (meq/l) |
| Sodium | 0.1 | 0.2 |
| Potassium | <0.01 | <0.01 |
| Calcium | 3.9 | 3.5 |
| Magnesium | 0.6 | 0.7 |
| Total | 4.61 | 4.41 |
| Major Anions | (meq/l) | (meq/l) |
| Carbonate | 0 | 1.4 |
| Bicarbonate | 4.0 | 2.2 |
| chloride | 0.8 | 0.7 |
| Sulfate | 0.1 | 0.1 |
| Total | 4.9 | 4.4 |

The above results indicates that the spring water is characterized as Carbonate-Hardness Type, although the total chemical constituents are not so rich as represented by TDS and EC. This spring water has fairly good quality for potable consumption provided however appropriate measures be taken up to remove color of water.

## 3. Conclusion and Recommendation

Based on the results of the field survey discussed previously, the following may be deduced:

It is very difficult to transport and maneuver a bigger sized drilling rig and its accessories in a steep mountainous area. On the contrary, in the coastal plain area, there might be a strong possibility of saline water intrusion.

The potentiality of groundwater development by means of deep wells is scarce because of the smallness of the catchment area.

The most possible measures to acquire stable water sources, therefore, will be the rehabilitation and reuse of the said springs not utilized effectively at present.

# II. CONCEPTUAL WATER SUPPLY SYSTEM

## 1. Existing Water Supply Conditions

### 1.1 Water Use Condition

As it has been discussed in the Progress Report, readily accessible drinking waster sources are quite limited in the Poblacion area due to hydrogeological restrictions.

At present, no piped water supply system is functioning in the Poblacion area. Sources of drinking water available in the subject area are shallow tube/dug wells usually equipped with jetmatic or pitcher pumps, some of which are public wells with concrete apron constructed by DPWH. Most privately constructed shallow wells have potential risks of water source contamination due to inappropriate manner of construction and/or usage, i.e., seepage of wastewater being discharged on the ground due to absence of sanitary seal, and the presence of potential pollution source in the vicinity of the well such as toilet facility and poultry cage.

As a whole, lack of potable water supply has hampered the economic activities and community development in relation to public hygiene in the subject area.

Reestablishment of the piped water supply system will require the over-all renovation/rehabilitation of abandoned facilities. Institutional development is also a prerequisite to insure proper operation and management of the piped water supply system.

### 1.2 Existing Water Supply System and Problems Encountered

A level III Water Supply System was constructed in the early 1970's to serve the Poblacion area, but the operation of this system was abandoned after a few years of service due to poor management, operation and maintenance. This system had the following configurations at the time of the inauguration:

- spring box (RC, 1.90 mW, 2.15 mL, 0.97 mH, GL +125 m) at upper spring about 2.5 km away from the Poblacion area.

- ground storage tank (RC, approx. 60 cu.m, 6.52 mW, 4.39 mL, 2.38 mH, GL +105 m) nearby lower spring at about 300 m downward from the spring box.

- transmission line (GI, ø 100 mm) from the spring box to the Poblacion area via the storage tank for about 2.5 km of the total length.

- distribution lines in the Poblacion area.

The spring box has incurred a leakage from the junction point to the transmission line. The yield from this upper spring was measured at 280 cu.m/day. As discussed in the foregoing section, this yield is considered the minimum yield throughout the year.

An attempt was made to relocate the transmission line after the original one was destroyed, but this was not accomplished. The existing pipe has a length of about 1.3 km from the spring box to the capped pipe end (GL +88 m) via the storage tank. The capped pipe end has a small hole from which water can be drawn for the use of the neighboring residents. During the field survey, however, no water flowed into this pipeline from the spring box due to the said leakage. No pipes were observed to have existed in the remaining section leading to the Poblacion area.

The debris of old distribution lines were seen in the Poblacion area, but investigations revealed that no technical data or drawings of the water supply system could be found at the office of the municipal government.

