PN-ABU-455

INTERIM REPORT

to

Local Water Utilities Administration
Republic of the Philippines

on

WATER SUPPLY FEASIBILITY STUDY

METROPOLITAN CEBU WATER DISTRICT

JUNE, 1975

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Camp Dresser & McKee International Inc.
DCCD Engineering Corporation

CAMP DRESSER & McKEE INTERNATIONAL INC.

CONSULTING ENVIRONMENTAL ENGINEERS

ONE CENTER PLAZA BOSTON, MA 02108 TEL. 617 742-5151 CABLE: CAMDRES

Local Address:
PHILCOMCEN BLDG., SEVENTH FLOOR
ORTIGAS AVENUE
PASIG, RIZAL
REPUBLIC OF THE PHILIPPINES
TEL. 70-11-76
70-11-77

Please Reply To:
CAMP DRESSER & McKEE INTERNATIONAL INC.
P.O. BOX 1251, MCC MAKATI, RIZAL
REPUBLIC OF THE PHILIPPINES

26 August 1975

Mr. Carlos C. Leaño, Jr.
General Manager
Local Water Utilities Administration
5th Flr., Philcomcen Building
Ortigas Ave., Pasig, Rizal

LOCAL WATER UTILITIES ADMINISTRATION
DATE 8-26-75 9:05 am

Subject: Interim Report - Metropolitan Cebu Water District/ Water Supply Feasibility Study

Dear Mr. Leaño:

We are pleased to submit the subject Interim Report in accordance with decisions made in a meeting with you on 25 March 1975. As agreed upon, the Interim Report will provide for early review of LWUA, the Water District and interested lending agencies of the findings and early action guidelines to upgrade the water supply and service to the District consumers.

The report covers the following:

1. Description of the existing facilities.
2. Known deficiencies of the water supply system.
3. Identification of alternative sources of water; transmission routes; treatment possibilities and water distribution schemes.
4. Evaluation of the alternative plans; screening and selection of a tentative plan.

Because of its early submission, the Interim Report does not include the economic and financial feasibility studies. These additional studies will be submitted in October 1975 in the draft final report. It is possible that the selected tentative scheme as identified herein may have to be modified in the final version to fit the consumers' "ability to pay" and the outcome of the financial studies. Also this Interim Report has not been reviewed nor approved by the CDM-Boston Design Review Committee because of the time constraints associated with this early submission. Their review will parallel yours.

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During the course of the study, the project team was engaged in the following activities:

1. review and collation of available data;
2. field work to fill in data gaps and develop design parameters;
3. establish design criteria and address the issue of "ability to pay";
4. analyze all available data to develop an economically defensible long range water supply plan to the year 2000.

The Interim Report shows that the long-term water supply of Metropolitan Cebu will come from impoundments on the Balamban River and the Mananga River. Raw water will be transported from the impoundments to new water treatment plants and to an upgraded distribution network.

Capital costs for the early action works, interim improvements and the initial phase of the first stage of the long-term program total to roughly ₱712.8 million, of which $23.9 million will be in foreign exchange.

We wish to express our sincere appreciation for the excellent team work and cooperation given us by your office, the Water District, DCCD/EDP and other governmental agencies.

We are confident that you will have questions concerning some of the findings. Please feel free to raise them so that we could discuss these at your earliest convenience.

Very truly yours,

Leonardo V. Gutierrez, Jr.
LEONARDO V. GUTIERREZ, JR.
Project Manager

cc: MCWD (3)
ADB- Manila (6)
AID- Manila (4)
CDM- Boston (3)

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LIST OF ABBREVIATIONS

Agencies

BCWD	Butuan City Water District
CDM	Camp Dresser and McKee International Inc.
CNWD	Camarines Norte Water District
DCCD	Design Consultation Construction and Development Engineering Corporation
EDF	Economic Development Foundation
LWUA	Local Water Utilities Administration
MCWD	Metropolitan Cebu Water District
MOWD	Misamis Occidental Water District
MWSS	Metropolitan Waterworks and Sewerage System (formerly National Waterworks and Sewerage Authority or NWASA)
NEDA	National Economic Development Authority
NIA	National Irrigation Administration
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration (formerly Weather Bureau)
ZCWD	Zamboanga City Water District

Units

BOD	Biochemical Oxygen Demand
°C	degrees centigrade
cm	centimeter
cum	cubic meter
cumd	cubic meter per day
cumd/m	cubic meter per day per meter
cum/day/ha	cubic meter per day per hectare
cum/sqkm/yr	cubic meter per square kilometer per year
ha	hectare
HGL	hydraulic grade line
kg	kilogram
km	kilometer
lpcd	liter per capita per day
lpd	liter per day
lps	liter per second
lps/m	liter per second per meter
m	meter
mg/l	milligram per liter
mm	millimeter
mm/yr	millimeter per year
%	per cent
pH	logarithm (base 10) of the reciprocal of the hydrogen ion concentration in water, moles per liter
ppm	parts per million
sqkm	square kilometer

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TABLE OF CONTENTS

Chapter	I	SUMMARY	I- 1
Chapter	II	INTRODUCTION	
		A. Purpose	II- 1
		B. Metropolitan Cebu Water District	II- 1
		C. Local Water Utilities Administration	II- 1
		D. Historical Background Metropolitan Cebu Water District	II- 4
Chapter	III	DESCRIPTION OF THE PROJECT AREA	
		A. Physical Description	III- 1
		B. Population	III- 3
		C. Living Conditions	III- 5
		D. Present Economy	III- 5
Chapter	IV	EXISTING WATER SUPPLY FACILITIES	
		A. General	IV- 1
		B. Existing Waterworks Facilities	IV- 1
		C. Water Quality	IV-10
Chapter	V	FEASIBILITY STUDY CRITERIA	
		A. General	V- 1
		B. Planning Criteria	V- 1
		C. Design Criteria	V- 2
		D. Economic Criteria	V- 3
		E. Basis of Cost Estimates	V- 6
		F. Construction Methods and Materials	V- 6
		G. Implementation Schedule	V- 7
Chapter	VI	POPULATION AND WATER DEMAND PROJECTIONS	
		A. Introduction	VI- 1
		B. Population Projections	VI- 1
		C. Demand Projections	VI- 7
Chapter	VII	WATER RESOURCES	
		A. General	VII- 1
		B. Groundwater	VII- 1
		C. Surface Water	VII-12
		D. Water Quality	VII-17
Chapter	VIII	ALTERNATIVE STUDIES	
		A. General	VIII- 1
		B. Alternative Water Supply Schemes	VIII- 2
		C. Water Treatment Alternatives	VIII-22
		D. Distribution Alternatives	VIII-25
		E. Other Alternatives on Water Conservation and Augmentation	VIII-40
Chapter	IX	DESCRIPTION AND COST OF THE (TENTATIVE) SELECTED PLAN	
		A. General	IX- 1
		B. Early Action Guidelines	IX- 1
		C. Interim Improvements	IX- 5
		D. First Stage of Long Term (Tentative) Program	IX- 9
		E. Second Stage of Long Term (Tentative) Program	IX-22
		F. Capital Cost Summary	IX-30
		G. Annual Operational and Maintenance Costs	IX-30
		H. Sewerage/Drainage Concepts	IX-32
		Appendix to Chapter VII	

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CHAPTER I SUMMARY

Findings

The Metropolitan Cebu Water District which covers the Cities of Cebu, Mandaue, Lapu-Lapu and the Municipalities of Compostela, Liloan and Consolacion was established on May 9, 1974 by virtue of Resolution No. 873 of the Cebu City Council. Upon the establishment of the MCWD, the Osmeña Waterworks System which was inaugurated in 1912 was dissolved and its ownership and management were transferred to the MCWD.

The project area is located between 5 m and 90 m above mean sea level. About 12,570 ha, the project area consists of two parts: the present service area (2,370 ha) of the MCWD and the projected additional service area through the year 2000. The present service area comprises portions of Cebu, Mandaue, Lapu-Lapu and Compostela, all with existing public water systems.

Based on the 1970 population census, there were 446,400 residents in the project area. During the period 1960-70, the project area population increased at an average growth rate of 4.1 per cent the average density was 36 persons/ha. The urban sector mostly living in Cebu, Mandaue and Lapu-Lapu comprised 92 per cent of the population in contrast to the rural sector of only 8 per cent.

Central geographical location and varied natural resources are important factors in the economic development of the project area. In recent years, industry has overtaken agriculture as the leading economic activity with its greatest concentration in the cities and Liloan. However, agriculture continues to be the main industry in Compostela and Consolacion.

The Port of Cebu, the Mactan International Airport and the Opon-Mandaue Bridge have contributed greatly to the recent development of commerce and trade in Metropolitan Cebu. The port, the second largest in the country, serves as the key link of foreign trade in the Visayas and Mindanao region.

Cebu is a priority area in the Philippine tourism program. Its development is concentrated in the project area since the best tourist spots in the province are located therein.

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5

Like in most cities in the Philippines, the water supply system for Metropolitan Cebu is inadequate, unsafe and poorly managed. The basic water system is more than 65 years. The present level of service of the MCWD is seriously deficient. Water pressure in the poblacions of Cebu City, Mandaue and Lapu-Lapu is inadequate at most times. Night time demands are severely restricted because of the need to ration flow during this period.

Cebu and Mandaue share one public water system originally built in 1911. It underwent three major stages of source development: the Buhisan River in 1911, the Hagubiao Spring in 1934, and the 26 deep wells in 1958 and 1964. Twelve additional wells are under construction at present. The public water supply system of Compostela was developed in 1939. Lapu-Lapu's water supply system was established in 1962. Liloan began the construction of its water system in 1973, which will be turned over to the MCWD upon its completion.

The main water supply facilities of the MCWD are as follows: the Buhisan Dam, a concrete arch structure that can impound water up to 230,000 cum; the Hagubiao Spring, a reinforced concrete chamber utilizing a 4-unit pump station; the 26 deep wells which vary in diameter from 125 mm to 250 mm with depths ranging from 20 to 105 m; the Tisa Treatment Plant, which treats impounded surface water from the Buhisan Dam (partial source of MCWD). Lapu-Lapu derives its water supply from 2 wells. Compostela's source is a spring from which water is collected in a 300 cum storage tank before it flows into the system. Liloan also has a spring as its principal source.

The MCWD service area suffers from inadequate water and poor quality of the surface water supply. With treatment facilities available only part of the year, water in the project area is therefore partially treated. In the Cebu-Mandaue water system, 80 per cent of the Buhisan Reservoir's original capacity is filled up with silt, thus only 20 per cent is serviceable. The pumping units

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at the Hagubiao Spring are antiquated and are in constant disrepair. The small spring which is the only source of supply for Compostela is reportedly drying out. The Tisa Treatment Plant is only operative from 4 to 8 months every year due to lack of raw water supply. It is poorly designed and its operation needs improvement.

Analysis of water from the Buhisan Reservoir indicated high color, taste and hardness while other parameters were within acceptable limits of the Philippine Drinking Water Standards. The Hagubiao Spring is considered of good quality except for marginal excess in hardness. Of the 6 wells in the Cebu-Mandaue system checked for chlorides, 4 showed excess amounts. Water from Lapu-Lapu well has excessive hardness, calcium and chlorides.

Potential water sources in the Cebu area (which include the Balamban, Kotkot and Mananga Rivers) have been sampled. Results of the analyses from Balamban River indicated excess color, turbidity, total solids, calcium, magnesium, sulfates, manganese and as much as 25 mg/l of iron. One sample taken from the Kotkot River indicated marginal excess in turbidity and hardness and 1 mg/l of iron. Samples taken from Mananga River showed marginal excess in turbidity, hardness, and 2.1 mg/l and .85 mg/l of iron.

Within the present and future service area, the population is projected to increase from 446,000 in 1970 to 1.1 million in the year 2000, with Cebu City accounting for about two-thirds of the total. The growth rate between 1970 and 1980 is projected to average about 3.6 per cent per annum while the growth rate between 1980 and 1990 is projected to be about 3.1 per cent. Of the total project area population, the served population is projected to be about 55 per cent in 1980, 70 per cent in 1990 and 85 per cent in the year 2000. Thus, the served population will increase from 191,000 in 1970 to about 605,000 in 1990 and 960,000 in the year 2000, a 5-fold increase in 30 years.

Projections show that the per capita average daily water demand including allowance for unaccountable water will increase from 152 lpcd in 1975 to 267 lpcd in the year 2000. The combined domestic and non-domestic portion of the water demand will also increase from 76 lpcd in 1975 to 201 lpcd inthe year 2000. Average daily water demand is projected to increase from 40,500 cumd in 1975 to 155,700 cumd in 1990 and to 256,300 cumd in the year 2000, at which time, over 60 per cent represents domestic demand.

Hydrologic (surface water) and hydrogeologic (groundwater) information is scarce and inadequate to make accurate assessment of the future potential water resources in the study area. However, broad estimates have been based on judgment and available data.

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The tentative recommended water supply program may be implemented in 7 steps: (1) early actions which should be started and implemented as soon as possible; (2) interim improvements to minimize the worsening water shortages until the year 1982; (3) Phase A of the first stage of construction (1978-82); (4) Phase B of the first stage of construction (1982-87); (5) Phase C of the first stage of construction (1986-89); (6) Phase A of the second stage of construction (1989-94), and (7) Phase B of the second stage of construction (1995-99).

Groundwater potential in the MCWD area is estimated to produce about 13 per cent of the max-day water supply requirements by the year 2000. Consequently, the long term water supply for Metropolitan Cebu will come from the development of the Balamban and Mananga Rivers as supply sources. Two dams will be constructed: initially, an 82 m high dam on the Balamban River and in 1989, a 72 m high dam on the Mananga River. Raw water transmission lines, two new treatment plants and an expanded distribution network have to be provided to allow better and effective service for the present and future public water supply users.

By the time the new surface water sources are available, some wells will have to be phased out of operation to permit groundwater recharge to areas of overpumping and to flush the salinized aquifer out with fresh water. Salinization due to overpumping is the major groundwater problem in the project area.

Project costs for the early action works, interim improvements and Phase A of the first stage of construction program are as follows:

Early Action Works		₱ 5,400,000
Interim Improvements		10,820,000
Stage I, Phase A		696,530,000
Lusaran Dam and Appurtenances	₱167,800,000	
Raw Water System	94,756,000	
Water Treatment Plant	51,500,000	
Transmission Facilities	88,812,000	
Distribution Works	39,688,000	
Engineering & Contingencies (25%)	110,639,000	
Administrative and Legal Fees (3%)	16,595,000	
Interest during Construction	126,740,000	
Total Project Cost		₱712,750,000

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8

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Foreign exchange component of the foregoing project costs is estimated to be about ₱23.9 million.

Annual operation and maintenance costs are estimated to increase from ₱6.9 million in 1982 to ₱13 million in 2000.

Early Action Guidelines

While the findings and recommendations of the interim (and final) reports are being discussed, and pending their approval by the Water District, LWUA and financial agencies, certain steps may be taken in the meantime to facilitate "early action" in the MCWD water supply system. These early action guidelines are as follows:

1. Continue the publicity and promotional campaign about the water feasibility study so that water district customers are made fully aware of the improvements that are about to happen and prepare them for the corresponding water rate increases.

2. Discuss in detail within the water district ideas relative to raising the implementation funds (local and the foreign exchange component).

3. Strengthen the legal basis for development of new water sources, its implementation and enforcement.

4. Acquire the land surrounding the proposed water sources, treatment plant, distribution storage sites and right of way for the transmission lines, and conduct a detailed topographical survey of such land and right of way. The water district new administration building and shop and laboratory facilities may be located at the proposed treatment plant site.

5. Acquire a complete laboratory testing and sampling equipment; meter repair, testing and shop equipment; assorted tools; and supplementary water district vehicles.

6. Acquire disinfection (chlorination) equipment and operate the same as soon as possible at effective locations of the existing system.

7. Continue water meter installations to have all the water services metered as soon as possible.

8. Initiate a routine hydrologic and meteorological data collection program in the Kotkot, Balamban and Mananga Rivers (in cooperation with the National Water Resources Council) to

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9

develop stream flows, evaporation, rainfall and siltation measurements over a period of at least 10 years; initiate a well water level and discharge gaging and monitoring program at the existing and the proposed well fields identified as a long term source of MCWD.

9. Initiate routine water sampling and analysis at the proposed surface sources, well water sources and distribution system.

10. Conduct a physical inventory and survey of the water system and sewer system facilities and their connections to the private premises. Inventory private wells, septic tanks, private and public drainage systems.

11. Initiate a sewerage/drainage feasibility study as soon as the water supply planning is completed. In conjunction with this, conduct an oceanographic survey of the Bohol Strait and Camotes Sea.

12. With consultation, adopt a flexible, enforceable plumbing code in anticipation of the water supply improvements and near-future sewerage/drainage system.

13. Carry on with leakage and corrosion survey of the water system, identifying actual and potential cross-connections of water supply and pollutional material.

14. Initiate a jar test program at the Tisa Water Treatment Plant to maximize the use of existing facilities and optimize the use of chemicals for coagulation (in the interim period to 1982). Provide a by-pass piping to the filter to save on washwater and to eliminate back-up overflow in the sedimentation basins, during non-rainy periods; unthrottle the valve on raw water line from Buhisan to Tisa.

15. Initiate improvements to the management, engineering and operation and maintenance procedures of the Water District in accordance with the established LWUA guidelines and in anticipation of future requirements that may be imposed by loaning agencies.

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CHAPTER II INTRODUCTION

A. PURPOSE

This interim technical report is being presented (July 1975) prior to the completion of the full technical, economic and financial feasibility study to give the probable configuration and rough costs of the emergency and first phase construction program of the water supply improvements for the Metropolitan Cebu Water District. Also, this report will serve as a basis for early technical evaluation by LWUA or any interested international financing agencies.

This report does not provide the detail required of a feasibility study. The full study (due in draft form in October 1975) will provide the technical, economic and financial details to support the recommended program.

B. METROPOLITAN CEBU WATER DISTRICT

Metropolitan Cebu area is situated along the eastern coast of Cebu Province. The study area includes the cities of Cebu, Mandaue and Lapu-Lapu, and the municipalities of Consolacion, Liloan and Compostela. (See Figure II-1.)

C. LOCAL WATER UTILITIES ADMINISTRATION

The Local Water Utilities Administration (LWUA) was established by Presidential Decree No. 198 issued on May 25, 1973. The decree sought to establish, operate, maintain and develop reliable, adequate and economically viable municipal water supply and wastewater disposal systems. As differentiated from the Metropolitan Waterworks and Sewerage System which operates within Metropolitan Manila, LWUA covers provincial urban population centers in the entire country. LWUA was formally organized on September 18, 1973.

In order to attain its objectives, LWUA has been actively encouraging the formation of independent, locally controlled public water districts in provincial urban areas. This is a step designed to ensure safe and sufficient potable water supply by the district and its operation on a business-like basis.

Primarily, LWUA renders assistance to local water districts in financial, training and technical matters. It also establishes standards for water quality and service, operations, management and administration including accounting practices. In

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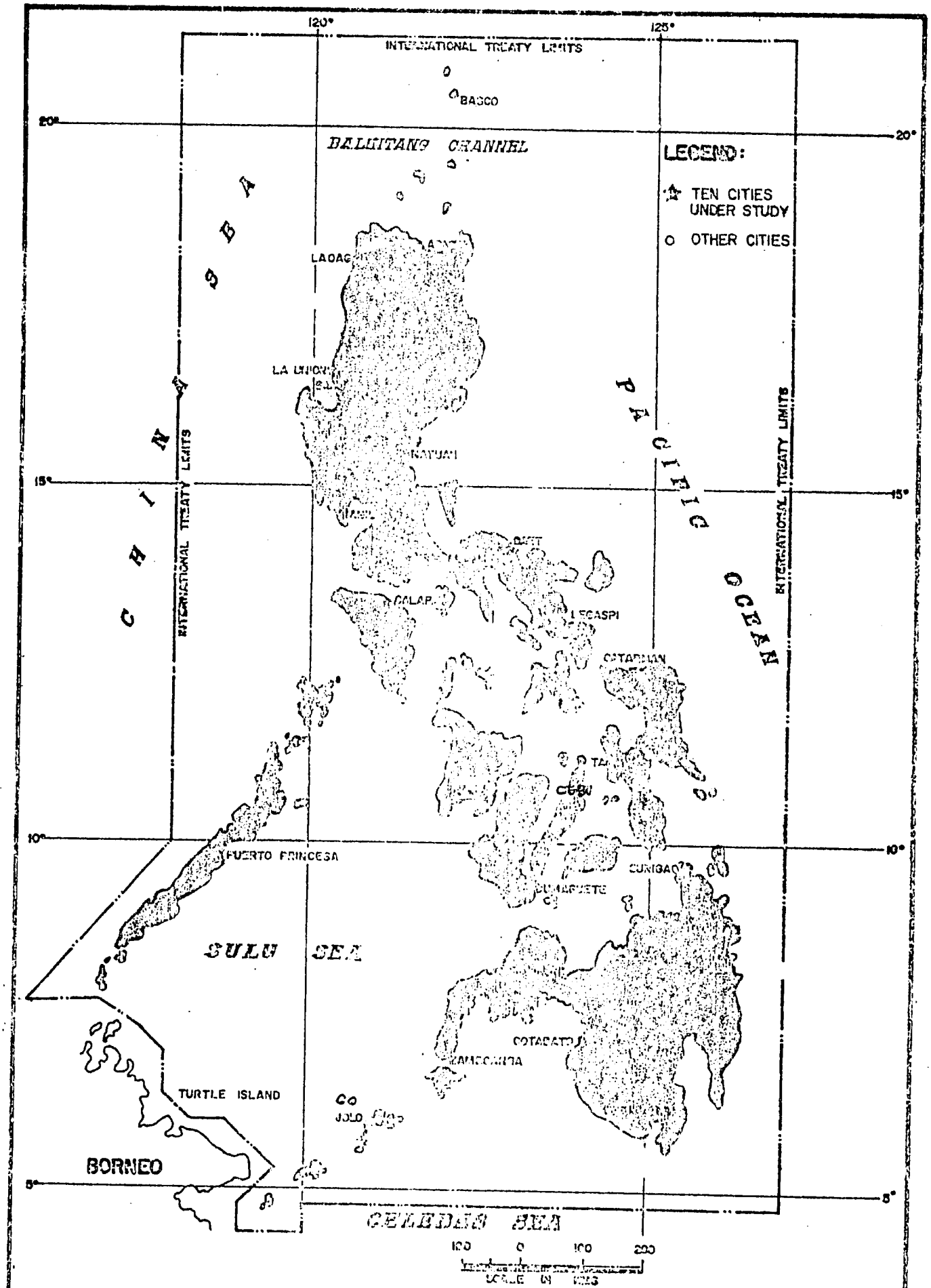

FEASIBILITY STUDY FOR WATER SUPPLY OF TEN PROVINCIAL AREAS CDM-LWUA

FIGURE II-1
LOCATION MAP

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addition, it prescribes activities necessary to ensure conformance with such standards.

In recognition of the vital role water supply performs in contributing to the well-being of the people, LWUA has been placed under the National Economic Development Authority, the highest economic planning body of the country.

Organisational Set-Up

LWUA is directed by a five-man Board of Trustees through a General Manager. The Board formulates policies on all the business affairs of LWUA and the General Manager is responsible for the implementation of such policies.

In order to carry out its functions, LWUA maintains 5 operating divisions, each headed by a director.

The Loans and Programs Division administers LWUA's revolving fund and relending program. It develops loan application criteria and covenants and processes loan applications of duly constituted local water districts. It also negotiates domestic and international loans.

The Technical Services Division provides technical assistance to water districts and at the same time develops design, construction and operational standards.

The Regulatory Division monitors the performance and operations of water districts. It also processes and administers the Administration's certification program for water districts.

The Management and Training Division conducts seminars among the board of directors of water districts, their general managers and other key personnel and technicians. Such seminars are aimed at strengthening the institutional structure of water districts.

Finally, the Administrative Division provides the necessary staff support to LWUA in terms of personnel recruitment, records management, general services and related functions.

Only duly organised water districts which have been issued a Conditional Certificate of Conformance can avail themselves of financial assistance from LWUA.

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Accomplishments

As of December 1974, LWUA had issued a Conditional Certificate of Conformance (CCC) to 11 water districts out of 16 which have been filed. A CCC is issued to a water district once it has taken significant steps towards the improvement of domestic water supply to the public, according to certain criteria prescribed by LWUA.

By the end of 1974 or after one year and three months of operation, LWUA had a staff complement of 53. By the end of 1975, this is expected to increase by about 80 to enable the Administration to cope adequately with its expanding operations.

In addition, 9 other water districts have been organized but their resolutions have not been filed yet with LWUA. Another 5 cities and municipalities are in the process of organizing their water districts and 7 more have signified their intention to organize.

To carry on its provincial waterworks development program, LWUA has planned the following projects for early implementation:

1. The design and construction of improved waterworks systems in Bacolod City, San Pablo City, Cagayan de Oro City, Davao City and Tacloban City;

2. The feasibility study, design and construction of waterworks systems in Marawi City and Batangas City;

3. The water resources evaluation study for Baguio City; and

4. The water supply feasibility study of 10 provincial areas, including this report.

As part of its training program, LWUA has conducted 7 seminars in 4 different parts of the country among the key personnel of water districts. It has also developed the concept for a long-range planning survey and interim demonstration program. Such a plan is aimed at setting up a data bank for water needs and subsequently, undertake immediate high impact improvements on the waterworks systems of several hundred cities/municipalities.

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D. HISTORICAL BACKGROUND: METROPOLITAN CEBU WATER DISTRICT

Until 1974, the water systems of the cities of Cebu, Mandaue and Lapu-Lapu and the municipality of Compostela were owned and managed by their local governments. The oldest and most developed of these systems was the Osmeña Waterworks System which serviced both Cebu and Mandaue. This system was inaugurated in 1912 by the United States Government during its occupation in the Philippines (1898-1941) and was initially managed by the municipal government of Cebu then under its head, the municipal president.

When Cebu became a chartered city in 1937, a new waterworks superintendent from the City Engineer's Office managed the Osmeña Waterworks System. In 1959, the Cebu City Mayor appointed a manager who, until 1974, took charge of the administration and operation of the system.

On May 9, 1974, the Osmeña Waterworks System was dissolved. Its ownership and management were transferred to the Metropolitan Cebu Water District (MCWD) formed by virtue of Resolution No. 873 of the Cebu City Council. This resolution, however, was amended by Resolution No. 1378 on July 18, 1974, to include provisions on the funding of the District. The MCWD integrates as well, the existing water systems of Mandaue, Lapu-Lapu, Compostela and includes the municipalities of Liloan whose water system is currently under construction and Consolacion which has no public water system. In separate resolutions, their local governments endorsed and concurred with the formation of the water district.

As constituted under Presidential Decree No. 198 (Provincial Water Utilities Act of 1973) which governs its operations, the MCWD is a government corporation but politically independent from the local governments. The decree stipulates that financial and technical assistance shall be granted to water districts through the Local Water Utilities Administration in order to provide adequate water systems. Thus, the MCWD was established for the purposes of acquiring, installing, improving, maintaining and operating the water supply and distribution systems as well as the wastewater collection, treatment and disposal facilities. The decree also provides that the water district shall operate on a financially self-sufficient basis.

The water district is headed by a five-member board of directors appointed by the Cebu City Mayor. The district can only be dissolved through the act of this board.

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CHAPTER III DESCRIPTION OF THE PROJECT AREA

A. PHYSICAL DESCRIPTION

Location and Size

The project area also known as Metropolitan Cebu occupies the central portion of the province of Cebu. It covers 12,570 hectares or 2.5 per cent of the province's area. The project area includes Cebu City (central portion), the north-central cities of Lapu-Lapu and Mandaue, and the northern municipalities of Compostela, Consolacion and Liloan. Except Lapu-Lapu which is located in Mactan Island, the rest of the project area lie adjacently to one another. The project area consists of 2 parts: the present service area (2,370 hectares) of the Metropolitan Cebu Water District (MCWD) or 24 per cent of the total project area and the projected additional service area through the year 2000. The present service area comprises portions of Cebu, Mandaue, Lapu-Lapu and Compostela, all with existing public water systems; Consolacion and Liloan do not have piped water at present. (See Figure III-1.)

Topography

The landscape of Cebu Province is rugged and mountainous, with a few peaks reaching from 1,000 to 3,000 feet. The project area, however, is located in the small coastal plains jutting out east of the province's Central Highlands. Lapu-Lapu, Liloan, Compostela and Consolacion lie on flat coastal lands about 10 meters above sea level; Cebu and Mandaue are situated at gradually sloping elevations that range from 6 to 30 meters.

The rivers which drain the project area are the Buhisan, Mananga, Balamban, Mandaue and Kotkot. Buhisan River, one of the present supply sources of Cebu City, drains an area of 509 hectares and empties eastward into the Bohol Strait. The Mananga River, flowing through a distance of about 24.5 kilometers, drains southwest and then southeast into the Bohol Strait. The Balamban River with headwaters at Barrio Lusaran flows northeast, then northwest and finally westward into the Balamban Bay. Mandaue River has its source northeast of Mandaue City and drains southeast into Cansaga Bay. Northeast of the study area is the Kotkot River draining towards Compostela.

Geology

The study area is made of 3 geologic formations of the eleven found in the province. These formations, of sedimentary and metamorphic structure, are recent alluvium, Carcar formation and base-

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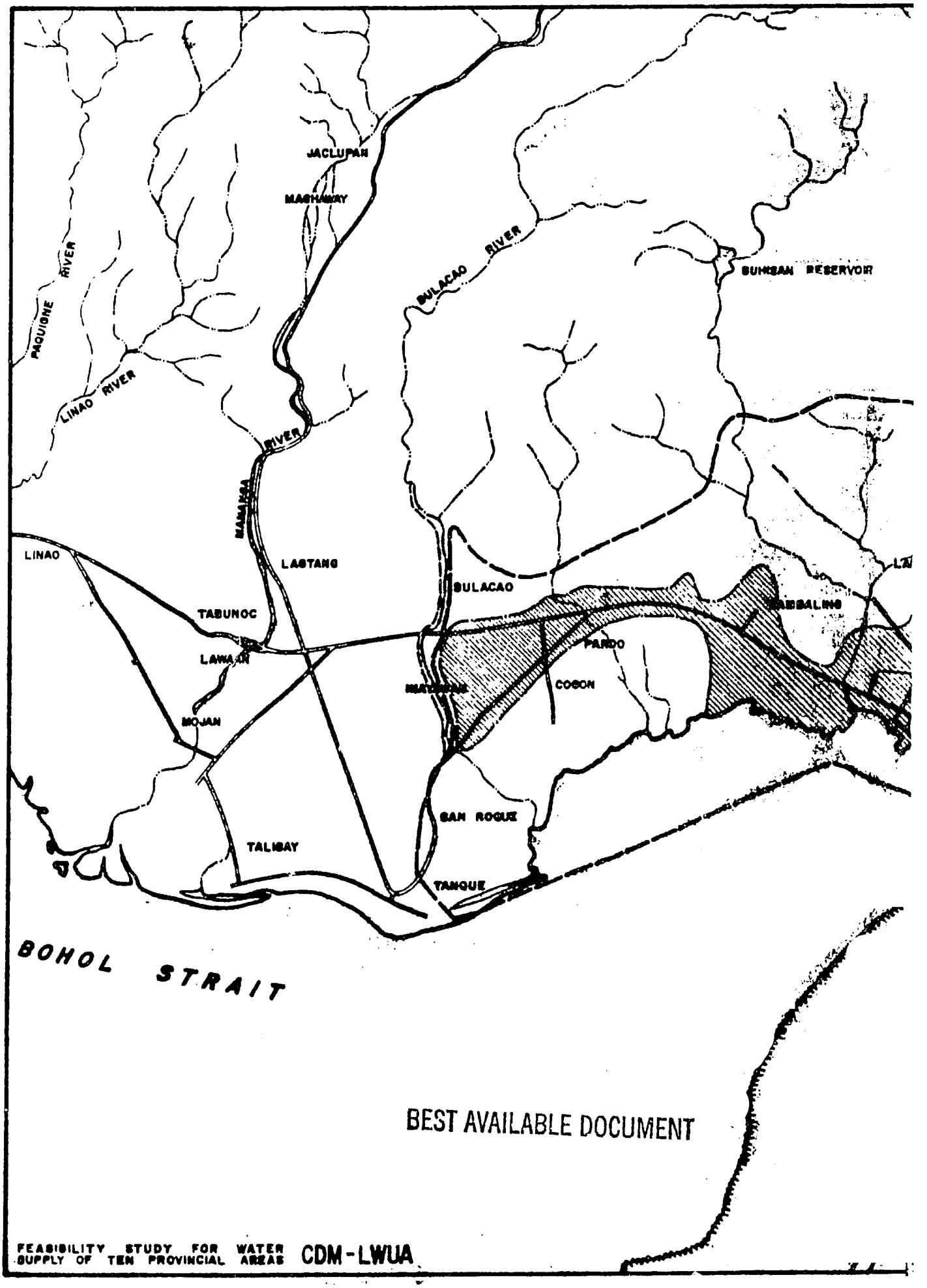

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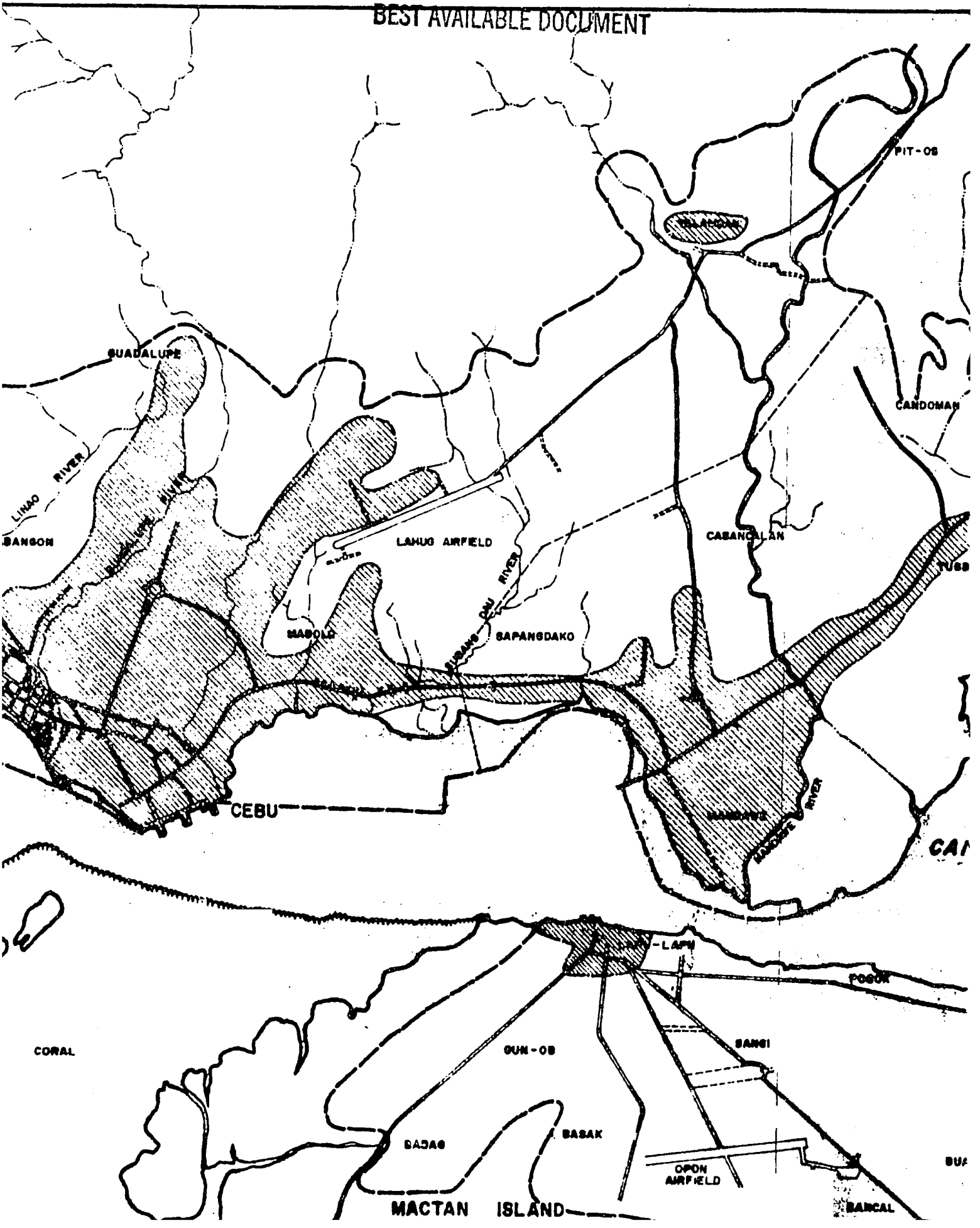

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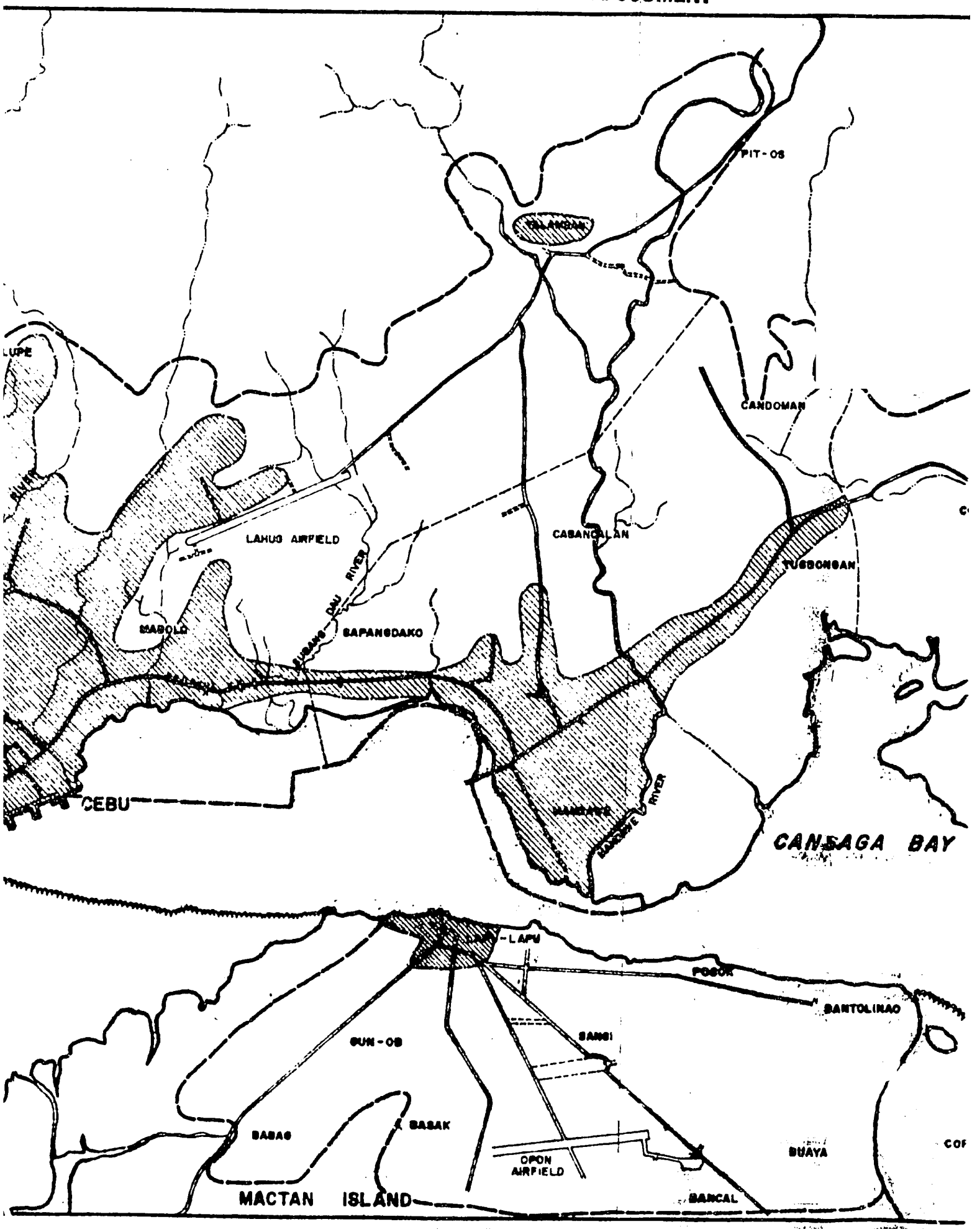

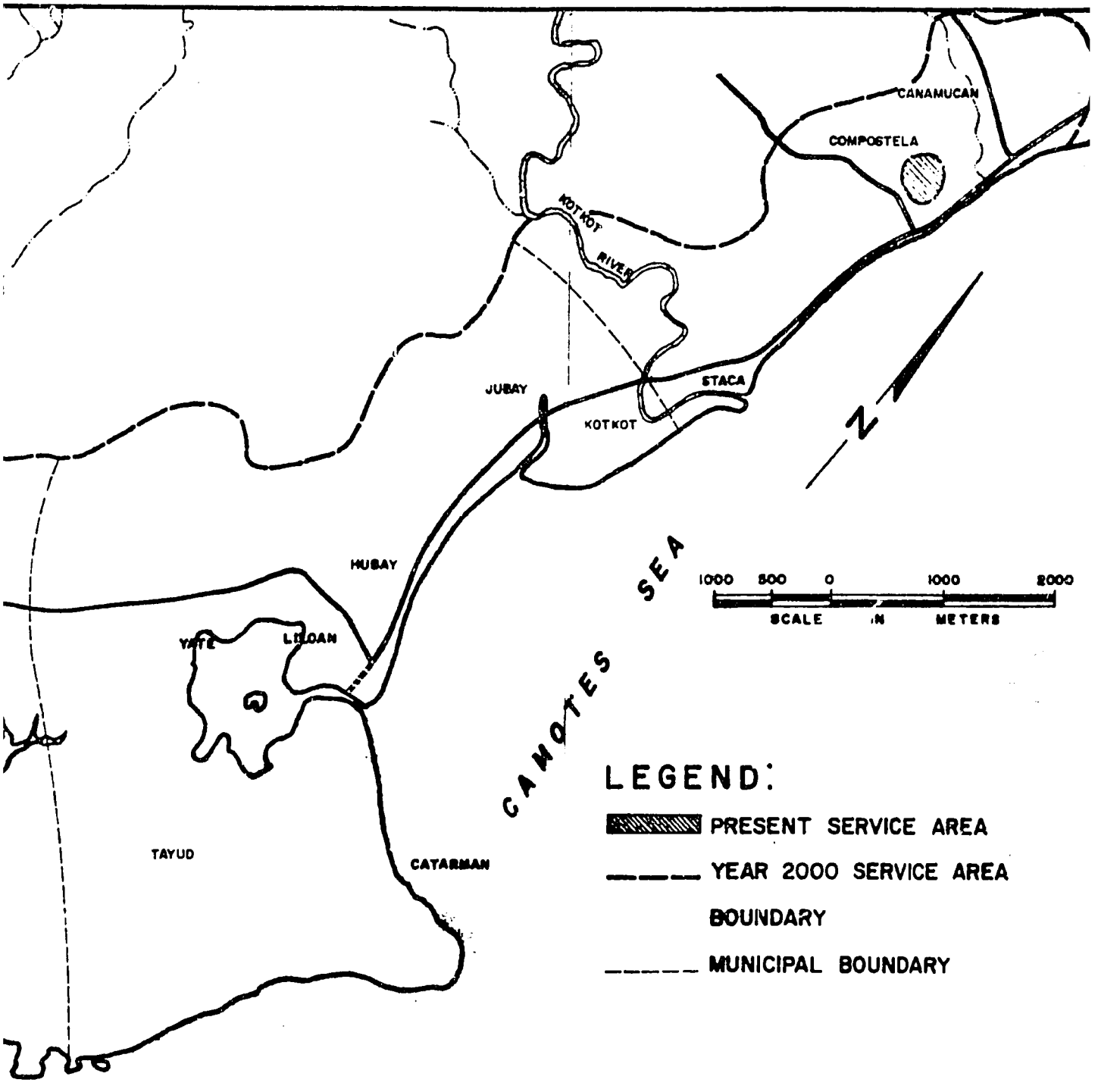

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FIGURE III-1
PROJECT AREA MAP

ment complex.

Recent alluvium is the predominant geologic formation in the project area. It includes rubble, clay, silt and gravel deposited by present streams in the eastern coastal plains and river flood plains. Carcar formation is a limestone group that dates from Pliocene to Pleistocene age and is deposited as a mixture of rubble, gravel and marl. Of unknown age, basement complex is made chiefly of diorite and quartz found in the Central Highlands.

Soil and Vegetation

Several soil types are represented in the project area. Cebu Province especially supports clay loam, a fertile, organic soil said to be more productive to corn than to rice. This explains why corn and not rice (the national staple) is the main crop in the project area as well as in the province.

Mandaue clay loam in the moderately-drained plains of Cebu, Mandaue and Compostela, is considered the best agricultural soil in the province. The soil surface is free from salt concentration and outcrop, allowing deep plowing and cultivation. The Medellin clay of the uplands is formed from limestone and shale. This black and heavy soil is very sticky when wet and hard when dry but can be improved for planting when properly fertilized. Sugar grows well in this soil type. Hydrosol in the wet lands along the eastern coast of the project area is commonly used as mangrove fields, fishponds and salt-making beds because of the soil's poor agricultural value.

Most of Cebu Island, including the project area, has lost a significant portion of its top soil and in its place is either subsoil or weathered rock.

Climate

The Philippines has 4 distinct climatic types based on rainfall. The project area is classified under the third climatic type, one of 2 types prevalent in the Cebu Province. The project area has no well-defined dry and wet seasons; it is relatively dry from November to April and wet during the rest of the year. (See Figure III-2.)