## 2. Water Demand Projection

### 2.1 Criteria

Per capita potential water demand is assumed at 90 lpcd based on the LWUA Methodology Manual and on the experience in similar water supply feasibility study, "Municipal Water Supply Project" conducted by JICA in 1987.

Design unit water consumption is also estimated in accordance with the said Manual for domestic, commercial and institutional purposes, respectively:

- Domestic unit water consumption is estimated at 100 lpcd for the year 1995 with an annual increase ratio of 2% from 1988 to 1990 and 1.5% from 1990 to 1995 against 90 lpcd in 1988.

- Commercial unit water consumption is estimated at 1.4 cu.m/connection/day in 1995 with its connection density ratio of 1.2 per 100 inhabitants.

- Institutional unit water consumption is estimated at 5.2 cu.m/connection/day in 1995 with its connection density ratio of 1.0 per 2,000 inhabitants in the service area.

In accordance with the LWUA Methodology Manual, the unaccounted-for water is considered at 25% of the total distributed amount. This is the standard ratio to be applied for new pipelines since all the abandoned pipelines shall be replaced with new ones.

### 2.2 Areas to be Served

The target year for water supply planning is set for the year 1995 as an intermediate water supply development/improvement. In this regard, the planned service area of this target year is determined to be the densely populated area and some priority areas. The Poblacion and Barangay Dumlog are likewise designated as the target area for water supply planning. Dumlog is adjacent to the Poblacion and is located at an inland area where spring water sources are situated.

Other barangays in Malay are located mostly along the coastal line toward Barangay Caticlan. These barangays are therefore excluded from the target area owing to the distance from the Poblacion and considerably scattered habitation conditions.

## 2.3 Population Projection

The National Economic and Development Authority (NEDA) has projected the municipal population in each calendar year from 1981 to 2000 based on population census conducted in 1980.

The municipal government also estimated the municipal and barangay population toward the year 1992 based on 1980 census data. The municipal population estimated by the municipality is approximately 2.1 percent higher than that made by NEDA, These data are presented in TABLE A-5.

TABLE A-5 Population Projection of Malay

| Year | NEDA Projection Municipality | Municipal Projection Municipality | Poblacion | Dumlog |
|---|---|---|---|---|
| 1980 | 9,148 | 9,148 | 709 | 404 |
| 1985 | 9,810 | 9,780 | 760 | 430 |
| 1990 | 10,370 | 10,480 | 820 | 460 |
| 1992 | 10,550 | 10,780 | 840 | 480 |
| 1995 | 10,800 | -- | -- | -- |
| 2000 | 11,000 | -- | -- | -- |

The municipal government applied a uniform growth rate of 1.4 percent per year, while NEDA employed declining growth rates for every 5 years; 2.1 percent per year from 1980 to 1985; 1.82 percent per year from 1985 to 1990; 1.46 percent per year from 1990 to 1995; and 1.13 percent per year from 1995 to 2000, respectively.

When the actual average growth rate of 1.85 percent per year from 1970 to 1980 is taken into account, the NEDA projection is considered to be more realistic than the municipal projection.

The barangay population of the Poblacion and Dumlog are likewise estimated in accordance with the municipal population projected by NEDA. Percentage share of barangay population to municipal population in 1995 is determined to be the same as the 1980 census result. The result of population projection of these two barangays are shown in TABLE A-6.

TABLE A-6 Population Projection of Service Area

| Year | Municipality | Planned Service Area | | |
|---|---|---|---|---|
| | | Poblacion | Dumlog | Total |
| 1980 | 9,148 | 709 | 404 | 1,113 |
| 1985 | 9,810 | 760 | 430 | 1,190 |
| 1990 | 10,370 | 800 | 460 | 1,260 |
| 1995 | 10,550 | 820 | 470 | 1,290 |

With regard to the percentage of population to be served, 80 percent of the Poblacion residents and 40 percent of Dumlog are considered reasonable when the habitation conditions are taken into account. As a whole, a total of 850 (660 in the Poblacion and 190 in Dumlog) will be the planned service population in the year 1995. Average number of persons per household is assumed at 5.00 based on the standard figure adopted by NEDA.