The average annual rainfall for the past 20 years is 1,609 mm. Much moisture is lost, resulting in moderate rainfall, when the northeast and southwest monsoons cross the mountains within and outside the province. The Weather Bureau (PAGASA) records show an average monthly temperature of about 27°C for the project area while

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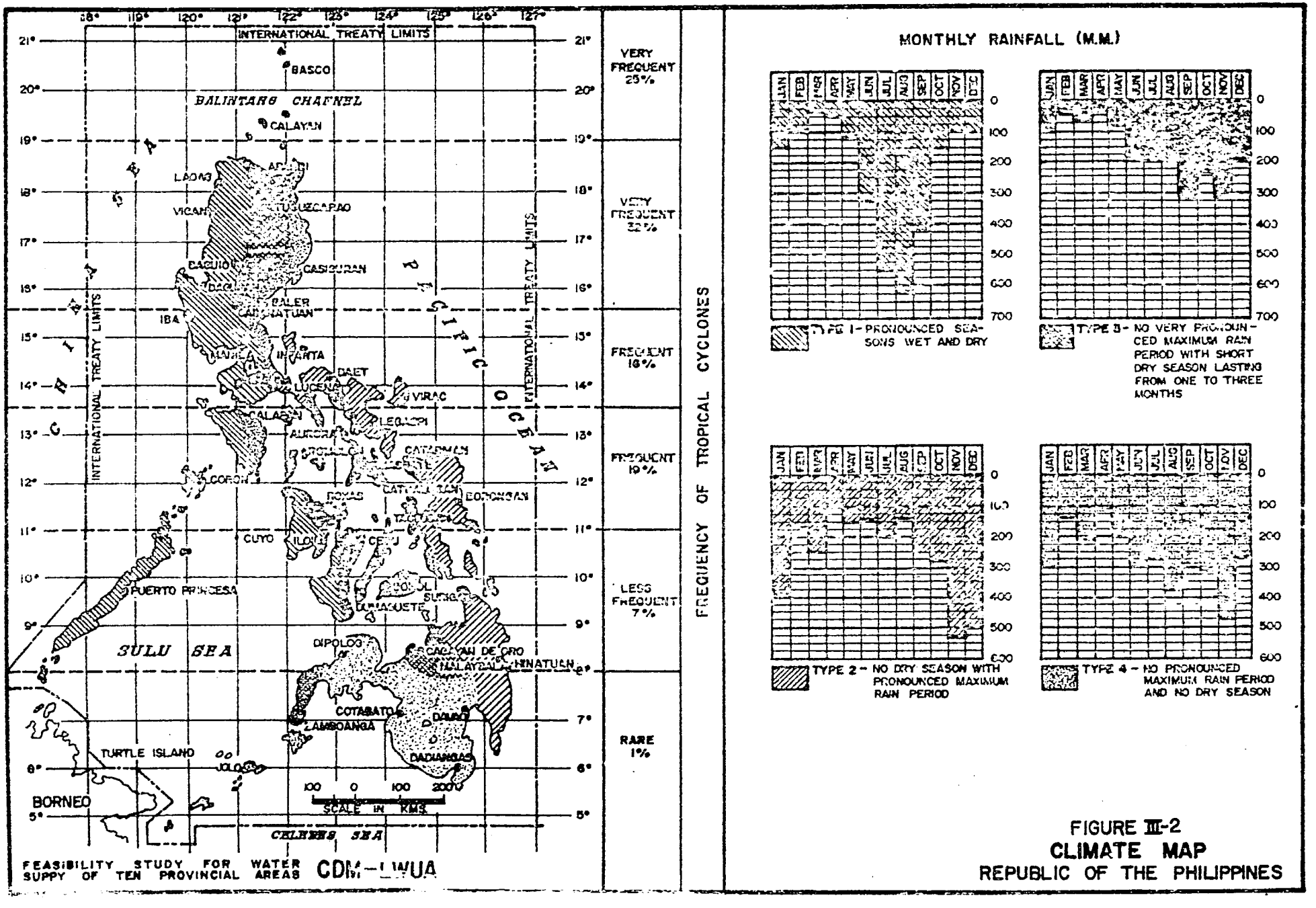

FIGURE III-2
CLIMATE MAP
REPUBLIC OF THE PHILIPPINES

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average relative humidity is about 80 per cent. The project area is considered warmer than other parts of the country.

The wind directions change gradually from southwest to northeast in October and vice versa in June. The wind directions can be altered by local thunderstorms any time, more likely, during the latter half of the year.

B. POPULATION[1]

Metropolitan Cebu area is considered the densest part of Cebu Province. In 1970, there were 445,400 residents in the project area, who represented about 29 per cent of the province's population. During the period 1960-1970, the project area population increased at an average growth rate of 4.1 per cent and the average density was 36 persons per hectare. The urban sector comprised 92 per cent of the project area population in contrast to the rural section of only 8 per cent.

Cebu, Mandaue and Lapu-Lapu are classified as totally urban areas. The most heavily populated areas are Cebu and Mandaue where 84 per cent of the project area population resided in 1970. The population was further distributed as 8 per cent in Lapu-Lapu, 4 per cent in Liloan, 2.5 per cent in Consolacion and 1.5 per cent in Compostela.

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[1] As of 1970, the Philippines (area: 300,000 sqkm) had a population of 36.7 million with a growth rate of 3 per cent, density of 122/sqkm and a median age of 17.4 years. As such, the country ranked seventh and sixteenth in population in Asia and in the world, respectively.

Expectedly, these demographic characteristics are imposing pressures on the country that prevent further economic development. A high population growth rate magnifies problems in the economy, environment/ecology, social services and factors that affect the quality of human life in general.

To counteract these pressures, the Philippines has adopted two approaches to population control: the contraceptive or family planning approach and the integrated approach in which population control becomes part of the national development plan.

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Population Growth Trend

From 1948 to 1960, economic development stimulated migration off the rural areas into the cities. As a result, the populations of Cebu and Mandaue, with the exception of Lapu-Lapu, grew rapidly while the populations of the municipalities increased slowly. The making of Mandaue into an urban center is greatly attributed to its immediate proximity to Cebu City (the country's fourth most populated city in 1970). Lapu-Lapu did not match Cebu's rapid population increases because of its location in the offshore Mactan Island.

In the 1960-1970 decade, larger increases in urban population gave rise to the conversion of Mandaue and Lapu-Lapu into cities and the birth of Metropolitan Cebu. Meanwhile, Cebu's growth rate declined from 3.5 per cent to 3 per cent as migrants and industries were beginning to disperse to the new satellite cities. There were also increases in the growth rates in the municipalities during the same decade.

Population Characteristics

Persons born in the project area represented about 84 per cent of the population in 1970. Those born in other municipalities of Cebu Province totalled about 10 per cent while migrants from other provinces represented 6 per cent.

The project area population with a median age of 16.5 years is young, the rural residents being younger than those in the urban areas. About 44 per cent are classified within the age bracket 0-14 years; 52 per cent comprise the working age group (15-64 years) and 4 per cent belong to the older group (65 years and above).

In 1970, there were 95 males to 100 males in the project area as a whole.

While the average literacy rate in the project area was about 80 per cent in 1970, urban areas had a larger literate group than the rural areas. The high literacy rate of the project area is due to Cebu City's being the educational center in Southern Philippines.

In 1970, the economically active sector of the project area was composed of some 200,000 employed or 42 per cent of its population. The heavy industrial growth of Cebu, Mandaue and Lapu-Lapu has resulted in a manufacturing workforce bigger than that of agriculture. The municipalities have slightly larger proportion of farmers, fishermen and loggers than the manufacturing workforce.

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C. LIVING CONDITIONS

According to the 1970 census, 88 per cent of the total 86,000 dwelling units were of the single-family type and 4 per cent were of the duplex type. The remaining 8 per cent included low-class apartments, barong-barong (makeshift h s), commercial, light industrial and institutional buildings.

In 1970, 44 per cent of more than 80,000 households were served with electricity; over 50 per cent used kerosene for lighting. Wood was the most common cooking fuel and was used by nearly 90 per cent of the households in 1970.

Those provided piped water service by the MCWD included 43 per cent of the total project area population or 57 per cent of the service area population in 1970. Over 60 per cent of the households derived their water supply from groundwater sources while the rest used surface water.

(Technical details of existing water supply follow in Chapter IV.)

The most common toilet type, flush/water-sealed system is used by 32 per cent of the households in 1970. Other toilet facilities included closed pit (29 per cent); open pit (7 per cent); and public toilet (2.5 per cent). The rest of the households did not have toilet facilities.

D. PRESENT ECONOMY

Since the imposition of martial law in the late 1972, the Philippine economic structure has been undergoing various reforms. Concrete results were achieved in 1973 when all economic indicators of the country reached unprecedented levels.

In 1974, however, inflationary and recessionary developments and domestic food shortages disturbed the improving economy. As a result, the gross national product (GNP) declined from 9.9 per cent in 1973 to 5.9 per cent in 1974. However, the country managed to realize a modest balance of payments (BOP) amounting to $80 million despite the price decreases of some main export products, notably copper and wood products. In addition, international reserves stood at a comfortable level of $1.16 billion at the end of the year.

Traditionally, the country has been heavily dependent on agriculture. The national accounts for 1974 showed that agriculture,

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forestry and fishing accounted for 29.2 per cent of the GNP. The services sector followed with a share of 17.2 per cent for the same year. The construction industry posted the highest growth rate, 18.5 per cent.

Project Area

Central geographical location and varied natural resources are important factors in the economic development of the project area. In recent years, industry has overtaken agriculture as the leading economic activity with its greatest concentration in the cities and in the municipality of Liloan. However, agriculture continues to be the main industry in Compostela and Consolacion as well as in the entire province.

Agriculture. In the rural sections of the project area, about 10 crops are harvested and marketed to nearby cities and provinces, and among them are corn, cassava, coconut, sugar, rice and maguey. The most notable of the fruits grown in the project area are mangoes in Cebu City and grapes which are rare in the Philippines but grown in productive vineyards in Cebu and Mandaue.

Fishing in the project area, except in Lapu-Lapu City, is mainly for sustenance. The waters around Lapu-Lapu are reportedly rich in crustaceans. Artificial culture of milkfish (bangus) is limited to the hydrosol areas of Mandaue and Lapu-Lapu.

Industries. The people in the project area are engaged in a wide range of industries. Large industrial activities such as mining and food processing are concentrated in the urban centers and cities. Mandaue, for instance, has for its heaviest taxpayers, 7 beverage and liquor companies. Cebu is the location of one of the biggest oil refineries in the Far East.

Consolacion and Compostela are especially known for blacksmithing; Liloan specializes in potmaking. Cottage industries like guitar-making, garment-making, handicraft and shellcraft are spread throughout the project area.

Land Use. In Cebu City, land use is principally commercial and residential, with about 10 per cent of its area occupied by industrial establishments. Mandaue which follows Cebu in the matter of economic activity has developed about 9 per cent of its area to industrial use. Lapu-Lapu has 30 per cent of its poblacion developed to commercial and industrial activities. In Compostela, only 3 per cent of the poblacion is used for light industrial and commercial activities and the rest includes residential units.

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Public Utilities. In general, the project area has an efficient road system and adequate transportation system. With Cebu City as central point, the road network stretches to the southernmost and northernmost points of the province.

The Port of Cebu, the Mactan International Airport and the Opon[1]-Mandaue Bridge have been significant factors in the recent development of commerce and trade in the project area. The port, the country's second largest, continues to serve as key link of foreign trade in the Visayas and Mindanao Region. One of the longest bridges in the country, the Opon-Mandaue Bridge makes possible cross trips between the Mainland and Mactan Island. The Mactan airport is one of the country's 2 international airports.

Tourism. Cebu province is a priority area under the Philippine tourism program. Its development will be concentrated in the project area as the best tourist spots of the province are found therein.

The project area stands out as a tourist attraction primarily because of its historical significance. The best-known tourist spots in Cebu City are Magellan's[2] Cross symbolizing the coming of Christianity to the Philippines in the sixteenth century, Basilica Minore del Santo Niño housing the country's oldest religious relics, Fort San Pedro and Plaza Independencia. In Lapu-Lapu, another historical tourist attraction is the Lapu-Lapu[3] Monument. Outside of Cebu and Lapu-Lapu are several beach resorts.

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[1] Lapu-Lapu City.

[2] Explorer-Navigator.

[3] Local chieftain who killed Magellan.

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CHAPTER IV EXISTING WATER SUPPLY FACILITIES

A. GENERAL

On the basis of studies made on the first 5 cities of this 10-Provincial Water Supply Feasibility Study, the following have been found to be the common problems to all water supply systems.

Inadequate System

In general, the systems consist of inadequate mains and storage facilities, poorly designed and maintained pump or well systems and insufficient distribution systems. Pressures are very low particularly during the peak hours. Service is non-existent during fire-fighting situations and, in general, there is no continuous 24-hour service.

Unsafe System

Water is generally bacteriologically unsafe. Many opportunities for cross-connections exist. Because of the marginally low pressures back-siphonage can easily occur. Chlorination equipment when available is not generally in use.

Poorly Managed System

Until recently, authorities have tolerated wastage of water. So far, there has been no prior leakage survey conducted in any of the water districts except during the study. Financing is poor; collection is low. There is hardly any enforcement of penalty. In general, there is no master plan, little maintenance and operation, and hardly any operator training. Recordkeeping is almost non-existent.

B. EXISTING WATERWORKS FACILITIES

In the project area, only Cebu, Mandaue, Lapu-Lapu and Compostela have piped water. Consolacion has no public water system; Liloan's public water system is in the process of construction.

Cebu and Mandaue share one public water system originally built in 1911. It underwent three stages of source development: the Buhisan River in 1911, the Hagubiao Spring in 1934, the 26 deep wells in 1958 and in 1964. Twelve additional wells are under construction at present. (See Figure IV-1.) In 1974, the water system was turned over by the Cebu City Government to the Metropolitan Cebu Water District.

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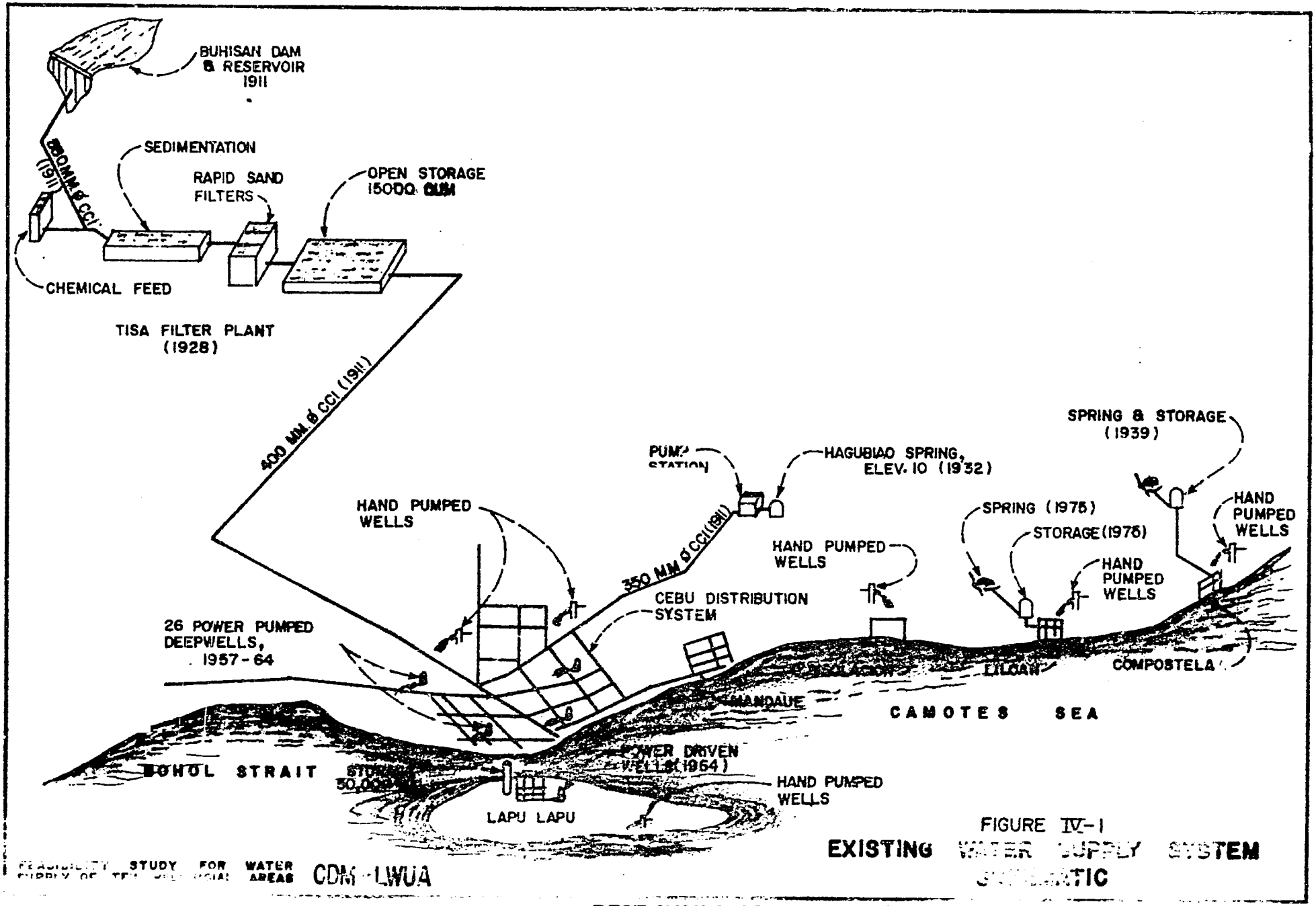

FIGURE IV-1
EXISTING WATER SUPPLY SYSTEM
SCHEMATIC

FEASIBILITY STUDY FOR WATER SUPPLY OF THE URBANIZED AREAS CDM - LWUA

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The public water system of Compostela was developed in 1939; Lapu-Lapu's system was established in 1962. Liloan began the construction of its water system only in 1973, which will be turned over to the MCWD upon its completion.

Water Supply (Source) Facilities

The main source facilities of the Cebu-Mandaue water system are the Buhisan Dam, the collection chamber at Hagubiao Spring and 26 deep wells. The Buhisan Dam is a concrete arch structure that can only impound water up to 0.23 million cum. The raw water main, 350 mm in diameter and 3.5 km long, conveys water from the Buhisan Dam to the Tisa treatment plant. (See Figure IV-2.)

Spring water at Hagubiao is first collected in a reinforced concrete chamber and then pumped into the system through a 4-unit pumping station. (See Figure IV-3.) The 26 deep wells vary in diameter from 125 mm to 200 mm and 250 mm; have depths ranging from 20 m to 105 m; and actual pump discharge rates of 0 to about 30 lps.

Lapu-Lapu derives its water supply from 2 wells which are operated alternately. Compostela's supply source is a spring from which water is collected in a 300 cum storage tank before it flows into the system. Liloan also has a spring as its principal source.

Treatment Facilities

The Tisa Treatment Plant treats impounded surface water from the Buhisan Dam. Treatment processes consist of coagulation, sedimentation and filtration. Flow measurements taken from the raw water main range from 5,700 to 7,000 cumd. The facilities include a chemical feed facility, 2 sedimentation basins, 3-bay rapid sand filter, an open top storage well, 1 wash water tank and backwash pumping system. The chemical feed facility accommodates 4 lime/alum feed tanks and chlorination facilities. (See Figure IV-4.)

Water from the Hagubiao Spring is chlorinated; water from the 26 deep wells is untreated.

Water Transmission Lines

In the Cebu-Mandaue system, the treated water from the Tisa plant is conveyed to the service area through a cast iron transmission main, 400 mm in diameter and 2.3 km long. The treated water from Hagubiao is conducted to the city through a cast iron pipe, 350

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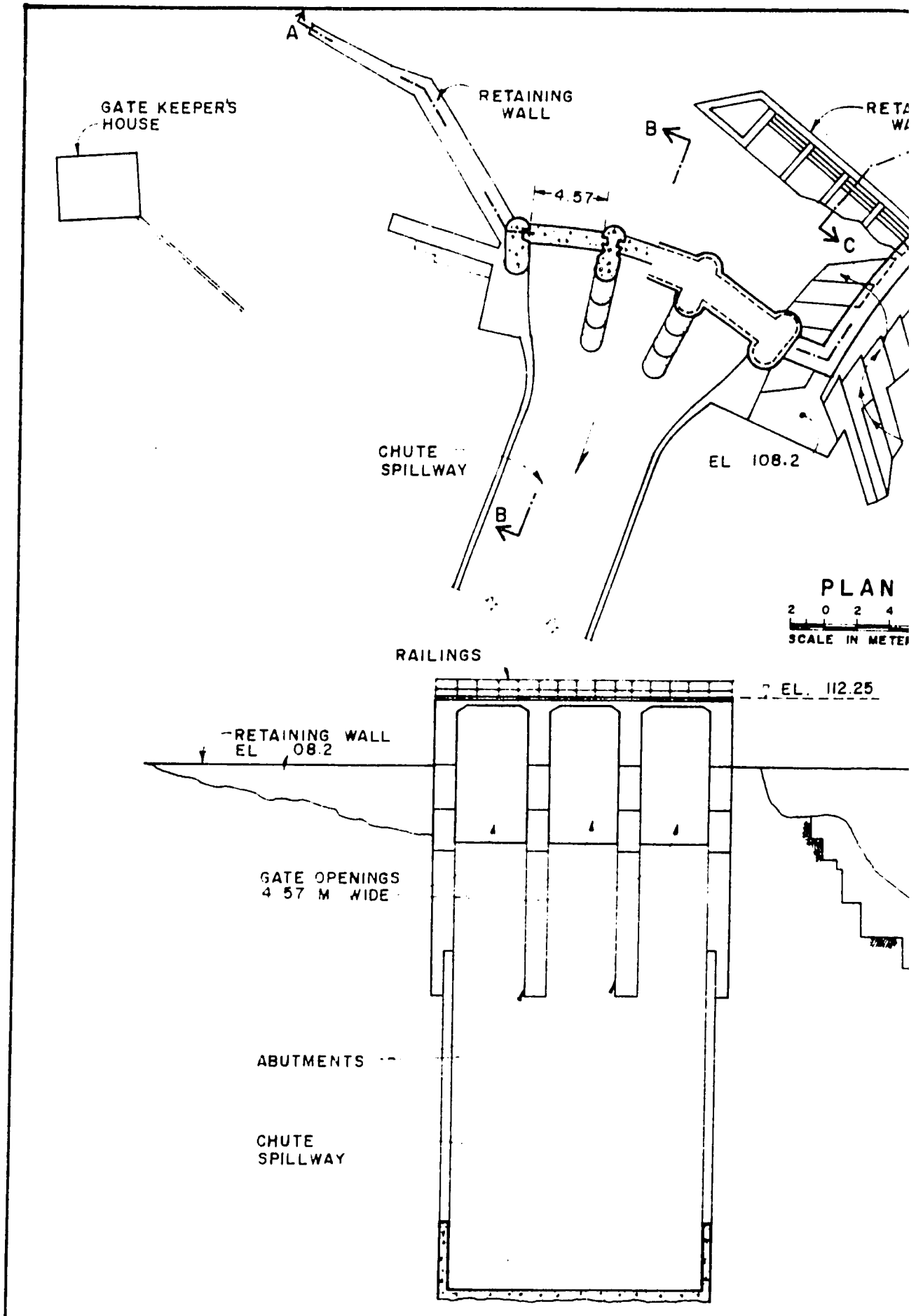

FEASIBILITY STUDY FOR WATER SUPPLY OF TEN PROVINCIAL AREAS CDM-LWUA

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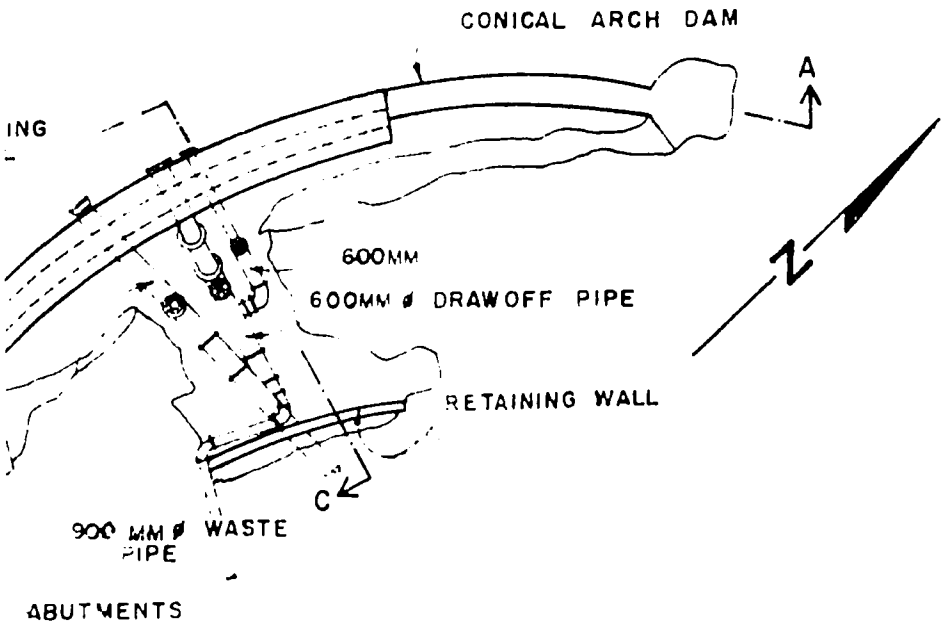

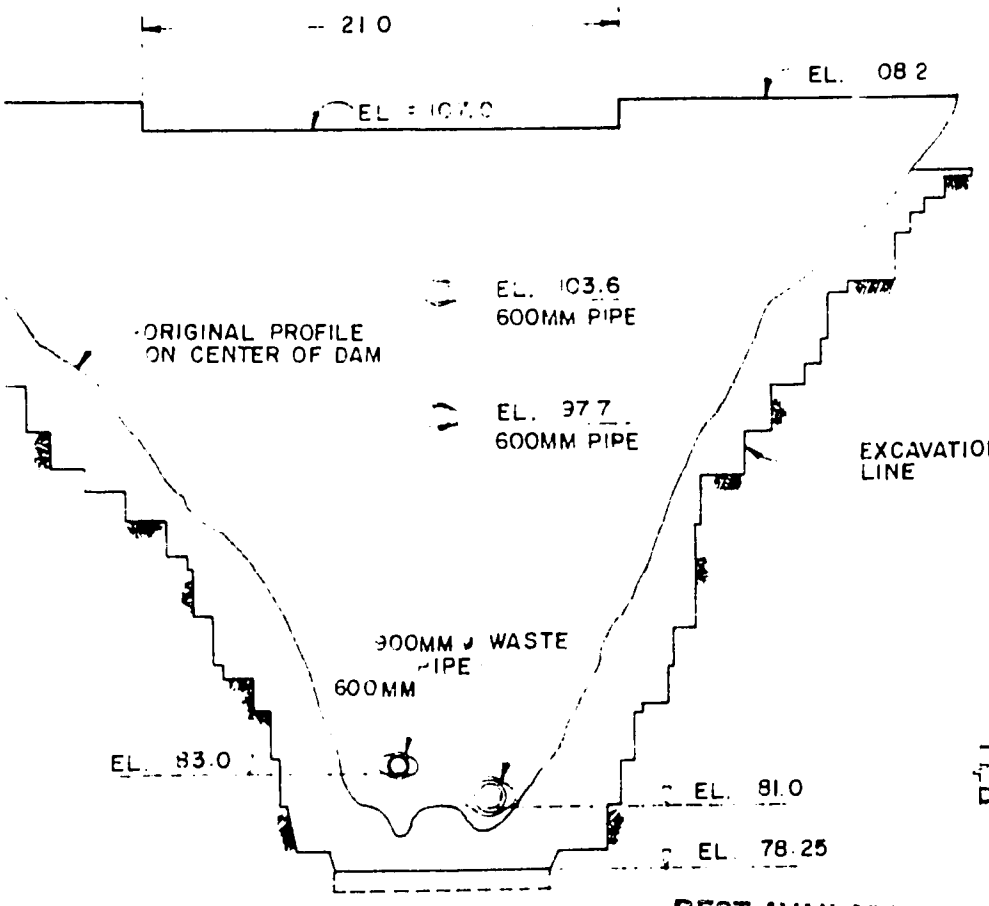

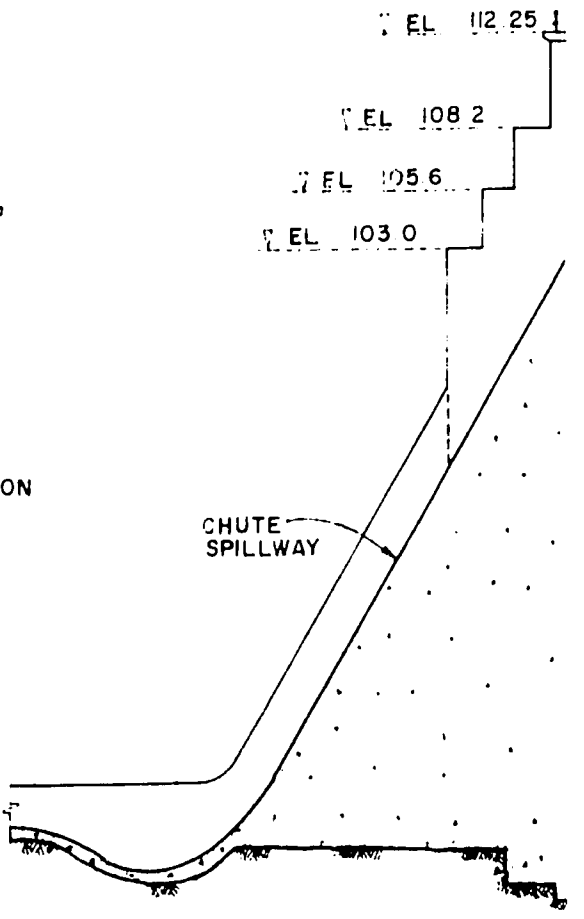

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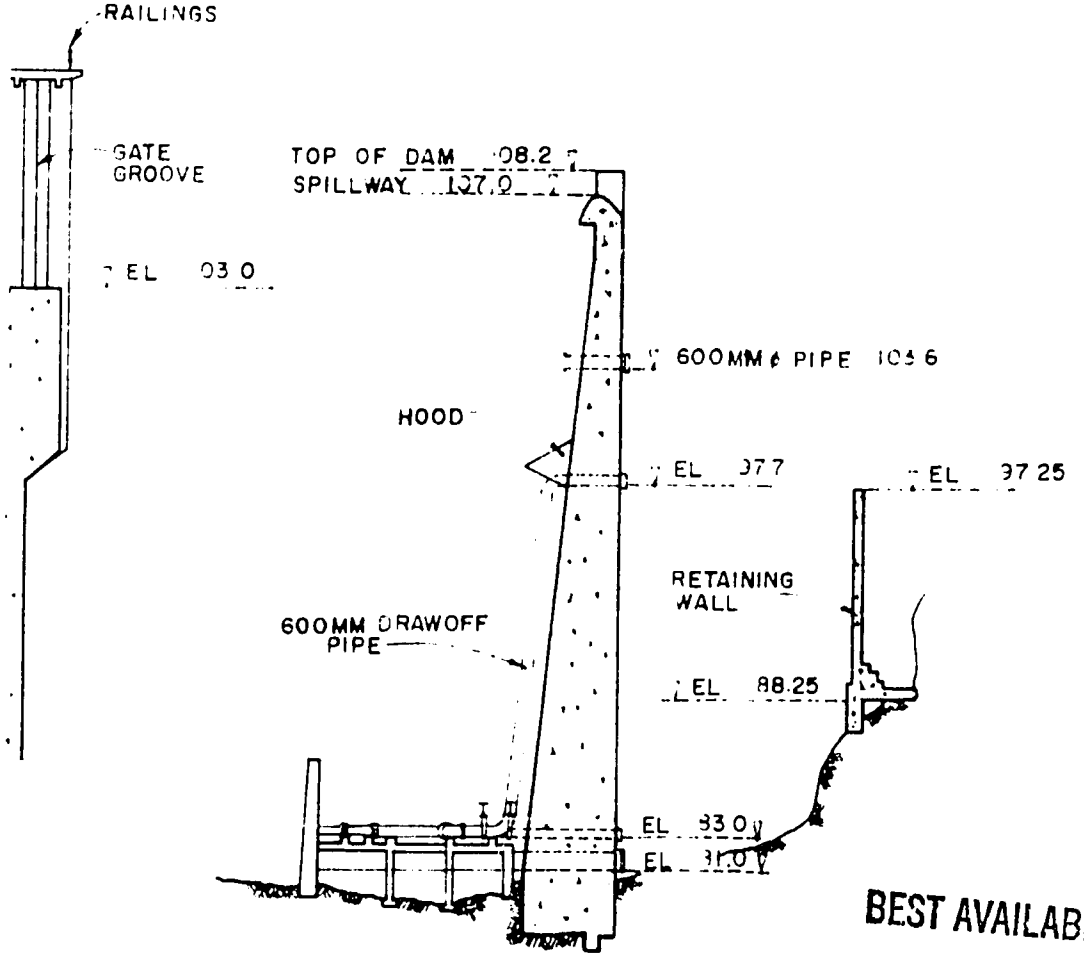
SECTION B-B



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SECTION C-C

FIGURE IV-2
EXISTING BUHISAN DAM

mm in diameter and 11.6 km long.

Compostela's existing transmission main is a 100 mm diameter, 7 km long cast iron pipe. In the Liloan water system, water will flow by gravity to the service area through a transmission main. Lapu-Lapu's well is directly connected to the distribution system.

Water Distribution System

A summary of the distribution systems within the present MCWD service area is listed in Table IV-1. At this time the MCWD supplies 42,790 cumd of water to about 227,000 consumers through 98 km of distribution piping. A brief discussion is presented in the following sections on the distribution systems of the component cities and municipalities.

Cebu. The existing distribution system is shown schematically in Figures IV-5-a, b, e. The initial construction stage for the Cebu distribution system was in 1912 when the Tisa transmission line brought water from the Buhisan River by gravity flow to the core city area. By 1932 some 27 km of pipes was in place. Virtually all of the distribution pipes were 100 mm and larger in diameter. Of the 76 km of pipes in place today, 6.2 km or 8 per cent is less than 100 mm in diameter, and 36 per cent is at least 43 years old.

The maximum total water supplied to the Cebu distribution system is 35,920 cumd, assuming the following production:

19 wells, operating	23,900 cumd	
Tisa Filter Plant	7,840 "	(varies)
Hagubiao Spring	4,180 "	

(Hagubiao produces a total of 8,710 cumd, with Mandaue consuming 4,530 cumd.) Often less water is delivered to the system because of pump failures at the wells and Hagubiao pump station; and during the dry season the supply to the Tisa plant reduces to 1,000 cumd. Hydraulic tests have been performed in the transmission lines from Tisa and the Hagubiao Spring. The 350 mm line from Tisa, which was constructed in 1912, has a Hazen Williams C-value of 83. The 350 mm line from Hagubiao, installed in 1928, has a C-value of 71. Both lines are made of cast iron and show considerable loss of carrying capacity. This loss of carrying capacity is not unusual for pipes which have been in service for over 45 years. It is likely that

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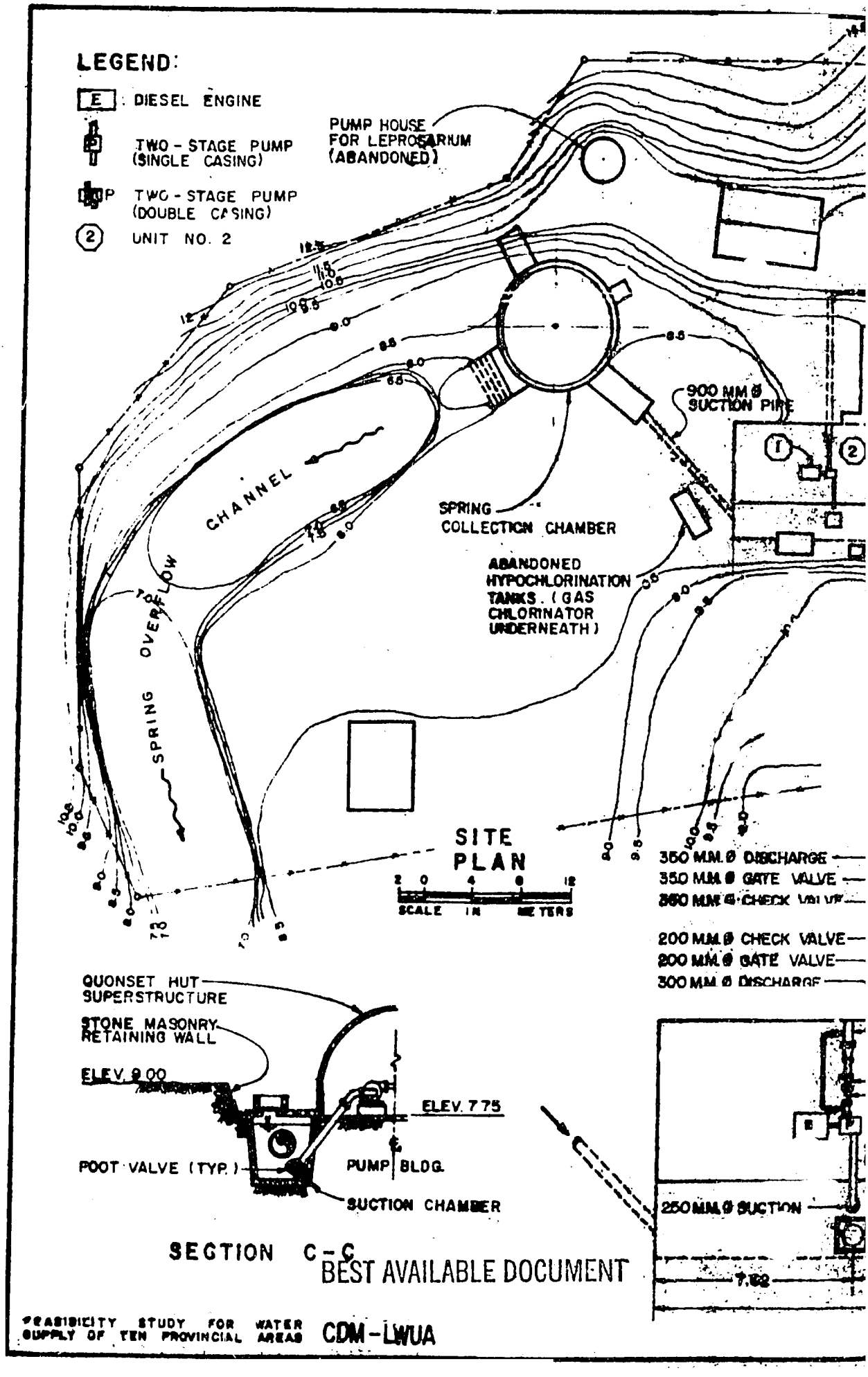

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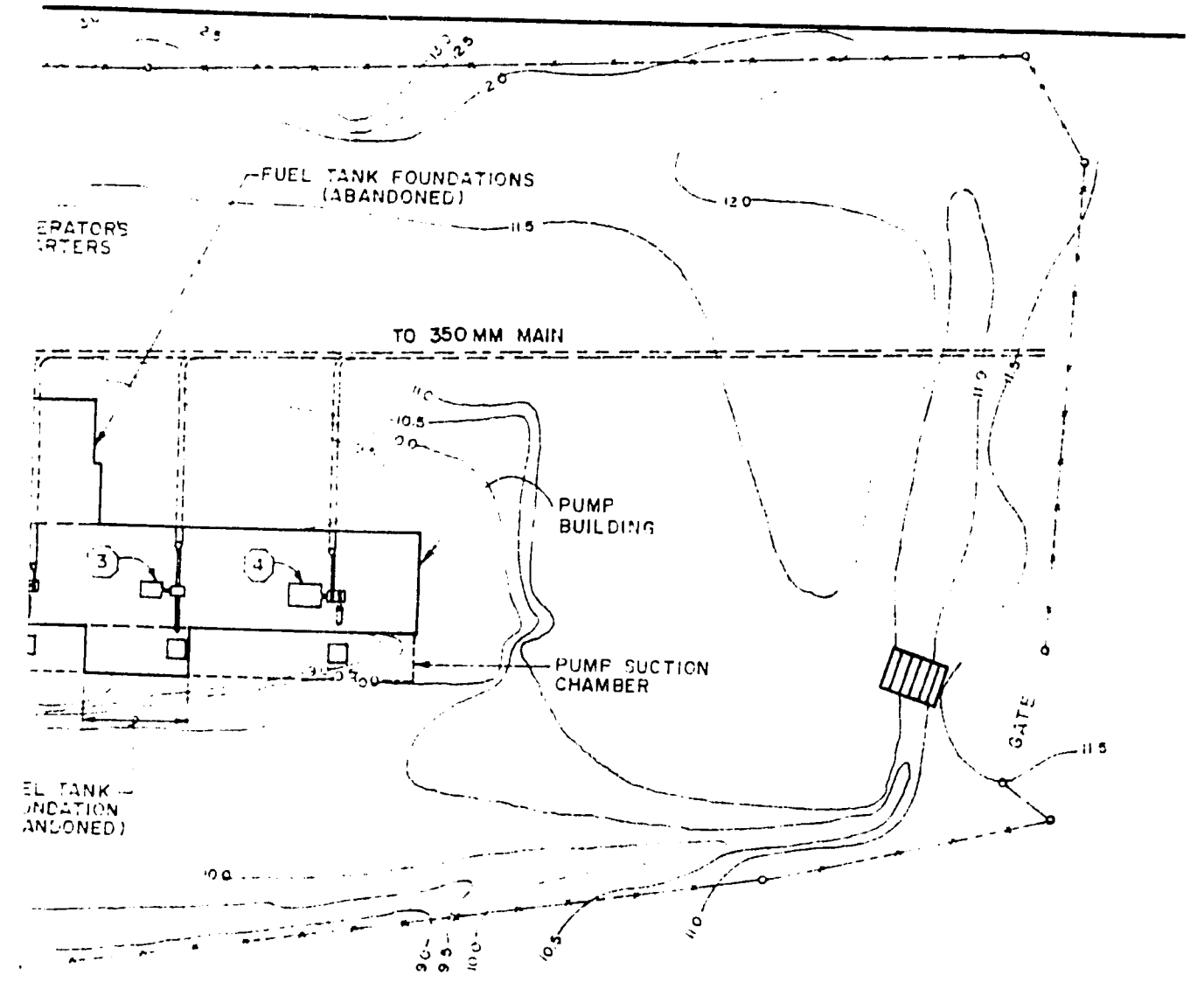

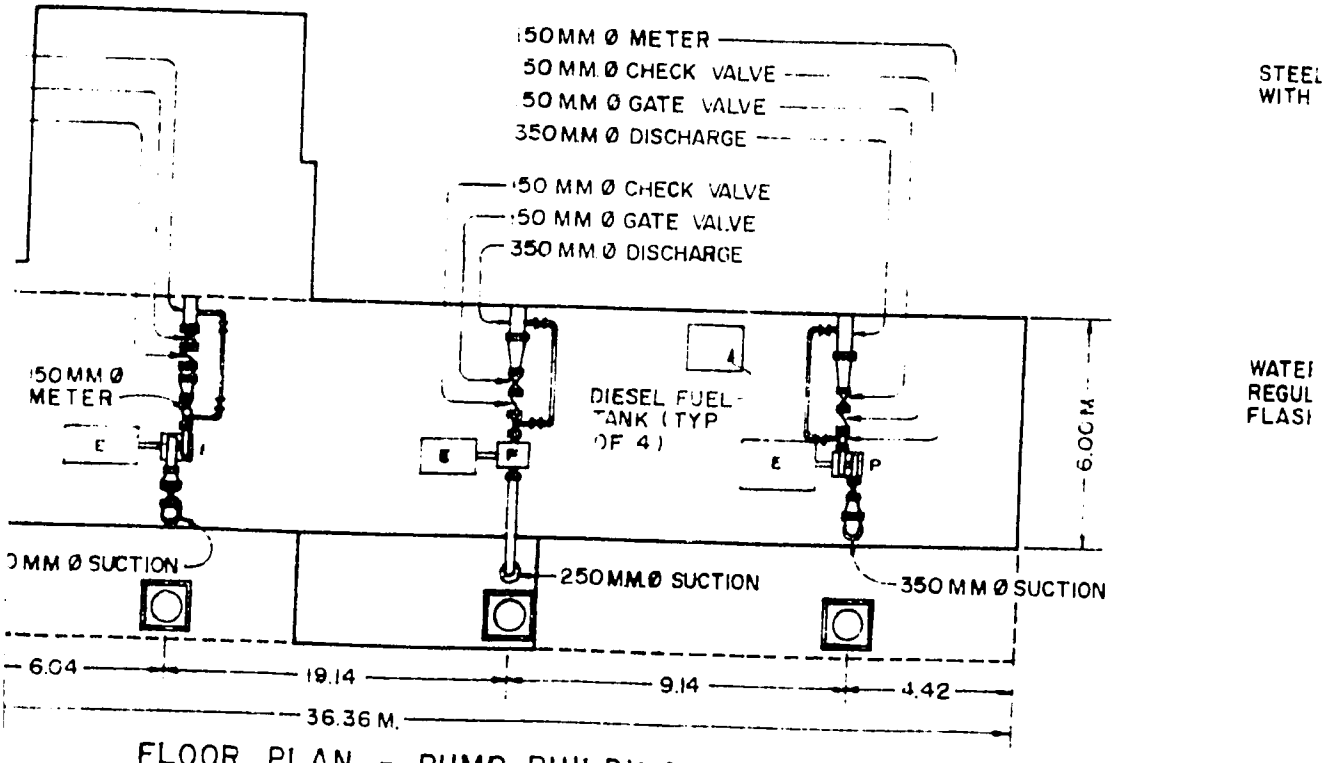

FLOOR PLAN - PUMP BUILDING

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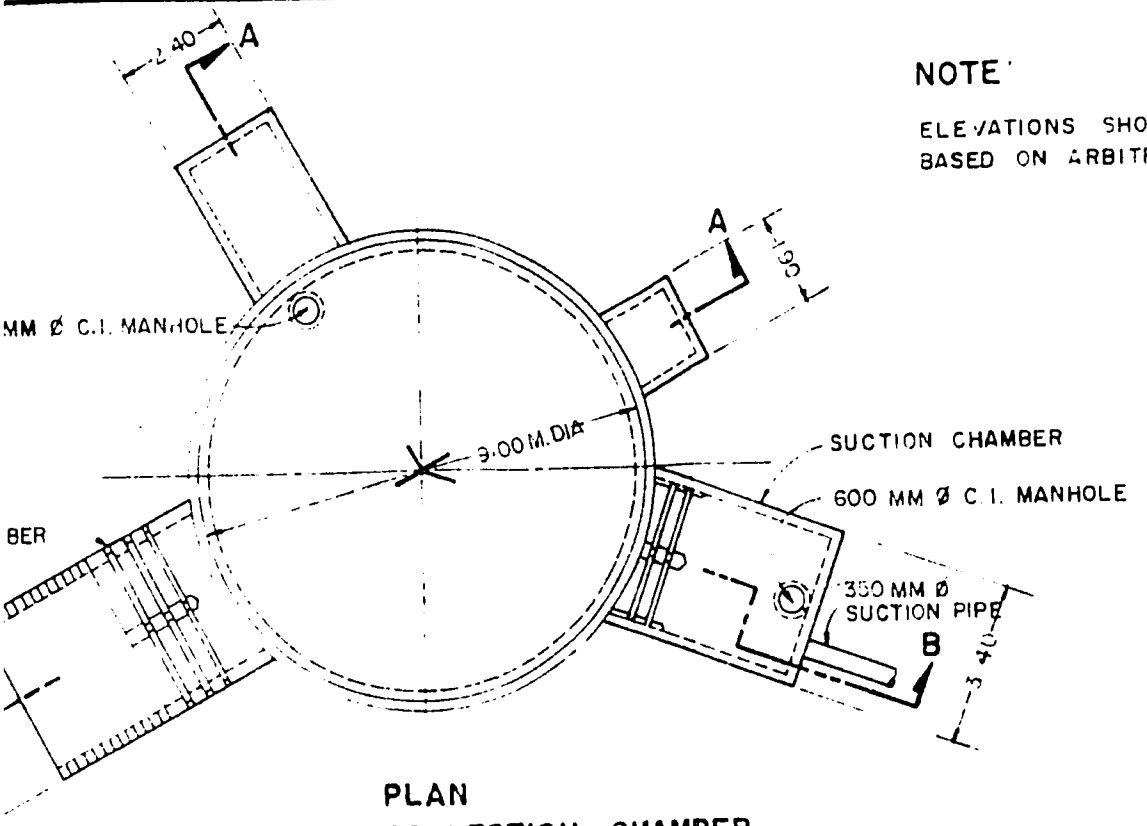
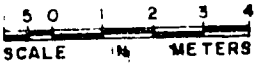
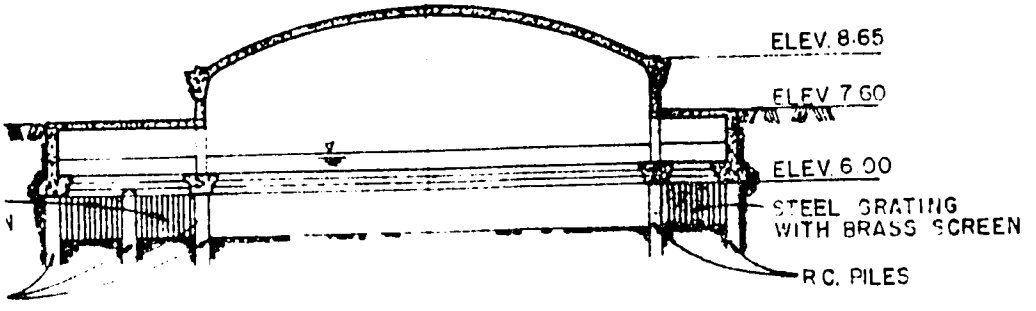
NOTE:

ELEVATIONS SHOWN ARE BASED ON ARBITRARY DATUM.