## 2.4 Water Demand Projection

The future water consumption in 1995 is estimated based on the aforementioned planned service population and design unit water consumption by consumer type..

One institutional connection is considered for the Poblacion and Dumlog, although their service area population is below the criteria. The estimated number of connections and future water consumption are presented in TABLE A-7.

TABLE A-7 **Water Consumption in 1995**

| Service Area | Poblacion | Dumlog | Total |
|---|---|---|---|
| Served Population | 660 | 190 | 850 |
| No. of Connection | | | |
| Domestic | 132 | 38 | 170 |
| Commercial | 8 | 2 | 10 |
| Institutional | 1 | 1 | 2 |
| Total | 141 | 41 | 182 |
| Water Consumption (cu.m/day) | | | |
| Domestic | 66 | 19 | 85 |
| Commercial | 11 | 3 | 14 |
| Institutional | 5 | 5 | 10 |
| Sub-total | 82 | 27 | 109 |
| Unaccounted-for Water | 27 | 9 | 36 |
| Total | 109 | 36 | 145 |

The ratio of the daily maximum water demand to the daily average water demand is determined in relation to the planned service population based on the LWUA Methodology Manual as shown in TABLE A-8.

**TABLE A-8 Demand Variation Factor for Daily Maximum Water Demand**

| Service Population | Ratio (Daily Max./Daily Ave.) |
|---|---|
| Less than 30,000 | 1.30 : 1 |
| 30,000 to 200,000 | 1.25 : 1 |
| Over 20,000 | 1.20 : 1 |

The estimated daily maximum water demand is shown in TABLE A-9.

**TABLE A-9 Daily Maximum Water Demand**

| Service Area | Water Demand (cu.m/day) |
|---|---|
| Poblacion | 142 |
| Dumlog | 47 |
| Total | 189 |

The peak hour water demand is estimated in proportion to the daily maximum water demand and service population in accordance with the LWUA Methodology Manual as shown below:

C = (Peak Hour Demand x 24)/(Daily Maximum Demand)

= 2.2 - 0.3 x log (Service Population/1,000)

Likewise, the ratio of peak hour water demand in the year 1995 is calculated as 2.22. TABLE A-10 shows the peak hour water demand.

**TABLE A-10 Peak Hour Water Demand**

| Service Area | Water Demand (cu.m/day) |
|---|---|
| Poblacion | 315 |
| Dumlog | 104 |
| | |
| Total | 419 |

## 3. Proposed Water Supply Facilities

### 3.1 Basic Approach for Water Supply Improvement

#### 3.1.1 Conditions and Constraints

The conceptual plan for water supply improvement is focused on major water supply facilities, such as water source, main transmission and distribution pipelines, and reservoir. Branch lines, service connections and fire hydrants are likewise excluded from conceptual planning. However, following conditions are taken into account as much as possible:

(1) Low cost in construction, operation and maintenance,
(2) Seasonal fluctuation of source capacity will not seriously affect stable water supply,
(3) Water source will be located within the administrative boundary of respective municipality.

#### 3.1.2 Water Source Development

Two existing springs yield potable water which conforms to the National Standards for Drinking Water and sufficient quantity through the year to meet with the water demand projected for the year 1995. Furthermore, these springs locate at high altitude on the mountain slope within the reasonable distance from proposed water supply service area. This locational condition enables application of gravity flow for water transmission and distribution. Likewise, full utilization of these springs is deemed appropriate for water supply improvement.

#### 3.1.3 Transmission and Distribution Facilities

The abandoned transmission line, which is approximately 1.3 km length of ø 100 mm GI pipe, will be fully utilized upon minor repair and realignment.

The existing ground reservoir, which has also been abandoned, needs thorough check-up and repair of leakage. In addi tion, the storage water level of this reservoir is higher than the intake elevation of the lower spring. Therefore, reuse of this abandoned reservoir is considered inappropriate and two new reservoirs are proposed for water supply improvement.

Some of abandoned distribution pipe still exist in poblacion area, but are only debris and not serviceable. Likewise, distribution line will be completely renewed.

## 3.2 Plan for Improvement of Water Supply Facilities

### 3.2.1 Water Source Facility

The intake box of existing spring will be reconstructed for effective utilization of its yield.

The other undeveloped spring has three outlets and each of which will be provided with appropriate intake box.

Through development of these springs, a total of 650 cu.m/day (280 cu.m/day from upper spring and 370 cu.m/day from lower spring) will be expected for water supply through the year.

### 3.2.2 Transmission Facility

The abandoned transmission line will be utilized upon minor repair and realigned to pass through new reservoir-1 which will be located at about 60 m downward from the abandoned reservoir.

The lower spring and the said reservoir-1 will be connected by new transmission line.

Additional transmission line will be laid from the end of existing line to new reservoir-2 which will be located at about 500 m downward from the new reservoir-1.

All these transmission line will have flow capacity to meet with the daily maximum water demand.

### 3.2.3 Distribution Facility

Two new reservoirs will have following functions in addition to their original purpose for water storage:

(1) Reservoir-1 will be a junction point of transmission lines from two springs.

(2) Reservoir-2 will release water pressure increased in transmission line.

Total capacity of two reservoirs is planned to have 3-hours volume of daily maximum water demand which is equivalent to the sum of emergency storage and 10% of the daily maximum water demand as operational storage. Chlorination facility will be installed at new reservoir-2.

New distribution main will be installed from reservoir-2 to poblacion area and form a loop line in poblacion area. This pipeline will have flow capacity to meet with the hourly maximum water demand.

### 3.2.4 Required Water Supply Facilities

Location of major water supply facilities is shown in FIGURE A-4 flow diagram of facilities in FIGURE A-5 and detail of distribution pipeline in proposed service area in FIGURE A-6.

Size and quantity of required facilities are listed below:

(1) Water Source Facility

Upper spring intake box:
RC, 2.0 mW x 2.5 mL x 1.30 mH, GL +125.0 m, 1 unit

Lower spring intake box:
RC, 2.0 mW x 2.0 mL x 1.30 mH, GL +105.0 m, 3 units

(2) Transmission Line

Rehabilitation/realignment of existing transmission main from upper spring to Reservoir-1:
ø 100 mm, 300 m

Transmission main from lower spring to Reservoir-1:
ø 100 mm, 60 m x 3 lines

Rehabilitation/realignment of existing transmission main from Reservoir-1 to the end of line:
ø 100 mm, 500 m