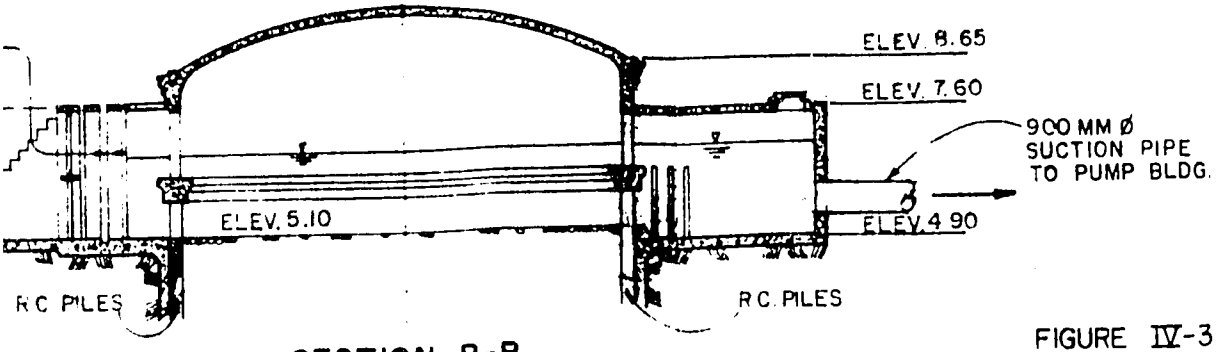


PLAN
SPRING COLLECTION CHAMBER





SECTION A-A



SECTION B-B

FIGURE IV-3
EXISTING HAGUBIAO SPRING AND PUMP STATION

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TABLE IV-1

SUMMARY OF WATER DISTRIBUTION SYSTEMS

	Cebu City	Mandaue	Lapu-Lapu	Consolacion	Liloan	Compostela
Source of Public Supply	Buhisan Dam Hagubiao Spring Wells	Obtains water from MCWD	Well	No public supply	Spring	Spring
Amount Produced (cumd)	35,920	4,530*	2,180		200**	160***
Year Distribution Placed in Operation	1912	1933	1974	Proposed System	1974-75	1939
Total Length of Distribution System Piping (km)	76.620	13.880	2.740	6.520****	2.980	5.015
Total System Storage (cum)	11,600	None	190		300	270
Total Number of Connections	9,708	894	437		105	191
Area Served (ha)	1,800	504	35		80	28
Estimated Population Served (1975)	200,000	20,000	5,000		1,000	2,000

*Measured supply to Mandaue - May 1975.
**Measured supply - May 1975.
***Supply rationed by valving procedure.
****Proposed system.

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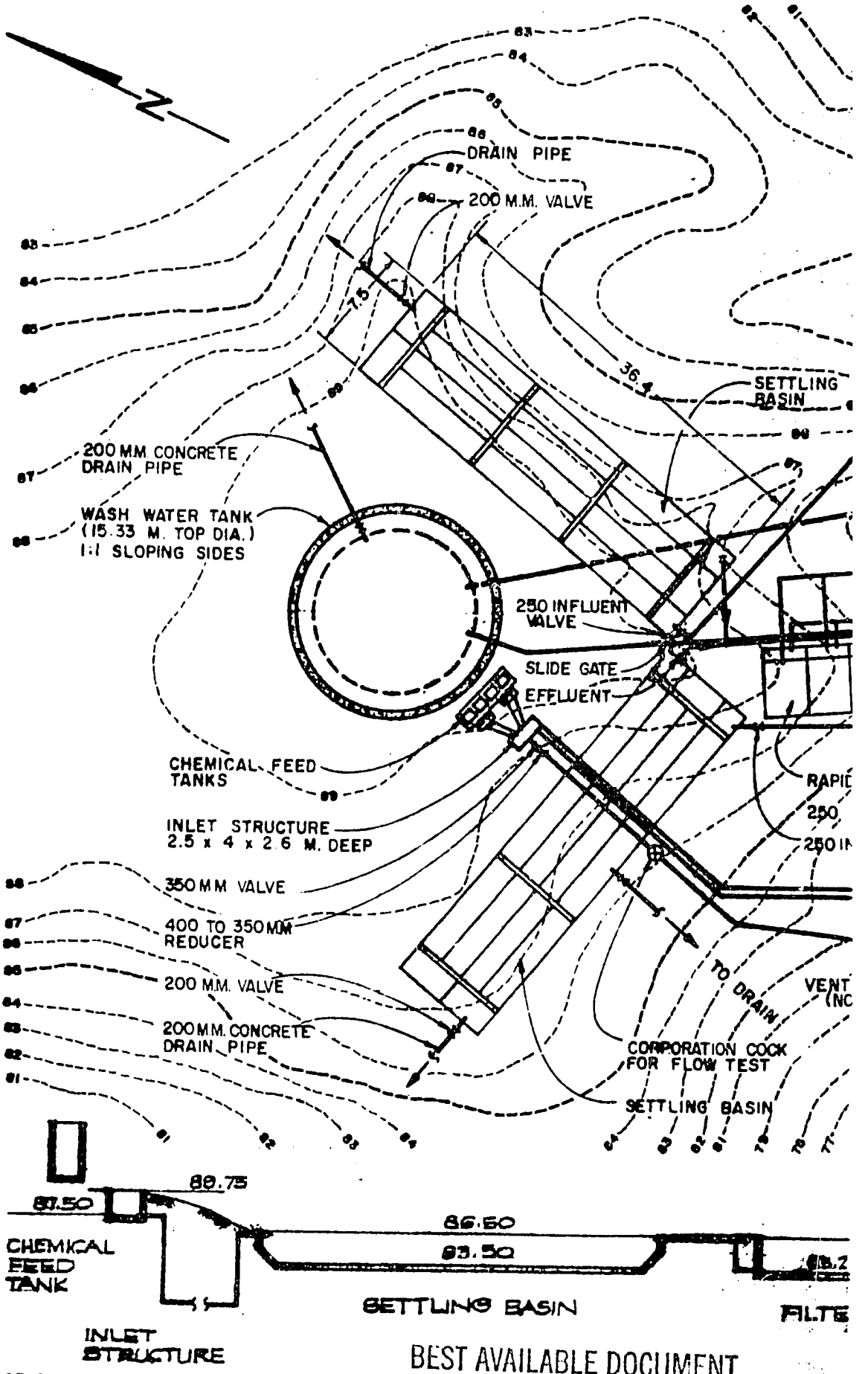

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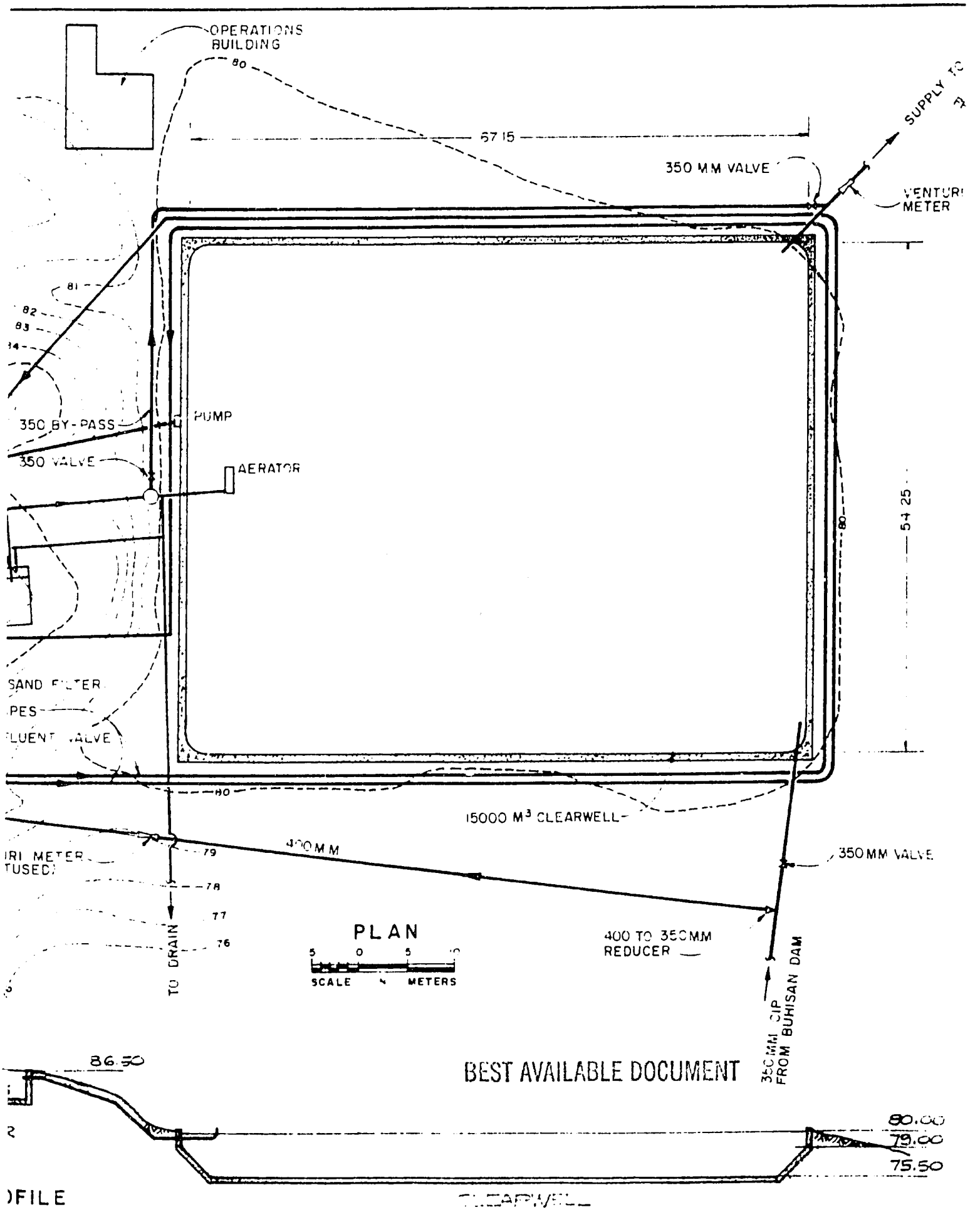

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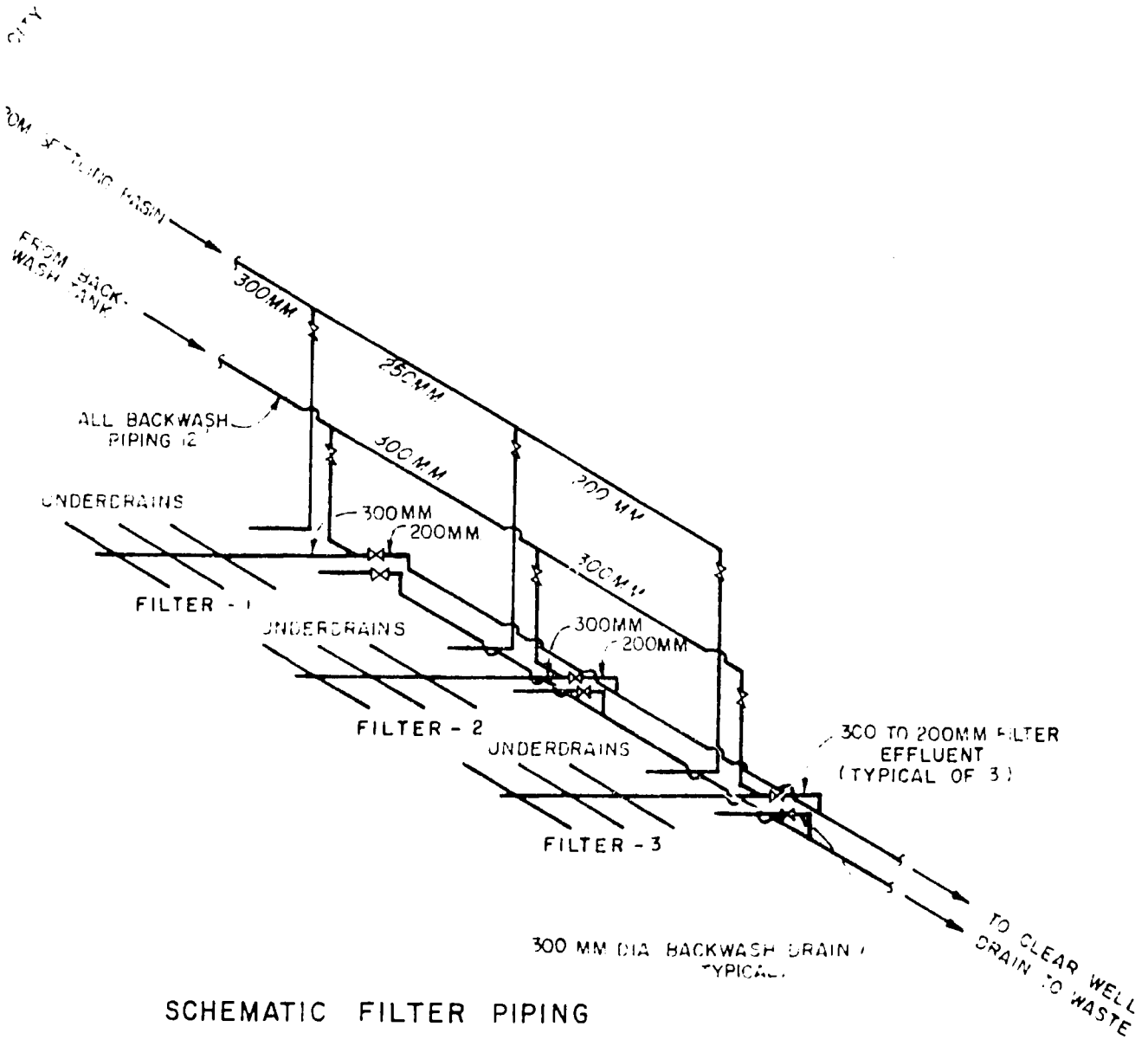

SCHEMATIC FILTER PIPING

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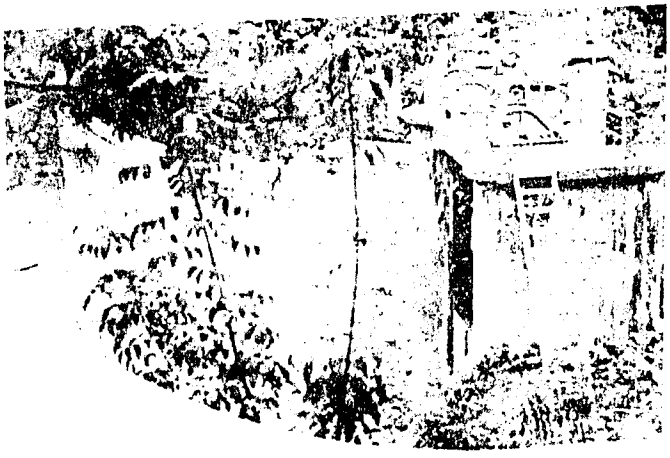
FIGURE IV-4
EXISTING TISA
WATER TREATMENT PLANT

BUHISAN DAM GATES



BUHISAN DAM GATE CONTROLS

CHLORINATION FACILITIES AT THE TISA FILTRATION PLANT

SAMPLING AT THE LAPU–LAPU WELL

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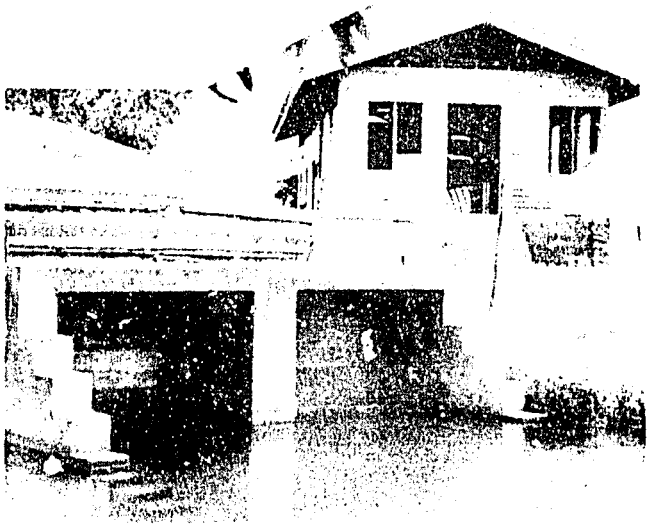
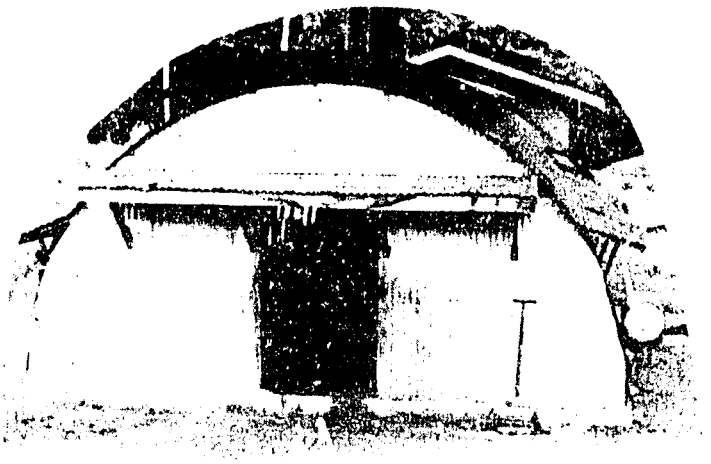


HAGUBIAO SPRING



PUMP HOUSE AT HAGUBIAO SPRING

SETTLING BASINS AT TISA FILTRATION PLANT

CHANNELS AT SOUTH CLARIFIER – TISA PLANT

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smaller pipes of similar age within the distribution system have severely reduced carrying capacity and little useful life remaining.

System Storage

The Cebu system has 3 storage tanks - a 190 cum tank near the Capitol, a 75 cum facility at Talamban, and 11,360 cum Basilan Tank near Lahug. The Capitol tank has been taken out of service. Because of the shortage of water in the Cebu area, it is not possible to fill this storage tank. The tank at Talamban serves a small area consisting of 110 connections. The Talamban system is not connected to the Cebu distribution system; it serves an isolated service area.

The Basilan storage tank is being completed. The tank is at an elevation over 100 m. The overflow elevation is approximately 110 m. A 300 mm pipeline connects the tank to the distribution system near Camp Lapu-Lapu. A pump station is planned at the point of connection to pump the water into the storage tank. This facility is poorly designed - the hydraulic grade line it will establish is about 40 m higher than the recommended maximum HGL of 70 m. Furthermore, a 150 horsepower pump installation is planned, but to fill the reservoir during an overnight filling cycle requires a pump station capacity of 1,200 horsepower. Also, the reservoir has no cover to protect the water from contamination.

System Pressure

Existing pressures within the distribution system fluctuate over a wide range. Several 24-hour pressure readings were taken within the distribution system and are summarized below:

Location	Date	Ground Elevation	Day-Time Pressure	Night-Time Pressure
El Filibusterismo St (near Node 55	May 13	2.2 m	0-.7 m	0-.7 m
Figure IV-5a)	May 12		0-.7 m	0-.7 m
Jones Avenue (near Node 139	May 16	12.5 m	1.4-6.3m	2.8-12.6 m
Figure IV-5a)	May 17		.7-5.6m	.7- 8.4 m
Don Jil Garcia St. (near Node 152	May 14	28 m	0-3.5m	0-.5 m
Figure IV-5b)	May 15		.7-7 m	3.5-9.1 m

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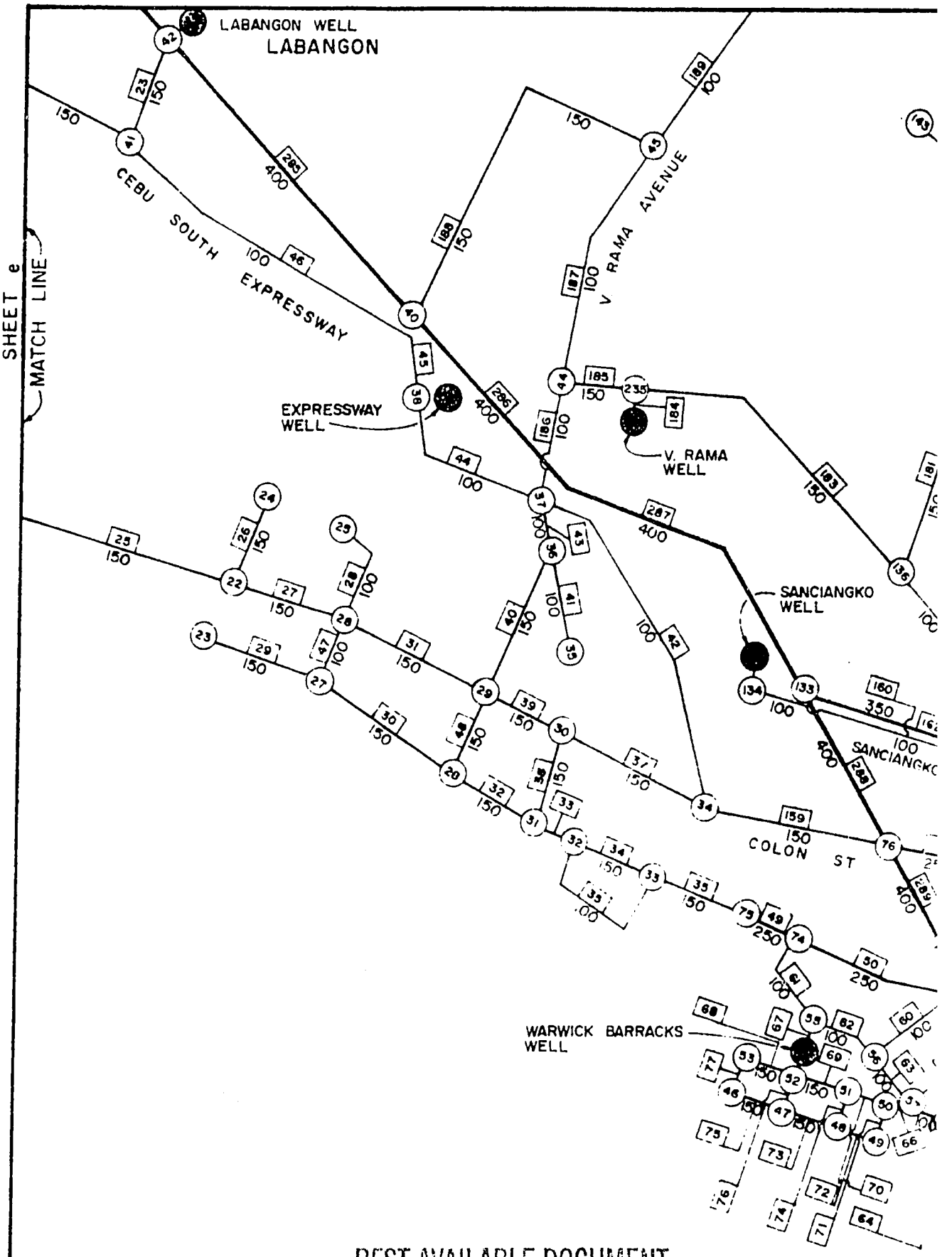

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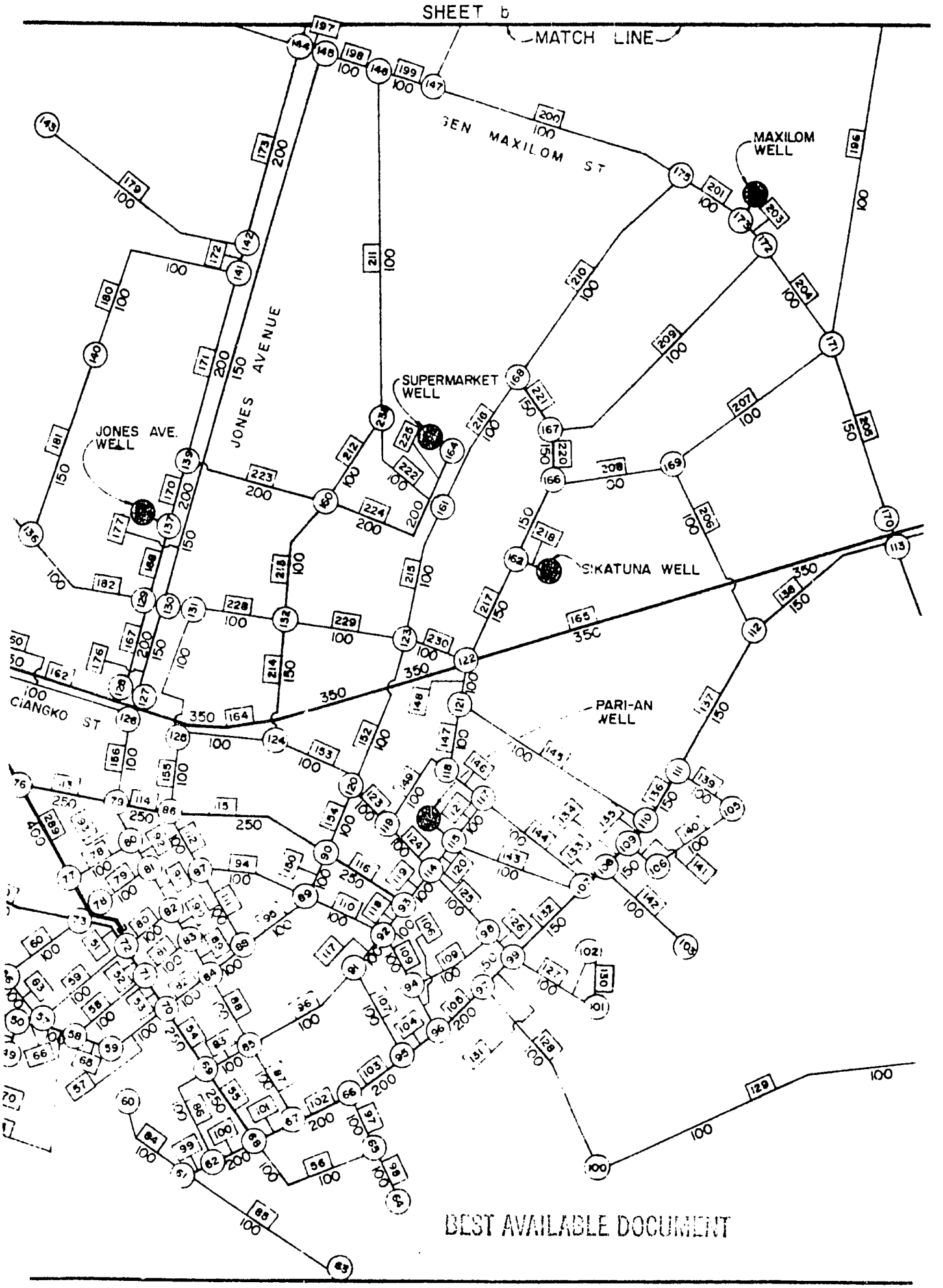
FEASIBILITY STUDY FOR WATER SUPPLY OF TEN PROVINCIAL AREAS CDM - LWUA



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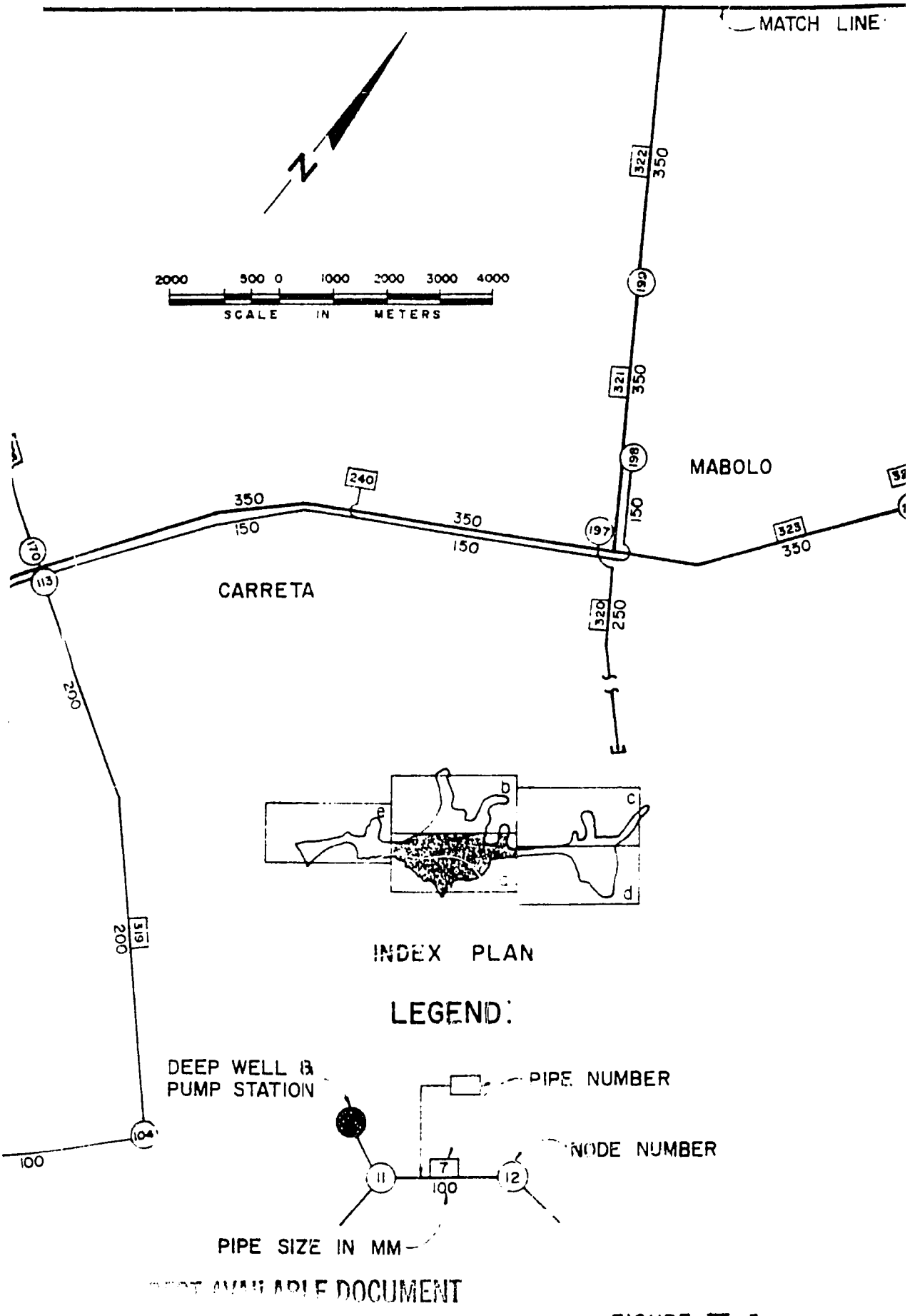

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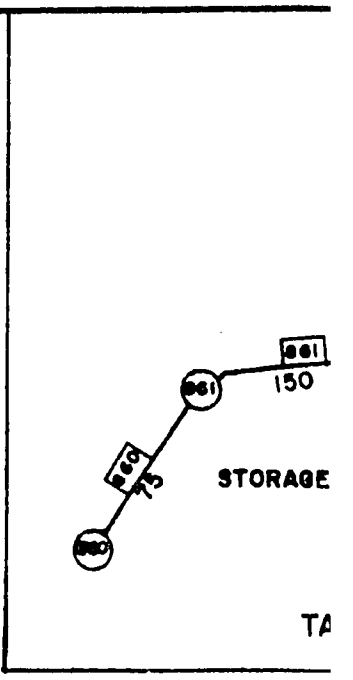
FIGURE IV-5a
EXISTING WATER DISTRIBUTION SYSTEM
SCHEMATIC PLAN



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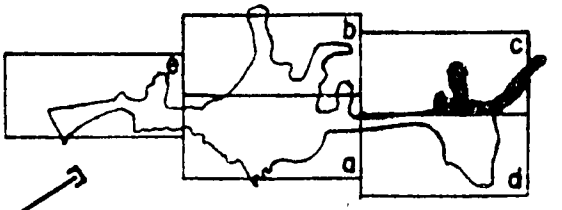

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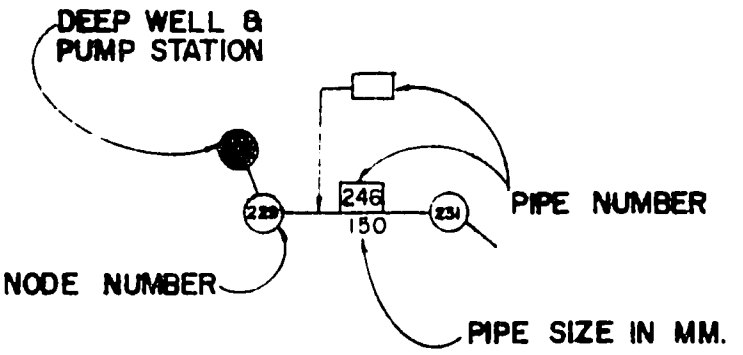

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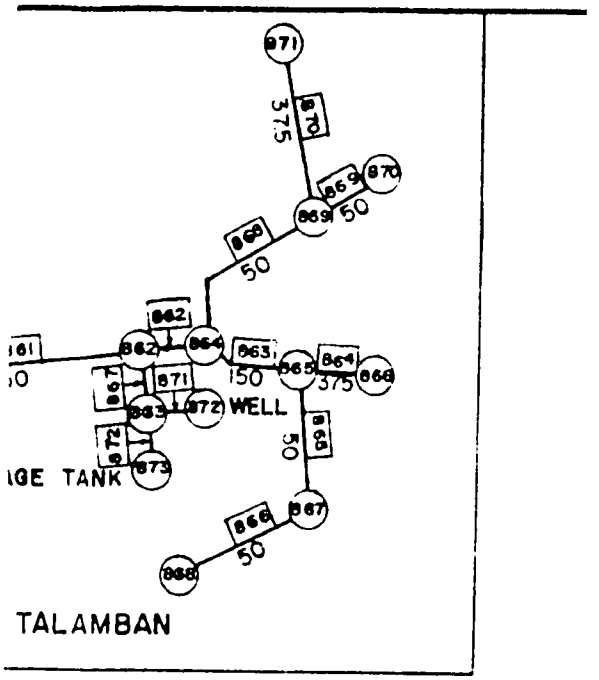
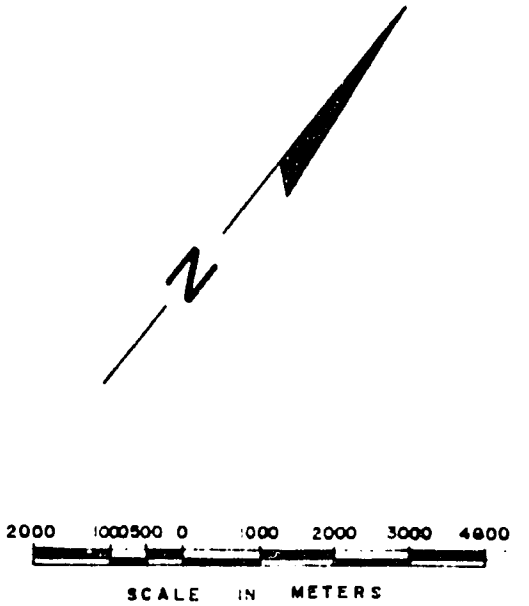
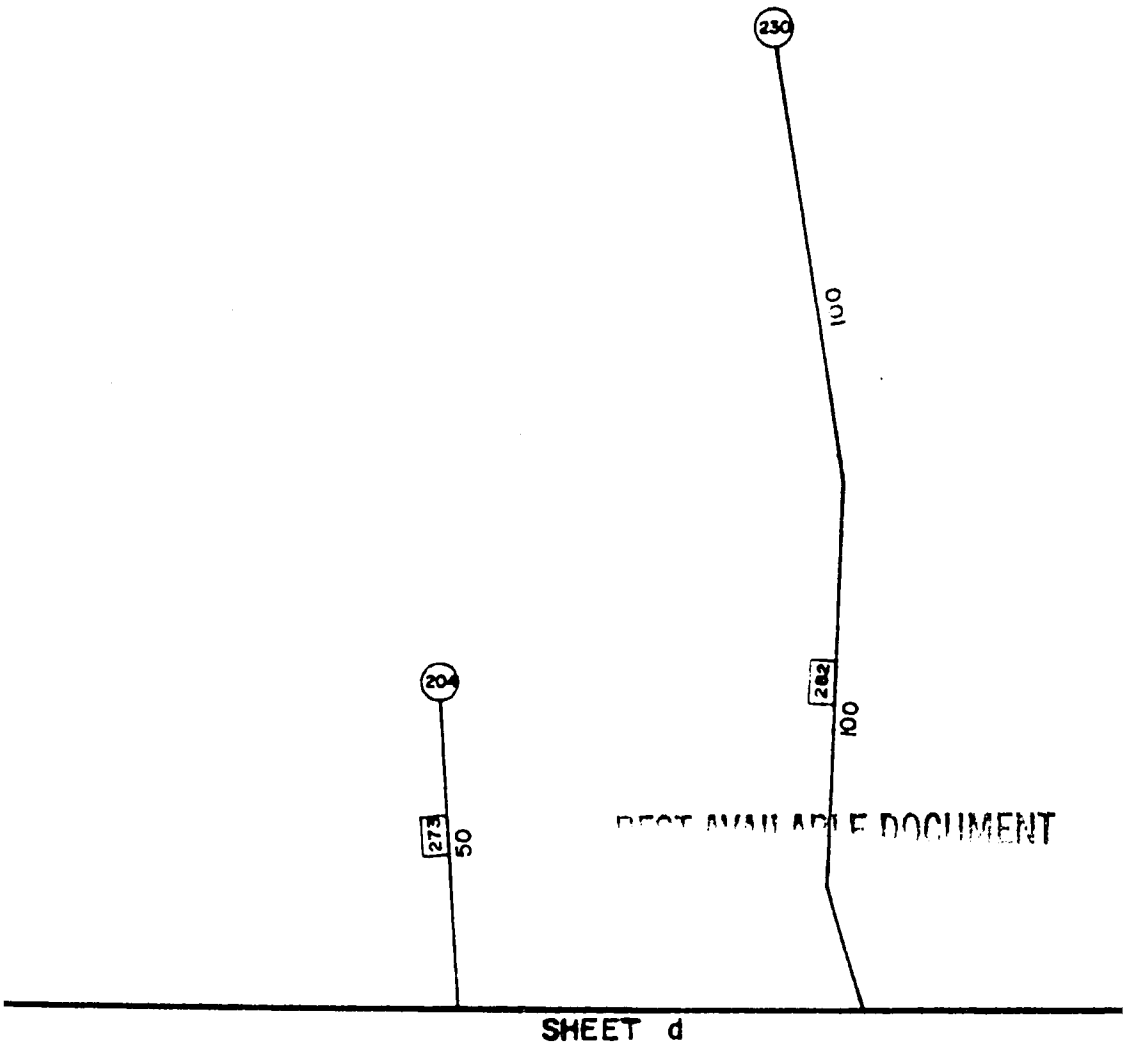
MATCH LINE







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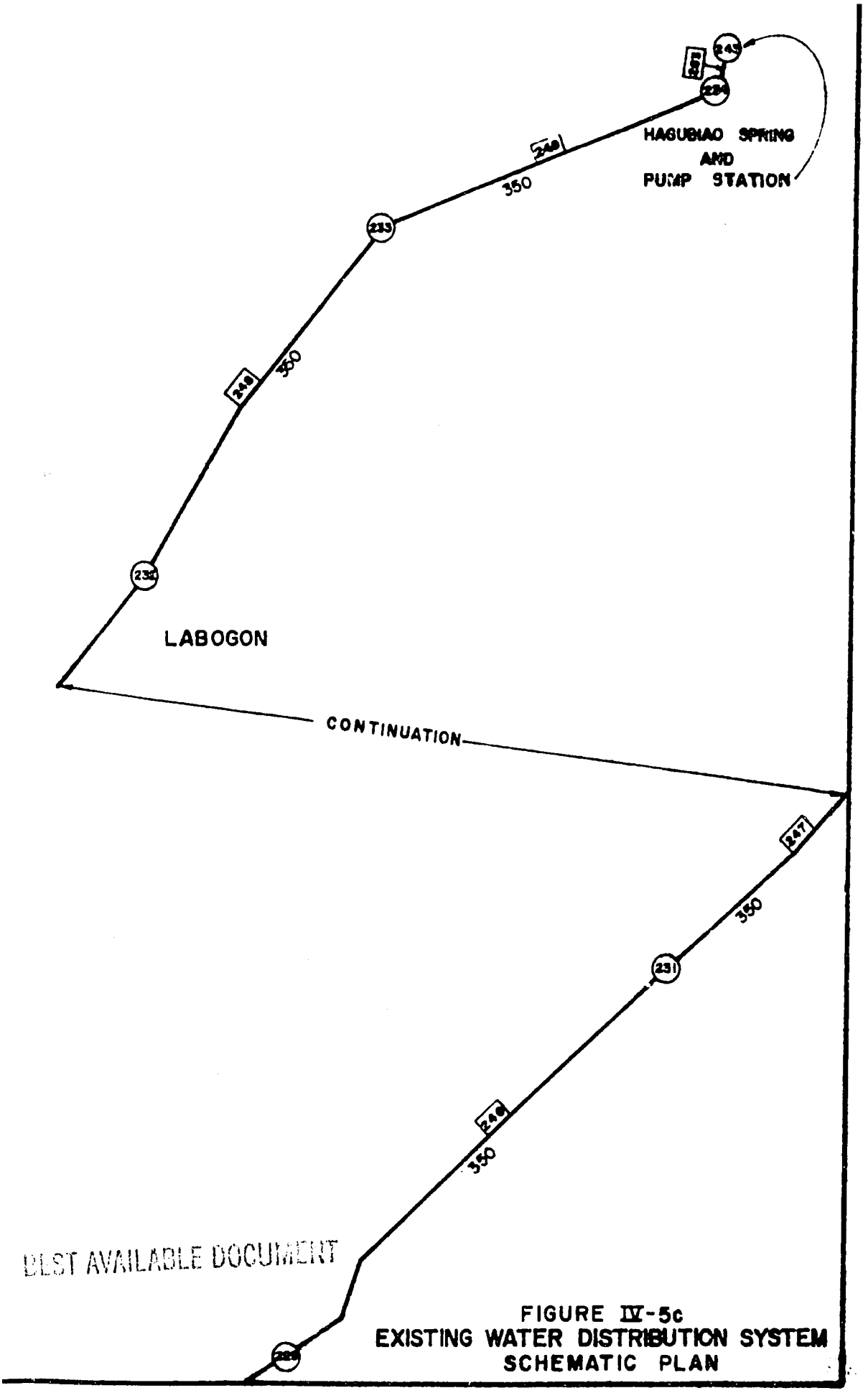

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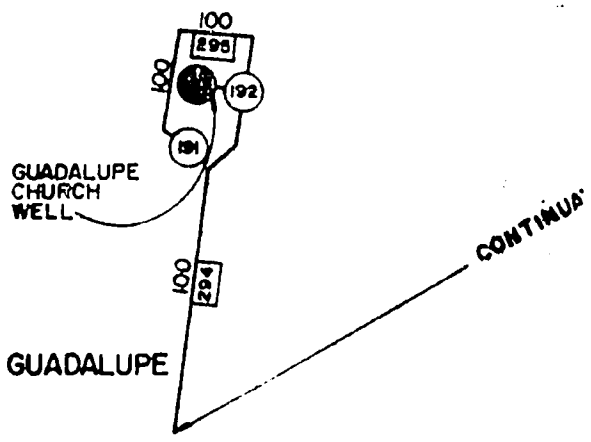
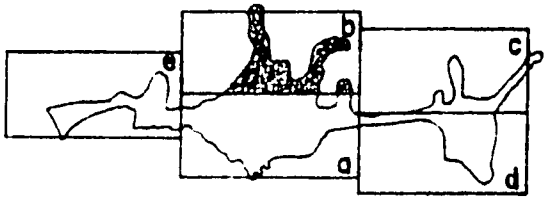
FIGURE IV-5c
EXISTING WATER DISTRIBUTION SYSTEM
SCHEMATIC PLAN





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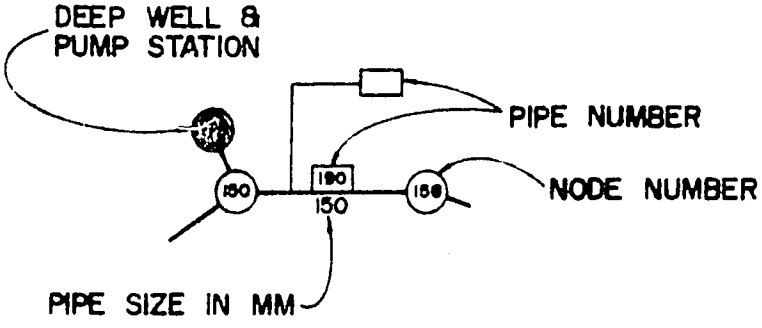

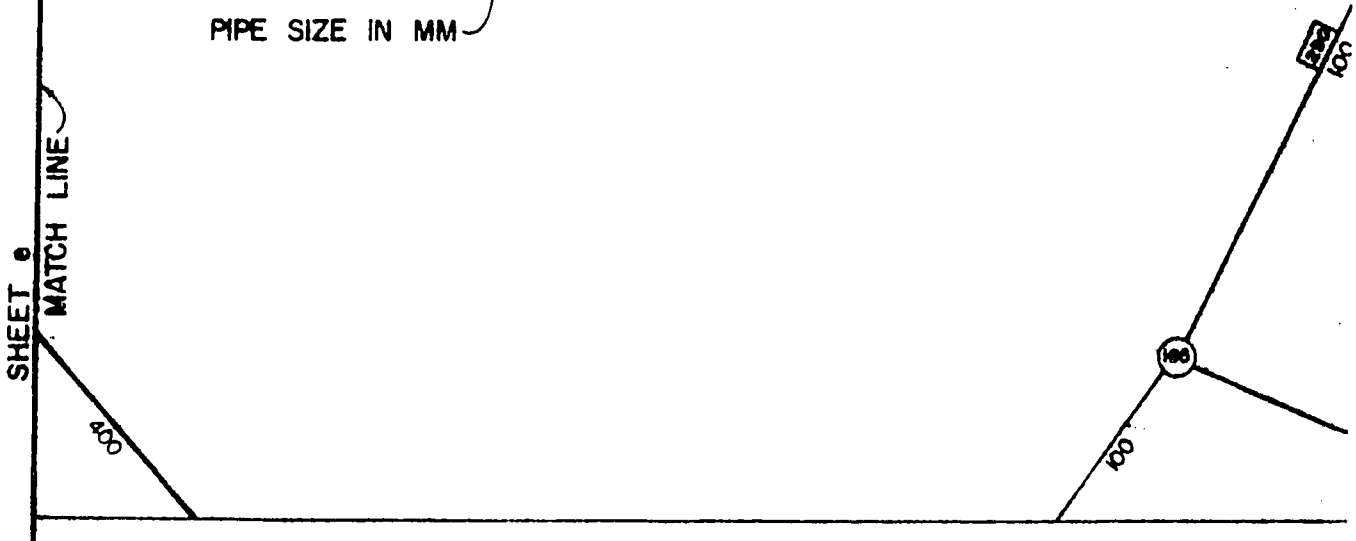

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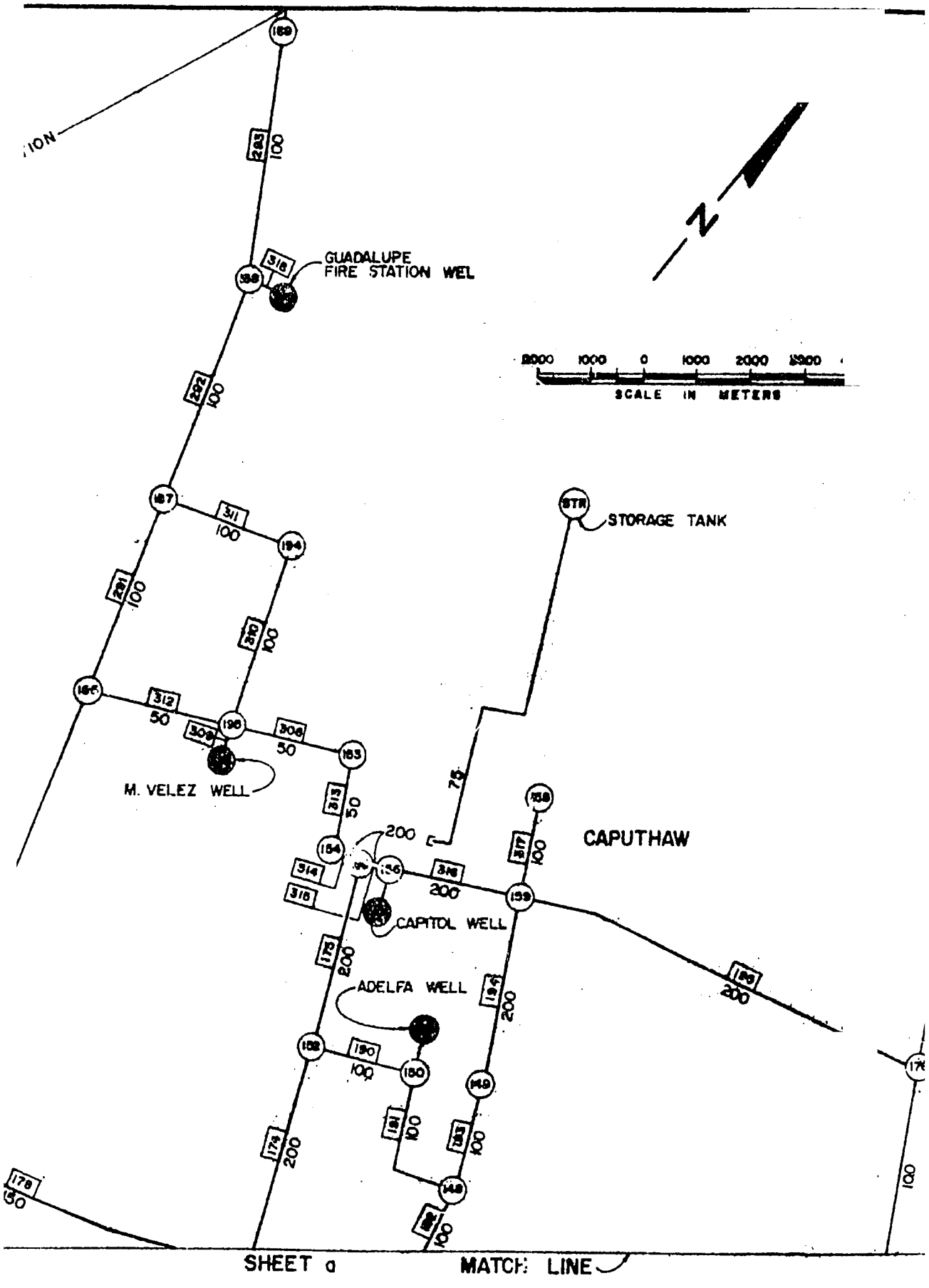

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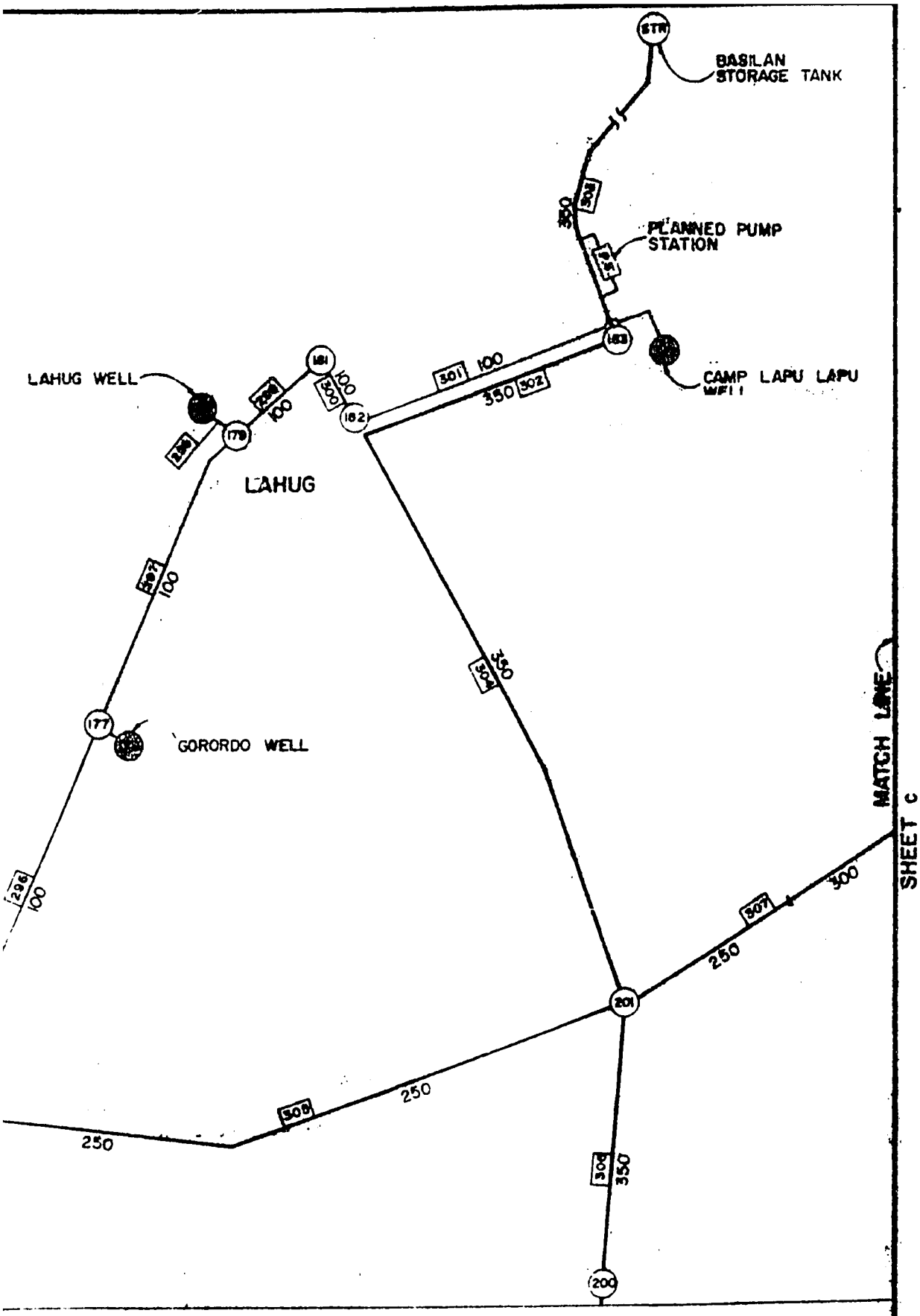

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FIGURE IV-5b
EXISTING WATER DISTRIBUTION SYSTEM
SCHEMATIC PLAN

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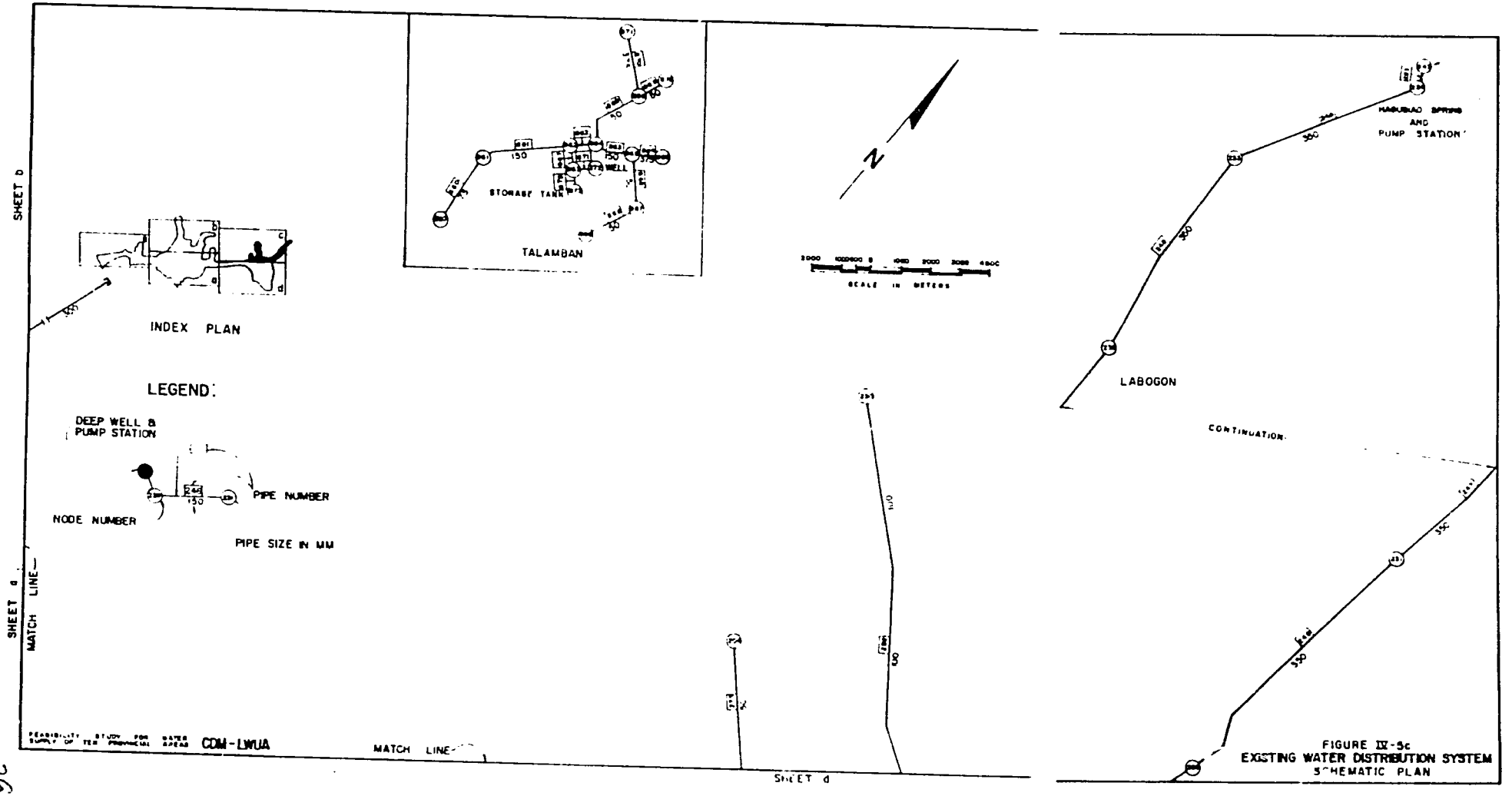
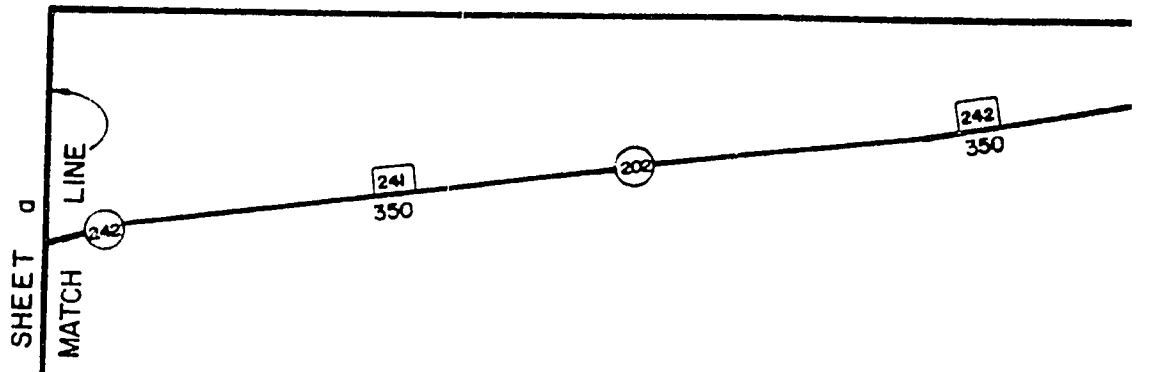
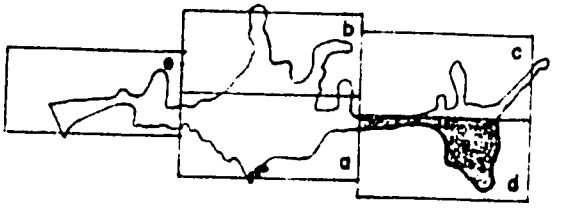


FIGURE IV-5c
EXISTING WATER DISTRIBUTION SYSTEM
SCHEMATIC PLAN





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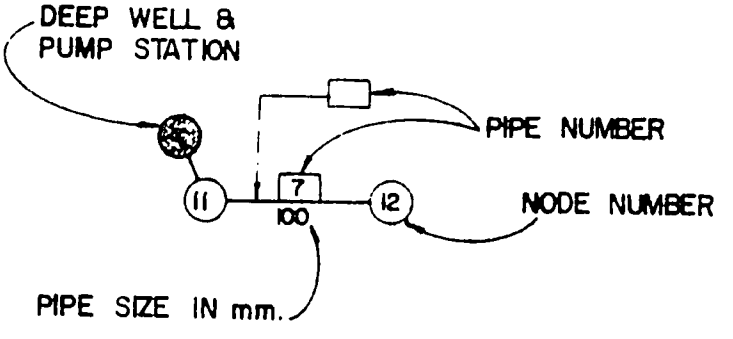

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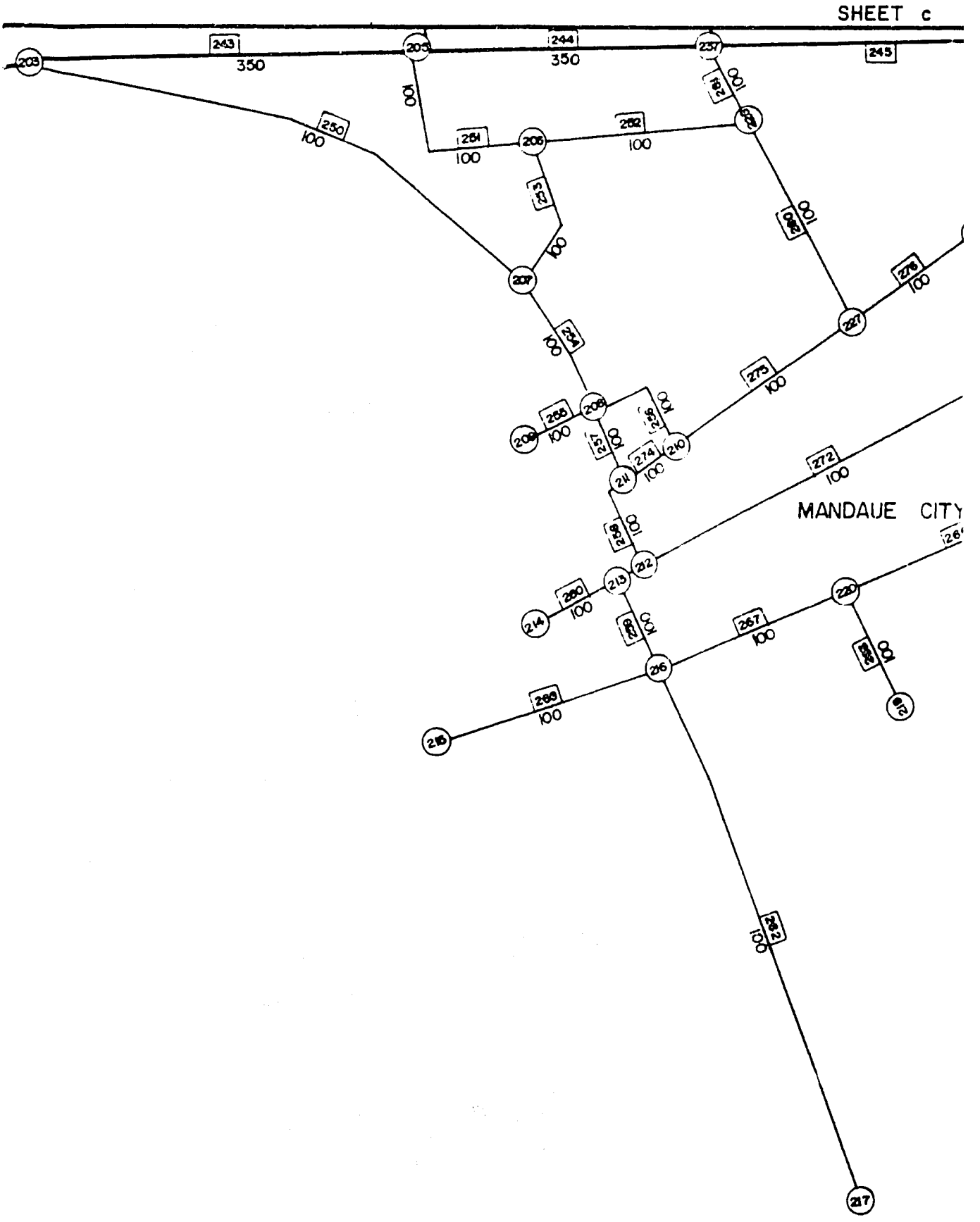
FEASIBILITY STUDY FOR WATER SUPPLY OF TEN PROVINCIAL AREAS CDM-LWUA



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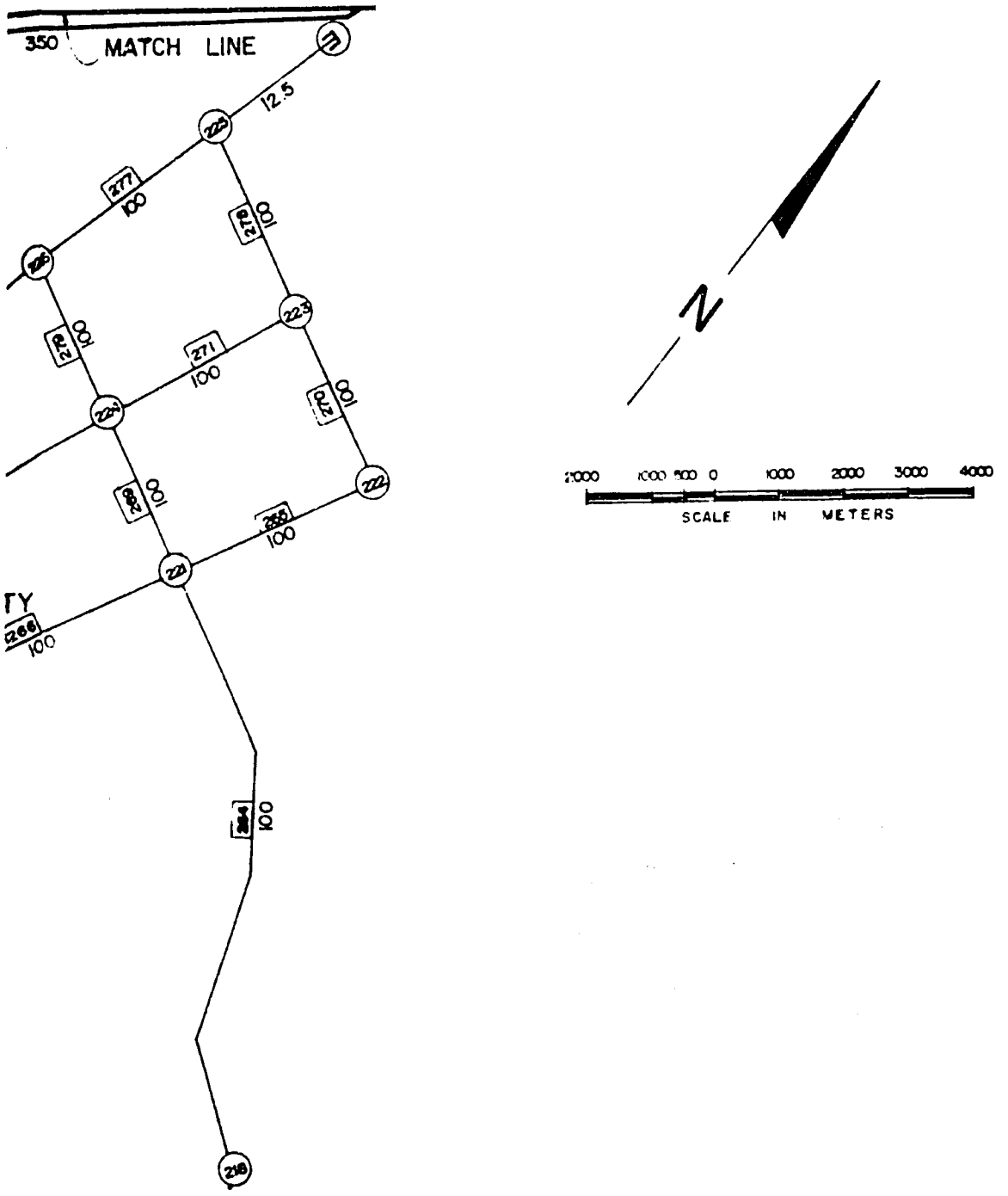

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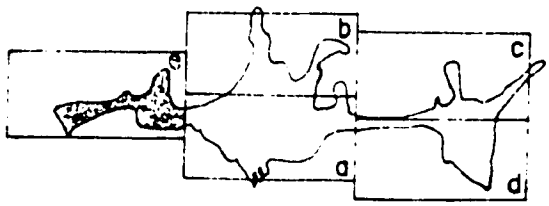
FIGURE IV-5d
EXISTING WATER DISTRIBUTION SYSTEM
SCHEMATIC PLAN



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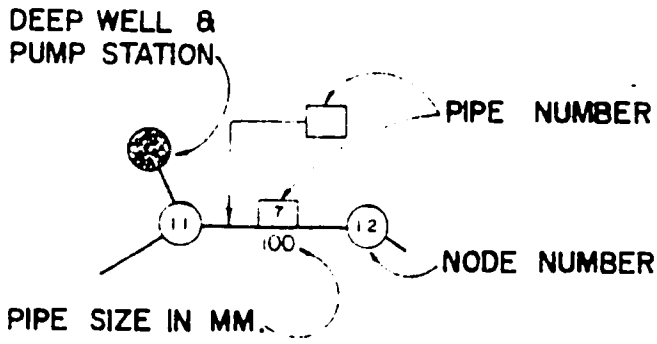

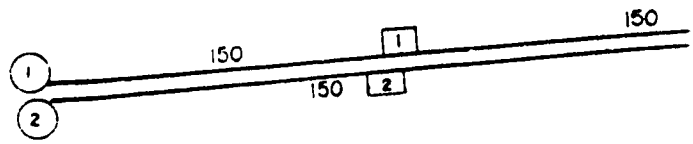

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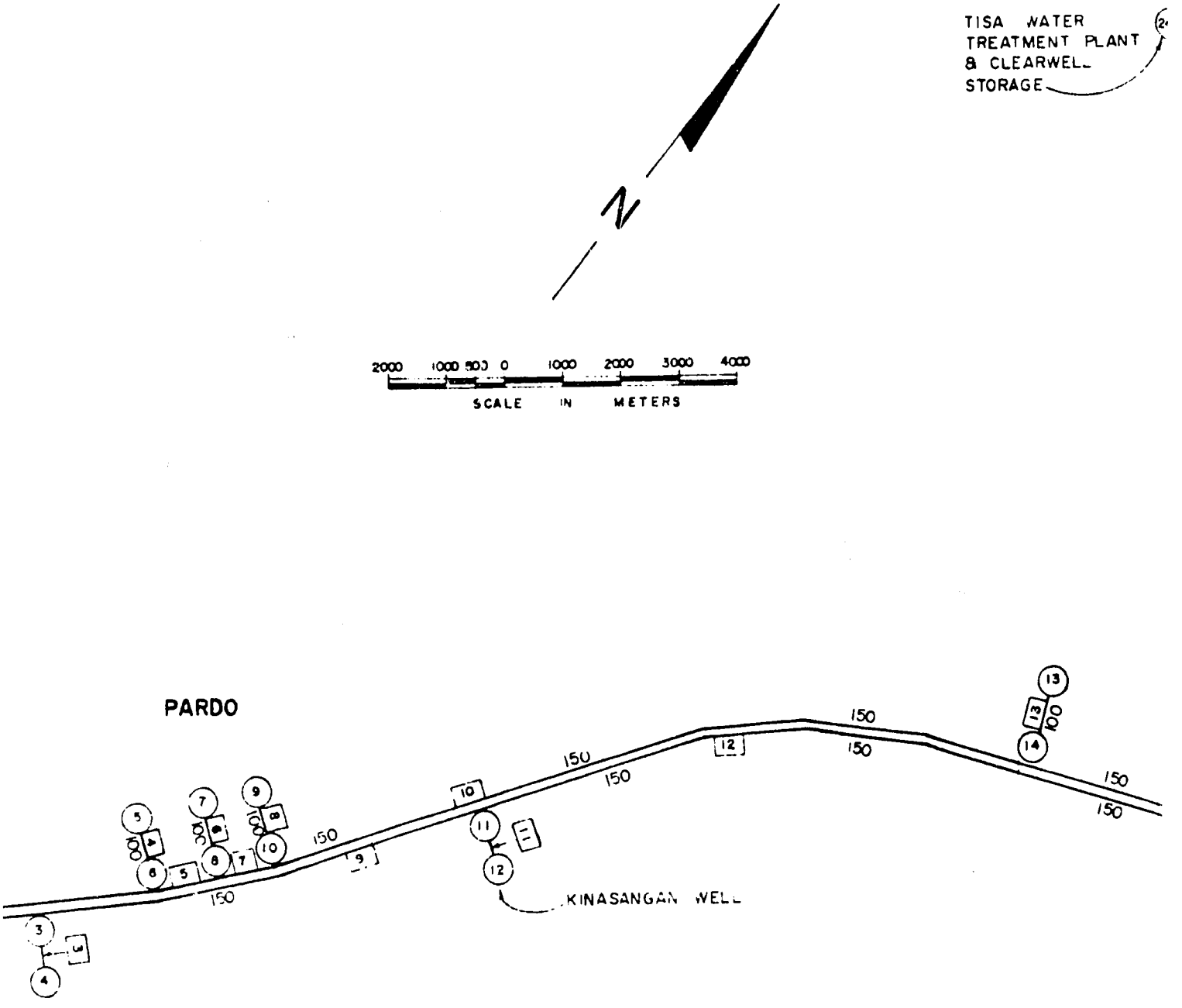

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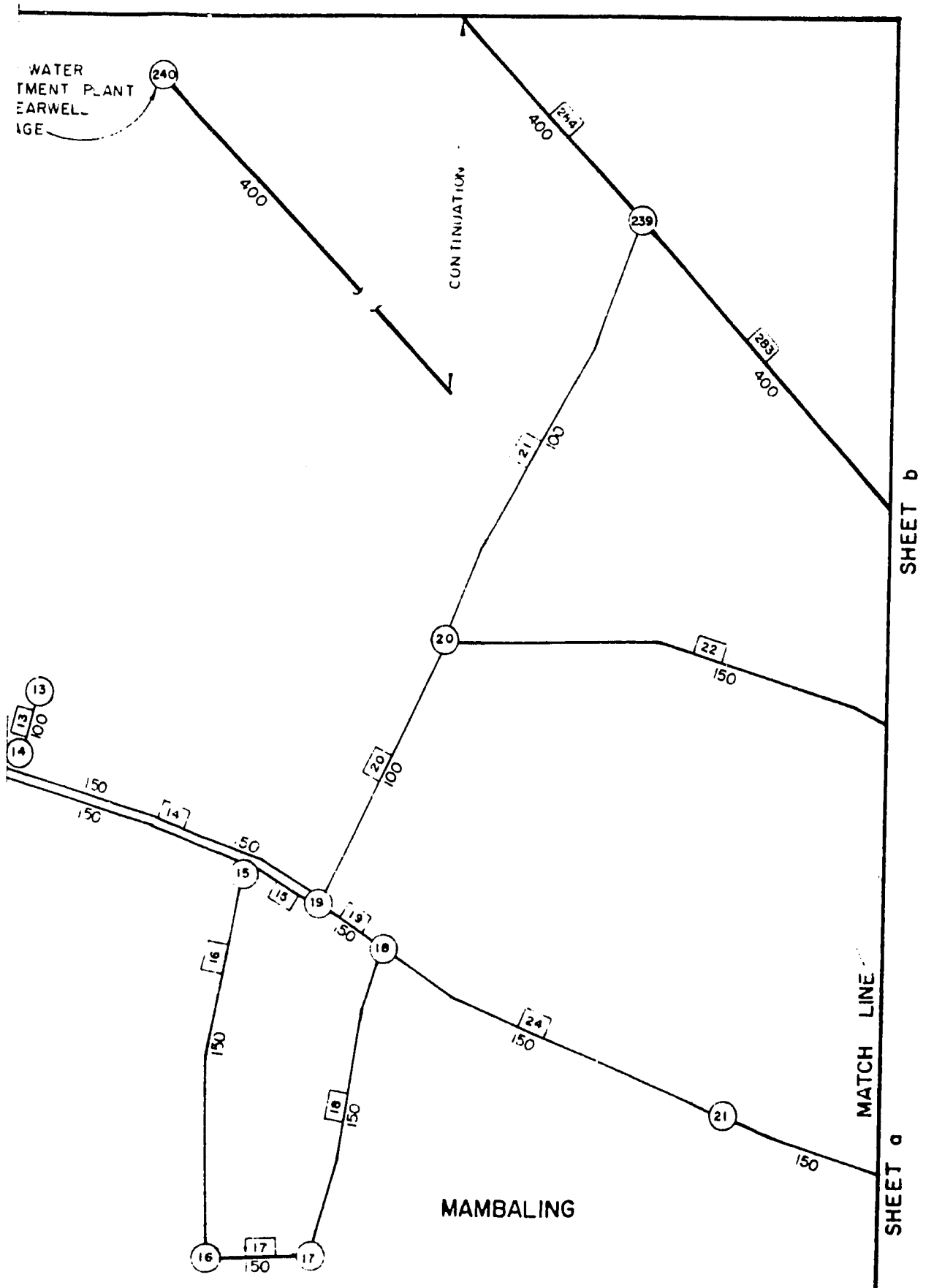

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FIGURE IV-5e
EXISTING WATER DISTRIBUTION SYSTEM
SCHEMATIC PLAN

Because of the shortage of water, the MCWD rations water to areas within the water district. This is accomplished by means of opening and closing some 33 valves. Each valve is operated in a routine manner; it is opened and closed at specified times every day. This causes wide fluctuations in water pressure as shown in the summary of pressure readings. Some areas experience negative pressures, increasing the possibility of contaminated water entering the distribution system. Because of the low pressures and the rationing plan, the distribution system is of doubtful utility during fire fighting periods.

Unaccounted-for-Water

The unaccounted-for-water, consisting of leakage and unrecorded usage, is approximately 70 per cent of total water supplied to the system. The greater portion of the unaccounted-for-water is unrecorded usage estimated to be 50 per cent of water production. The water loss due to leakage is estimated to be 20 per cent of the total production. The high unrecorded usage is due to under-billing of non-metered use. MCWD records indicate that of the 10,602 connections to the system, 5,212 are metered. An intensive water consumption study of a small area during April and May 1975 showed that metered customers use 23 per cent less water than unmetered customers.

Borrowers and Vendors

The water shortage in Cebu is emphasized by the presence of "borrowers" and the sale of water by private vendors. Tabulation of dwelling units receiving MCWD water in the intensive study area showed almost every dwelling unit connected to the distribution system [illegible] another dwelling unit with hand-carried water. (Actual data were 30 connections with 23 sub-users.) Each sub-user consists of one household with an average of 6 members. The average sub-user pays P7 per month to the MCWD customer for the water.

Water is vended to customers in bulk quantities by tank trucks and in 20 liter cans by tricycles. The tank truck vendors obtain water from MCWD or from their own deep wells and sell it to ships, hotels, industries, commercial establishments or private homes. The price of bulk water ranges from P1.25-8.25/cum depending on the type of customer. The tricycle vendors sell water to private homes at P5-15/cum, depending on the distance the vendor must travel. In comparison, MCWD customers pay P0.50/cum of water. Obviously, water vendors are able to get much higher prices because of the water shortage.

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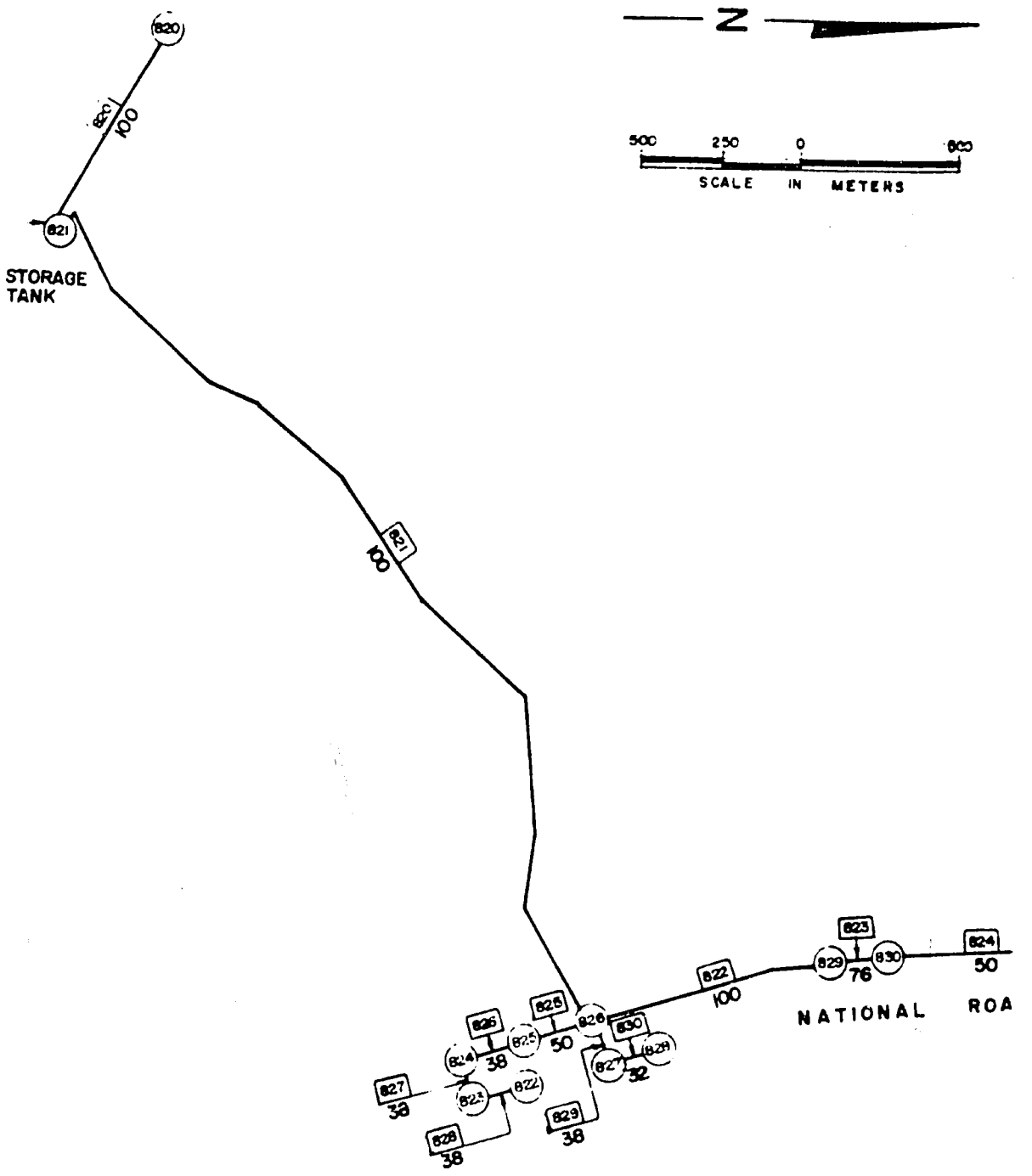

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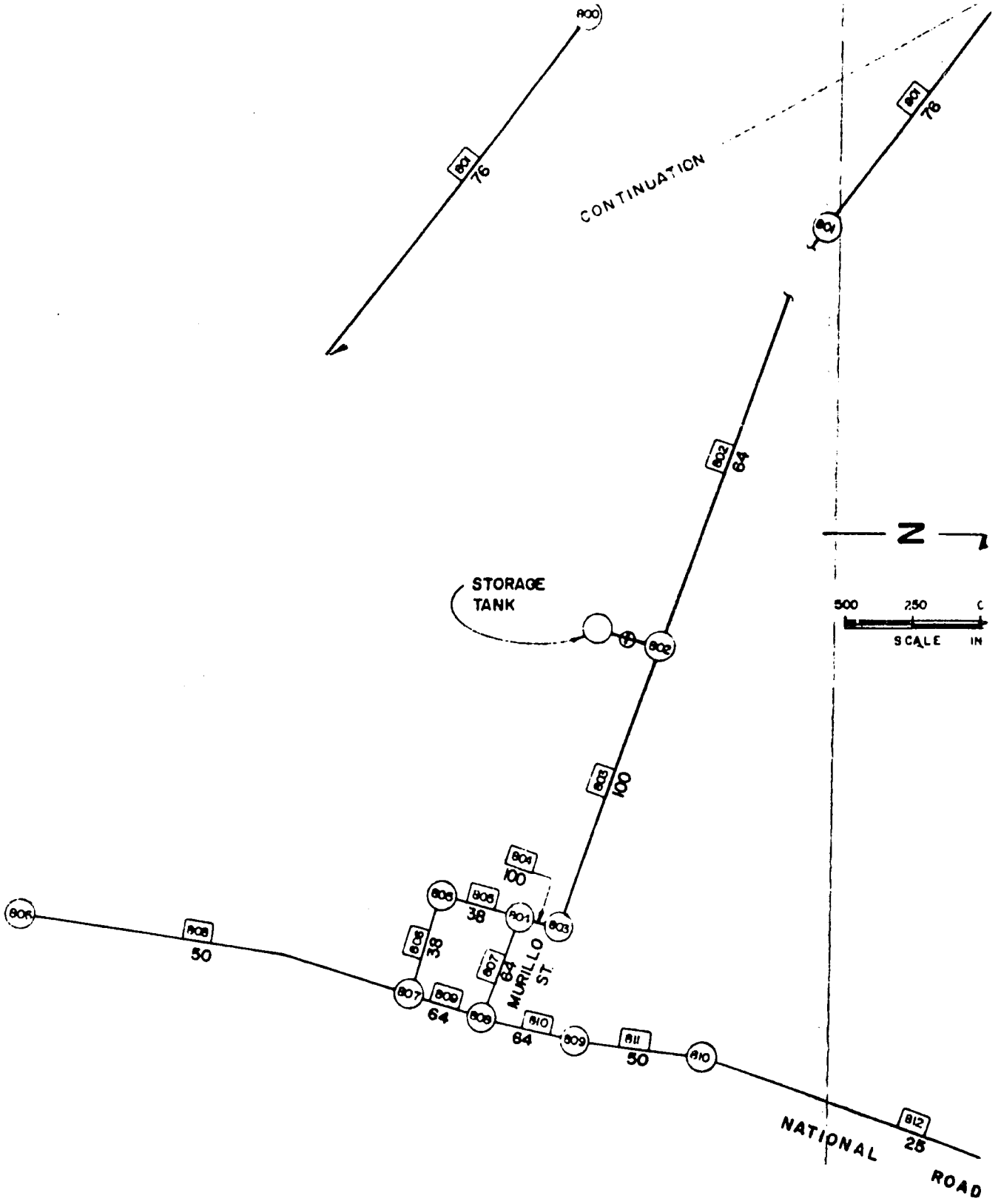
FEASIBILITY STUDY FOR WATER SUPPLY OF TEN PROVINCIAL AREAS CDM - LWUA



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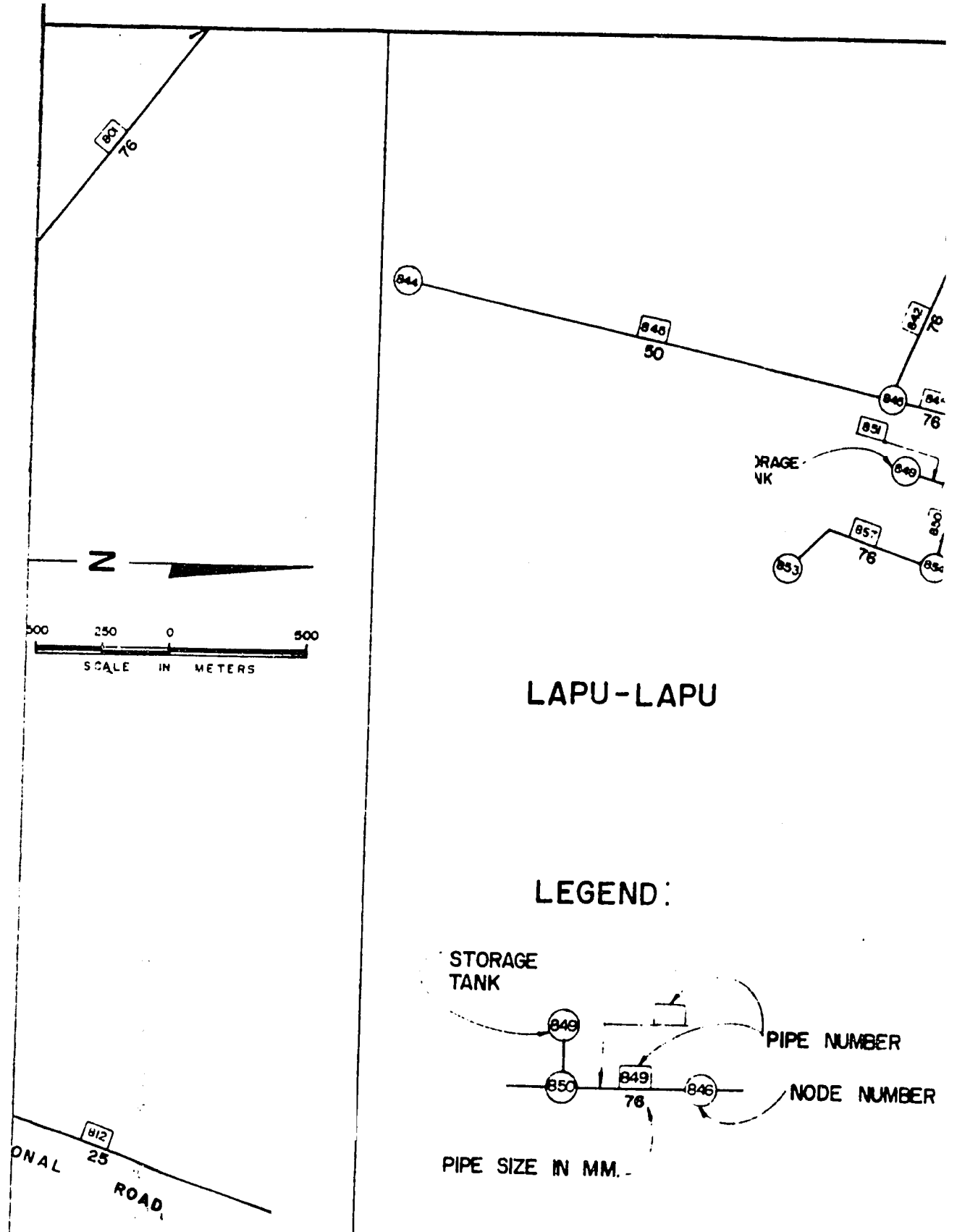

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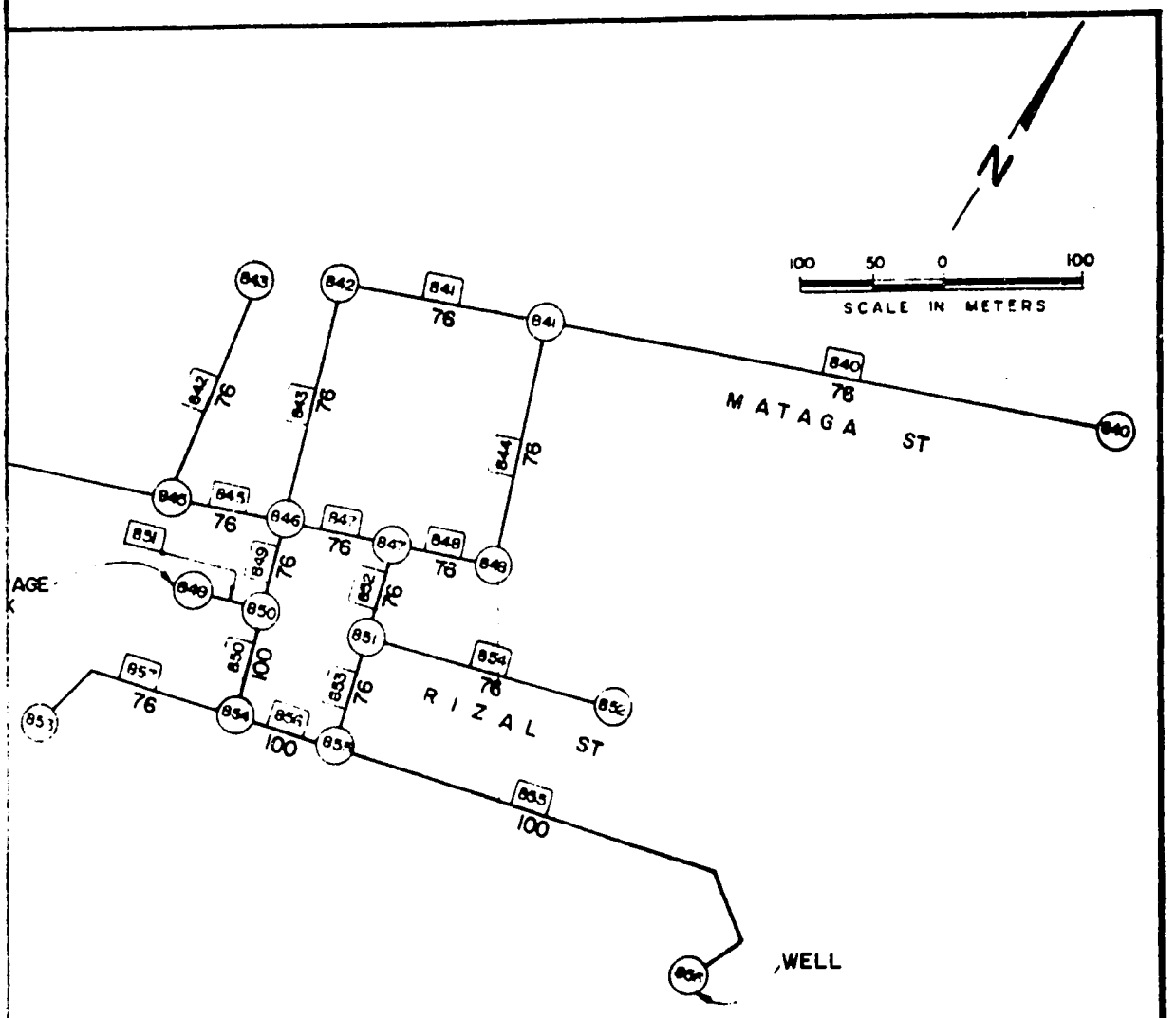

PIPE NUMBER

NODE NUMBER

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FIGURE IV-6
EXISTING WATER DISTRIBUTION SYSTEMS
SCHEMATIC PLANS

Mandaue. The distribution system in Mandaue (Figures IV-5c,d) was installed in 1933. The entire system consists of 100 mm or smaller diameter pipes. Some 4,530 cmmd is delivered to the distribution system through 3 connections to the Magubiao transmission line - Nodes 203, 205, and 237 in Figure IV-5d. There are 394 connections to the system, of which 390 have meters. There is no distribution storage for the Mandaue system.