Transmission main from the end of existing line to Reservoir-2:
ø 100 mm, 700 m

(3) Distribution Facility

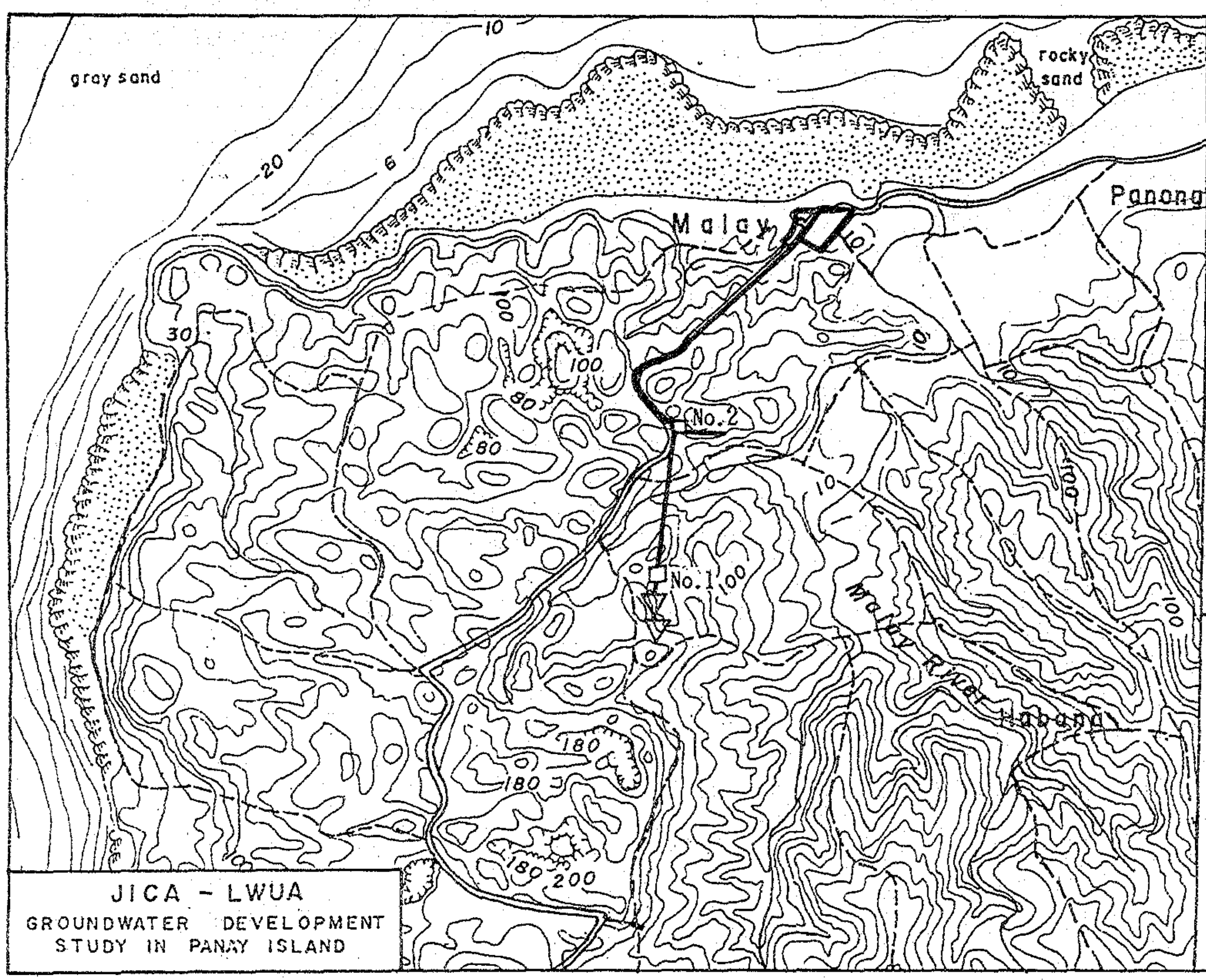
Reservoir-1:
RC, 3.0 mW x 3.0 mL X 2.0 mH, 18 cu.m, GL+100.0 m, 1 unit