Water pressures are also very low in the core city area. A 24-hour recording pressure gage showed that on May 13 pressures at the Mandaue fire station did not exceed .7m andfor long periods the pressure was zero.

Because the Mandaue system is only a sub-system of the MCWD, the same operational and maintenance problems discussed for Cebu are applicable to Mandaue.

Lapu-Lapu. The distribution system for Lapu-Lapu was constructed in 1974. Of the 2.74 km of pipes, 79 per cent is less than 100 mm in diameter. The distribution system is shown in Figure IV- 6 . The 2 wells pump about 2,180 cmmd of unchlorinated water into the distribution system. The system has a 190 cum storage tank located in the poblacion, which can store 8 per cent of the average daily supply. There are 420 active connections to the system (17 connections have been valved-off) all with flat-rate accounts.

Compostela. The Compostela distribution system (Figure IV-6) was installed in 1939. Originally, water was supplied by gravity from a spring 5.5 km from the municipality. A 270 cum storage tank was constructed along the transmission line and 1 km from the poblacion. The spring yield has decreased in the last 20 years, and the storage tank has been valved-off since 1960. Today, water is rationed to 191 service connections by valve operations similar to that in Cebu. A 24-hour reading showed that pressures range from .7 m to 8 m. There are 3 public wells in the municipality which help alleviate the water shortage.

Liloan. The Liloan distribution system will be completed this year. (See Figure IV- 6 .) The system consists of 2.98 km of pipes, 58 per cent of which is less than 100 mm in diameter. Pressures in the system are positive most of the time but are reduced to zero when the storage tank empties. A 24-hour reading at the City Hall showed a maximum pressure of 21 m and a minimum pressure of 0 when the tank emptied.

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Consolacion. At this time, the municipality of Consolacion has no public water supply or distribution system. Private wells supply most of the water required by the residents. A proposed public water supply plan for the municipality consists of the installation of 6.5 km of piping and the development of the Villa Roca Spring.

Deficiencies of the Existing Water Systems

In the Cebu-Mandaue water system, 80 per cent of the Buhisan Reservoir's original capacity is filled with silt; only 20 per cent, thus, is serviceable. The pumping units at Hagubiao Spring are antiquated and are in constant disrepair. All supply sources of the system lack control valves and flow measuring devices.

The small spring which is the only source of supply for Compostela is reportedly drying out. Chloride content of the Lapu-Lapu wells already exceeds the allowable limits.

The Tisa Treatment Plant is only operative from 4 to 8 months every year due to lack of raw water supply. It is poorly designed, inadequate and inefficiently operated. The plant has no flow-measuring devices. The alum concentration is merely estimated and uncontrolled. The filters are uncontrolled and lack necessary appurtenances for flexible operation. Moreover, the filter material is not of the appropriate size and gradation to provide optimum performance. The backwash system is inadequate; backwashing does not remove most of the accumulated solids on the filter media. Chlorination is uncontrolled. Chlorine gas from the storage system is simply allowed to flow under pressure to the solution tank.

Almost all the water produced in the MCWD area is delivered unchlorinated. The only existing treatment facilities can be found in the Cebu-Mandaue area. Therefore, significant potential exists for water-borne disease outbreaks.

The existing Cebu-Mandaue transmission system is inadequate for present demands and has no valves or meters for proper operation.

Most deficiencies in the 5 distribution systems within the present MCWD service area are similar. The significant deficiencies are the water shortage, system age, water accountability, inadequate chlorination, and poor design of system improvements.

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Water Shortage

The water shortage affects the system pressures, fire-fighting potential, and consumption patterns. Because water must be rationed, pressures fluctuate over a wide range and often become negative. The negative pressures increase the possibility of contaminated water entering the distribution system. Areas receiving no water are extremely vulnerable to fires until water service can be restored to the area. Many water district customers must modify their consumption patterns because of the water rationing. Some get water only during night-time hours and others only during day-time hours. Such service strains any goodwill developed between customers and the water district.

Potential water customers are, in the best of circumstances, sub-users who obtain their water from dwellings connected to the distribution system. Other potential customers must pay vendors excessive rates for water which they could buy from MCWD at much lower rates.

Distribution System Age

The distribution system for Cebu and Mandaue is largely over 40 years old. Field tests show that because of reduced carrying capacity the older pipes have likely contributed to the low pressures and marginal fire fighting capabilities in these areas.

Water Accountability

Of the approximate total production of 40,000 cmd, only 12,000 cmd is actually billed to the customers. Approximately 50 per cent of the connections are metered and of these 62 per cent are estimated to function properly. Connections without meters and non-functioning meters are billed on a flat-rate basis, a situation that encourages the wastage of water.

Poor Design of System Improvements

Improvements made to the distribution system are poorly designed. Two improvements made in recent years illustrate the situation. The Mabolo pump station was installed for the purpose of improving system pressures in the Cebu Central District area. On its initial operation, the pump station pumped the Hagubiao transmission line dry in a matter of minutes. The station was not operated again. The present improvement program includes the storage tank and pump station described in the preceding section on the existing distribution system. Both the storage tank and pump

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station are hydraulically incompatible with the existing system. These improvements represent capital expenditures that will not necessarily help in solving the operational difficulties of the existing system.

C. WATER QUALITY

Samples were taken from the Cebu-Mandaue and the Lapu-Lapu water systems. Analysis of water from the Buhisan Reservoir indicated high color, taste and hardness while other parameters were within the acceptable limits of the Philippine Drinking Water Standards. Results showed that taste and color of the water were removed by the Tisa plant although hardness remained. Samples also showed that the filter effluent slightly increased in turbidity.

The Nagubiao Spring is considered of good quality, except for marginal excess in hardness. Of the 6 wells in the Cebu-Mandaue system checked for chlorides, 4 showed excess amounts. Water from the Lapu-Lapu wells has excessive hardness, calcium and chlorides. Field tests indicated that samples from a public well in Compostela and from a spring in Liloan contained excessive chlorides.

Results of the analysis of the samples are shown in Table IV-1, and Appendix Table VII-B-2.

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TABLE IV- 2

WATER QUALITY TEST RESULTS
METROPOLITAN CEBU WATER DISTRICT

Cebu-Mandaue System

Test \ Location Date of Sampling		Allowable Limits *	Buhisan Reservoir Effluent (19-12-74)	Tisa Filter Effluent (10-12-74)	Hagubiao Spring (18-12-74)	Lapu-Lapu System Deep Well (18-12-74)
PHYSICAL						
Color	(unit)	15	20.0	0.0	0.0	0.0
Taste	(unit)	3	20.0			nil
Odor	(unit)					
Turbidity	(unit)	5	3.4	7.02	3.4	2.10
Solids	(mg/l)					
a. Total		500	414	384	440	1,480.0
b. Suspended			5.2			
CHEMICAL						
pH		7-8.5	8.1	7.4	7.8	7.6
Alkalinity(mg/l)						
a. Phenol			nil	nil	5.02	26.88
b. Methylorange			213.52	214.20	273.73	224.67
Total Hardness	(mg/l)		280.39	269.60	180.30	502.20
Calcium	(mg/l)	75	50.70	50.70	50.70	107.40
Magnesium	(mg/l)	50	16.81	22.28	18.96	24.14
Iron	(mg/l)	0.3	0.16	0.05	0.11	0.22
Fluoride	(mg/l)	1.5	0.10	0.10	0.22	nil
Chloride	(mg/l)	200	2.01	8.03	4.06	765.93
Sulfate	(mg/l)	200	56.50	61	32.5	54.50
Nitrate	(mg/l)					
Nitrite	(mg/l)		0.05	nil	nil	0.24
Manganese	(mg/l)	.1	nil	.05	nil	nil
Copper	(mg/l)	1.0				

* Philippine National Standards

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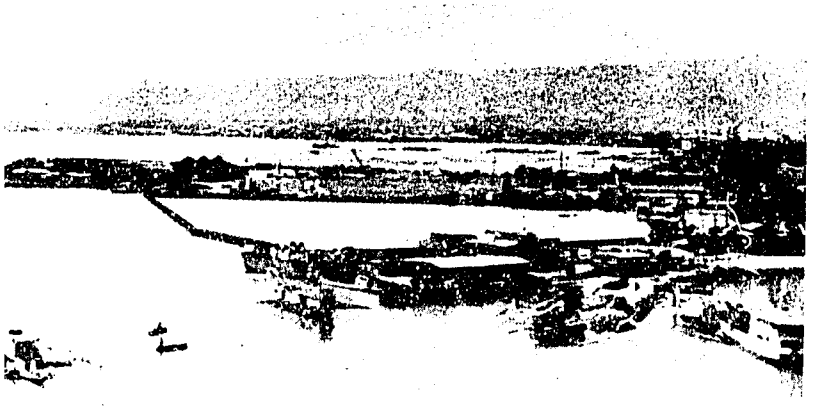
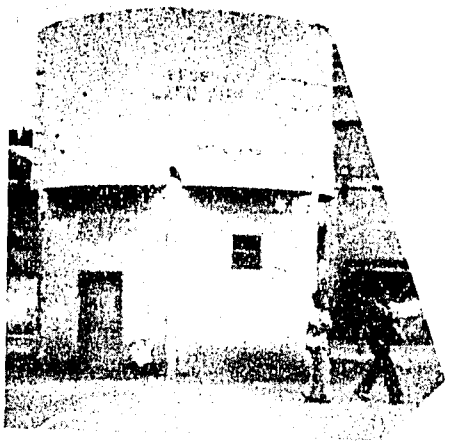
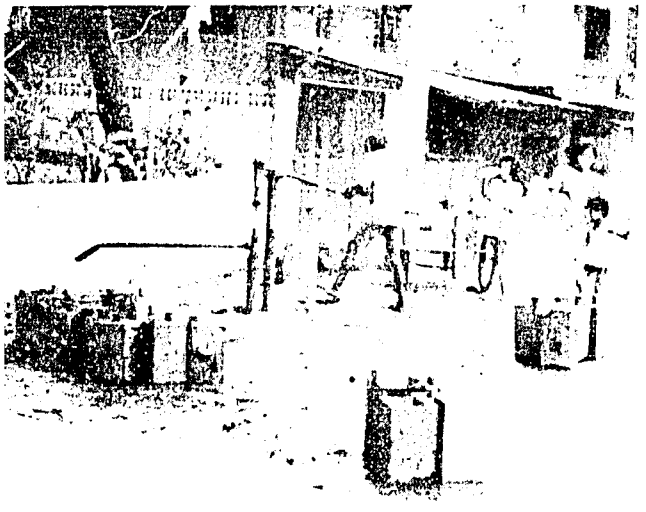


ECLAMATION AREA FROM MACTAN BRIDGE

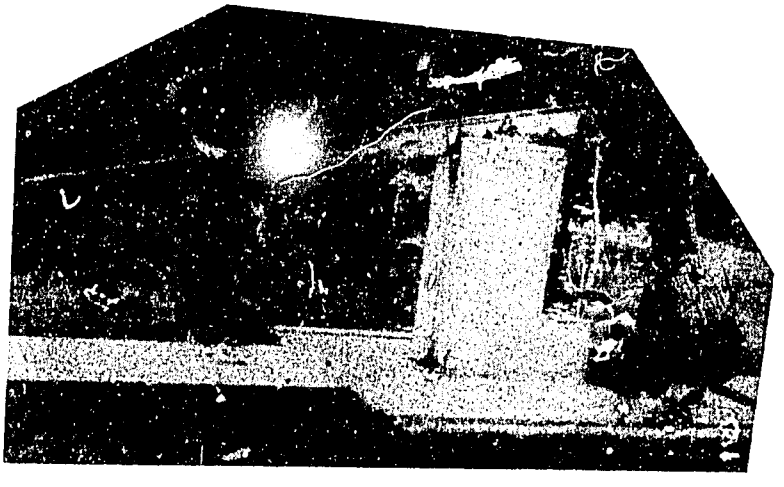


FIRE STORAGE RESERVOIR



PUBLIC WELL AND WATER CANS

DUG WELL IN MACTAN ISLAND



WATER SAMPLING – PUBLIC WELL COMPOSTELA

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CHAPTER V FEASIBILITY STUDY CRITERIA

A. GENERAL

The planning, design and economic criteria used in the feasibility studies have been derived from studies of local conditions, accepted practices, standards and methods here and abroad. These, together with a developed basis of cost estimates, have been utilized to evaluate and compare the various alternatives identified in the course of the study.

In the alternative analysis and evaluation, feasibility study criteria need not be as refined as that used in the detail development of the recommended scheme. The key point, however, must be consistency. As long as each alternative to be analyzed is subjected to similar criteria (or rules) the screening would be accomplished in a fair and consistent manner.

B. PLANNING CRITERIA

This water supply feasibility study has been guided by the following planning criteria (not in order of importance):

1. Regional Approach: Planning of facilities will be based on a regional basis, taking into account for the short-term district boundaries and in the long-term logical service areas beyond present district or political boundaries.

2. Sources of Water: Groundwater and surface water will be given equal emphasis as potential sources of water.

3. Self-Sufficiency: The recommended plan will be based on a system which would provide the highest quality of water service within the "ability to pay" by the consumers.

4. Conservation: Selection of alternative plans will consider water, power, chemicals and foreign exchange as a valuable resource which must be conserved to the best extent possible.

5. Stage Development: The long range implementation program will be based on four construction stages to satisfy projected requirements of a specific design year:

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Stage	Construction Implementation		Target Design Year
Emergency	1976-78	Continuous program	1980
First Stage	1978-80		1990
Second Stage	1987-90		2000
Future Stage	1997-2000		2020 (optional)

6. Alternative Plan Screening and Selection

From an array of identified plan alternatives, an interim plan will be selected on the basis of least (present worth) cost and other non-economic parameters. The selected (interim) plan will be tested for economic/financial feasibility.

If the interim plan is beyond the customers' "ability to pay", ways will be determined to reduce costs to consumers such as, lowering initial design standards; postponing treatment, fire protection for later stages; reducing effective interest rates to water districts, etc.

7. Skilled Manpower Shortage. The recommended plan must recognize, in the short term, the apparent shortage in skilled technical and managerial expertise. Emphasis will be given on the need for district personnel training and certification.

8. Water Quality. The feasibility study must identify present and future water quality problems and make recommendations towards providing a water supply that is safe, healthful and wholesome. It will develop conceptually long range water quality management plans to conserve the integrity of this valuable resource.

C. DESIGN CRITERIA *

Unit Water Demands

Average per capita domestic water consumption has been estimated for the project area, using past and historical water use records and those from similar cities. For the analysis of existing and current conditions, actual metered (or connected) customers and "borrowers" are considered separately. However, for near- and long-range planning, it has been assumed that "borrowers" will eventually become metered consumers. Per capita domestic use

* Refer to Appendix V-A.

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has been increased each year to account for economic growth within the community. (See Chapter VI for detailed unit water demands.)

Institutional and commercial water demands have been estimated as a percentage of domestic demand. Where no reliable records are available, a unit flow of 5 cum/day/ha (gross) has been used.

There is currently little or almost no heavy and/or "wet" industry in the project area. Land zoning plans, where available, show those areas designated for future industrial developments. Where no records are available, a unit flow of 10 cum/day/ha has been used in the water demand estimates.

Demand Variation

Maximum daily and peak hourly demands have been estimated from available records. For the basic analysis of the water supply facilities, the following ratios have been used:

- maximum day to average day ratio = 1.2
- peak hour to average day ratio = 1.5 - 2.0

Unaccountable Water

Review of the available records and consumption patterns indicate present unaccountable water to be in the order of 50% or more of the total water production. For preliminary design purposes, it has been assumed that:

- unaccountable water will be reduced gradually as positive improvements are added to the system.
- by 1990, unaccountable water will be about 25-30% of the total water production.
- by 2000, unaccountable water would be reduced to 20-25%.

(Unaccountable water includes leakage losses and unrecorded usage.)

D. ECONOMIC CRITERIA

Discount Rate

The opportunity cost of capital or discount rate proposed for use in this feasibility study is 12%. The discount rate will be used for economic screening of the technically viable alternatives.

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Two other rates have been developed: borrowing rate and social rate. The "borrowing rate" ranges from 9.9 to 10.2 per cent depending on the proportions coming from both foreign and local sources of financing. The "social rate" is a low interest rate such as those granted by financing institutions (Social Security System) for low cost housing loans. The "social rate of time preference" in the Philippines is now estimated at 6%.

Inflationary Trends

Over the two decades preceding 1970, the Philippines had enjoyed quite a reasonable degree of price stability, marred only by a brief period of inflation resulting from the 1960-62 devaluation. From 1959 to 1969, the Philippines experienced an average inflation of 5% per annum.

However, the pace of inflation from 1969 to the present has been at least double that of the post-1962 inflationary period. Political unrest, extraordinary monetary expansion in 1969 (election), typhoons, plant diseases, floods and a second devaluation early in 1970, and lately the oil crisis and worldwide inflation explain the greater severity of the recent inflation. Price control policies failed to suppress the spiralling prices.

While it is difficult to separate clearly the effects of domestic and external factors in the price level, it appears that in most recent years before 1973, external factors played a relatively small role in the price increases.

By contrast, the large price increases in 1973 were attributable mainly to external factors, i.e., the oil energy crisis. In this sense, the inflation of mid-1973-1974 was largely imported. The sharp increases in the price of crude oil, coupled with massive price increases in essential imports, primarily factor inputs, rigidities attendant to the aforementioned dualistic structure, and the usual reinforcing inflation psychology, have triggered off the almost 40% double-digit inflation in the country.

The NEDA foresees that the government can effectively combat inflationary tendencies in the economy so much so that inflation rate could be brought down to about 12 to 18 per cent for fiscal year 1975. A 12% to 18% rate of increase per year may sound optimistic given recent experiences, but it is not likely to be a remote possibility. This is because the rate of inflation in industrial countries is expected to decelerate from 15 to 10%. Commodity prices after posting substantial increases will start to

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drop.

The NWSA Water Supply Study for Greater Manila in 1969 assumed a 5% inflation rate based on 1965 prices. The LWUA project undertaken in 1972 assumed the same inflation rate based on mid-1972 prices. Recent developments such as the large increases in import bills due to oil crisis signify that the 5% inflation rate would be too low.

Projections done in this feasibility study indicate a general price escalation rate of 12% for the period 1975 through 1980, and about 15% for the years beyond until 1990, subject to the following conditions:

- o no major changes in the structure and stability of international political relation;
- o no significant changes in production technology as to reduce dependence on oil;
- o no dramatic increases in the price of energy originating from the cartel countries;
- o the government will not retrench (i.e., fight inflation at the price of the recession that goes with it) as forecasted;
- o no significant oil discoveries in the country and
- o no internal political upheavals of significant proportions.

For detail analysis, following rates are suggested:

- o 18% - for cost of construction materials
- o 10% - for wages and salaries (both during the construction and operating phases of the project)
- o 6-8% - for the cost of fuel (oil and power) on the assumption that the operation is either oil-based or utilizes electric power
- o 14% - for the cost of imported machinery and equipment (both during the construction and operating phases of the project)

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E. BASIS OF COST ESTIMATES

For purposes of cost comparison, a construction cost index for water supply projects has been developed, using 1965 prices as the base (=100). Unit costs and prices for the water supply feasibility studies have been projected to July 1976 price levels (=384). The construction cost index referred to above was developed by classifying water supply projects into general categories, such as equipment, local and imported; labor, skilled and unskilled; profit and overhead. To each category, a particular cost index as developed by the Central Bank of the Philippines was applied. The construction cost index, shown in Figure V-1, is a composite curve of these individual cost indices.

Construction cost curves have been developed for water treatment plants, pump stations, covered concrete ground reservoirs, elevated tanks, deep wells and water pipe complete and in place. Details are shown in Appendix V-B.

A word of caution: these cost curves are only to be used for estimating the relative cost magnitudes of the various plan alternatives. Use of these curves expedites the cost comparison and evaluation. It is not intended that these curves be used in the detailed cost estimates of the recommended plan.

F. CONSTRUCTION METHODS AND MATERIALS

The construction of water supply system components such as source of supply facilities, transmission mains, treatment and distribution system works requires a wide range of construction procedures and specific materials designed for each purpose. Construction may vary from the laying of small underground pipelines to the construction of relatively large structures; including the construction of buildings, installation of complicated mechanical and electrical equipment, excavation of all types, construction below ground level, pavement removal and replacement, and a host of other types of construction depending on the nature, magnitude and complexity of the waterworks project. Appendix V-C describes the materials and methods of importance in obtaining the class of construction needed to carry out the intent of the preliminary design. Construction must be such that proper and economical operation is assured in order to protect the large investment that must be made to achieve the goal, which is to make an adequate supply of safe and potable water available to the people, within reasonable cost.

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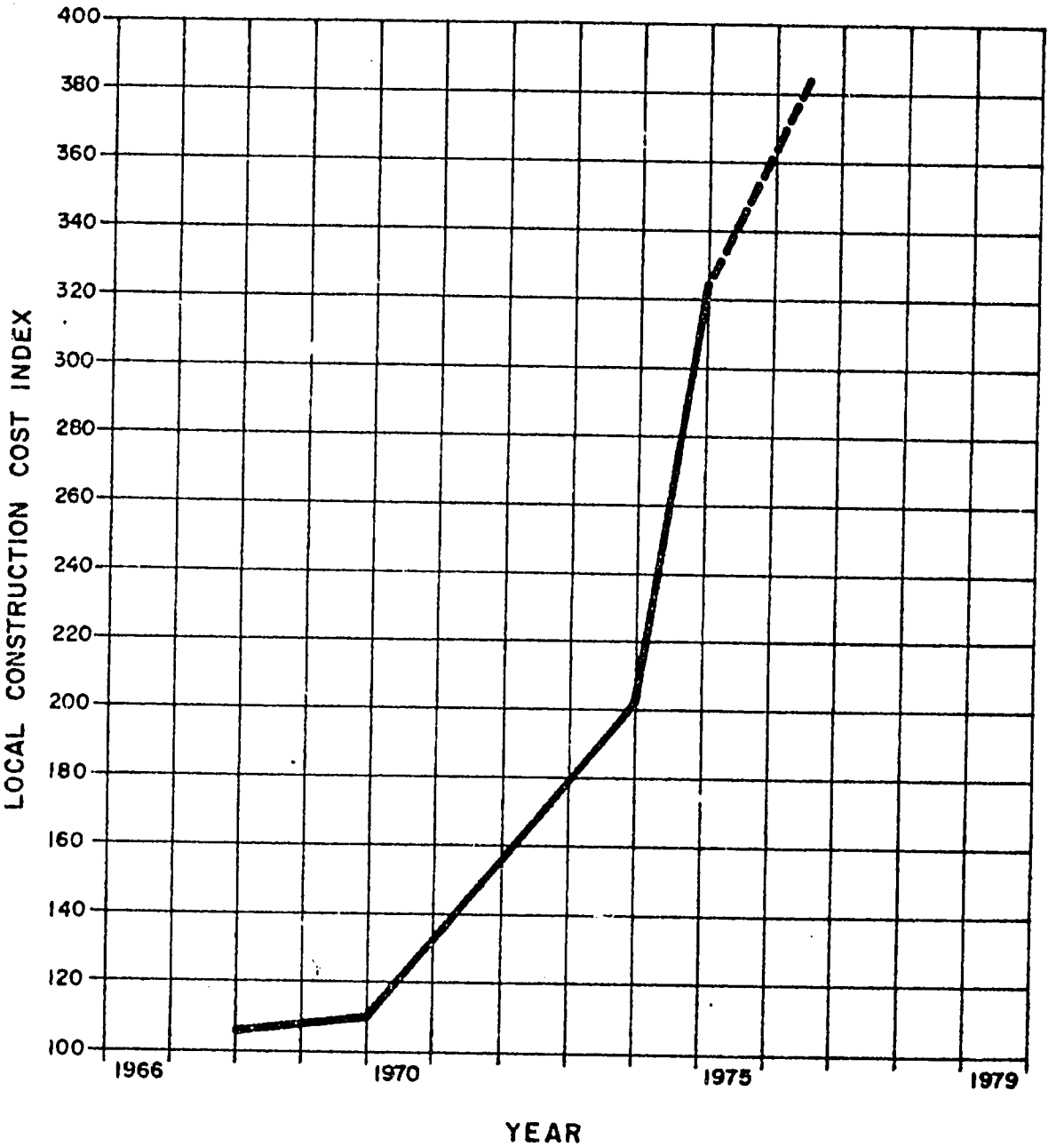

NOTE :

BASE YEAR IS 1965, WITH
CONSTRUCTION COST INDEX = 100

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FIGURE V-1
LOCAL CONSTRUCTION COST INDEX

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G. IMPLEMENTATION SCHEDULE

For purposes of feasibility study and economic/financial analyses, an implementation schedule has been assumed. This probable time-table which covers the planning, design and construction phases is shown as follows :

Submission of Final Report of Feasibility Studies	July 1976
Acceptance of Water District, LWUA and Other Governmental Agencies	Sept 1976
Submission to Loan (Financing) Agency, Select Design Engineer	Dec 1976
Start Final Design	June 1977
Complete Final Design; Prequalify Contractor	Mar 1978
Start Construction	June 1978
Complete Construction (simple structures) . .	June 1980
(complex structures) . .	June 1981

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CHAPTER VI POPULATION AND WATER DEMAND PROJECTIONS

A. INTRODUCTION

Projecting future conditions has one specific application: to estimate trends into the future. Whether it is called forecasts, extrapolations, estimates or projections, it consists merely of extending some recorded pattern of growth from the past into the future. To accomplish such goal, it becomes necessary to outline a course of vital events by means of assumptions. Any calculations, for example, of future population are, by their nature, hypothetical. As actual predictions, they usually turn out rather poorly. However, experience in many engineering projects shows that it is more worthwhile to investigate or evaluate possible impacts on the proposed scheme of a different future condition of growth rate than what has been projected rather than to spend too much time and effort on the projection itself.

B. POPULATION PROJECTIONS

Population projections have taken into account individual past population trends in the component cities and municipalities of the project area, physical limits of the urban areas, current and proposed transport facilities, regional infrastructure, schools and colleges, military installations and national offices. The projected land use of the project area is shown in Figure VI-1.

Population trends indicate that within the present and future service area, population would increase from 446,000 in 1970 to 1,129,300 in the year 2000 with Cebu City accounting for about two-thirds of the total. (See Figure VI-2, Tables VI-1 and VI-2.) The growth rate between 1970 and 1980 is projected to average about 3.6 per cent per annum while the growth rate between 1980 and 1990 is projected to be 3.1 per cent. Growth rate for 1990-2000 is 2.7 per cent. Mandaue has the projected highest growth rates. Average densities will increase from 36/ha in 1970 to about 90/ha in the year 2000.

Of the total project area population, the served population is projected to represent 55 per cent in 1980, 70 per cent in 1990 and 85 per cent in the year 2000. (See Tables VI-3 and VI-4.) Thus, the served population would increase from 190,900 in 1970 to about 605,000 in 1990 and 960,000 in the year 2000. This represents a five-fold increase in 30 years.

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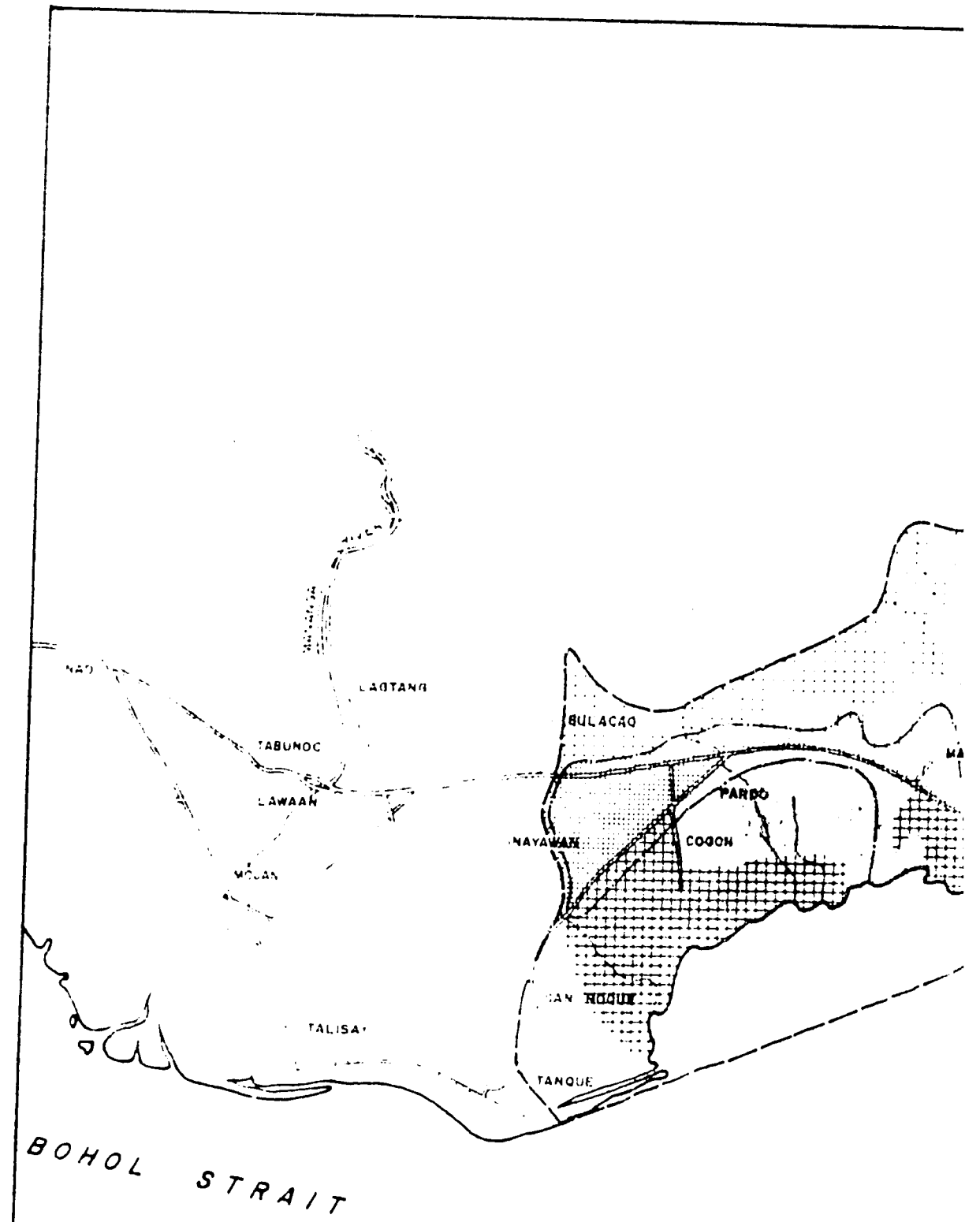

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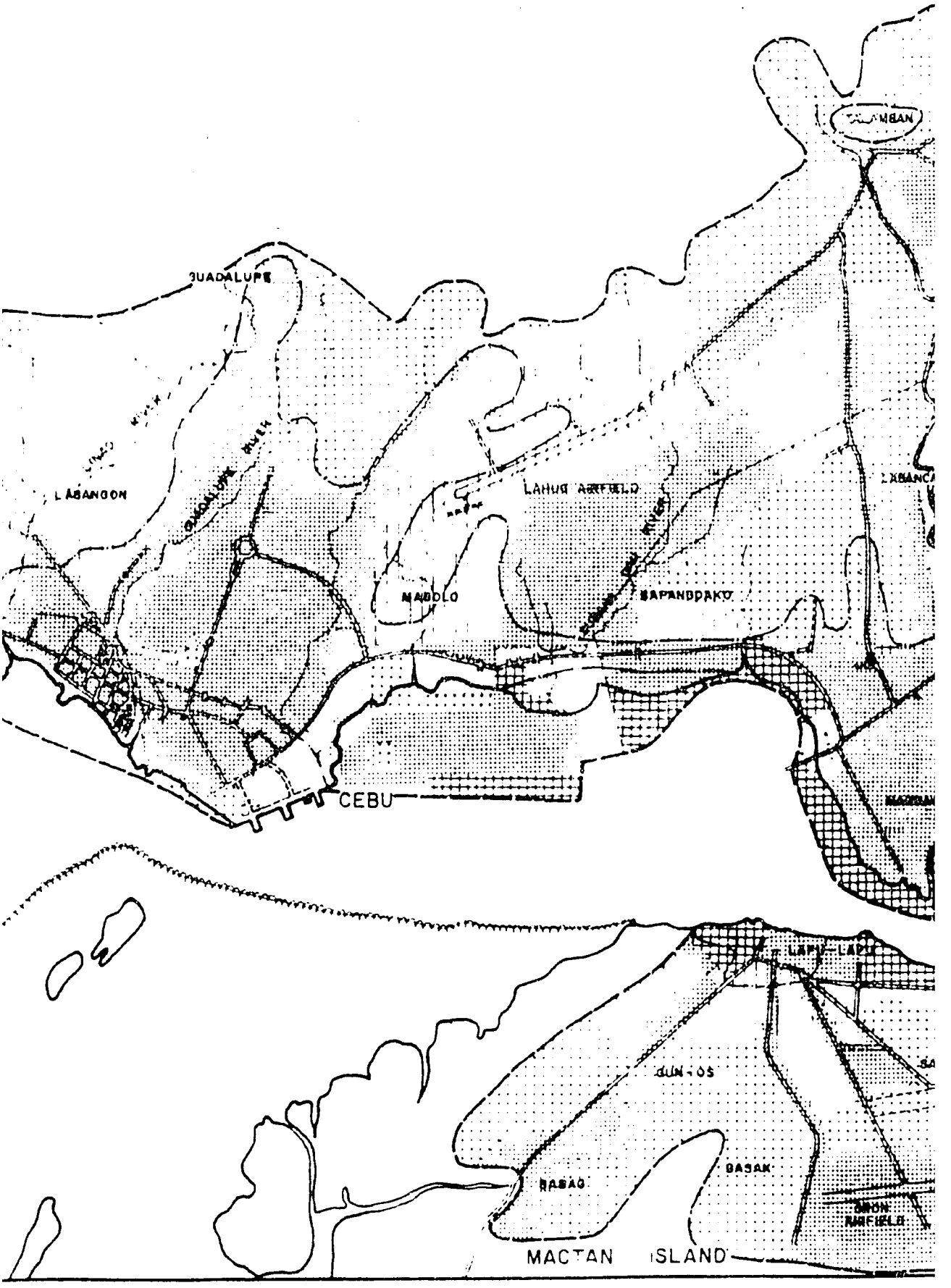
CDM - LNUA



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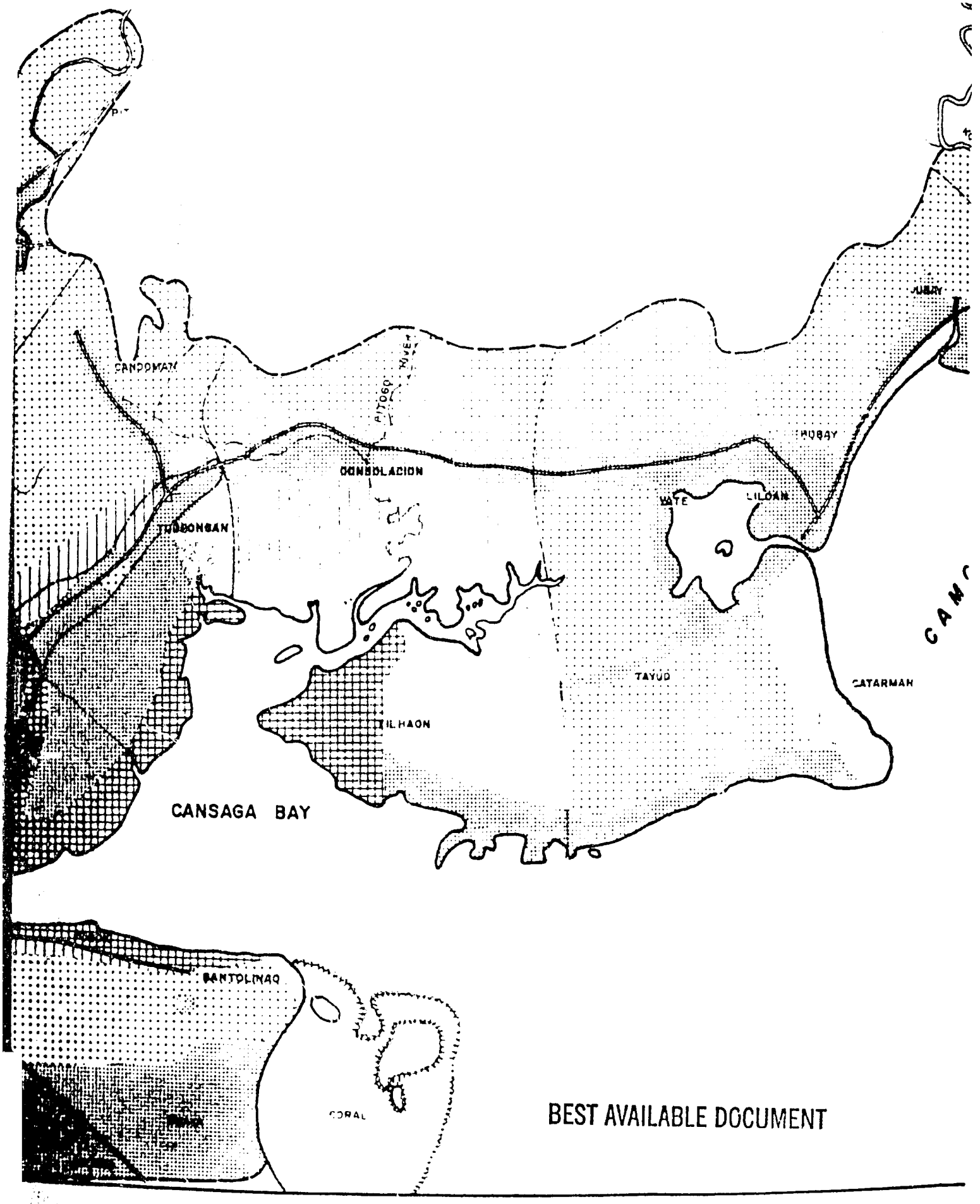

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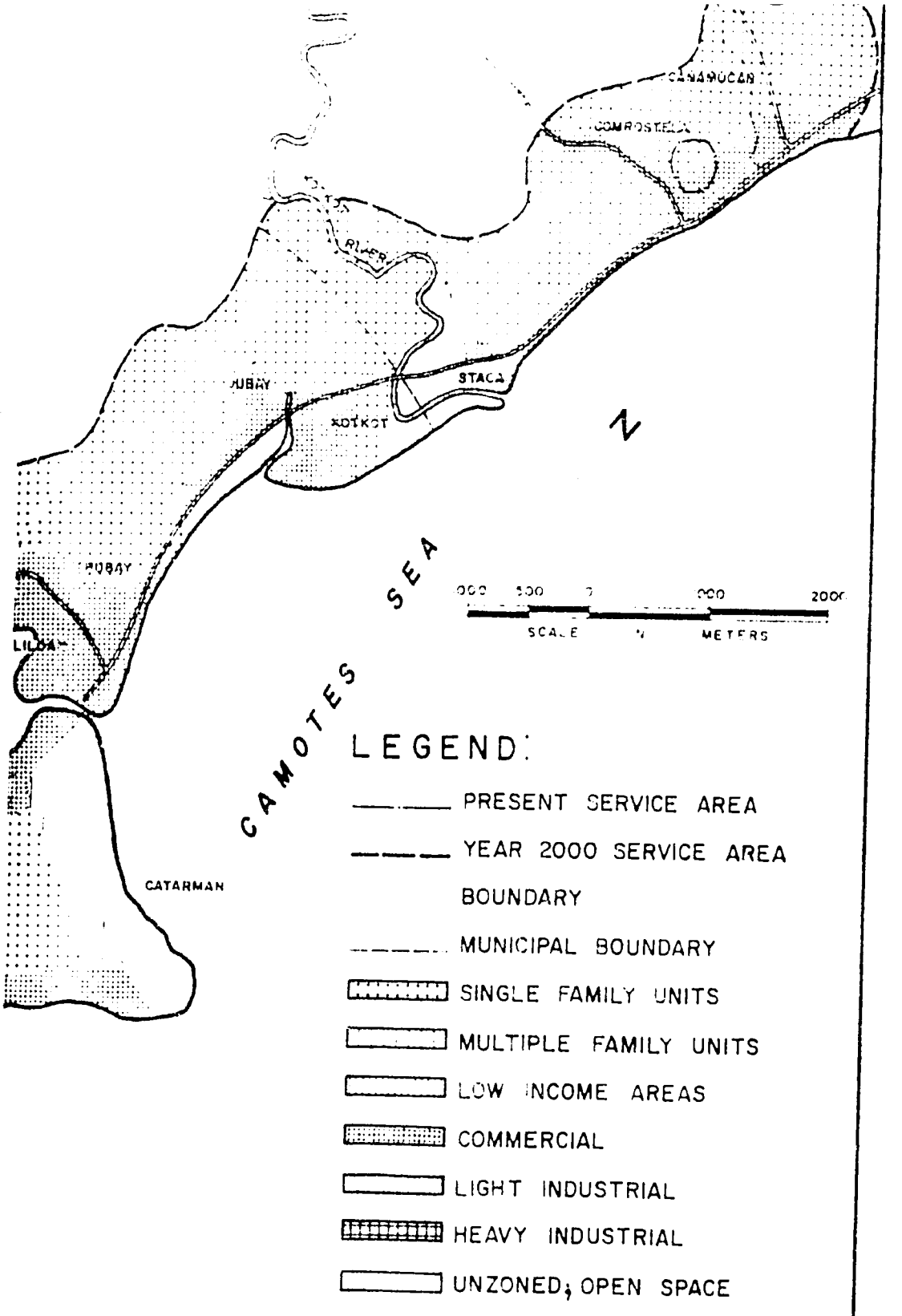

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FIGURE II-
LAND USE MAP

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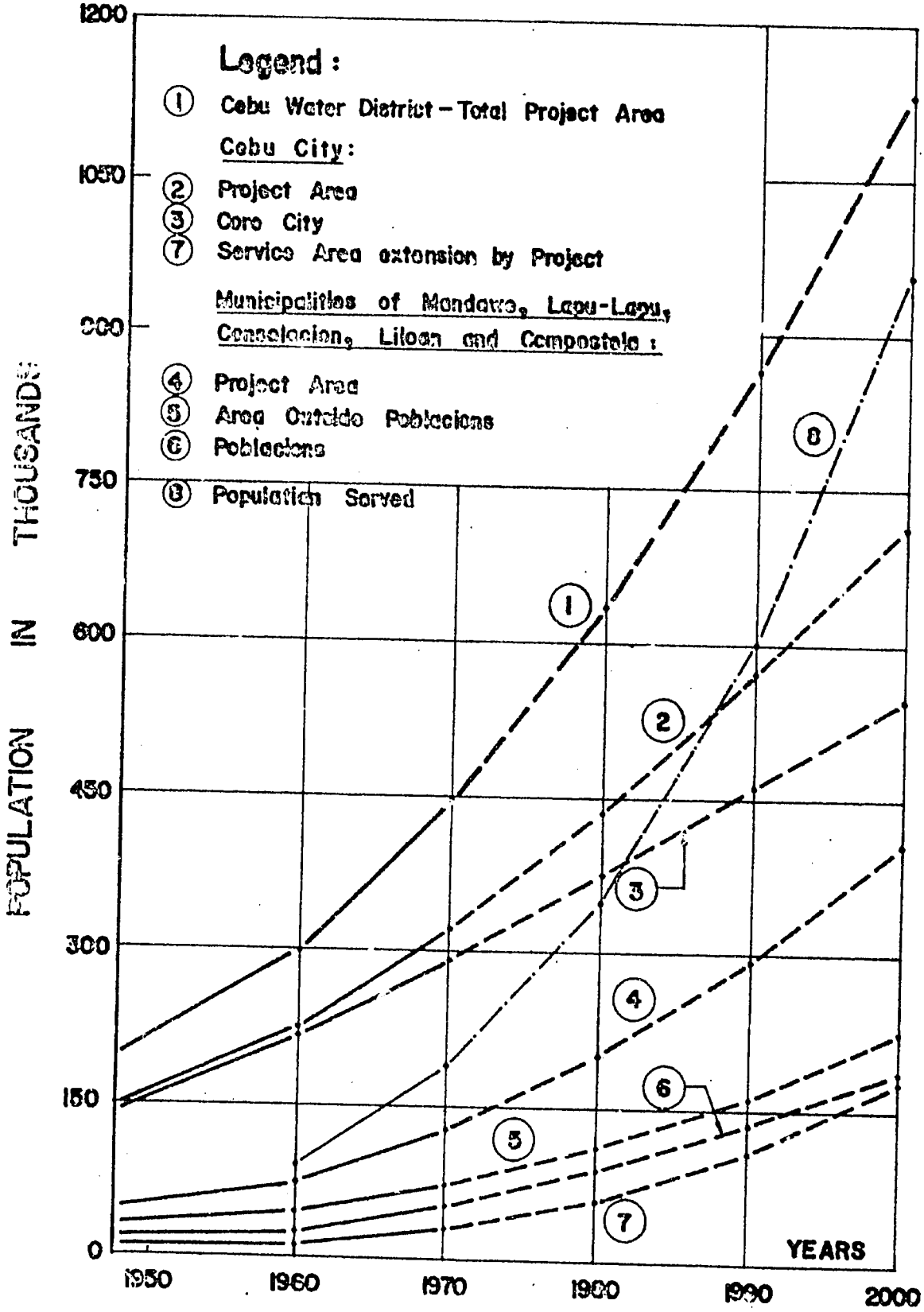

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FIGURE VI-2
METROPOLITAN CEBU WATER DISTRICT
POPULATION PROJECTIONS

TABLE VI-1

POPULATION - PAST TRENDS AND PROJECTIONS
METROPOLITAN CEBU WATER DISTRICT

	CEBU CITY								
	Core City A = 1,800 ha			Year 2000 Extension A = 3,500 ha			Total A = 5,300 ha		
Year	Population	Density (P/Ha)	Growth Rate (%)	Population	Density (P/Ha)	Growth Rate (%)	Population	Density (P/Ha)	Growth Rate (%)
1948	141,103	78		7,215	2.1		148,324	28.4	
			3.5			5.1			3.5
1960	213,100	118		13,608	3.9		226,708	42.8	
			3.0			8.0			3.5
1970	290,325	161		30,427	8.7		320,752	60.5	
			2.8			7.0			3.0
1980	375,500	209		59,800	17		435,300	82.1	
			2.2		6.0				2.8
1990	464,000	258		107,000	31		571,000	108	
			1.7			5.0			2.4
2000	543,300	302		175,000	50		718,300	136	

	MANDAUE								
	Present Service Area* 534 ha			Year 2000 Extension (1,685 ha)			Total 2,190 ha		
Year	Population	Density (P/Ha)	Growth Rate (%)	Population	Density (P/Ha)	Growth Rate (%)	Population	Density (P/Ha)	Growth Rate (%)
1948	8,120	16		6,800	4.0		16,920	6.8	
			6.3			3.3			5.0
1960	17,178	34		9,800	5.8		26,978	12.3	
			8.0			5.2			7.4
1970	38,532	76		16,200	9.6		54,732	25.0	
			6.0			5.0			6.0
1980	69,000	137		26,400	15.7		95,400	43.6	
			6.0			4.0			4.0
1990	102,000	202		39,000	23.2		141,000	83.7	
			3.0			4.0			3.3
2000	137,000	271		58,000	34.4		195,000	116.0	

*Includes the poblacion (area: 420 ha).

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61

TABLE VI-1 (Cont.)

LILOAN

Year	Poblacion A = 260 ha Population	Density (P/Ha)	Growth Rate (%)	Year 2000 Extension A = 1,515 ha Population	Density (P/Ha)	Growth Rate (%)	Total A = 1,775 ha Population	Density (P/Ha)	Growth Rate (%)
1948	2,122	8.2		5,838	3.9		7,960	4.5	
			2.5			2.6			2.4
1960	2,812	10.8		7,668	5.1		10,480	5.9	
			4.0			5.5			5.1
1970	4,152	16.0		13,168	8.7		17,320	9.8	
			3.5			4.5			4.3
1980	5,850	22.5		20,400	13.5		26,250	14.8	
			5.0			4.0			4.3
1990	9,600	36.9		30,200	20.0		39,800	22.4	
			4.0			4.0			4.0
2000	14,200	54.6		44,700	29.5		58,900	33.2	

COMPOSTELA

Year	Poblacion A = 470 ha Population	Density (P/Ha)	Growth Rate (%)	Year 2000 Extension A = 190 ha Population	Density (P/Ha)	Growth Rate (%)	Total A = 660 ha Population	Density (P/Ha)	Growth Rate (%)
1948	1,572	3.3		1,450	7.6		3,032	4.6	
			3.4			2.5			2.7
1960	2,290	4.9		1,930	10.2		4,220	6.4	
			3.5			3.0			3.2
1970	3,210	6.8		2,600	13.7		5,810	8.8	
			3.5			3.0			3.2
1980	4,500	9.6		3,500	18.4		8,000	12.1	
			4.0			3.0			3.6
1990	6,700	14.3		4,700	24.7		11,400	17.3	
			4.0			3.0			3.6
2000	10,000	21.0		6,300	33.0		16,300	24.7	

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TABLE VI-1 (Cont.)

LAPU-LAPU

Year	Poblacion A = 100 ha Population	Density (P/Ha)	Growth Rate (%)	Year 2000 Extension A = 1,290 ha Population	Density (P/Ha)	Growth Rate (%)	Total A = 1,390 ha Population	Density (P/Ha)	Growth Rate (%
1948	3,351	33.5	0	13,330	10.3	3.25	16,681	12.0	2.5
1960	3,321	33.2	2.5	19,300	15.0	5.19	22,621	16.2	4.8
1970	4,142	41.4	3.0	32,010	24.8	4.0	36,152	26.0	3.9
1980	5,600	56.0	3.5	47,400	36.7	3.5	53,000	38.1	3.5
1990	7,800	78.0	3.0	66,800	51.8	3.0	74,600	53.7	3.0
2000	10,500	105.0		89,500	69.0		100,000	72.0	

CONSOLACION

Year	Poblacion A = 400 ha Population	Density (P/Ha)	Growth Rate (%)	Year 2000 Extension A = 860 ha Population	Density (P/Ha)	Growth Rate (%)	Total A = 1,260 ha Population	Density (P/Ha)	Growth Rate (%)
1948	2,046	5.1	0	3,454	4.0	4.0	5,500	4.4	2.7
1960	2,019	5.1	4.5	5,531	6.4	4.3	7,550	6.0	4.3
1970	3,141	7.8	4.0	8,459	9.8	4.0	11,600	9.2	4.0
1980	4,600	11.5	6.0	12,500	14.5	4.0	17,100	13.6	4.6
1990	8,200	20.5	5.0	18,500	21.5	4.0	26,700	21.2	4.3
2000	13,400	33.5		27,400	31.8		40,800	32.4	

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TABLE VI-2

SUMMARY - POPULATIONS IN PROJECT AREA
METROPOLITAN CEBU WATER DISTRICT

	Cebu	Mandaue	Lapu-Lapu	Consolacion	Liloan	Compostela	Total
1948	148,324	16,920	16,681	5,500	7,960	3,032	198,417
1960	226,708	26,978	22,621	7,550	10,480	4,220	298,557
1970	320,752	54,732	36,152	11,600	17,320	5,810	446,366
1980	435,300	95,400	53,000	17,100	26,250	8,000	635,685
1990	571,000	141,000	74,600	26,700	39,800	11,400	865,364
2000	718,300	195,000	100,000	40,800	58,900	16,300	1,129,300

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TABLE VI-3

POPULATION SERVED ESTIMATES
METROPOLITAN CEBU WATER DISTRICT

	Cebu City						Other Municipalities					
	Core City (1,800 ha)			Outside Core City (3,500 ha)			Poblacion (1,735 ha)			Outside Poblacion (5,540 ha)		
Year	Pop.	Served	%	Pop.	Served	%	Pop.	Served	%	Pop.	Served	%
1960	213,100	75,435	25	13,600	-	-	27,600	15,120	55	44,230	-	-
1970	290,325	166,000	57	30,427	-	-	53,180	24,850	47	72,440	-	-
1980	375,500	245,000	65	59,800	18,000	30	89,550	54,000	60	110,200	33,000	30
1990	454,000	370,000	80	107,000	48,000	45	134,300	107,000	80	159,200	80,000	50
2000	543,300	515,000	95	175,000	113,000	65	185,000	175,000	95	225,900	157,000	70

TABLE VI-4

POPULATION SERVED ESTIMATES
METROPOLITAN CEBU WATER DISTRICT

Year	Total Population	Population Served	% Served
1960	298,600	90,600	30
1970	446,400	190,900	43
1980	635,100	350,000	55
1990	865,400	605,000	70
2000	1,129,300	960,000	85

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C. DEMAND PROJECTIONS

Water supply projections have been based on residential, commercial/institutional, industrial and unaccounted-for-water demands. Analyses were conducted on metered water use in the project area. The projections have considered income levels, multi-family residences, type of industry and zoning. Present (1975) and future (1990, 2000) average unit consumptions and average daily demands are presented in Tables VI-5 and VI-6.

The per capita average daily water demand, including an allowance for unaccountable water, is estimated to increase from 152 lpcd in 1975 to 267 lpcd in 2000. The combined domestic and non-domestic portion of the water demand will also increase from 76 lpcd in 1975 to 201 lpcd in 2000.

Average daily water demand is projected to increase from 40,500 cumd in 1975 to 256,300 cumd in the year 2000, at which time over 65 per cent represents domestic demand.

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TABLE VI-5

AVERAGE UNIT CONSUMPTION AND SUPPLY REQUIREMENT
METROPOLITAN CEBU WATER DISTRICT

Item/Year	1975[1]	1980[2]	1990[2]	2000[2]
Domestic, lpcd	45	135	155	175
Commercial/Institutional:				
(% of Domestic)	(10)	(10)	(10)	(10)
Equivalent lpcd	5	14	16	18
Industrial:				
(cumd/ha)	(45)	(10)	(10)	(10)
(area, ha)	340	355	755	1,155
Equivalent, lpcd	7	10	12	12
Sub-Total, lpcd	57	159	183	205
Unaccounted-For-Water				
(% Production)	(69)	(40)	(30)	(25)
Equivalent, lpcd	127	105	74	62
Losses, lpcd	37	40	37	37
Unrecorded Use, lpcd	90	65	37	25
Total Unit Demand/Supply Requirement	184	264	257	267

TABLE VI-6

AVERAGE DAILY WATER
DEMAND AND SUPPLY REQUIREMENT PROJECTIONS (CUMD)

Item/Year	1975	1980	1990	2000
Domestic	9,680	47,610	93,800	168,000
Commercial and Institutional	970	4,370	9,380	16,800
Industrial	1,540	3,550	7,550	11,550
Sub-Total	12,190	55,530	110,730	196,400
Unaccounted-For-Water	28,260	37,020	44,990	59,900
Total	40,450	92,550	155,720	256,300

Note: [1]Includes Cebu City and Mandaue City only.

[2]Includes all cities and municipalities in project area.

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CHAPTER VII WATER RESOURCES

A. GENERAL

The Metropolitan Cebu Water District obtains most of its supply from groundwater sources. The projected water requirements for the service areas, however, are much greater than the area's groundwater potential. Therefore, in addition to groundwater, it is necessary to consider surface water for future source development.

B. GROUNDWATER

The Metropolitan Cebu Water District overlies a typical coastal aquifer system and derives most of its water supply from groundwater, largely from wells and partly from springs. Wells have been investigated to be more productive than springs and can be considered as good supplement for surface water supply in the future improvement program.

The geologic section in the MCWD has been known from wells to a depth of 140 m and from outcrops in the hills to the west of the study area. The general geologic section is composed of the following (from bottom to top layers):

Cretaceous:	interbedded sandstones, siltstones, shales (predominant), locally carboniferous and local limestones.
Cretaceous:	andesitic volcanic rocks.
Miocene :	shales, sandstones, conglomerates, limestones.
Pliocene-Pleistocene:	Carcar formation, transgressive, coralline limestone with sandy, gravelly and rubbly beds; and its clastic facies.
Recent :	alluvium and beach deposits.

Aquifers. The aquifer systems of interest include the Carcar formation and alluvium, both widespread in the study area. These units have been examined from available information on existing wells and springs.

Figure VII-1 is a location map of existing wells and springs. Appendix Table VII-B-1 is a summary of aquifer data on 102 wells. Appendix Figures VII-B-1, 2 and 3 are stratigraphic logs of typical wells. Appendix Figures VII-B-4, 5, 6 and 7 are geologic cross-

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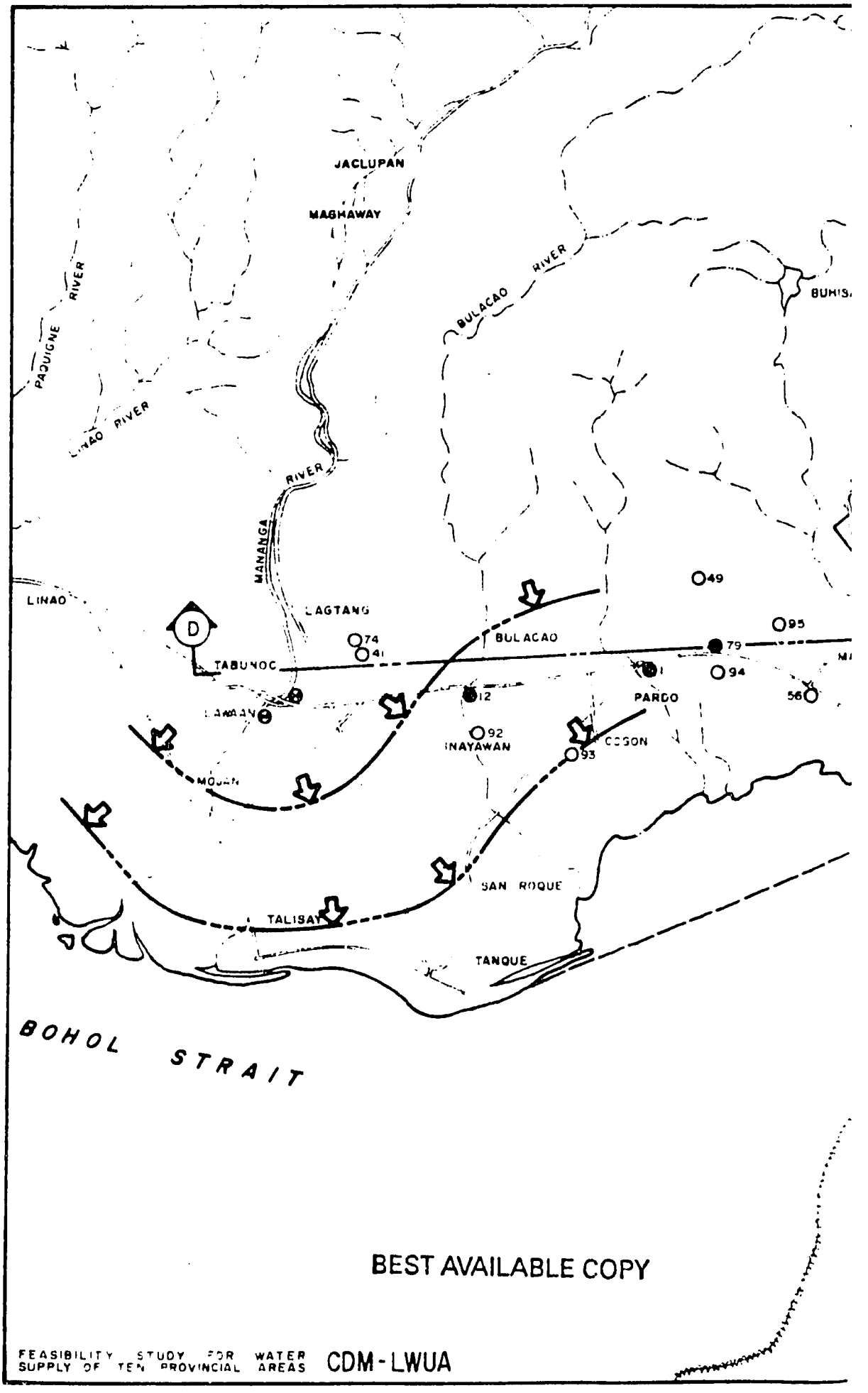

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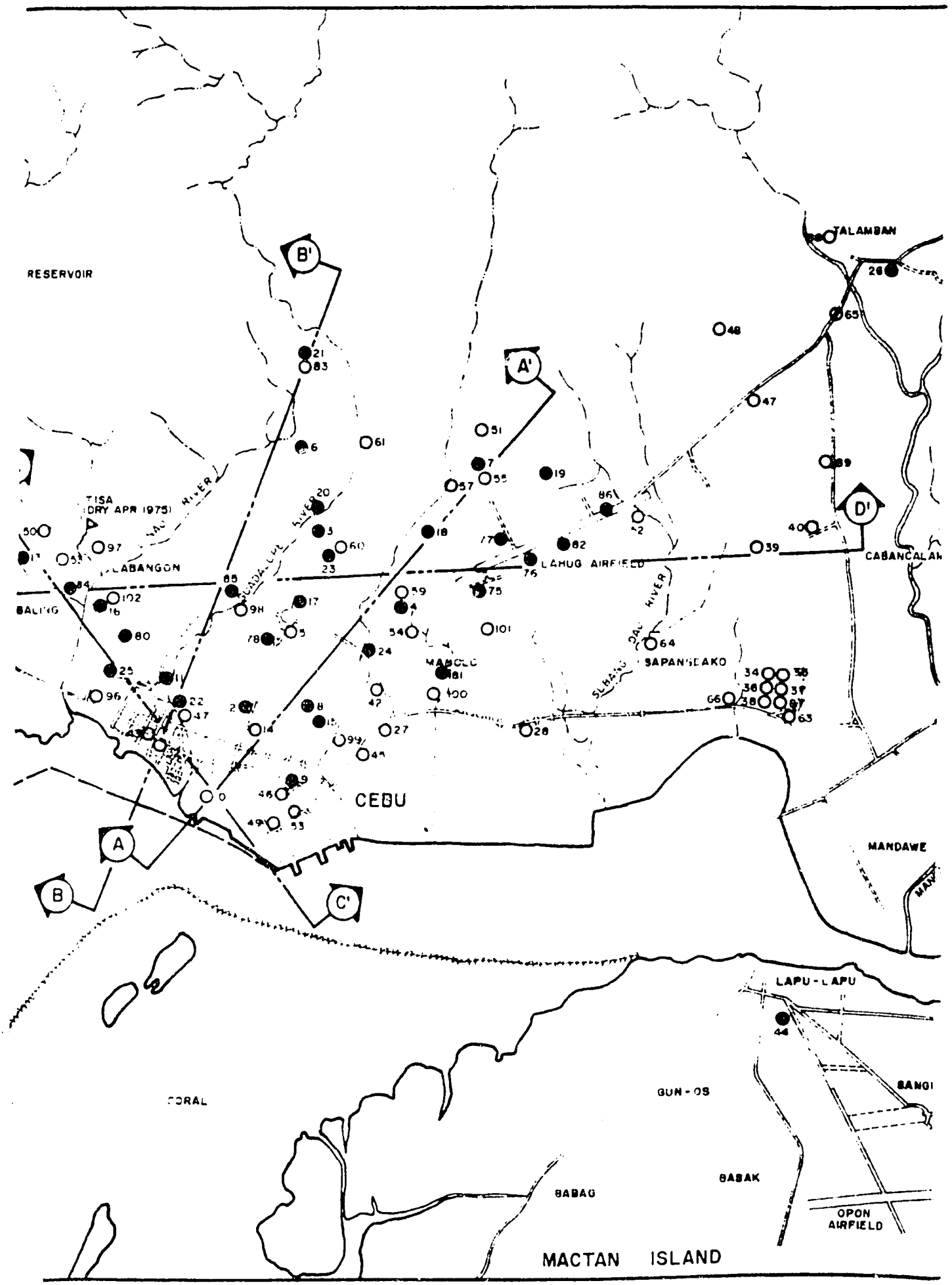

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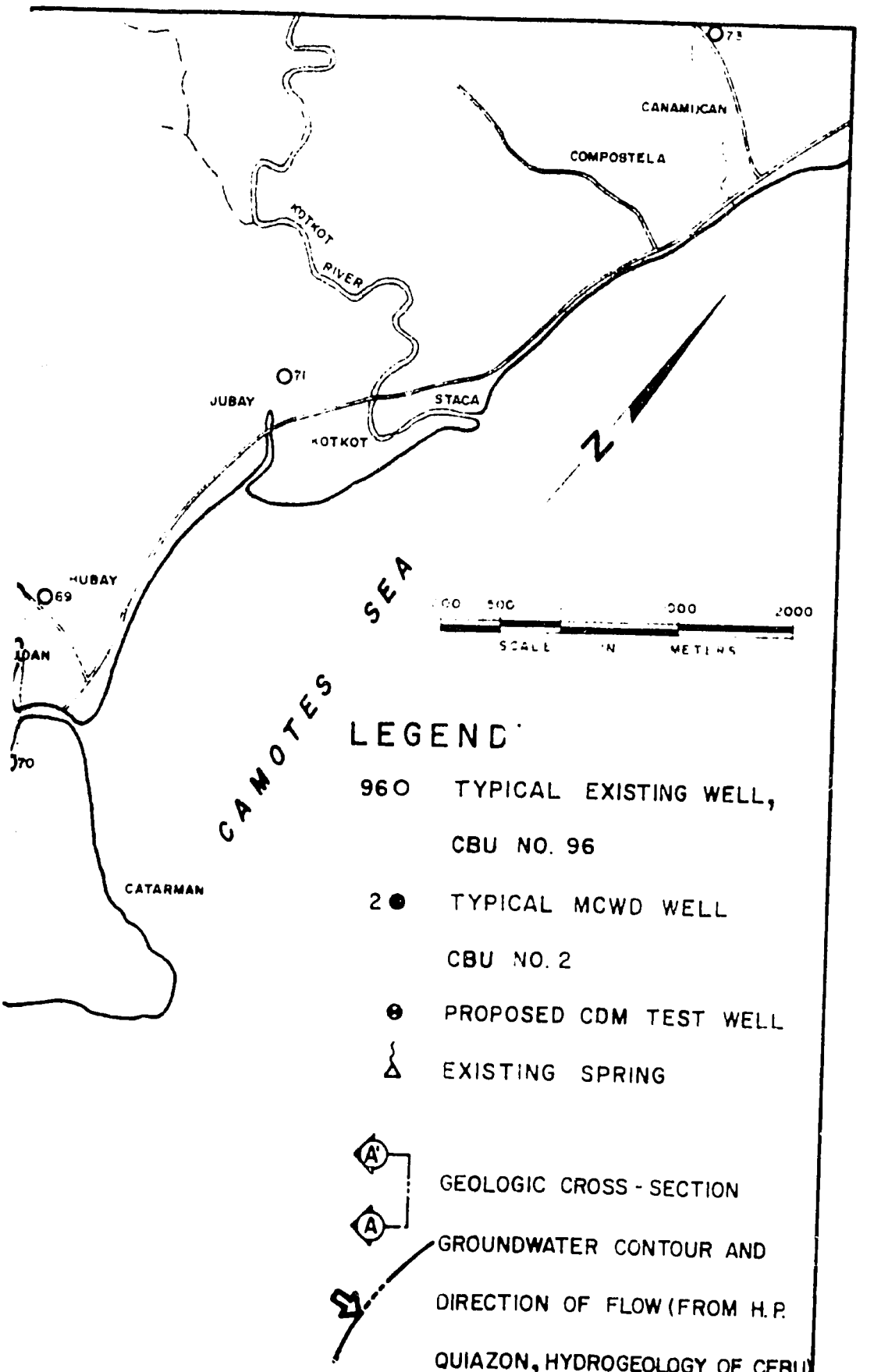

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FIGURE VII-1
WELL & SPRING LOCATION MAP

sections (their location is shown in Figure VII-1).

Based on the cross-sections and the well logs, the wells are produced from the Carcar limestones and interbedded gravel in inland areas and from gravel and sand beds near the shore. Data available on 17 wells show the following specific capacities (pumping rate divided by drawdown): maximum, 8.6 lps/m; average, 3.1 lps/m; and minimum, 0.2 lps/m. These imply aquifer transmissivities of about 1,025 sqmd, 375 sqmd and 25 sqmd, respectively. A reported pump test on the wells of the San Miguel Plant in Cebu City indicated a high transmissivity of about 1,700 sqmd. These figures show an aquifer system of variable characteristics. The productive wells will be able to produce more than 30 lps; most of the wells will produce more than 15 lps and other wells will simply not produce enough water supply.

The coarse-grained deposits of the Kotkot and Mananga Rivers are also potentially good aquifers in the study area. It is possible to catch most of the low flow of these 2 rivers with a series of shallow wells that can induce infiltration in the coarse gravel aquifer of the river channels. If these wells are of adequate sizes, enough water will pass downstream to recharge the aquifers supplying downstream towns such as Talisay.

Springs. Springs occur whenever a water table intersects the land surface or whenever a natural conduit extends to the land surface from an aquifer with enough hydraulic head to force the water out. Springs are common in areas of high water table, either from a fully saturated section or perched as a result of an underlying impervious bed, where erosion incises the land surface. Thus, they tend to occur in gulleys or canyons.

Springs occur at many places in Cebu island. They tend to be concentrated in the coastal plains around the periphery of the island between the mountainous interior and seashore. A Bureau of Mines reconnaissance survey in 1972 noted springs at about 30 different locations, with measured yields ranging from 25 cumd to 65,450 cumd.

In the MCWD, there are several springs generally occurring in the Carcar formation. In this chapter, the Hagubiao, Liloan and Compostela Springs are discussed since they are partially developed as public supply sources. Other smaller springs relevant to this study, namely Pulpugan Spring and Danao City Springs (outside MCWD) yield very small quantity of water and Tisa Springs have already dried out.

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Hagubiao Spring. This is the largest known spring in the MCWD. (Chapter IV describes the existing facilities in the spring.) The spring emerges at an altitude of about 4 m above sea level in two prominent outlets a few meters apart. The discharge combines in an adjacent small pool from which it flows to waste through a channel meandering to the seashore, about 1,500 m to the northeast. Available drawings suggest that a temporary gaging weir was installed in this channel in 1922. Surviving records dated September 1922 show observations on the spring yield: 28,590 cumd and 24,620 cumd.

The pumping station which was constructed in 1934 has had minor structural modifications and numerous major revisions to pumps, engines and piping. Records suggest that there have always been 4 pumps in the station, each with nominal capacity of about 5,400 cumd. All spring yield in excess of pump capacity flows to waste in the original spring outlet channel to the sea. There are no operating records on the pump station to permit accurate estimates of either spring yield or quantity pumped to the city over the operational history of the facility. However, the technical staff associated with the system for many years has reported an obvious long term decline in yield. They have indicated that the spring yield has normally appeared to fluctuate directly with the seasons, such that it is usually possible to operate 3 or 4 pumps only during the rainy months while spring flow is inadequate to support this rate of pumping in the drier periods.

There are no operative flow measuring facilities on any of the 4 pumps at Hagubiao or to determine the volume overflowing to waste. Accordingly, as part of this investigation, pumped discharge was measured by installing a pitotmeter in the 350 mm diameter main (discharge line) just outside the pump station. A temporary gaging weir was installed in the spring overflow channel, to measure the overflow. Total spring yields were determined on 2 dates and are shown as follows:

Date 1975	Pumped Discharge (cumd)	Overflow (cumd)	Total Spring Yield (cumd)
17 Apr	10,380	3,070	13,450
1 May	8,700	4,300	13,000

On these 2 dates, 2 pumps (numbers 3 and 4) were operating; the other two were put out of service for repair.

If the 1922 (rainy season) flow observation records are accepted as correct, the discharge measured in April 1975 suggests a reduction in yield of about 50 per cent over the

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71

intervening 53 years.

As discussed, data available are insufficient to permit definite quantitative analysis of the factors contributing to this apparent decline in flow. However, given the length of time it has supplied a substantial fraction of the city's water and its present measured yield, it may be reasonable to expect a change in yield relatively slowly from year to year. If the spring outlet structure is cleaned to insure that the yield is not being locally restricted by accumulated sediment and the flow is regularly measured and recorded, it may be assumed that the spring can yield about the observed 13,000 cumd for the short-term future (5 years) and from then on, the longer-term trend will be determined.

Liloan Spring. The Liloan water supply, which is under construction, is derived from this nearby spring estimated to produce from 1,350 to 4,000 cumd. From a brief examination, the lower quantity is considered more likely. This spring is not considered suitable for long term local supply to Liloan.

Compostela Spring. Water supply for Compostela is derived in part from a small spring with a measured discharge of 158 cumd. This is too small to be considered in an integrated water supply.

Wells (Cebu City-Mandaue Area). The MCWD water supply comes mainly from wells. In the Cebu City-Mandaue area which is the most developed area in the MCWD, current yield of the operating MCWD wells is estimated to total about 25,000 cumd. Private wells in the area are estimated to yield 11,000 cumd, about 4,000 cumd of which goes to one particular consumer. In addition, Hagubiao Spring provides about 12,000 cumd but it is located 3 km northeast of the area of high well development and its recharge area is, or originally was, separate. Thus, the area of major pumping, about 10 km along the coastline, produces about 36,000 cumd of groundwater which must be supported by the recharge area directly inland.

The recharge area is essentially the belt covered by the Carcar formation and the Recent sediments (although a small amount of additional recharge may come from the older rocks to the northwest and additional recharge is derived locally from infiltration into the coastal limestones and gravel from rivers with catchments in the mountains). This area is bounded by lines perpendicular to the coast and 10 km apart, within which pumping wells are concentrated. This area comprises about 50 sqkm.

The average annual rainfall is about 1,600 mm distributed in a short dry season and a long rainy season. Considering the nature

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72

of the aquifer outcrop area, and increasing the allocation of rainfall to compensate for additional recharge from imported water from the northwest, allocating 10 per cent of rainfall or 160 mm/yr to recharge seems reasonable and will result in an annual estimated recharge of 8 million cum or 22,000 cumd. A portion of this recharge water must be allowed to flow to the sea to preserve the seaward groundwater gradient and prevent the intrusion of saline water into near-shore wells. Normally, a little over 80 per cent of the recharge can be safely pumped in such a situation without requiring extensive measures to provide protection from saline intrusion. This would indicate that the 10-km zone would safely produce about 19,000 cumd of groundwater. Since the aquifer system obviously has been overpumped and saline water has intruded, it is suggested that withdrawals be limited to about 15,000 cumd or less as soon as possible to permit at least partial recovery of the aquifer. These estimates of safe yield are very rough and are based on very limited data. However, this observation is supported by an analysis of the progressive aquifer salinization and loss of piezometric head that reflects current gross overpumping.

Progressive Salinization. The Cebu City area is typical of many coastal groundwater provinces where recharge from rainfall and from streambed infiltration occurs. The coastal groundwater flows through alluvial and bedrock aquifers to the sea, the flow being at about right angle to the general direction of the coastline. Thus the area can be considered a corridor of groundwater flow extending from the mountains in the northwest to the sea in the southeast. This corridor is about 10 km wide from the northeast to southwest and supplies the major wells for Cebu City and Mandaue. Before significant pumping withdrawals began, this groundwater corridor was mainly a stable system[1] with the average annual recharge in the northwest balancing the discharge to the sea in the southeast. The water table, under this condition, sloped from the recharge area gently toward the sea, with some variations in slope resulting from differential aquifer permeability. At that time, the water table near the coast was above sea level. In some aquifers or aquifer zones, probably, even the groundwater piezometric level under the sea was considerably above sea level as a result of aquifer recharge and permeability relationships. Under these conditions, fresh water was flushing the aquifers and seawater was kept out.

As pumping on a small scale began (probably near the coast), the stability of the system was upset. Pumping removed water from storage, lowering the water table. This reduced the seaward gradient, consequently reducing the flow to the sea. The water table in the pumped area sank until a new equilibrium was formed

[1] Almost all groundwater was flowing to the sea with some slight loss to evapotranspiration where the water table approached the land surface and perhaps some loss to springs where the water table intercepted the land surface.

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wherein inflow (recharge) balanced a reduced outflow(seaward discharge plus pumped water). As rate of withdrawal by pumping increases, a situation has been reached where pumped discharge currently exceeds recharge. The water table in the area of heavy pumping continues to lower to below sea level. The lowering table has caused the groundwater discharge to the sea to cease, thus, inducing the seawater to flow into the aquifer and supply the pumping demand. In effect, another equilibrium is established wherein recharge plus seawater intrusion into the aquifer equals pumped discharge.[1]

This is a serious situation because as the water table (or piezometric level) approaches sea level pumping, the wells tend to draw saline water. Likewise, as the water table (or piezometric level) sinks below sea level, seawater intrudes the aquifers and the handpump wells in the area of intrusion become unfit for use. This situation is clearly shown in the decline in static water levels in the wells near the coast to below sea level. This situation is also shown in the progressive salinization of water produced from wells in that same coastal area. Recent tests of water from 11 wells originally tested 5 years ago showed significant increases in chlorides in 10 wells. (See Appendix Table VII-B-2.)

Another factor indicating progressive decline in piezometric levels is the decrease in yield of the Bagubiao and Pulpugan Springs. This is due to a local water table decline as water is drained off by the large groundwater sink under Cebu City. Tisa Springs in Cebu City have been completely dry for the same reason.

All of these factors indicate a pumping rate grossly in excess of recharge rate. Very roughly, they tend to confirm the previous approximation of a safe yield for this 10 km zone of 15,000 to 19,000 cumd.

The basic problem, therefore, is the overpumping of the aquifer, that is, pumpage exceeds recharge. However, the solution is not to construct new wells inland for additional water supply (as

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[1] In all the previous discussions, recharge has been assumed constant. This is not true, however, because as the levels in the corridor of groundwater flow decline, groundwater will be induced to flow into the corridor from the aquifers to the north and south as new directions of the steepest groundwater gradients are established, consequently, adding external recharge to the corridor. This effect normally does not significantly change the situation. Therefore, a simplified discussion has been chosen for this study. It does indicate that the pumping exceeds recharge to the 10 km corridor even more than the effects on the local water table would indicate. It also explains the decline of springs outside this corridor.

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is being done) because these new wells intercept the same limited flow of recharge water further upstream. Furthermore, new wells will deprive the existing wells of recharge and will accelerate the lowering of the groundwater levels with consequent increased salinization.

If a number of the wells in the congested pumping area that are equal in pumpage rate as the new inland wells would be phased out when the new wells are put into service, the critical situation in the coastal area would be slightly alleviated for a short time. The stored groundwater would, thus, tend to fill the below sea level depression in groundwater levels. But as pumping would continue at rates greater than recharge, the situation would also continue to deteriorate.

The ultimate solution is to reduce pumping in this area to 15,000 cumd or even less to allow the aquifer to recover (a long and slow process) or, at least, to prevent its deterioration. Meanwhile, it is obviously unrealistic for the MCWD to reduce pumping until alternate groundwater or surface water supplies are available.

Mananga River Area. Southwest of Cebu City, the Mananga River area offers prospects of a large interim and a less permanent groundwater source for MCWD. The water table contours (Figure VII-1) arch in semi-circle around the point where the river leaves the hills, outlining a groundwater mound indicative of a large concentrated recharge area.

A test program of 2 test wells is planned to determine if shallow infiltration wells can recover much of this water. It is expected that 10 shallow production wells, each producing 19 lps, can be installed. All these wells are outside the MCWD and might eventually compete with those of Talisay for water supply when the Talisay demand increases and the pumping rate eventually might have to be reduced. However, MCWD men have allowed exploration and planning in the area because they anticipate Talisay's eventual membership in the MCWD.

Half a kilometer from the Mananga River, well CBU-41 encountered an excellent section and was tested at 38 lps. It is proposed that 2 production wells, each producing at least 16 lps, can be constructed in this area, outside the MCWD.

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About 1 km northeast of CBU-41, on the northeast side of the Bulacao River, it is expected that 3 production wells, each producing 13 lps, can be constructed on the basis of data from existing nearby wells. This area is within the present MCWD.

Thus, the total additional supply expected from the Mananga River area is about 22,000 cumd. This quantity would be considered too much for so limited an area although the greater portion of it is expected to come directly from natural or induced infiltration of Mananga River water and the remainder should be within the recharge capability of the area.

Hagubiao, Pulpugan, Liloan Area. This 8 km-long zone northeast of Mandaue currently provides 15,000 cumd or more of spring water. The greater portion of the spring yield is used as municipal supply to Cebu City-Mandaue and the remaining portion is supplied to Liloan, with some of it wasted.

The spring discharge already appears to be close to the safe yield of the zone and the springs are very sensitive to changes in water table. In fact, Hagubiao and Pulpugan Springs appear to be less productive due to water level decline resulting from overpumping in the Cebu City-Mandaue area. Thus, it is recommended that no municipal wells be drilled in this 8 km zone from Mandaue to beyond Liloan in order to preserve the springs. If the springs eventually dry up, wells can then be drilled and probably produce as much or more water than the springs but at considerable expense.

Kotkot River area. The Kotkot River area, about 12 km northeast of Mandaue, also appears to have considerable potential as an intensive source of water produced from infiltration wells. It is anticipated that the river gravels can support 10 wells, each producing 19 lps. The water would be derived from river flow by natural or induced infiltration into the gravels.

Two wells, each producing 16 lps, are expected to be constructed from 1 to 2 km south of the river and should not affect the groundwater table, in order to protect the Liloan Spring.

The Kotkot River area is expected to produce about 19,000 cumd for the MCWD.

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Mactan Island

The effective area of Mactan Island for the purpose of estimating recharge would appear to be that area not cut off by salt estuaries or covered by salt swamps. This core area appears to be about 25 sqkm on the topographic map, but records indicate that wells in the southeastern portion of the island are saline and, for some reason, the fresh water zone does not reach to that point. Thus an effective recharge area of 20 sqkm is used. The estimated recharge is 140 mm/yr (considering the flat topography and thin soil cover overlying porous rocks and no imported water is added to recharge). The consequent recharge to the island that is effective in maintaining a bubble or lense of fresh water floating on the seawater in the deep beds is about 7,500 cumd. The greater part of this should not be pumped but should be allowed to flow to sea to maintain the fresh water lense under the island and to prevent further salt water encroachment into the aquifers. Thus, perhaps, 3,500 cumd could be developed safely. The population currently obtaining water from private wells is estimated to be over 90,000. If the daily per capita consumption is 20 lpd, the current private use is over 1,800 cumd. In addition, piped water is supplied to the city of Lapu-Lapu from 2 wells which are pumped alternately and deliver an average of about 1,200 cumd. Thus, the current withdrawals total about 3,000 cumd, almost the full safe yield if proper well location and spacing were used to minimize saline intrusion.

Under these conditions, it appears that groundwater on the island should be reserved for rural use and the metropolitan piped supply for Lapu-Lapu should be provided from the mainland as soon as possible. The existing wells for Lapu-Lapu piped supply produce saline water which has about 1,480 ppm of dissolved salts and is not generally used for drinking. Many or most of the other wells on the island are also saline. If further development of groundwater for interim supply to Lapu-Lapu is a necessity, the maximum development should be 3 dug or shallow drilled (15 m) wells located near the airport where the groundwater, at present, seems of the best quality. These wells should be pumped at a maximum rate of 6 lps and each will deliver a total of 1,500 cumd. The existing municipal wells should be phased out.

Proposed Test Well Program

The proposed test program is divided into 2 phases. The first phase which is in progress concerns testing the Mananga River area aquifers. Two 200 mm wells are being installed in the gravels of the active flood plain to a depth of about 25 m and will be tested

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to assess the potential of infiltration wells in intercepting the Mananga River surface flow and underflow. In addition, a pump test is planned for nearby well CBU-41 to determine the potential for production of the apparently favorable section.

The second phase is planned to test the Kotkot River area gravels to determine the potential of this area for infiltration wells. One or two 150- or 200-mm wells are proposed to be constructed in the Kotkot gravels to test their depth and permeability.

Estimated Groundwater Potential and Phasing. Under existing conditions, the estimated long term potential of groundwater in and near the MCWD area for total use includes the following:

Mananga River area	22,000 cumd
Cebu City-Mandaue area	15,000 "
Haguhiao-Pulpugan-Liloan area	14,000 "
Kotkot River area	19,000 "
Mactan Island	3,500 "

However vital considerations of water requirements, economics and timing make these estimates purely of academic interest for some time. Groundwater will have to provide all of the MCWD requirements until the surface water system becomes operational in 1982. The suggested phasing of groundwater exploitation consists of the installation of filtration wells as required to meet the demand along the floodplain of the Mananga River until aquifer response to pumping at low river flow indicates that the potential is fully utilized. At this time, further wells can be drilled to the northeast of the river until estimated potential of the area is fulfilled. After the Mananga River area is fully developed, the same procedure should be applied to the Kotkot River area with the use of infiltration wells as required until this potential is fully utilized. Subsequently, well construction should be extended toward the south. Economy of new well field development in the Mananga and Kotkot gravel beds, for the MCWD supply, will be investigated.

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The possible MCWD groundwater sources in 1982 are:

Mananga River area	22,000 cumd
Cebu City-Mandaue area	
Pre-1975 wells	19,000 "
12 1975 wells	14,000 "
Total MCWD wells	33,000 "
Hagubiao-Pulpugan-Liloan area	14,000 "
Kotkot River area	19,000 "
Mactan Island	1,500 "
Total (MCWD)	89,500 cumd

In addition to the 33,000 cumd produced from MCWD wells in the Cebu City-Mandaue area, it is estimated that about 11,000 cumd will still be pumped from private wells, reaching a total of 44,000 cumd but the system can probably safely supply less than 20,000 cumd. The entire system will still be short of water. It is only realistic to recognize that all operational wells producing even marginally acceptable water will be pumped. As a result, water quality in the Cebu City-Mandaue area will continue to deteriorate until surface water becomes available.

As surface water supply becomes available, the wells (particularly in Cebu City-Mandaue) should be phased out to allow the aquifer to recover, to reduce the salinization problem and to rejuvenate the springs. In later years, groundwater will again become necessary as a supplementary supply to defer further dam construction. Wells, by that time, should be phased back into the system as needed, reactivating the Cebu City-Mandaue wells and not reactivating any MCWD Mactan Island wells at all.

By the year 2000, the groundwater availability to MCWD is expected to be as follows:

Mananga River area	5,000 cumd
Cebu City-Mandaue area	15,000 "
Hagubiao-Pulpugan-Liloan area	14,000 "
Kotkot River area	10,000 "
Mactan Island	0
Total (MCWD)	44,000 cumd

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C. SURFACE WATER

Metropolitan Cebu Water District has 3 major potential surface water sources of supply. These are Balamban, Kotkot and Mananga Rivers whose basins are located to the north and west of Cebu City, as shown in Figure VII-2.

The average daily water demand for the year 2000 has been estimated to be about 256,300 cumd. Since yield from groundwater and/or any one of the 3 potential surface water sources will not be sufficient to supply this demand, studies on several reservoir sites have been conducted for a staged source development.

Approximate locations of the potential dam-reservoir sites in the 3 river basins are shown in Figure VII-2 and also listed below:

River Basin	Dam Site
Balamban	Near Barrio Lusaran
Mananga	9 km north of Tabunoc Junction
Kotkot	a) Lower - About 1 km south of Barrio Mulao
	b) Middle- About 1.5 km north of Barrio Mulao
	c) Upper - About 5 km upstream of Barrio Mulao

For an increased catchment area, further downstream sites have also been investigated in the Mananga and Kotkot Rivers, but foundation materials at these sites are found to be unsuitable for dam construction and reservoir impoundment.

A gravity flow diversion from the Balamban River into the Kotkot basin is a topographically feasible alternative by which safe yield of the Kotkot River can be augmented.

Meteorological Data. Meteorological data utilized in analyzing safe yields of the sources include records of rainfall, streamflow and evaporation which were obtained from meteorological stations shown in the location map (Appendix Figure VII-C-1 and Appendix Table VII-C-1). Period of record for these stations is relatively short and data had to be extended for applicable stations.

The records for rainfall and evaporation are presented in Appendix Tables VII-C-2 and VII-C-3, respectively.

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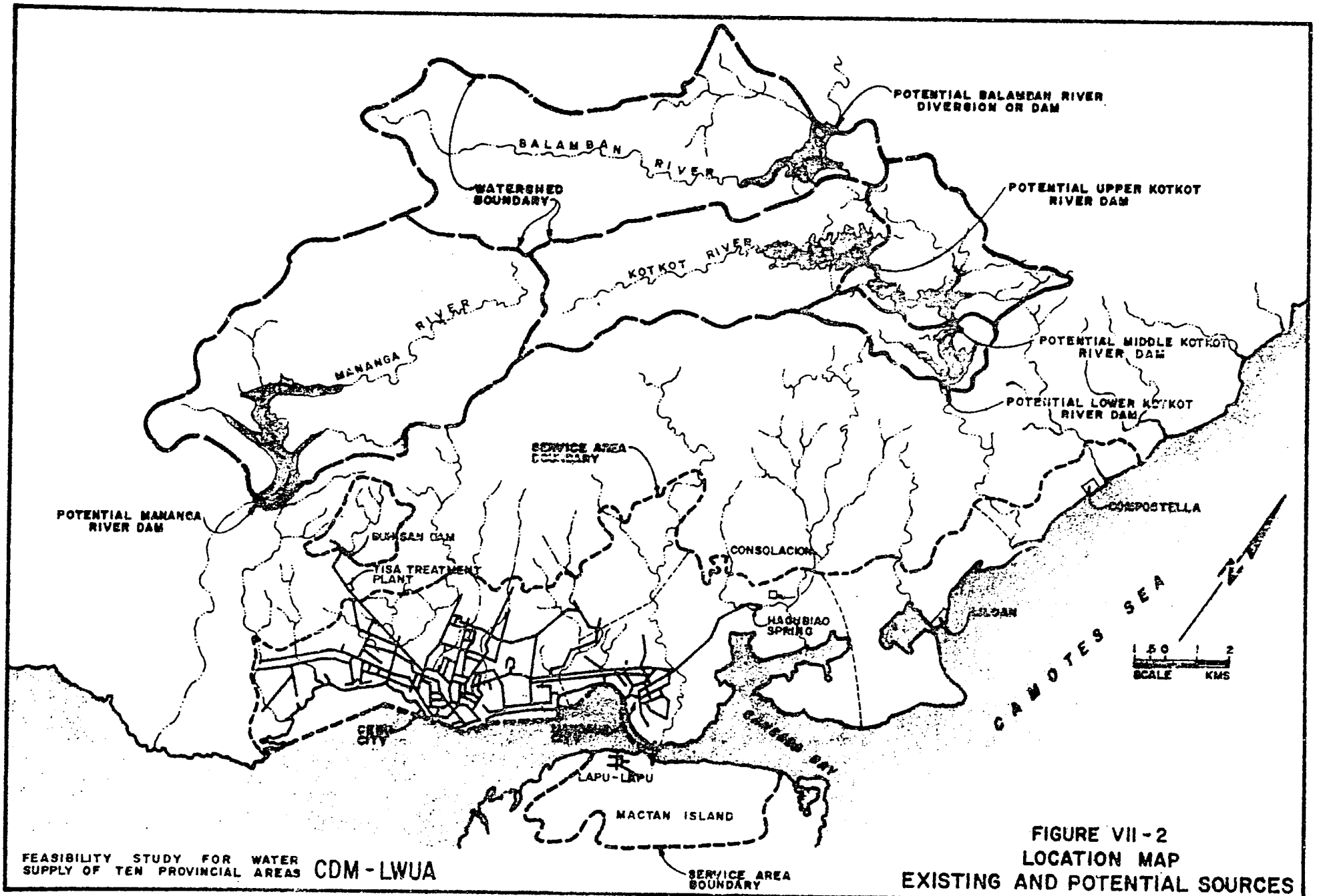

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FIGURE VII - 2
LOCATION MAP
EXISTING AND POTENTIAL SOURCES

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18

Stream Flow Data. The available stream flow data at gaging stations of Lusaran-Balamban River, Mulao-Kotkot River and Consolacion-Pitogo River, are presented in Appendix Table VII-C-4. Since the period of these stream flow data is very short, it is necessary to extend these records by correlation with rainfall to study safe yields of the sources.

Stream flow of the Lusaran gaging station of the Balamban River was correlated with monthly rainfall data of the station at Cebu City which has 30 years of record. The resulting correlation curve is shown in Appendix Figure VII-C-2. The stream flow record with extended data is shown in Appendix Table VII-C-5.

This data is applied to the proposed Lusaran and Mananga dam sites in proportion with the catchment areas to obtain monthly stream flows at these dam sites and resulting data are shown in Appendix Tables VII-C-6 and 7.

The stream flow of the Mulao and Consolacion gaging stations were correlated with monthly rainfall data of the station at Lahug airfield, Cebu City, which has 19 years of record. The extended stream flow data at these stations are shown in Appendix Tables VII-C-8 and 9. These flows are prorated for the upper, middle and lower Kotkot dam sites and the results are shown in Appendix Tables VII-C-10, 11, and 12.