Reservoir-2:
RC, 3.5 mW x 3.5 mL x 2.5 mH, 30 cu.m, GL +45.0 m, 1 unit

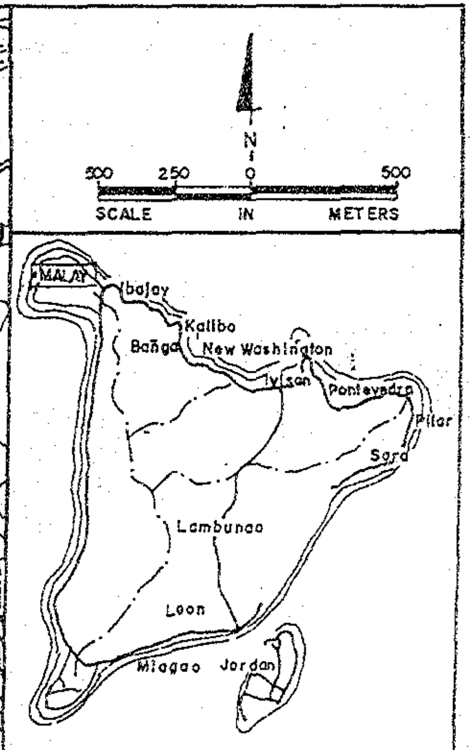
Chlorination tank at new reservoir-2:
RC, 1.5 mW x 2.5 mL x 2.0 mH, 1 unit

Distribution main from new reservoir-2 to the entrance of poblacion area:
ø 150 mm, 1,200 m

Distribution main for barangay Dumlog:
ø 100 mm, 1,500 m



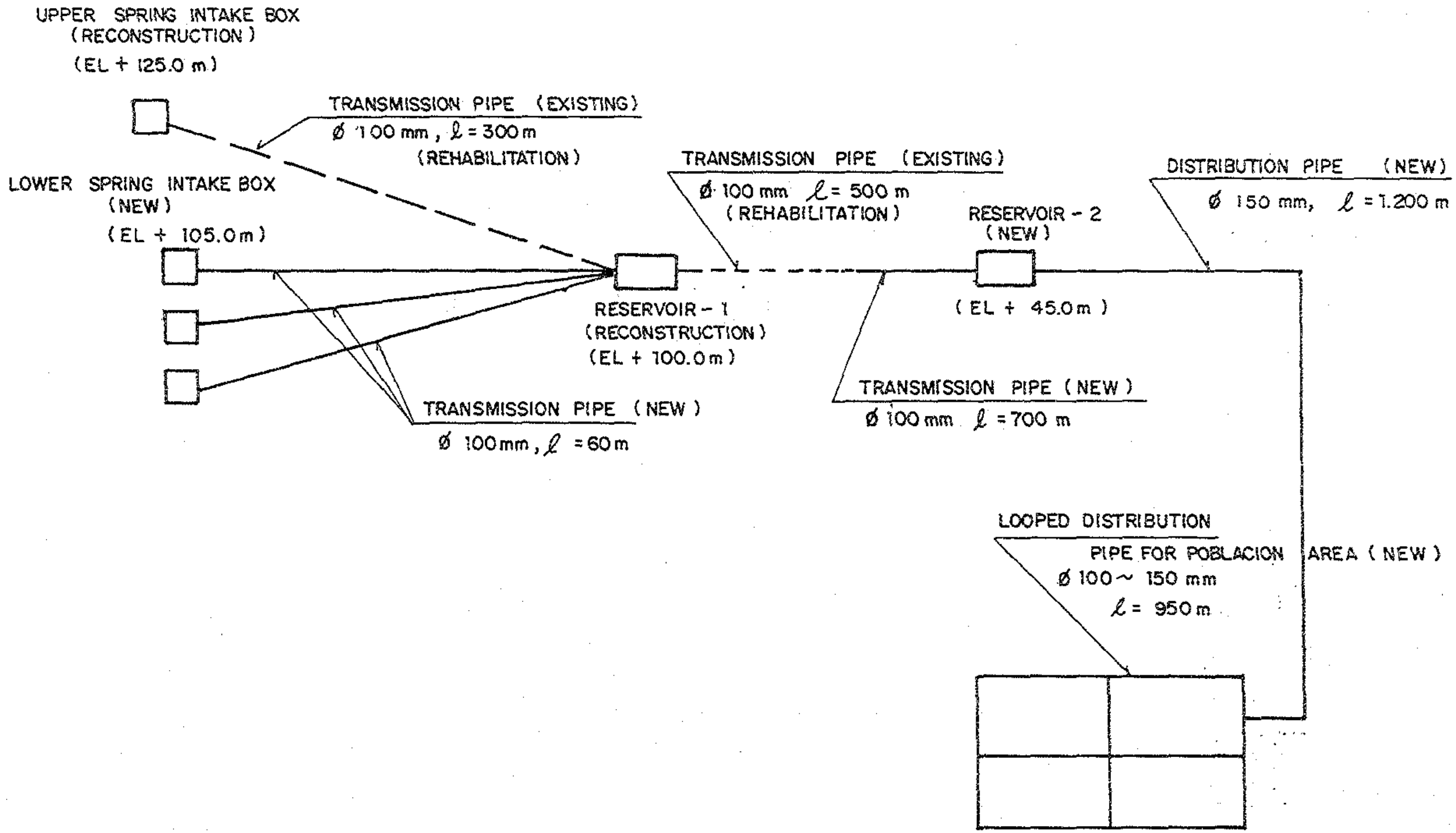

JICA - LWUA
GROUNDWATER DEVELOPMENT
STUDY IN PANAY ISLAND




LEGEND:

- ▽ Spring Intake Box
- □ Storage Tank or Reservoir Tank
- — Main Pipe

FIGURE A-4
LOCATION OF MAJOR FACILITIES
MALAY, AKLAN

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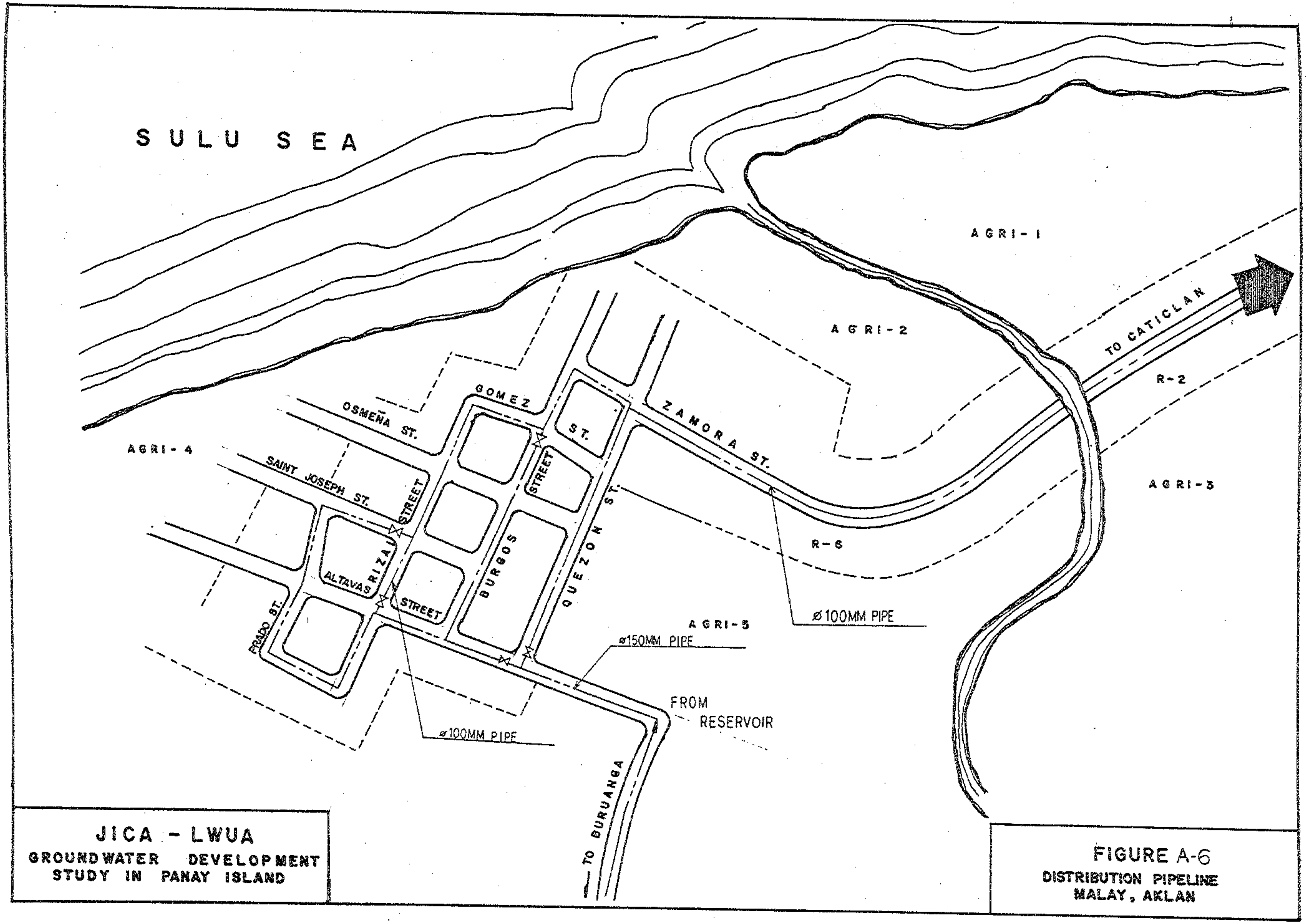
GROUNDWATER DEVELOPMENT
STUDY IN PANAY ISLAND