Sedimentation Estimates. Sedimentation of reservoirs for this study is based on measured siltation that occurred in the existing Buhisan Reservoir, located west of Cebu City and constructed in 1911. The Buhisan Reservoir has had a siltation rate of 2,906 cum/sqkm. This sedimentation rate appears high and possibly caused by deforestation of the catchment area during 1942-45 resulting in a serious erosion problem. Assuming that the MCWD and other agencies will participate jointly in a soil conservation project for the reservoir catchment areas, a siltation rate of 1,000 cum/sqkm/year is assumed in this study. A dead volume for 50 years, the assumed service life will be provided in the proposed reservoirs.

Riparian Rights. There are no known rights for downstream water users in the Kotkot and Balamban basins, therefore no water allocation is made for the riparian water rights during the safe yield studies on these rivers. The Mananga River which flows through the Talisay municipality, is not under the jurisdiction of MCWD. Therefore, a water allocation in the amount of 16,500 cumd is made from the potential yield of the Mananga River source for the future water requirements of the Talisay poblacion and the surrounding urbanized areas.

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Safe Yield Analysis. Reservoir safe yields for the proposed alternative dam sites of the applicable rivers were determined by utilizing the mass diagram method. This method involves plotting a curve of accumulated monthly stream flow volume at the proposed site, versus time. Adjustment of stream inflow is made for evaporation from the surface of the reservoir. Demand lines drawn tangent to the high points of the mass curve represent rates of withdrawal from the reservoir. Assuming the reservoir to be full wherever a demand line intersects the mass curve, the maximum departure between the demand line and the mass curve represents the net reservoir capacity required to satisfy the demand. Dead storage, as necessary for accumulation of silt and the assumed service life of the facility, was considered in determining required storage volume.

Stage-area and capacity curves (Appendix Figures VII-C-3 through C-7) appropriate for the dam sites were developed to determine the height of dam necessary to provide the required storage volume. The total dam height includes allowances for spillway overflow and freeboard. The maximum potential yield of a river is the demand line which spans a significant dry period and is drawn tangent to the high points of the mass curve. The estimated potential safe yields of the river basin at the proposed sites with the related reservoir volume and dam heights are shown in Table VII-1.

The results shown for the Mananga dam site in this table are based on assumptions that hydrological characteristics of the Mananga River are similar to the Balamban River.

The stream flow records show that the annual surface flow in the Kotkot River basin is about 50 per cent less than the Balamban River basin. Therefore, the estimated potential safe yields for the Kotkot dam sites are about 50 per cent of the Balamban dam sites with the same drainage area.

The minimum flows, reservoir safe yield and dam height requirements for the selected river basins must be verified during design stage with actual flow measurements at the selected sites.

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TABLE VII-1

POTENTIAL SAFE YIELDS

River Basin	Potential Dam Site	Catchment Area (sqkm)	Mean Flows 10^6 cum/yr	Mean Flows 10^3 cumd	Potential Safe Yield (10^3 cumd)	Reservoir Vol. (10^6 cum) Dead	Active	Total	Total Dam Height (m)
Balamban	Lusaran	63.2	67.5	185.0	154.0	3.1	80.2	83.3	82
Kotkot (1 dam)									
	Upper	38.5	18.5	50.6	45.0	1.9	65.1	67.0	52
	Middle	60.3	28.9	79.1	73.0	3.0	103.0	106.0	103
	Lower	67.2	32.1	88.0	81.0	3.4	114.6	118.0	96
Kotkot (2 dams) *									
	Middle	21.8	10.4	22.5	27.0	1.1	38.9	40.0	80
	Lower	28.7	13.6	37.4	35.0	1.4	47.6	49.0	74
Mananga	(See Figure VII-1)	67.5	72.1	198.0	165.0	3.4	85.2	88.6	98
Kotkot (1 dam) With Balamban Diversions to:									
	Middle	123.5	99.7	273.0	212.0	5.0	174.0	179.0	116
	Lower	130.4	103.3	283.0	221.0	6.0	185.0	191.0	117
Kotkot (2 dams) * With Balamban Diversions to:									
	Middle	85.0	79.4	217.0	166.0	3.0	111.0	114.0	104
	Lower	91.9	82.5	226.0	173.0	4.0	119.0	123.0	99

* Assuming Kotkot upper dam will be built first and the middle or the lower Kotkot dam to be constructed later.

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Dam Site Geology

(a) Kotkot River Basin: Three dam sites are under consideration in this basin. The lower Kotkot dam site is underlain by the intercalated sequence of andesite flows, andesite breccia, some pyroclastics, and highly indurated sandstones and siltstones. The sedimentary members apparently belong to the upper horizon of the whole formation with the basal section predominantly made of massive andesite flows. The foundation material beneath the proposed embankment consists mainly of andesite flows. The borehole drilling which was carried out in June 1975, intercepted the fresh bedrock at a depth of 13.4 m and up to the bottom of the hole at 34.75 m, it encountered the same andesite flows. It is estimated that the grout take of the dam foundation will be nominal. A larger grout consumption will be recorded only where the grout holes intersect a severely fractured zone, which is not very likely, however, since no major faults or shears pass through the dam site. The reservoir is mainly underlain by the same intercalated andesite and indurated sedimentary rocks similar to those underlying the dam site. In spite of the major faulting in the region where some minor ones have traversed the reservoir, the expected water losses along these fault zones are negligible. Investigation for construction materials for a rockfill dam has shown that clay for the earth core, sand and gravel for filter sections are available within 3 km distance. A possible source of good rockfill material is the massive porphyritic andesite some 650 m downstream of the proposed dam site. Geologic setting for the middle and upper Kotkot dam sites is likely to be similar to that of the lower dam site.

(b) Mananga River Basin: The abutments and foundation of the proposed Mananga dam are basically made up of andesite flows which have undergone regional metamorphism. Grout take of foundation is expected to increase substantially in the fractured zones. The andesite rock itself is impervious and the grout holes should intersect the fractures to effectively grout the foundation. The whole reservoir area is practically underlain by the meta-andesite belonging to the Cretaceous formation. The upper reaches, however, of the Mananga River are underlain by interbedded conglomerate, sandstone and shale. With the exception of clay for an impervious core, all the necessary construction materials for a rockfill dam are available within the vicinity of the proposed Mananga dam site.

(c) Balamban River Basin: The Lusaran dam site is underlain by a medium grained andesite in fault contact with the sedimentary formation underlying the reservoir and the catchment areas. Foundation and abutments of the proposed dam will be on

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85

the andesite. All the necessary construction materials for a rockfill dam are available within a short distance from the proposed dam site.

Seismicity of the Area

Active volcanism is entirely absent in Cebu Island. The known active volcanos nearest to Cebu are those in Negros Island to the west and the Camiguin Island farther south. Both these areas are at least 100 km away and separated by deep sea water. Thus, any activity in these volcanos will not affect the area. In the design of earth structures, therefore, a seismic factor of about 0.05/g may be enough to counteract any ground acceleration during earthquakes affecting the Island of Cebu.

D. WATER QUALITY

Groundwater

Spring water is of good quality except for moderately excessive hardness. Well water quality is variable. Water from wells near the coast where the aquifer is being overpumped is excessively saline. On Mactan Island, a greater number of wells is producing saline water. Some well water on the mainland from limestone aquifers is excessively hard but, in general, the remainder of the wells produce good water.

Surface Water

Results of physical and chemical analyses of water from Balamban, Kotkot and Mananga Rivers are shown in Table VII-2. Two samples were taken from the Balamban River. The first sample which was tested in two different laboratories shows excess iron, turbidity and manganese. Tests on the second sample verify the previous results. Analysis of samples taken from Kotkot and Mananga Rivers indicates marginal excess in turbidity, hardness and iron.

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TABLE VII-2

WATER QUALITY TEST RESULTS

Test	Location & Date of Sampling	Allowable Limits*	Balamban River Lusaran dam site 20-12-74 (1a)	Balamban River Lusaran dam site 20-12-74 (1b)	Balamban River Lusaran dam site 23-1-75 (2)	Kotkot River Lower dam site 23-1-75	Mananga River dam site 19-12-74	Mananga River dam site 23-1-75
PHYSICAL								
Color	(unit)	15	150.0				15.0	
Taste	"	3						
Odor	"							
Turbidity	"	5	1,335.40		110	6	67.9	0
Solids								
a. total	(mg/l)	500	1,264		1,370	436	440	451
b. suspended			2.54		1,175	30		12
CHEMICAL								
pH		7-8.5	8.05	7.7	7.8	8.1	8.0	8.1
Alkalinity								
a. total	(mg/l)				140	164		162
b. Phenol	"		nil		0	2	8.36	2
c. Methylorange	"		94.36				157.77	
Total Hardness	"		195.1		180	262	255.5	294
Calcium	(mg/l)	75	281.4 **	31.0	57.5	57.5	47.1	63.0
Magnesium	"	50	5,850.82**	1.0	19.8	22.2	18.10	23.9
Iron	"	0.3	25.75**	19.2	11.85	1.00	2.08	0.85
Fluoride	"	1.5	0.22		.32	0.44	.22	0.48
Chloride	"	200	nil		12	8	4.01	8
Sulfate	"	200	845		28.8	155.2	87.5	123.2
Nitrate	"							
Nitrite	"		0.08				nil	
Manganese	"	0.1	10	1.37	.90	.02	nil	.01
Copper	"	1			.048	.004		.002
Zinc	"	5			.050	.012		.002

Underlined figures indicate excess over allowable limits.
*Philippine National Standard.
**Results may not be reliable.

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87

MANANGA RIVER – POTENTIAL DAM SITE

BALAMBAN RIVER AT BARRIO LUSARAN

KOTKOT RIVER – POSSIBLE DAM SITE

MANANGA RIVER – UPSTREAM OF HIGHWAY BRIDGE

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CHAPTER VIII ALTERNATIVE STUDIES

A. GENERAL

Alternatives on water sources, source development, water treatment, transmission and distribution of treated water are presented in this chapter. Other water conservation measures such as reuse or reclamation, desalinization, water augmentation and dual plumbing are also included.

Total water supply to the project area in 1974 was about 40,000 cumd while the estimated maximum daily demand was about 80,000 cumd or twice the available supply. The projected maximum daily water demands of the project area in the years 1990 and 2000 are 186,800 and 307,600 cumd, respectively. The gap between the present supply and demand indicates that growth in the project area will be hampered unless new supply, transmission and distribution facilities are planned for immediate construction.

Potential sources of water supply for the project area are ground and/or surface waters. Almost all of the present supply comes from wells and springs. Salt water intrusion has been an acute problem in wells which are relatively nearer the seashore. At present, 12 new deep wells are being constructed in Cebu City and may increase the total supply by about 10,000 to 15,000 cumd. However, some of the existing wells subject to salinity problem will eventually have to be phased out. Thus, addition of these 12 wells in an aquifer area that is already overpumped, is not expected to increase the supply without subjecting more coastal wells to salt water intrusion. More usable groundwater potential may be found on the northeastern and southwestern extension of the project area. New wells in the Pardo area and shallow infiltration wells in the Mananga and Kotkot alluviums may yield additional water for the service area on an interim basis. A test well program is being carried out for better determination of the groundwater potential in these specific areas.

Studies and observations, thus far, clearly indicate that groundwater potential is not adequate for the long term needs of the project area.

For the long range water supply needs of the area, the available surface water sources were investigated and large size reservoir impoundments were found to be feasible on the Kotkot, Mananga and Balamban Rivers.

Several alternative supply and transmission layouts were developed. As part of the source development analyses, demand versus supply

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charts were prepared to optimize the construction staging for each alternative. The staging of dam and reservoir development was based on the average daily demands while the staging of groundwater facilities, diversion works, water treatment plant units and transmission facilities was based on the maximum daily demand. Distribution storage capacity is based on the supplementary flow requirements during peak hourly demands.

B. ALTERNATIVE WATER SUPPLY SCHEMES

A long range water supply scheme for MCWD will include about 40,000 cumd safe yield from the groundwater sources as explained in Chapter VII. The rest of the supply can be obtained by alternative combination of Balamban, Kotkot and Mananga River sources with construction of dams. There is one feasible dam site on Balamban and on Mananga Rivers as against 3 sites (lower, middle and upper) on Kotkot River. The river cross-section at the lower Kotkot site is not as favorable as the middle or upper sites. The lower site, in comparison to the upper site, requires larger dam embankment for the same amount of safe yield, and hence more costly. A present worth cost comparison between the lower and middle Kotkot dams and transmission lines thereof, based on the available data, showed that the lower Kotkot scheme would be about ₱40.0 million more expensive. The potential safe yield of the upper Kotkot dam site is estimated to be 47,000 cumd. As this much flow is not sufficient to meet the projected demands of MCWD for the year 1982, construction of another reservoir scheme will be required simultaneously. This will obviously be a more expensive scheme than a single dam construction during the first stage of construction.

Therefore, no further consideration is given to the lower and upper Kotkot dam sites in this report. These dam sites may be reevaluated when more reliable stream flow and topographical survey data are available.

Treatment of groundwater and surface water would be significantly different. For satisfactorily developed groundwater wells in MCWD, treatment of water with chlorination will be sufficient. For all the surface sources, a complete treatment is considered for removal of color, turbidity and bacteria.

Five alternative schemes were developed and studied for water supply to MCWD. Each alternative scheme includes source, transmission and treatment components. Essentially, the distribution system is not affected by the alternative supply schemes and, therefore, is not included in the cost analysis of the alternatives. Water supply augmentation for MCWD in relation to the various alternative schemes is presented in Table VIII-1.

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TABLE VIII-1

ALTERNATIVE SUPPLY AUGMENTATION

Alternative Scheme	Source Development	Construction Period	Cumulative * Supply (cumd)	Year Augmented	Remarks
S-T-1	a) Middle Kotkot Dam	1978-82	73,000	1982	Average yield
	b) Balamban Diversion	1980-83	212,000	1983	" "
S-T-2	a) Mananga Dam	1978-82	148,500**	1982	" "
	b) Middle Kotkot Dam	1989-93	216,000	1993	" "
S-T-3	a) Lusaran Dam	1978-82	154,000	1982	" "
	b) Mananga Dam	1989-93	216,000	1993	" "
S-T-4	a) Mananga Dam	1978-82	148,500	1982	" "
	b) Lusaran Dam	1989-93	216,000	1993	" "
S-T-5	a) Lusaran Dam	1978-82	154,000	1982	" "
	b) Middle Kotkot Dam	1989-93	216,000	1993	" "

* 40,000 cumd from the ground sources not included

** Excluding 16,500 cumd which is allocated for the Talisay area

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Water Supply Alternatives

Interim Improvements. It is estimated that development of a major surface supply scheme for MCWD will take at least 3-4 years. During the period from 1976 to 1982, water supply to MCWD can be increased somewhat, by construction of new deep wells towards the southwest and northeast of the city and by improvements to the Hagubiao Spring pump station. In addition to this, the presently high water waste can be cut down with (1) continued meter installations, and (2) pipe repairs following a leakage survey in the transmission and distribution system. As a result of these early actions, the amount of water available to the customers can be increased by about 25-30 per cent. With the proposed overall interim improvements which are discussed in Chapter IX, the total water supply to MCWD is expected to reach about 76,000 cumd rate. In comparison to the projected maximum daily demand curve (Figure IX-2), there will be an increasing water shortage during the period from 1978 until new supply facilities are put into service.

A preliminary cost analysis is made for the proposed interim supplies from the Mananga and Kotkot well fields, including well and pump station and transmission lines. The results of this analysis are shown in the following table:

Well Field and Estimated Yield	Construction Period	Construction Cost (₱)	Total Project Cost (₱)	Net PW Costs for 20-Year Operation		Net PW Costs for 4-Year Operation	
				Capital & Annual (₱)	Unit Cost (₱/cum)	Capital & Annual (₱)	Unit Cost (₱/cum)
Mananga (Q =22,000 cumd)	1976-78	7,695,000	10,927,000	11,600,000	0.24	6,300,000	0.32
Kotkot (Q =19,000 cumd)	1976-78	15,336,000	21,870,000	19,570,000	0.46	11,530,000	0.69

It can be concluded from this table that development of the Kotkot well scheme may not be economically feasible unless the ₱17.0 million pipeline cost can be reduced or eliminated. This can be achieved by an early construction of the treated water transmission line which is proposed in the main scheme for this area.

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Alternative S-T-1 Kotkot Middle Dam and Balamban Diversion. As shown in Table VII-1, the potential safe yield of the middle Kotkot reservoir, is estimated at 73,000 cumd with a 103 m high dam. This safe yield can be increased by the Balamban River diversion into the Kotkot basin, as shown in Figure VIII-1. For an average reservoir safe yield of about 216,000 cumd to meet the year 2000 demands, a dam height of 116 m will be required to regulate the combined flows of the Kotkot River and the Balamban diversion. The necessary works in this scheme are summarized below by the construction stages:

Construction Stage I - Phase "A" (1978-83):

a) A rockfill dam at the middle Kotkot site (H= 116 m), and appurtenances;

b) Raw water intake structure and transmission line, 1,300 mm diameter and 10.0 km long;

c) A conventional type water treatment plant with an initial capacity of 121,000 cumd and ultimate capacity of 267,000 cumd, the projected maximum daily demand in the year 2000 from the surface sources alone.

d) A 3 m high diversion dam on Balamban River, near Barrio Lusaran and an access road to it;

e) A raw water intake structure and 4.6 km diversion tunnel to divert Balamban River flows into the Kotkot basin;

f) Treated water transmission lines and storage tanks, as shown in Figure VIII-1.

Construction Stage I - Phase "B" (1984-87):

a) A new raw water line, 1,100 mm diameter and 10.0 km long, to parallel the previous line;

b) Water treatment plant capacity will be expanded by addition of new process units;

c) Treated water transmission lines and distribution storage capacity will be reinforced with new pipelines as shown in Figure VIII-1.

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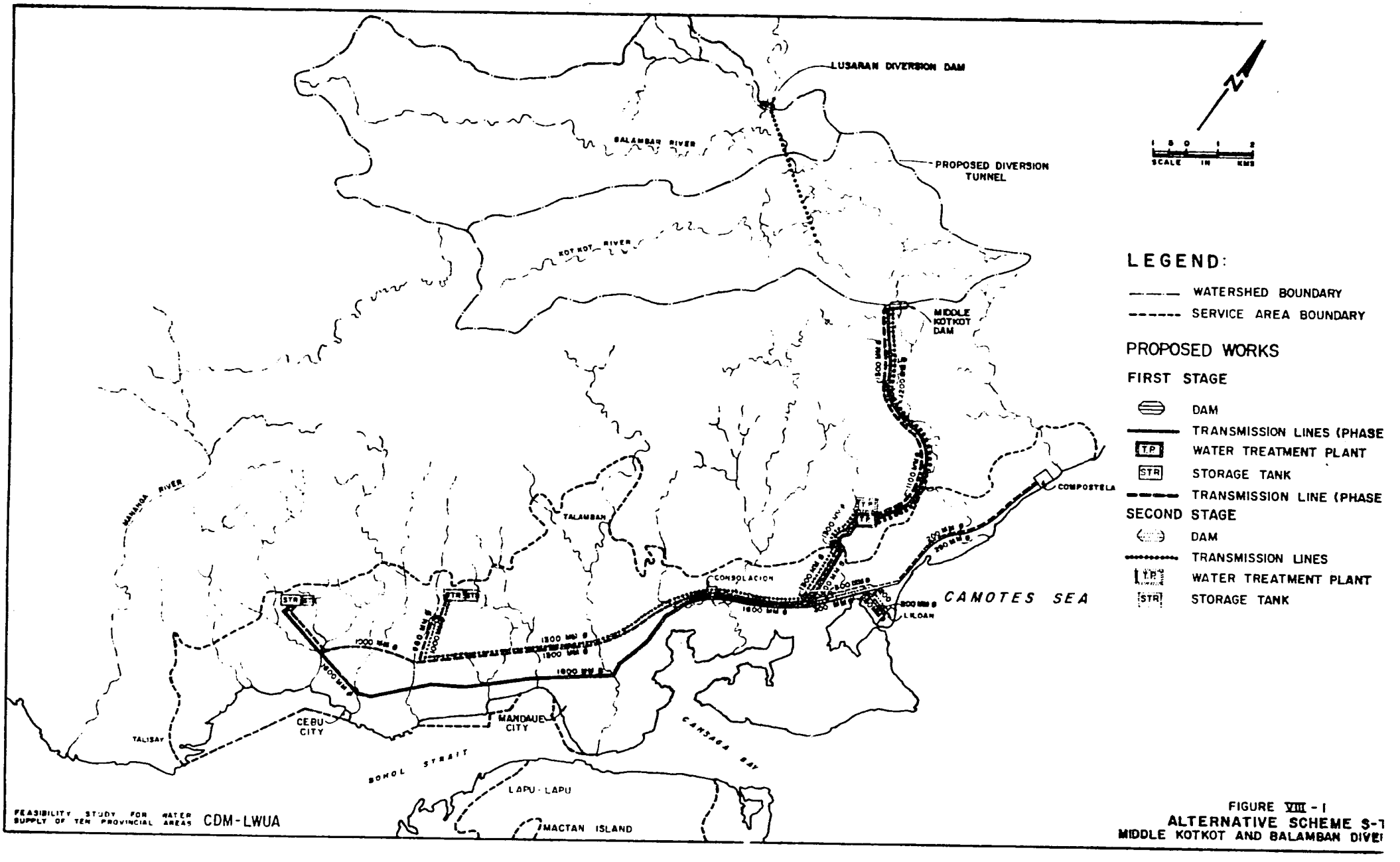

FIGURE VIII - 1
ALTERNATIVE SCHEME S-1
MIDDLE KOTKOT AND BALAMBAN DIVE

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75

With implementation of these works, capacity of the supply facilities will be increased by 72,000 cumd.

Construction Stage II (1990-94):

a) The third raw water line, 1,200 mm diameter and 10.0 km long, to convey water from the middle Kotkot dam to the proposed treatment plant;

b) The treatment plant expansion for an additional capacity of 74,000 cumd;

c) New treated water transmission lines and storage tanks.

Alternative S-T-2 Mananga Dam and Middle Kotkot Dam. In this alternative the Mananga source will be developed first with the following facilities:

Construction Stage I - Phase A (1978-82):

a) A 98 m high rockfill dam at the site shown approximately in Figure VIII-2, including diversion works during construction, regular and emergency spillways, and the road and barrio relocations.

b) Raw water intake and transmission line, 1,200 mm diameter and about 6.0 km long.

c) A conventional type water treatment plant with an initial capacity of 121,000 cumd and ultimate capacity of 178,000 cumd.

d) Treated water transmission lines and storage tank as shown in Figure VIII-2.

Construction Stage I - Phase B (1985-87):

a) A raw water transmission line, 900 mm diameter and 6.0 km long, will be laid parallel to the previous line.

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b) The water treatment plant capacity will be expanded for additional supply of 57,000 cumd.

c) The transmission facilities will be reinforced as shown in Figure VIII-2.

Construction Stage II (1989-93)

a) A 103 m high dam and appurtenances at the middle Kotkot dam site;

b) Raw water intake and transmission line, 1,200 mm diameter and about 10.0 km long;

c) A new conventional type water treatment plant, located at a site with ground elevations 7-75 m, about 1.5 km northwest of Liloan. The plant capacity will be about 88,000 cumd.

d) Treated water transmission lines and storage tanks as shown in Figure VIII-2.

Alternative S-T-3 Lusaran Dam and Mananga Dam. This scheme consists of two source developments, Balamban River with the Lusaran dam and Mananga River with the Mananga dam, with staged constructions. A general layout of the proposed facilities is shown in Figure VIII-3. As explained in Chapter VII, a water allocation in the amount of 16,500 cumd, is made from safe yield of the proposed Mananga reservoir for the estimated downstream water rights. An outline of the works involved in this scheme is as follows:

Construction Stage I - Phase A (1978-82):

a) An 82 m high dam on Balamban River, at a site near

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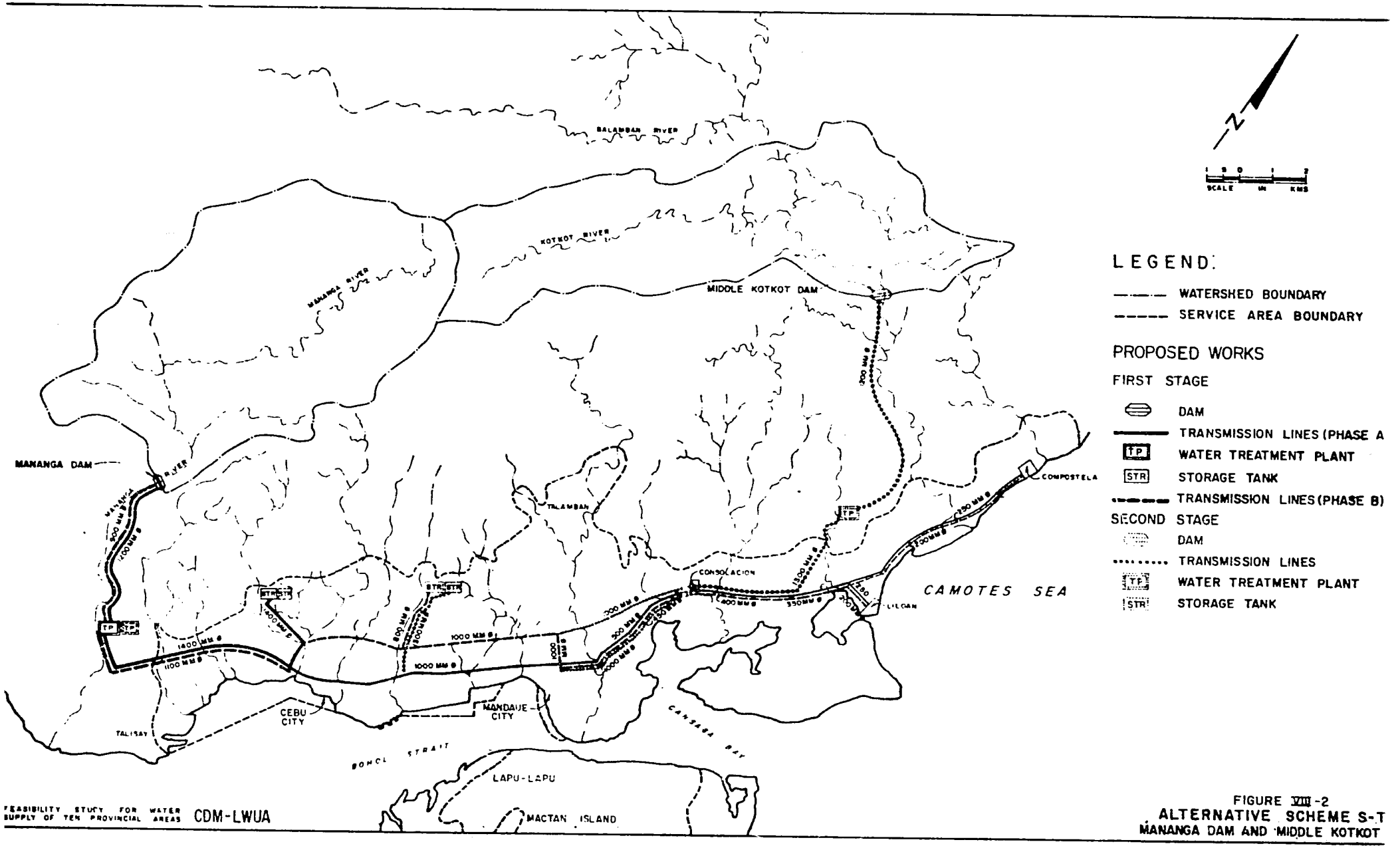

FEASIBILITY STUDY FOR WATER SUPPLY OF TEN PROVINCIAL AREAS CDM-LWUA

FIGURE VIII-2
ALTERNATIVE SCHEME S-T
MANANGA DAM AND MIDDLE KOTKOT

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Barrio Lusaran, and appurtenances;

b) A raw water system, consisting of an intake structure, 7.5 km long tunnel with a diameter of 2.5 m, and 900 mm diameter and 7.1 km long pipeline;

c) A conventional type water treatment plant near Barrio Talamban, with an initial capacity of 121,000 cumd and provisions for future expansions;

d) Treated water transmission lines and storage tank as shown in Figure VIII-3.

A raw water pump station near the intake of the Lusaran reservoir and a force main from it was studied as an alternative to the 7.5 km long tunnel, but it was found to be more expensive and was therefore eliminated.

Construction Stage I - Phase B (1985-87):

During this phase of construction Stage I, additional units will be installed for full utilization of the Lusaran source.

a) A raw water pipeline from the downstream end of the tunnel to the treatment plant, 800 mm diameter and 7.1 km long;

b) Water treatment plant expansion for a 64,000 cumd capacity increase;

c) Additional treated water transmission lines and storage tank as shown in Figure VIII-3.

Construction Stage II (1989-93):

During this stage, the Mananga River source will be developed with the following facilities:

a) A 72 m high dam on Mananga River at a site shown approximately in Figure VIII-3, including diversion works during construction, regular and emergency spillways, and the road and barrio relocations;

b) Raw water intake and transmission line, 1,000 mm diameter and about 6.0 km long;

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c) A new conventional type water treatment plant for the Mananga source, with a capacity of 82,000 cumd;

d) Treated water transmission lines and storage tank as shown in Figure VIII-3.

Alternative S-T-4 Mananga Dam and Lusaran Dam. This alternative scheme is basically similar to Alternative S-T-3, the difference being that potential safe yield of the Mananga River source is utilized first and later the Balamban River source is developed to meet the remaining demands for up to the year 2000. In other words, the Mananga system will have a larger capacity and the Lusaran system will have a smaller capacity in comparison with Alternative S-T-3. A summary of the proposed works in this scheme is as follows:

Construction Stage I - Phase A (1978-82):

a) A 98 m high rockfill dam and appurtenances on Mananga River;

b) Raw water intake and transmission line, 1,200 mm diameter and about 6.0 km long;

c) A conventional type water treatment plant for an initial capacity of 121,000 cumd with provisions for later expansion to a capacity of 178,000 cumd;

d) Treated water transmission lines and distribution storage tanks.

Construction Stage I - Phase B (1985-87):

During this phase, capacities of raw water system, water treatment plant and treated water transmission facilities will be expanded to a level of 178,000 cumd, the estimated maximum regulated yield from the proposed Mananga reservoir.

Construction Stage II (1989-93):

a) A 57 m high rockfill dam and appurtenances on Balamban River, near Barrio Lusaran;

b) Raw water intake, 2.5 m diameter and 7.5 km long tunnel and 900 mm diameter and 7.1 km long pipeline;

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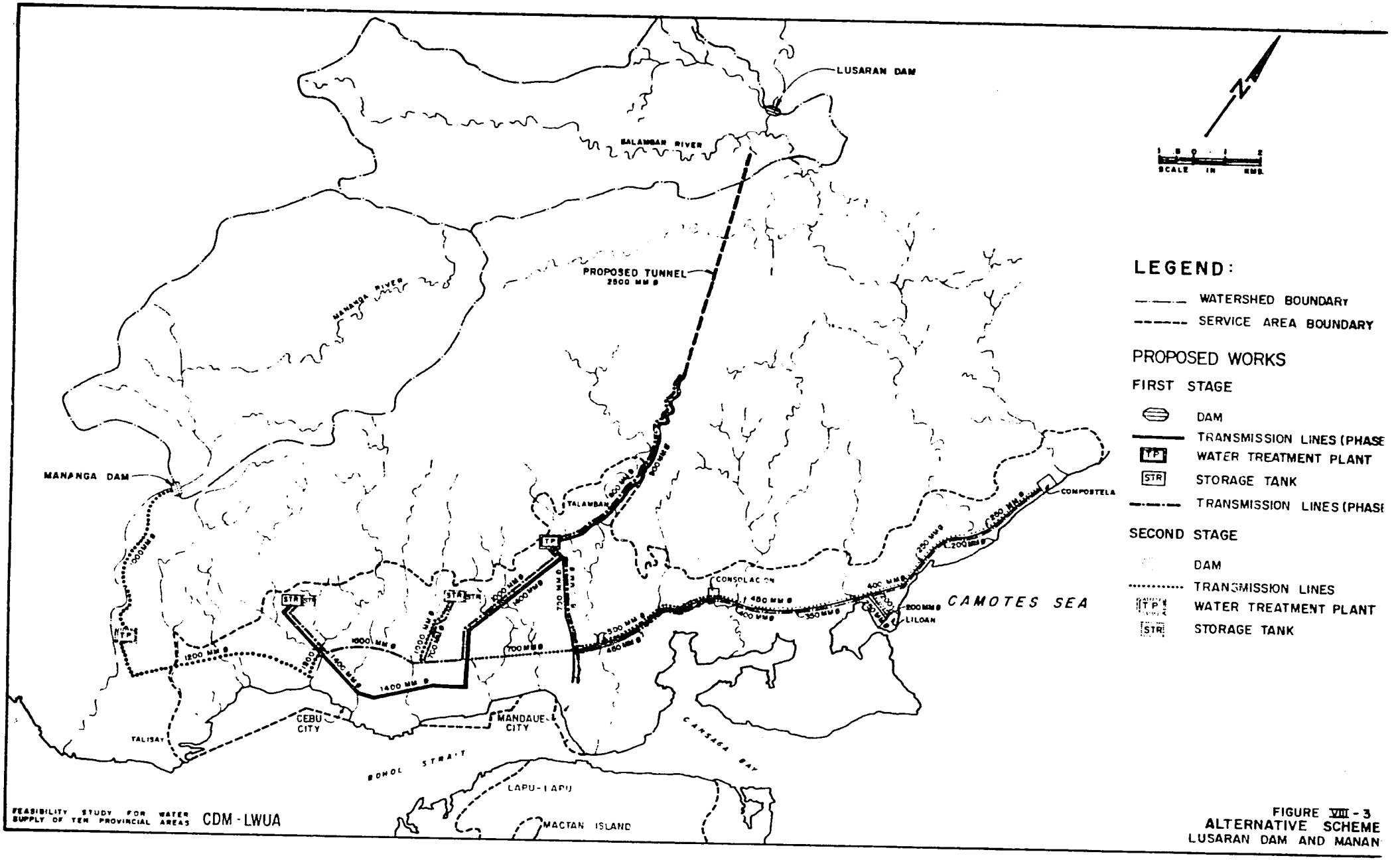

FEASIBILITY STUDY FOR WATER SUPPLY OF TEN PROVINCIAL AREAS CDM - LWUA

FIGURE VIII - 3
ALTERNATIVE SCHEME
LUSARAN DAM AND MANAN

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c) A new water treatment plant for the Balamban source near Barrio Talamban, with a design capacity of about 89,000 cumd;

d) Transmission lines from the treatment plant, and distribution storage tanks.

Alternative S-T-5 Lusaran Dam and Middle Kotkot Dam. Development of the Balamban River source with the Lusaran dam will be as explained for Alternative S-T-3. This scheme will be completed in two construction phases, 1978-82 and 1985-87 and will be adequate until the year 1993. The remaining supply for the year 2000 demands will be obtained from the middle Kotkot reservoir with the following facilities:

Construction Stage II (1989-93):

a) A 103 m high rockfill dam and appurtenances;

b) Raw water intake and 1,200 mm diameter and 10.0 km long transmission line;

c) A water treatment plant for a capacity of 88,000 cumd;

d) Treated water transmission lines and distribution storage tanks as shown in Figure VIII-4.

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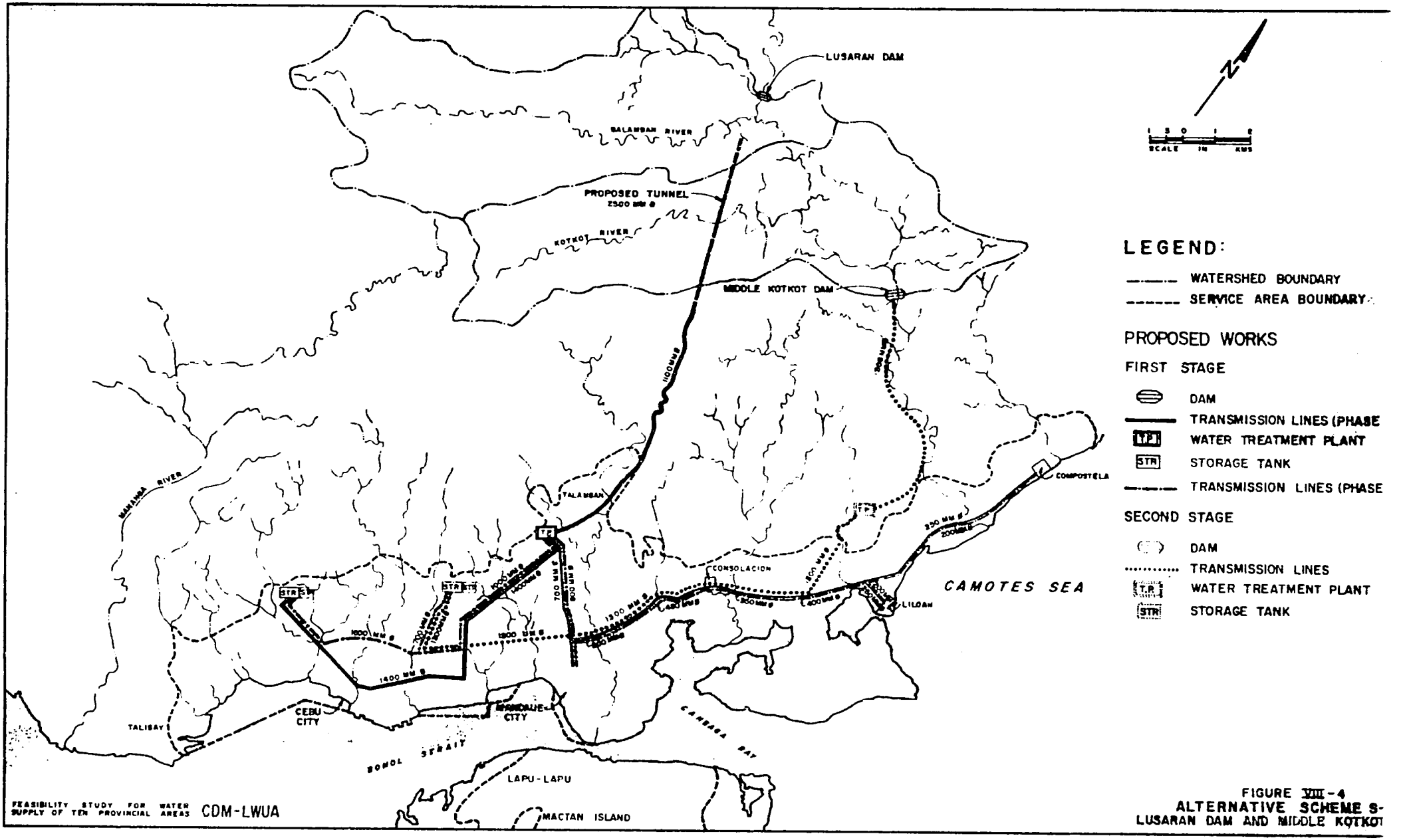

FEASIBILITY STUDY FOR WATER SUPPLY OF TEN PROVINCIAL AREAS CDM-LWUA

FIGURE VIII-4
ALTERNATIVE SCHEME S-
LUSARAN DAM AND MIDDLE KOTKOT

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102

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Cost Analysis of Alternatives

Criteria. Economic cost comparison of the proposed alternatives is made on the basis of present worth cost. Preliminary unit costs were developed for estimating construction costs of the proposed facilities (Appendix V-B). The criteria used in the analysis include the following:

Base year : 1976

Discount rate: 12%

Service life of facilities:

a) Structures and pipelines : 50 years

b) Mechanical equipment : 25 years

c) Land : infinite

For purposes of the analysis of the viable alternatives, it is assumed that the engineering design of the first stage works will start in 1977 and construction phase will be completed in 1982. Construction cost estimates of the proposed improvements are based on the projected July 1976 unit prices. All estimates on the imported items are based on an exchange rate of 7 pesos to 1 US dollar. It is assumed that no customs duty will be charged on items imported for this public water supply project.

Total project cost includes construction cost, engineering and contingencies, land cost, administrative and legal fees and interest during construction. Present worth of capital costs is calculated backward from completion time of construction.

Annual costs include personnel, power, chemicals and maintenance costs, where applicable. These estimates are carried out for 1982 (the year when the first stage of proposed improvements is completed), 1990 and 2000. Present worth cost of annual expenditures is based on uniform and gradient series (where applicable) at 12 per cent interest rate. Cost of any facility to be replaced during design period (1977-2000) is included under capital costs for that year.

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During economic analysis, no escalation factor is applied to July 1976 unit prices as it is assumed that all the alternative schemes will be affected approximately with the same rate.

Salvage value of a facility is estimated by using linear depreciation for its value throughout its service life.

Economic comparison of the alternative schemes is based on present worth of net disbursements during the period of 1977-2000. Annual maintenance cost estimates are based on construction costs of the facilities: for structures and pipelines, 0.5 per cent; and for equipment, such as pump and motors, 2.0 per cent of the estimated construction cost is used. Where applicable, diesel fuel cost of P1.00 per liter is used.

Personnel and maintenance costs may increase as more facilities are put under operation. Power cost at the pump station will increase gradually in relation to the daily pumpage of water.

Salvage values of the facilities at the end of the design period are important in the computation of net present worth of the total expenditures. With this, comparison of the alternatives can be made at the same economic base. As explained previously for estimating the salvage values, it is assumed that the value of the facility will depreciate uniformly throughout its service life. Therefore, a facility with longer service life will depreciate less than a facility with shorter service life during the same study period. Also, a facility constructed at a later stage will have higher salvage value than the similar one constructed at an earlier date.

The difference between the total present worth cost capital and annual expenditures, and the present worth of salvage values would give the net present worth cost of the alternative scheme.

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Capital Costs. A breakdown of the capital costs for the alternatives is shown in Table VIII-2.

TABLE VIII-2

CAPITAL COSTS

ALTERNATIVE S-T-1 *

Item	Construction Cost (₱)	Total Project Cost (₱)	Foreign Exchange Component (US$)
Stage I - Phase A (1978-83)			
Source Development**	489,700,000	777,160,000	19,140,000
Water Treatment Plant	57,200,000	91,550,000	3,500,000
Transmission Facilities	132,700,000	201,660,000	11,608,000
Total	679,600,000	1,070,370,000	34,248,000
Stage I - Phase B (1984-87)			
Source Development**	29,700,000	42,830,000	2,212,000
Water Treatment Plant	18,700,000	26,970,000	1,680,000
Transmission Facilities	89,900,000	129,660,000	6,996,000
	138,300,000	199,460,000	10,888,000
Stage II (1990-94)			
Source Development**	32,800,000	47,300,000	2,562,000
Water Treatment Plant	22,100,000	31,870,000	1,680,000
Transmission Facilities	72,800,000	105,000,000	6,016,000
	127,700,000	184,170,000	10,258,000

* Middle Kotkot dam and Balamban diversion

** Source development includes dam or diversion dam and appurtenances, raw water intake, transmission tunnel and/or pipeline.

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TABLE VIII-2 (Cont'd)

CAPITAL COSTS

ALTERNATIVE S-T-2 *

Item	Construction Cost (₱)	Total Project Cost (₱)	Foreign Exchange Component (US$)
Stage I - Phase A (1978-82)			
Source Development**	291,880,000	470,890,000	10,656,000
Water Treatment Plant	52,700,000	84,330,000	3,875,000
Transmission Facilities	68,050,000	108,660,000	5,668,000
	412,630,000	663,880,000	20,199,000
Stage I - Phase B (1985-87)			
Source Development**	14,160,000	20,420,000	924,000
Water Treatment Plant	15,300,000	22,060,000	1,400,000
Transmission Facilities	61,540,000	88,770,000	4,130,000
	91,000,000	131,250,000	6,454,000
Stage II (1989-93)			
Source Development**	360,300,000	576,830,000	14,422,000
Water Treatment Plant	40,000,000	64,020,000	2,448,000
Transmission Facilities	64,700,000	93,170,000	5,363,000
	465,000,000	734,020,000	22,233,000

* Mananga dam and Middle Kotkot dam

** Source development includes dam and appurtenances, raw water intake and transmission pipeline.

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VOID AFTER 1 NOV 1975

TABLE VIII-2 (Cont'd)

CAPITAL COSTS

ALTERNATIVE S-T-3 *

Item	Construction Cost (₱)	Total Project Cost (₱)	Foreign Exchange Component (US$)
Stage I - Phase A (1978-82)			
Source Development **	262,556,000	422,607,000	11,036,000
Water Treatment Plant	51,500,000	82,411,000	3,875,000
Transmission Facilities	82,416,000	125,235,000	6,673,000
Total	396,472,000	630,253,000	21,584,000
Stage I - Phase B (1984-87)			
Source Development **	14,484,000	20,886,000	1,024,000
Water Treatment Plant	8,500,000	12,257,000	1,400,000
Transmission Facilities	55,429,000	79,951,000	3,644,000
Total	78,413,000	113,094,000	6,068,000
Stage II (1989-93)			
Source Development **	140,820,000	227,732,000	5,467,000
Water Treatment Plant	37,000,000	56,395,000	2,729,000
Transmission Facilities	59,327,000	85,550,000	4,214,000
Total	237,147,000	369,677,000	12,410,000

* Lusaran and Mananga schemes

** Source development includes dam and appurtenances, raw water intake, transmission tunnel and/or pipeline.

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VOID AFTER 1 NOV 1975

TABLE VIII-2 (Cont'd)

CAPITAL COSTS

ALTERNATIVE S-T-4 *

Item	Construction Cost (₱)	Total Project Cost (₱)	Foreign Exchange Component (US$)
Stage I - Phase A (1978-82)			
Source Development **	291,880,000	470,886,000	10,656,000
Water Treatment Plant	52,700,000	84,327,000	3,875,000
Transmission Facilities	90,098,000	143,976,000	7,409,000
Total	434,678,000	699,189,000	21,940,000
Stage II - Phase B (1985-87)			
Source Development **	14,160,000	20,419,000	924,000
Water Treatment Plant	15,300,000	22,063,000	1,400,000
Transmission Facilities	65,027,000	93,792,000	4,375,000
Total	94,487,000	136,274,000	6,699,000
Stage II (1989-93)			
Source Development **	179,556,000	287,640,000	8,217,000
Water Treatment Plant	40,000,000	64,052,000	3,100,000
Transmission Facilities	45,468,000	69,077,000	3,243,000
Total	265,024,000	420,769,000	14,560,000

* Mananga and Lusaran schemes

** Source development includes dam and appurtenances, raw water intake, transmission tunnel and/or pipeline.

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INTERIM REPORT
VOID AFTER 1 NOV 1975

TABLE VIII-2 (Cont'd)

CAPITAL COSTS

ALTERNATIVE S-T-5 *

Item	Construction Cost (₱)	Total Project Cost (₱)	Foreign Exchange Component (US$)
Stage I - Phase A (1978-82)			
Source Development**	266,900,000	427,780,000	11,480,000
Water Treatment Plant	53,000,000	84,810,000	3,875,000
Transmission Facilities	82,400,000	125,180,000	5,986,000
	402,300,000	637,770,000	21,341,000
Stage I - Phase B (1985-87)			
Source Development**	-	-	-
Water Treatment Plant	16,000,000	23,070,000	1,400,000
Transmission Facilities	55,400,000	79,710,000	3,438,000
	71,400,000	102,780,000	4,838,000
Stage II (1989-93)			
Source Development**	360,300,000	576,830,000	14,422,000
Water Treatment Plant	40,000,000	64,020,000	2,448,000
Transmission Facilities	64,700,000	93,170,000	5,363,000
	465,000,000	734,020,000	22,233,000

* Lusaran dam and Middle Kotkot dam

** Source development includes dam and appurtenances, raw water intake, transmission tunnel and/or pipeline.

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Annual Costs

The estimated annual costs of the facilities which are included in the comparison of the alternative supply schemes, are shown in Table VIII-3.