FIGURE A-5
FLOW DIAGRAM
MALAY, AKLAN

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GROUNDWATER DEVELOPMENT STUDY IN PANAY ISLAND

FIGURE A-6
DISTRIBUTION PIPELINE
MALAY, AKLAN

Looped distribution main in poblacion area:
- ø 100 mm pipe, 200 m
- ø 150 mm pipe, 750 m

## 3.3 Rough Cost Estimate of Major Water Supply Facilities

### 3.3.1 Unit Construction Cost

Unit construction cost of required facilities is based on the "In-Place Cost of Waterworks Materials" (as of January 1989) of LWUA. Any unit cost not shown in this list is referred to "Unit Price Manual - Water Supply Feasibility Studies" (July 1983) upon consideration of price escalation that 15% per annum upto 1987 and 7% per annum from 1987 as adopted by LWUA.

All construction costs are estimated in Philippine Pesos and the total cost is only converted into U.S. Dollars and Japanese Yen based on the following exchange rate as of September 1989.

U.S. $1.00 = Yen 145.70 = Peso 20.78

Unit costs used in rough cost estimate are attached in Appendix-5.

### 3.3.2 Rough Cost Estimate

| Facility | Cost (Thousand Peso) |
|---|---|
| Water Source | |
| Upper spring intake box (6.5 cu.m ) | 11.0 |
| Lower spring intake box (5.2 cu.m x 3 units) | 26.4 |
| Transmission Line | |
| Rehabilitation for 20% of total length (800 m x 0.2 = 160 m, ø 100 mm) | 80.0 |
| New installation (60 m x 3 lines, ø 100 mm) | 90.0 |
| (700 m, ø 100 mm) | 350.0 |
| Distribution Facility | |
| New reservoir-1 (18 cu.m) | 52.1 |
| New reservoir-2 (30 cu.m) | 82.7 |
| Chlorination tank (7.5 cu.m) | 14.5 |
| Distribution line | |
| (ø 150 mm pipe 1,200 m) | 648.0 |
| (ø 100 mm pipe 1,500 m) | 405.0 |
| (ø 100 mm pipe 200 m) | 54.0 |
| (ø 150 mm pipe 750 m) | 405.0 |
| (ø 100 mm valve 2 pcs.) | 9.0 |
| (ø 150 mm valve 3 pcs.) | 17.1 |
| Total | 2,244.8 |

Total construction cost for improvement of major water supply facilities is estimated at approximately 2.24 million Pesos (15.7 million Yen or 0.11 million U.S. Dollar).