TABLE VIII-3

ANNUAL COSTS (P)

Alternative	Year	Personnel	Maintenance	Power	Chemicals	Total
S-T-1	1982	340,000	3,463,000	323,000	679,000	4,805,000
	1983	360,000	3,693,000	323,000	770,000	5,416,000
	1986	360,000	3,842,000	323,000	978,000	5,503,000
	1987	370,000	4,450,000	323,000	1,068,000	6,211,000
	1992	370,000	4,614,000	350,000	1,547,000	6,881,000
	1994	370,000	5,145,000	380,000	1,784,000	7,679,000
	2000	370,000	5,145,000	380,000	2,540,000	8,435,000
S-T-2	1982	340,000	2,063,000	320,000	679,000	3,402,000
	1987	350,000	2,624,000	320,000	1,041,000	4,335,000
	1990	350,000	2,624,000	320,000	1,313,000	4,607,000
	1993	670,000	4,911,000	650,000	1,630,000	7,861,000
	2000	670,000	4,911,000	650,000	2,444,000	8,675,000
S-T-3	1982	340,000	2,245,000	323,000	725,000	3,633,000
	1986	340,000	2,317,000	323,000	1,017,000	3,997,000
	1987	340,000	2,317,000	323,000	1,101,000	4,081,000
	1990	346,000	2,742,000	323,000	1,383,000	4,794,000
	1993	346,000	2,742,000	323,000	1,687,000	5,098,000
	2000	664,000	4,122,000	646,000	2,336,000	7,768,000
S-T-4	1982	340,000	2,123,000	323,000	679,000	3,465,000
	1987	340,000	2,123,000	323,000	1,030,000	3,816,000
	1990	340,000	2,581,000	323,000	1,312,000	4,562,000
	1993	346,000	2,581,000	323,000	1,619,000	4,869,000
	2000	660,000	3,860,000	646,000	2,503,000	7,669,000
S-T-5	1982	340,000	2,273,000	320,000	718,000	3,651,000
	1987	350,000	2,735,000	320,000	1,089,000	4,494,000
	1990	350,000	2,735,000	320,000	1,387,000	4,792,000
	1993	670,000	4,693,000	650,000	1,712,000	7,725,000
	2000	670,000	4,693,000	650,000	2,538,000	8,551,000

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VOID AFTER 1 NOV 1975

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INTERIM REPORT
VOID AFTER 1 NOV 1975

Salvage Values

Estimated year 2000 salvage values of the facilities proposed in the water supply alternatives are shown in Table VIII-4.

TABLE VIII-4

SALVAGE VALUES

Alternative	Construction Stage/Phase	Construction Cost (₱)	Salvage Value in Year 2000 (₱)
S-T-1	1-A	679,600,000	431,255,000
	B	138,300,000	99,576,000
	2	127,700,000	109,410,000
S-T-2	1-A	412,630,000	268,179,000
	B	91,000,000	65,543,000
	2	465,000,000	390,600,000
S-T-3	1-A	396,472,000	250,302,000
	B	78,413,000	55,935,000
	2	237,147,000	206,684,000
S-T-4	1-A	434,678,000	277,254,000
	B	94,487,000	68,120,000
	2	265,024,000	226,932,000
S-T-5	1-A	402,300,000	260,205,000
	B	71,400,000	52,820,000
	2	465,000,000	390,600,000

Net Present Worth Costs

The net present worth costs of the alternative water supply schemes are shown in Table VIII-5. The present worth of the alternatives includes cost of source, treatment and transmission facilities.

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TABLE VIII-5

WATER SUPPLY ALTERNATIVES
PRESENT WORTH COST COMPARISONS

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VOID AFTER 1 NOV 1975

Alternative	Construction Stage	Construction Period	Total Project Cost (₱ x 1,000)	Annual Costs (₱x1,000) 1982	1990	2000	PW Costs (₱x1,000) Capital	Annual	Total	PW of Salvage Value in Year 2000 (₱x1,000)	PW of Net Disbursemen (₱ x 1,000) 1978-2000
S-T-1	1-A	1978-83	1,070,370				538,622	10,065	548,687	28,420	520,267
	B	1984-87	199,460				57,345	6,681	64,026	6,562	57,464
	2	1990-94	184,170				23,942	6,171	30,113	7,210	22,903
				4,805	6,576	8,435	619,909	22,917	642,826	42,192	600,634
S-T-2	1-A	1978-82	663,880				336,322	6,890	343,212	17,673	325,539
	B	1985-87	131,250				37,734	5,405	43,139	4,318	38,821
	2	1989-93	734,020				106,873	5,445	112,318	25,740	86,578
				3,402	4,607	8,675	480,929	17,740	498,669	47,731	450,938
S-T-3	1-A	1978-82	630,253				319,286	6,954	326,240	16,495	309,745
	B	1984-87	113,094				33,235	5,604	38,839	3,686	35,153
	2	1989-93	369,677				53,824	4,888	58,717	13,621	45,096
				3,633	4,734	7,768	406,345	17,446	423,796	33,802	389,994
S-T-4	1-A	1978-82	699,189				354,207	6,583	360,790	18,271	342,519
	B	1985-87	136,274				39,178	5,317	44,495	4,488	40,007
	2	1989-93	420,769				61,264	4,749	66,013	14,955	51,058
				3,465	4,562	7,669	454,649	16,649	471,298	37,714	433,584
S-T-5	1-A	1978-82	637,770				323,094	7,280	330,374	17,147	313,227
	B	1985-87	102,780				29,550	5,470	35,020	3,480	31,540
	2	1989-93	734,020				106,873	5,340	112,213	25,740	86,473
				3,651	4,792	8,551	459,517	18,090	477,607	46,367	431,240

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112

INTERIM REPORT
VOID AFTER 1 NOV 1975

Conclusions

The present worth analyses of the five source alternatives indicate that Alternative S-T-1 is the most costly surface water alternative but that the other four are all within 15% of the least cost alternative (S-T-3). See table below :

Alternative	Sources or Dam Sites	Phase I-A Cost (₱x10^6)	Present Worth (₱x10^6)	Relative Present Worth Cost
S-T-1	Middle Kotkot/Balamban	1,070	600	1.54
S-T-2	Mananga/Middle Kotkot	664	451	1.15
S-T-3	Lusaran/Mananga	630	390	1.00
S-T-4	Mananga/Lusaran	699	433	1.11
S-T-5	Lusaran/Middle Kotkot	637	431	1.10

Lusaran Dam is an element in all the first three least cost alternatives. The hydrologic data for Balamban River or Lusaran Dam is of longer duration and appears to be rather reliable. Geologic conditions at the Lusaran Dam are also favorable to rockfill dam construction.

Alternative S-T-3 is ranked best for the following reasons:

(1) It has the least present worth cost and initial project cost.

(2) In the long range, it will provide MCWD water supply from two directions. Areas to the southwest such as Talisay may be eventually served, if they so desire to join MCWD.

However, involvement of 7.5 km long raw water transmission tunnel, relocation of Barrio Lusaran and construction of relatively long (about 20 km) access road through a rugged terrain are major disadvantages in the Lusaran scheme. For development of the Mananga system, Barrios of Jaclupan and Naghaway and about 9 km of the existing road will have to be relocated; the raw water pipeline and the water treatment plant will have to be built in a relatively difficult terrain; and also, water requirements of the Talisay area must be considered in sizing of the Mananga dam and reservoir.

Prior to final design of the elements of the long range program, additional hydrological and dam studies will be required. Stream flow gagings must be established as soon as possible at the Balamban, Mananga and Kotkot Rivers. Topographical surveys and more extensive soil (foundation) investigations must be conducted on all these potential dam sites.

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C. WATER TREATMENT ALTERNATIVES

It is assumed that the Tisa Filtration Plant will not be expanded nor upgraded as part of the long range program. This plant will be abandoned as soon as practicable.

Water quality test results of the surface water sources were shown in Table VII-2. These sources would require complete treatment before the water can be delivered to the service area.

Applicable alternatives which will be investigated for all phases of the treatment process, would include chemical mixing and coagulation, flocculation, sedimentation, filtration, taste and odor control, iron and manganese removal and chlorination. The proposed treatment plant sites for each alternative scheme area are shown in Figures VIII-1 through 6. For a gravity supply to the first pressure zone of the distribution system, the treatment sites must be located at an elevation of about 70 m.

For groundwater sources which have no turbidity and bacteriological contamination problems, only disinfection treatment will be provided. In some special cases, iron and manganese removal may be considered. The wells high in chloride content will have to be abandoned as treatment would not be economically feasible.

Disinfection Alternatives

Disinfection of water supply may be accomplished through chemical application of chlorine, iodine, ozone, ultra-violet radiation and oxidizing agents.

Chlorination is a universal disinfection process used in most municipal water systems. Chlorine, a potent oxidizing agent, destroys bacteria by mixing with it under certain time constraints and when applied in correct dosage.

Iodine has chemical properties that make it an effective agent against virus and certain bacterial cysts. However, research indicates that iodine treatment in excess of three weeks may have detrimental effects upon individuals afflicted with thyroid diseases.

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Ozone, a blue gas and active form of oxygen, is rated to be a more vigorous oxidizing agent than chlorine. This versatile element not only disinfects but also sterilizes besides performing color reduction, iron and manganese oxidation, taste and odor control. Despite its impressive known qualities, ozone is yet to achieve universal acceptance.

Ultra-violet radiation is another method of disinfection applicable to small water systems. It involves high-cost equipment and considerable amount of power is required. Moreover, this type of treatment requires high quality water, otherwise the ultra-violet rays may be absorbed by substances present in the water supply.

The use of metal ions with bactericidal properties such as copper, silver and mercury is limited by their cost, availability and potential adverse health effects if not properly dosed.

Bromine as a water disinfectant is costly and scarce. Liquid bromine produces irritating fumes and causes severe burns.

Oxidizing agents such as potassium permanganate and hydrogen peroxide have weak purifying qualities that require long contact time and high dosage.

The economics of disinfection serves as an important, if not sole, basis for the selection of treatment method suitable to a particular water system. Selection is not necessarily based upon the cheapest method available but on its dependability, effectiveness, suitability and reasonableness in cost. From this viewpoint, ozone and chlorine merit further consideration.

Ozone, as earlier indicated, lacks extensive practical application but its versatility makes it advantageous over chlorine under certain conditions. It can be more effective and economical when used for two or more stages of water purification. Where taste and odor in water are organic, ozone may be as effective as chlorine. Where disinfection only is required or water supply is clear, however, chlorine will be much more economical.

Plant-scale studies on ozonation show that it entails bigger capital investment than chlorination by the ratio of 3 or 4 to 1.

While ozone appears to be an efficient disinfectant, its practical application is supported with scarce data. This leaves chlorine, a proven disinfectant, as more dependable for treatment. Although considered a less rapid agent than ozone, chlorine fits well in large water supply systems.

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Since the early 1900's, chlorine has been widely used in water treatment but recently in the U.S.A., it has developed into a critical issue. Studies done by regulatory agencies revealed the presence of cancer-producing chlorine compounds in the drinking water of several cities in the eastern part of the United States as a result of treating river waters contaminated by certain organic and chemical wastes. The studies indicated that through chlorination, the hazard levels of man-made chemicals and pesticides that pollute the river sources are increased.

However, the critical aspect of chlorination does not apply to the study area at this period of its development. Rivers are not generally contaminated by agro-industrial chemicals, a condition foreseen to remain for quite some time.

For either groundwater or surface water sources, residual chlorine in the distribution system is desirable and chlorine booster stations will be considered for this purpose.

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D. DISTRIBUTION ALTERNATIVES

General

The distribution system, in general, is composed of a network of feeder mains, internal distribution networks, storage facilities, booster pump stations, booster chlorination stations, and appurtenances such as valves, fire hydrants, meters, and service connections. The distribution system conveys the water to the consumer. The feeder mains are the larger pipelines which take the water from the transmission lines to the demand areas. Booster pump stations are required to raise water from lower pressure zones to higher pressure zones where consumers are usually at higher ground elevations. The booster chlorination stations are required at the fringe areas of the water district to keep the chlorine residual at the desired concentration. The distribution storage facilities provide supplementary flows during the peak demand periods. The transmission lines convey the water to and from the storage facility depending on whether it is filling or emptying.

The valves are placed throughout the distribution system to permit small service areas to be isolated by shutting off the valves at times when maintenance is required. The fire hydrants are connected to the distribution system at regular intervals depending upon the type of area served. The service connections convey the water from the internal distribution system to the consumer. Meters are placed on the service connection line to measure the amount of water consumed by the customer. The components of the distribution system described above are illustrated in Figure VIII-5.

Service Area Growth

The present service area is expected to grow in a logical pattern from the present population centers and adjacent to the roadways along which transmission lines will be installed. The service area will increase from 2,450 ha in 1975, to 4,900 ha in 1990, and to 7,000 ha by year 2000. The area is divided among the cities and municipalities as follows:

City/Municipality	Service Area in Hectares 1975	1990	2000
Cebu	1,800	2,600	3,550
Mandaue	504	830	1,200
Lapu-Lapu	35	560	900
Consolacion	-	335	500
Liloan	80	470	700
Compostela	28	130	170
Total	2,447	4,925	7,020

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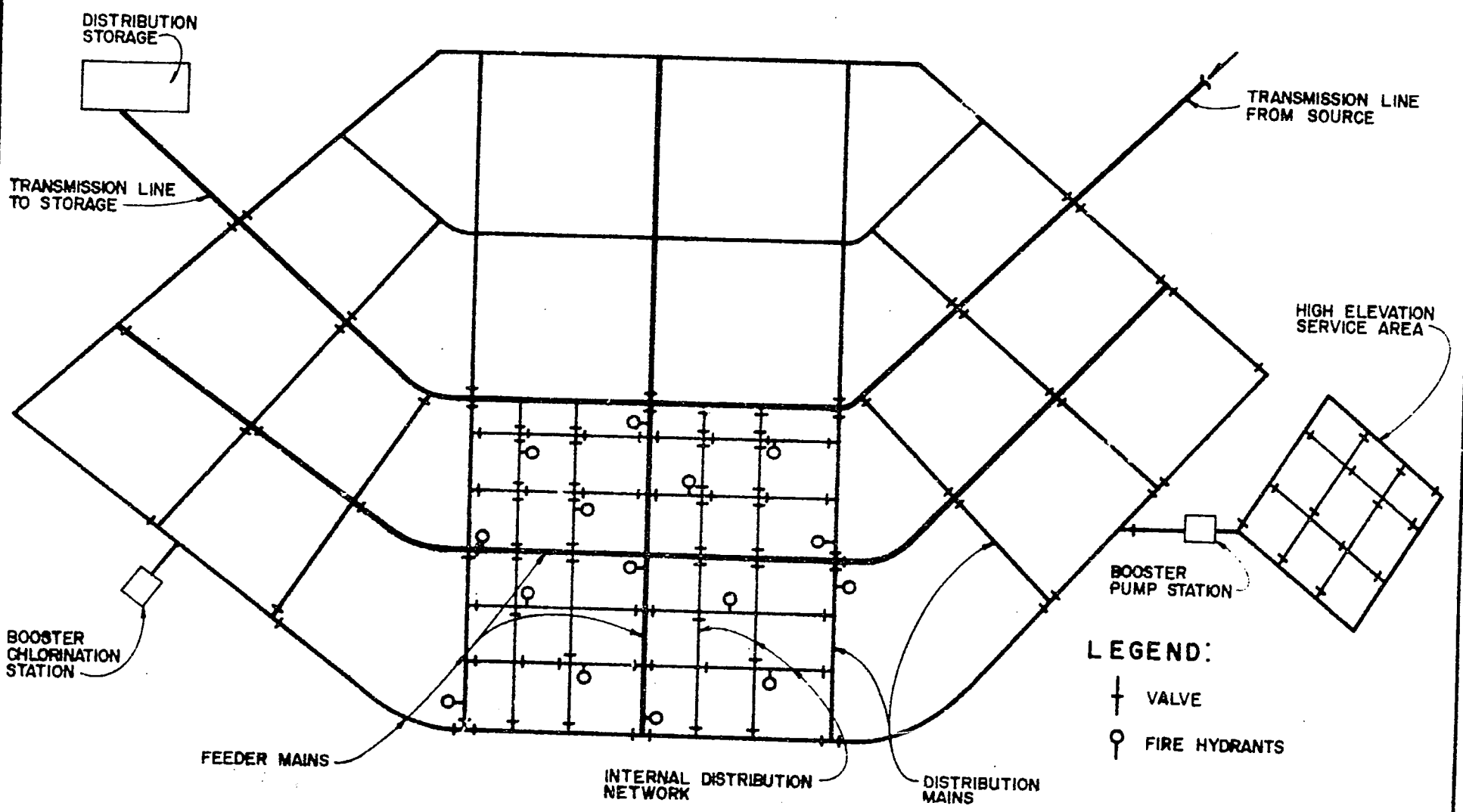

FEASIBILITY STUDY FOR WATER SUPPLY OF TEN PROVINCIAL AREAS CDM-LWUA

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FIGURE VIII-3
COMPONENTS OF THE DISTRIBUTION SYSTEM
NOT TO SCALE

The average-day demands for the cities and municipalities within the MCWD project area have been projected as follows:

City/Municipality	Average Day Demand (cumd) 1990	2000
Cebu	108,400	168,600
Mandaue	26,300	45,300
Lapu-Lapu	9,000	17,800
Consolacion	5,700	11,900
Liloan	4,400	9,200
Compostela	1,900	3,500
Total	155,700	256,300

Connection to Existing Systems

A great portion of the existing systems in Cebu City and Mandaue has aged beyond their useful life. It is recommended that the 150 mm and larger mains be renovated by cleaning and lining. Also, recently installed steel mains should be lined to prevent corrosion. The 100 mm pipe lines which are beyond their useful life, and all lines less than 100 mm should be replaced as the existing system is reinforced. These lines total 35.66 km of pipe.

Distribution systems in Lapu-Lapu and Liloan should be reinforced to provide adequate fire protection and peak-hour pressures. The entire system of Compostela (5.015 km) should be replaced since 84 per cent of the pipe is less than 50 mm in size and all of it is over 35 years old.

System Requirements

Hydraulics of the proposed distribution system alternatives has been checked for the design years of 1990 and 2000. The MCWD average water demands are projected to be 155,700 cumd in 1990 and 256,300 cumd in year 2000. These demands are projected according to consumer categories as follows :

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	Demand Year	
	1990 (cumd)	2000 (cumd)
Domestic	93,800	168,050
Commercial, Institutional and Industrial	16,930	28,350
Unaccounted for Water		
Leakage	22,500	25,900
Unrecorded Usage	22,500	24,000
Total	155,720	256,300

The distribution system must be designed to meet the peak hour demand and still maintain adequate system pressures (minimum peak hour pressure in feeder mains is 14 meters). The peak hour demand is the highest demand during any hour of the year and is assumed to be 75 per cent higher than the average daily demand for 1990 and 100 per cent higher for year 2000. By having proper placement of storage facilities within the distribution system, transmission mains and feeder mains can be sized for supplying maximum daily demands. This is because peak hour demands can be supplied from 2 directions - the source and storage facility. The maximum daily demand is estimated to be 20 per cent greater than the average daily demand. The projected maximum daily and peak hourly demands for MCWD are :

Year	Max-Day Demand (cumd)	Peak-Hour Demand (cumd)
1990	186,800	272,500
2000	307,600	512,600

The distribution storage will maintain the HGL at a higher level at remote parts of the distribution system. During periods when demand is higher than maximum daily demand, water is drawn from the storage tank. The storage tank is filled during periods when demand is less than the rate of supply from the source. The

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higher HGL due to the system storage will permit higher headlosses in the feeder mains and internal distribution network than would be the case without system storage. Also, the system storage contributes water during fires. The higher HGL will ensure adequate pressures at the fire hydrants. The volume required for distribution system storage is estimated to be about 20 per cent of the maximum-day demand. Storage facilities can be designed to coincide with transmission line staging and source development. In line with this, 3 periods are used for staging the necessary storage volume. The MCWD storage requirements are:

Design Year	Distribution Storage
1987	32,000 cum
1993 or 1994 *	45,000 cum or 47,000 cum *
2000	62,000 cum

* Depending on alternative proposed for the source development

Distribution System Alternatives

For the MCWD, the major distribution alternatives are concerned with the storage facilities, feeder mains, internal distribution system network, booster zone service, and service to Lapu-Lapu.

Storage Facilities. The choice of location for storage facilities is an important undertaking. The storage should be located as close to the demand center as possible and on the opposite side of the service area from the source. For operational purposes, the storage should be located at the same elevation as the HGL control on the transmission line coming from the water treatment plant. Since the HGL will be established at an elevation of 70 m, the location of storage is practically limited to a site having an elevation between 63 and 70 m, allowing a 7 m operational range. In the Cebu metropolitan area, 4 sites meet the desired criteria. These are located as follows:

Site 1 Near the present Tisa Water Treatment Plant and 4 km from the central city district of Cebu.

Site 2 Near Barrio Lahug about 4 km from the central city district of Cebu.

Site 3 The existing Basilan storage tank near Lahug.

Site 4 Near Barrio Talamban about 7 km from the central city district of Cebu.

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There are several other potential storage sites which are north of Cebu City and 4-7 km from the central district. However, these sites are not as accessible by road as those listed above. The sites listed are not intended to be the precise location but only a description of an area which is suitable. The exact determination of the storage sites will depend upon land availability and costs.

Of the 4 sites which are suitable for locating a distribution storage, all except the Basilan (Storage Site 3), can serve the first pressure zone which will provide service to ground elevations up to 50 m. The Basilan Tank has an overflow level of about 110 m which is too high for the lower pressure zone. However, this storage facility is suitable for the high pressure zone which will be served by booster pumpage. Thus, the booster zone can provide service up to a ground elevation of 90 m.

Computer analysis of several alternative transmission and storage schemes showed that proper location of storage was dependent upon the direction water was supplied from the source and the area of greatest demand. For all alternative source schemes, it was found that storage located near Talamban (Site 4) did not contribute sufficiently to peak hour demands. Storage located at Sites 1 and 2 were more suitable for all alternative source schemes.

The storage sites and the required volumes are summarized below:

	Stage I (Phase A)	Stage II (Phase B)	Stage II
Site 1	32,000 cum	5,000	
Site 2		8,000 or 10,000 cum	15,000 or 17,000 cum
Site 3	Booster zone	Booster zone	Booster zone
Site 4	None	None	None

Site 4 may be utilized in the future for distribution storage when the peak hour demands in the vicinity become sufficiently large. The Basilan Storage Tank is not covered at this time. For the tank to be incorporated into the MCWD planned distribution system improvements, a reinforced concrete cover should be constructed to protect the water supply from potential contamination.

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The storage tanks will be located approximately on-grade and will permit a HGL range of 7 m from 63 m at the outlet elevation to 70 m at the overflow elevation. The structures will be reinforced concrete construction and covered. Tank filling will take place during the minimum demand periods. Amount and duration of minimum demand can be determined by 24-hour consumption records. Since these data are not available, it is assumed that this minimum demand is about 30 per cent of the average demand for a period of 8 hours.

Placing the static HGL at an elevation lower than 70 m is not recommended because this will mean the areas at the extreme ends of the distribution system will have insufficient pressures unless inordinately large feeder mains are provided for. If locating the distribution storage tank at a lower elevation than the source is considered, a double acting altitude valve must be placed on the supply line to the tank. The valve closes when the water elevation in the tank gets to the overflow level and opens when the pressure drops in the distribution system, permitting water from storage to enter the system. If the valve is not maintained at all times, it could fail to operate properly and cause lower pressures in the distribution system than is required. Because the storage is at an elevation less than the source, it is difficult to obtain the required flow from storage during peak flow demands as most of the supply will come from the direction of the source - the location of the highest HGL.

Another storage alternative that must be considered is the staging of the required volume. Initially, adequate land area should be purchased so that the ultimate storage capacity of the site can easily be accommodated. The storage facility is designed and constructed in increments so that the desired capacity is available when needed. Elevated or standpipe type storage tanks should be avoided. This is because these structures are more expensive to construct and maintain than ground tanks and are usually objectionable from the environmental point of view.

Distribution and Feeder Mains. The alternatives for feeder mains are location, size, staging and the spacing in the network. To avoid land costs and also to place the mains as close to the demand center as possible, the alignments for future feeder mains have been chosen along existing and planned road and street right-of-ways. Where the service area extension is in areas without planned or existing roadways and streets, the feeder mains have been located arbitrarily while paying close attention to topographic features. As much as possible, the feeder mains have been looped to avoid dead-end service areas; to reduce the number of

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VOID AFTER 1 NOV 1975

customers affected by valving off of lines for maintenance; and to provide adequate pressure at times of maximum demand as the demand can be supplied from more than one direction.

The minimum size of feeder mains has been taken as 200 mm. In general, this size is large enough to provide adequate pressure during peak hour and fire flow conditions. In some residential areas, alternating 150 mm and 200 mm pipe sizes are adequate. Staging of feeder mains is economical at 10-year intervals in areas having wide streets and small population densities. However, in high density areas having small streets, it is usually preferable to avoid 2-stage construction. There is limited space for utilities in these areas and considerable disruption occurs when the street is excavated for the new water main. It is better to install the pipe size required for ultimate design in these congested areas so that these problems can be avoided.

It is desirable to maintain the maximum spacing of feeder mains at 1,000 m. This will provide uniform size and spacing for the internal mains as well as better pressure distribution throughout the system. A wider spacing of the feeder mains would require larger pipe sizes in the internal distribution network to maintain sufficient pressures during fire flow and peak hour periods.

It is not recommended that the minimum feeder main sizes be staged. However, larger feeder mains can be staged in some instances. A required pipe size of 250 mm for year 2000 demands can be conveniently staged with one 200 mm line in Stage I and another 200 mm parallel line in Stage II. However, in Stage II an extra cost of 15 per cent may be included in the construction of the parallel line because of the problem encountered with interties to the Stage I line and safeguarding and sometimes transferring the connections with the internal network. The economic evaluation of 2-stage versus 1-stage construction of a 250 mm line is presented below:

EVALUATION OF FEEDER MAIN STAGING

Alternative	Construction Period	Pipe Size (mm)	Construction Cost (P/m)	Project Cost (P/m)	Annual Cost (P/m)	1976 Present Worth* Capital Cost (P/m)	Annual Cost (P/m)	Total Cost (P/m)
Single-Stage	1980	250	430	587	3	373	14	387
						Total		387
	1980	200	260	355	2	226	9	235
	1990	200	300	409	2	84	2	86
						Total		321

* Discount rate = 12 per cent

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Comparison of the 2 alternatives shows that constructing 2 parallel 200 mm lines in each stage is more economical than a single 250 mm line in Stage I. Similar calculations for staging a 300 mm line with parallel 250 mm and 200 mm lines also indicate savings with 2-stage construction. Selection of feeder mains which should be staged must follow an analysis of the peak hour and fire flow conditions in 1990 to be sure that the smaller line constructed in Stage I will be hydraulically adequate.

The timing of the construction of the feeder main system should be such that an attainable level of growth in the distribution system is maintained. Areas having higher densities of potential customers should be connected in the early construction periods because the cost per connection will be lower and more revenues will be generated. Also, extension of service to large demand customers such as industries and commercial areas would be desirable when a reliable water supply is available. Service to this type of customer would have a positive impact on the economy of the project area.

Internal Distribution Network. The alternatives in the internal distribution network are dependent on the level of water service provided. A system designed for fire flow demands may require larger internal distribution pipes than a system designed only for peak hour demands. The fire flow requirements for MCWD are:

Type of Area	Fire Flow Demand
Commercial, Industrial and High Value Residential	20 lps at each of 2 adjacent fire hydrants
Single Family Residential	10 lps at each of 2 adjacent fire hydrants

The internal network design is controlled by either of 2 conditions: peak hour demands with minimum main pressure of 10 m or fire flow demand coincident with maximum-day demands with a minimum hydrant pressure of 7 m. In order to determine the range of flows which can be expected during peak hour and fire flow plus maximum-day conditions, a typical area in Cebu was studied in detail. Several computer analyses were made for varying population densities. The area studied was assumed to be an area of mixed residential and commercial land use. The domestic flow requirement was assumed to be 175 lpcd (the year 2000 projection), and the commercial and institutional demand was assumed to be 10 per cent of the domestic demand. The unaccounted for water was assumed to be 25 per cent of the area's total demand. The demand was applied uniformly over the entire area. The table

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below lists the flows found in the computer analysis for internal network pipes.

Population Served Density (persons/ha)	Total Flow to 100 ha Area (lps)	Maximum Flow During Peak Hour Condition (lps)	Maximum Flow During Fire Flow Condition Residential (lps)	Maximum Flow During Fire Flow Condition Commercial (lps)
100	30	16	16.8	19.4
200	60	17.5	17.4	20.0
300	90	19.3	18.2	20.5

In all cases, the pipe flows for the commercial fire tests are larger than the peak hour pipe flows. However, in residential areas, the peak hour flow is slightly larger than the fire flows. It is not sufficient, however, to determine only the controlling flow condition. One must also examine the pressures during peak hour and fire flow conditions because the minimum allowable pressure is different for each condition. Computer analysis of the area described above showed that the minimum pipe size which will meet the pressure requirements, is 150 mm for internal network mains connected to hydrants. For those mains not connected to hydrants, the minimum size is 100 mm. In single family residential areas with a maximum ultimate density of 150 persons per ha under the specified criteria, 100 mm mains can support fire flows.

Staging of internal network pipes is not usually economical or practical. Streets and utilities should be provided in accordance with development and zoning plans. The internal network should be designed with the ultimate plan of the area fixing the required demands and fire flows.

The valves in the piping network should be spaced so that interruptions in service due to maintenance affect as few customers as possible. Each internal network connection to a feeder main should have a valve so that repairs to an internal main do not require closing of valves on feeder mains. High demand areas should have more frequent valve spacing than low demand areas. Valves should normally be placed at street intersections with a minimum spacing of 300 m to 500 m depending on the character of the area.

Fire hydrants should be placed at street intersections to permit quick location and enable fighting fires in several directions. In high value areas, hydrants will be spaced a maximum of 150 m

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apart with 2 outlets-a 1 x 60 mm hose outlet and a 1 x 100 mm pumper outlet. The hydrant will be connected to a main with a minimum diameter of 150 mm. In single family residential areas, hydrants would be connected to 100 mm mains and spaced a maximum of 250 m apart. The outlet will connect to a 1 x 100 mm pumper or hose.

Customer service connections consist of a connection to the internal network main and a service line to the customer. The service line may be provided with a "gooseneck" for connecting to the distribution main and a service meter will be provided for continuous measurement of water provided to the customer. A valve should be inserted in the service ahead of the meter to permit the water district to terminate service when it becomes necessary.

As mentioned earlier, it is not practical to stage the construction of the internal network mains. Therefore, the only alternative is evaluating peak hour requirements vis-a-vis fire flow requirements. The internal network is designed for the type of land use plan, zoning requirements, or developments which will take place along the streets of the service area. Its design should take into account the ultimate water demands along the street. For ultimate flows into the internal network, the required flows for peak-hour and fireflow conditions are usually within 10-15 per cent of one another. Thus the required pipe sizes for peak-hour condition are likely to be the same as those for the fire flow conditions. The major cost difference between the 2 conditions is the fire hydrants that must be added for fire protection. In order to obtain the cost of fire hydrants in the internal network, 2 areas were chosen and the internal network was designed for each area. The results of this study are listed in Table VIII-6. The incremental cost of fire protection in the internal network distribution is 23 per cent in the core city area and 7 per cent in the service area extensions to residential areas. The reason for the higher incremental cost in the core city is mainly because the spacing interval for hydrants is less in high-value areas. The final determination to include fire protection must follow an assessment of the benefits accruing to fire protection. Such benefits include reduced fire insurance premiums and a decrease in monetary losses due to fire damages.

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INTERIM REPORT
VOID AFTER 1 NOV 1975

TABLE VIII-6

INTERNAL NETWORK COST

Type Area	Internal Network Component	Construction Costs ₱ per Ha
Core City (Reinforcement)	Pipes and Valves	14,000
	Hydrants	4,400
	Service Connections	4,800
	Total	23,200
Service Area Extension	Pipes and Valves	18,600
	Hydrants	1,500
	Service Connections	3,100
	Total	23,200

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Booster Zone. Portions of the present service area are at elevations too high to be served by gravity from the HGL of 70 m. These areas are at elevations above 50 m and must be served from a high pressure zone by booster pumping. Guadalupe, Lahug, and Talamban comprise the barrios which are presently served by the MCWD at elevations which will require booster pumpage. The future service area extension near Tisa will also require booster pumpage.

The Stage I improvements are scheduled so that it is not practical to construct the booster pump station to serve Guadalupe and Lahug until 1984 or 1985. At this time, the feeder main network will extend the improved service to this area. By using the existing Basilan Storage Tank as booster zone storage, the booster pump station can be designed to deliver maximum day requirements. The peak hour demands can be supplied from both storage and the booster station. The Basilan Tank has an overflow elevation of about 110 m which will enable the booster zone to extend service to areas with a ground elevation as high as 90 m. The location of the booster pump station should be opposite the demand center from the storage site. Since the storage is near Lahug, the booster station should be constructed southwest of Guadalupe. The booster station should also be located so that it is easily connected to the feeder main network.

Prior to service from the booster pumping stations, the areas of Guadalupe and Lahug should be isolated from the existing distribution system by closing valves in the feeder main network. Each area can be served by the existing wells at Guadalupe Church, Guadalupe Fire Station, Camp Lapu-Lapu and Lahug. The total production from these wells has been measured at 2,800 cumd, which should suffice until the booster pump station can be connected to the feeder main network. However, replacement of the existing pumps may be necessary for obtaining adequate operational heads. The existing service area at Talamban is served by a well which can produce 900 cumd.

At the present time, water from the well is pumped 4-5 times a day for one-hour periods into the Talamban storage tank. This operation of a separate supply to Talamban should continue until the well is pumping at capacity level. The Talamban area should remain a separate service area until 1992 to 1994 when it is projected that feeder main service will be extended as far as Talamban. At this time, the demand in the Talamban area should be sufficient to expand the system and provide service by construction of a booster pump station. The Talamban booster zone should be

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connected to the Guadalupe-Lahug booster zone. By so doing, the Basilan Storage Tank can serve the whole booster zone as it has sufficient capacity. By year 2000, the Guadalupe-Lahug booster zone will be expanded to include service in the Tisa area, thus making the total service area of the booster zone about 800 ha. Location of the booster zone facilities is shown in Figure IX-1. A summary of the booster zone expansion is provided below:

Area	Projected Year for Booster Zone Service	Booster Station Capacity
Guadalupe	1984	11,750 cumd
Lahug	1984	
Talamban	1994	7,600 cumd
Tisa	1998	Served by Guadalupe Booster Station

Service to Lapu-Lapu. The transmission line serving Lapu-Lapu will cross the Bohol Strait along the Mactan Bridge. The bridge was designed with provision for supporting a transmission line to serve Lapu-Lapu and Mactan Island. Three alternatives for providing service to Lapu-Lapu were examined:

ALT-1. Gravity service to Lapu-Lapu. This alternative is feasible because the HGL is 70 m at both the treatment plant and storage tanks. The highest roadway elevation on the bridge is 32 m. A HGL of 38-40 m at this point would provide a sufficient factor of safety to ensure positive pressure.

ALT-2. Booster pumpage to Lapu-Lapu. A booster pump station would be required in Mandaue to pump the water across the bridge to Lapu-Lapu. The station would be designed to deliver peak hour flow requirements to Lapu-Lapu.

ALT-3. Booster pumpage to Lapu-Lapu with storage in Lapu-Lapu. This is the same as ALT-2 except that providing storage in Lapu-Lapu will require the booster station to deliver maximum daily flows.

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The required pipes, booster station and storage tanks are listed in Table VIII-7 as well as the present worth of net disbursements. Computer analysis of ALT-1 within the overall MCWD system showed that the HGL at peak hour conditions for year 2000 wouldbe about 46 m for the 500 mm gravity flow bridge crossing. The gravity transmission line, though more expensive in Stage I, costs cheaper in the long term in comparison to ALT-2 and ALT-3. In addition, this pipe may be constructed in 2 stages to reduce the initial cost. The transmission line in ALT-1 will be able to serve Lapu-Lapu beyond year 2000 by two ways. First is by providing a storage tank in order to reduce peak hour flows from the source and second, by installing a booster station in Mandaue to further extend the serviceability of the transmission line. ALT-2 is attractive because of its low initial cost; however, the useful life of the pumps is only 25 years and will require replacement later. Also, the transmission lines which are smaller than those in ALT-1, must be periodically reinforced. Beyond year 2000, a third line would be required. Three lines across the bridge are probably not practical and a more expensive underwater crossing might be required. Thus, ALT-1 is economically and practically the best alternative.

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INTERIM REPORT
VOID AFTER 1 NOV 1975

TABLE VIII - 7

SUMMARY OF EVALUATION OF ALTERNATIVE TRANSMISSION LINE SERVICE TO LAPU-LAPU

Alternative	Construction Period	Component	Size	Construction Cost (₱1,000)	1976 Present Worth of Net Disbursements (₱1,000)	
ALT-1	1981-82	Transmission Line	500 mm	6,396	4,520	
ALT-2	1981-82	Transmission Line	300 mm	2,706	1,914	
		Booster Station	17,000 cumd	1,800	2,303	
		Sub-Total				4,217
	1989-90	Transmission Line	300 mm & 350 mm	2,982	740	
		Booster Station	18,600 cumd	1,900	684	
		Sub-Total				1,424
		Total				5,641
ALT-3	1981-82	Transmission Line	300 mm	2,706	1,914	
		Storage Tank*	2,100 cum	2,300	1,649	
		Booster Station	10,600 cumd	1,600	1,369	
		Sub-Total				4,932
	1989-90	Transmission Line	300 mm	2,706	771	
		Storage Tank*	2,000 cum	2,200	546	
		Booster Station	10,600 cumd	1,600	485	
		Sub-Total				1,802
		Total				6,734

* Storage tank volumes listed are operational volumes. Construction costs are for stand-pipes having a total volume of three times the operational volume. Large stand-pipes are required since ground elevation on Mactan Island is approximately 5-10 m.

E. OTHER ALTERNATIVES ON WATER CONSERVATION AND AUGMENTATION

Alternatives available to counteract future (and present) water shortages consist of the following: reuse of wastewater, desalting, precipitation augmentation, land management, and dual plumbing systems. These alternatives are discussed below.

Wastewater Reuse

One of the potential alternatives in meeting future water demand is the reuse or recycling of wastewater (sewage). In Singapore, reclaimed wastewater is used in the cooling process in industries. A full-scale municipal reuse facility in Windhoek in Southwest Africa built in 1969 provides a major source of potable water.

Reuse of wastewater can be accomplished in 2 ways: by natural self-purification which makes reuse possible for irrigation and recharging of ground and surface waters, and by technological process. The technology of reuse involves treatment of used water supplies from the community for domestic, industrial, irrigation and other purposes.

Complex treatment processes are necessary to remove the objectionable characteristics of wastewater and make it suitable for a particular use. There are 3 basic phases of treatment - primary, secondary and advanced. One of these or all may be applied depending on the types of use and pollutants present in the wastewater.

Studies on wastewater reclamation deal with enhancing its economic feasibility for large scale use and technological expansion. Achieving these objectives will depend on several factors.

It is technologically possible to produce water of any desired quality from any source. However, the controlling factor is economics. Because of its lesser solids content, wastewater reclamation is simpler than seawater desalting as an alternative source of supply.

The feasibility of wastewater reclamation as a source of water supply will be limited in the study area since collected wastewater volumes are currently minimal, with future increases in sewage expected to be slow.

Desalting

Desalting is the process of converting seawater into fresh water. It involves removing substantial amounts of the ocean's salts and minerals.

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There are 3 basic methods of desalting: distillation, freezing and electrodialysis, each with several variations.

Over 90 per cent of the present application of desalting is done by distillation. In this process, seawater is evaporated and the vapor is condensed. Salt deposits form on the surfaces of the evaporating equipment and the desalinated water is the resulting distillate. The least costly distillation unit uses solar energy as heat source.

Electrodialysis obtains fresh water by using an electric current to separate the ions of the contaminating salts. In the process of freezing, ice is formed from a saline solution and is melted to produce fresh water. The melted ice, however, sometimes has a salty taste.

In 1970, 33 small-sized desalting plants were put in operation throughout the world, with a combined capacity of 59.7 mgd. Kuwait has the largest plant with a 30 mgd capacity sufficient to supply a population of 150,000. Other plants are found in Netherlands, United States, Venezuela and Aruba.

For the most part, desalting is still experimental. At present it is not technically and economically feasible to convert meaningful amounts of seawater into fresh water. All the processes have inherent defects for general use, including the problem of disposing about 50 per cent of removed salts and minerals of the total treated seawater.

These processes are also costly because they involve significant quantities of energy. Whereas treatment of ordinary water supply costs about 5 cents per 1,000 gallons of fresh water, desalting costs about $1.00 per 1,000 gallons of desalted water. This cost covers only the plant itself and excludes necessary transmission facilities. (Also these are pre-energy crisis costs.)

Precipitation Augmentation

Rain can be artificially induced to increase water supply (although it does not diminish the need to collect it). The most common method of stimulating rainfall is cloud seeding.

The theory behind cloud seeding is that under certain conditions, air containing much moisture will not yield precipitation that might possibly occur because of the absence of particles of dust, crystal or chemical droplets. In cloud seeding, such particles

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are artificially implanted in supersaturated clouds to stimulate rainfall. These particles used in the method are called silver iodide crystals.

The costs of cloud seeding in 1971 ranged from $1.00 to $2.30 per acre-foot of additional runoff. This cost range, however, was derived from planning reports and as such, it might not represent actual operations.

Cloud seeding does not always yield the desired effect of increased rainfall. Experiments show that the method also results in decreases in the amount of expected precipitation. These effects have not been sufficiently explained although a theory advanced is that the amount of rainfall depends on the types of cloud systems being seeded.

Increases in precipitation do not necessarily produce proportional increases in usable water supply. The opportunities to increase precipitation depend on climatic conditions such that during the dry season, water supply increases are less frequent. Precipitation augmentation encourages the growth of vegetation that can reduce usable water yield.

Land Management

Land management can affect the amount and quality of water available for use. It is a method of both increasing and conserving water supply.

Two potential techniques of land management that apply to Philippine conditions are forest management and control on streambank vegetation. Forests impact upon water supply on a number of ways. They intercept rain from the surface of the leaves. They draw moisture from the soil and release it into the atmosphere by transpiration. Through their roots, leaves and other parts, forests facilitate the infiltration of precipitation into the soil. They also tend to shade the soil, reduce wind velocity, thus, reducing evaporation from the soil surface. Any alteration on the amount and type of vegetation, such as deforestation, will affect water supply.

Phreatophytes or deep-rooted vegetation along the banks of canals and rivers consume much water in their growth. Especially in cases as when precipitation is low, this vegetation reduces the streamflow and the discharges of springs. Sometimes, it also tends to increase flood stages when it invades stream channels and reduces channel capacity. Phreatophytes are useful in the sense that

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they provide important wildlife habitat. Otherwise, they do not have food value. Based on these uses and effects on water supply, they have to be managed carefully as uprooting them is not necessarily the best answer to increasing water supply.

Dual Plumbing Systems

A relatively small increment of the total public water supply demands highly potable and clean water such as that required for drinking, cooling, bathing and washing clothes. It is possible, for instance, to use seawater for toilet flushing, washing streets, fire fighting. Where fresh potable water is in short supply, such as in Singapore and Hongkong, a dual system has demonstrated its efficacy. For example, in Hongkong during the severe drought of summer 1963, water service was rationed into the various city sectors 4 hours every 4 days. Extraneous uses of water such as toilet flushing were therefore severely curtailed. In some of the high-rise government housing in Hongkong, dual plumbing system had been used, with seawater for toilet flushing.

There are 2 main objections that have been identified in the use of dual system - cross-connections and associated cost. Dual water supply system where one system delivers potable water and the other system furnishes untreated water can very well lead to serious water-borne disease outbreaks. Where proposed, the dual water supply system should have the non-potable supply clearly indicated and separated from the potable supply. Proper plumbing codes and supervision of plumbing installation could minimize this health hasard.

If an existing system is to be replaced entirely by a dual system the cost may well be unreasonable. However, if the existing water supply piping is retained for potable (drinking) system and a new non-potable pipe network utilizing seawater is added there is a possibility that the economics may prove the dual system to be worthwhile. Savings accrue where the non-potable system serves high-rise multi-family dwelling units with high density. The increased cost resulting from the independent system may be offset by eliminating the need for developing new water resources and above all retaining high quality premium water for domestic consumption. Accordingly, the feasibility of dual systems has already been proven under certain conditions.

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CHAPTER IX DESCRIPTION AND COST OF THE (TENTATIVE) SELECTED PLAN

A. GENERAL

To achieve the required long range water supply system of MCWD will entail undertaking an extensive construction program including new source development, treatment, transmission and distribution facilities. As analyzed in the previous chapter, Alternative S-T-3 has been selected as the tentatively recommended scheme for the water source development and transmission system.

This chapter describes the early actions and interim improvements required; the first stage and second stage facilities of long term construction program. Chapter IX also presents capital and annual costs; sewerage and drainage concepts; and management of groundwater sources.

The recommended plan may be implemented in 7 steps: (1) the early actions which should be started and implemented as soon as possible; (2) interim improvements to minimize the worsening water shortages until the year 1982; (3) Phase A of the first stage of construction (1978-82); (4) Phase B of the first stage of construction (1982-87); (5) Phase C of the first stage of construction (1986-89); (6) Phase A of the second stage of construction (1989-94); (7) Phase B of the second stage of construction (1995-99).

B. EARLY ACTION GUIDELINES

While the findings and recommendations of the interim (and final) reports are being discussed, and pending their approval by the Water District, LWUA and financial agencies, certain steps may be taken in the meantime to facilitate "early action" in the MCWD water supply system. These early action guidelines are as follows:

1. Continue the publicity and promotional campaign about the water feasibility study so that water district customers are made fully aware of the improvements that are about to happen and prepare them for the corresponding water rate increases.

2. Discuss in detail within the water district ideas relative to raising the implementation funds (local and the foreign exchange component).

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3. Strengthen the legal basis for development of new water sources, its implementation and enforcement.

4. Acquire the land surrounding the proposed water sources, treatment plant, distribution storage sites and right of way for the transmission lines, and conduct a detailed topographical survey of such land and right of way. The water district new administration building and shop and laboratory facilities may be located at the proposed treatment plant site.

5. Acquire a complete laboratory testing and sampling equipment; meter repair, testing and shop equipment; assorted tools; and supplementary water district vehicles.

6. Acquire disinfection (chlorination) equipment and operate the same as soon as possible at effective locations of the existing system.

7. Continue water meter installations to have all the water services metered as soon as possible.

8. Initiate a routine hydrologic and meteorological data collection program in the Kotkot, Balamban and Mananga Rivers (in cooperation with the National Water Resources Council) to develop stream flows, evaporation, rainfall and siltation measurements over a period of at least 10 years; initiate a well water level and discharge gaging and monitoring program at the existing and the proposed well fields identified as a long term source of MCWD.

9. Initiate routine water sampling and analysis at the proposed surface sources, well water sources and distribution system.

10. Conduct a physical inventory and survey of the water system and sewer system facilities and their connections to the private premises. Inventory private wells, septic tanks, private and public drainage systems.

11. Initiate a sewerage/drainage feasibility study as soon as the water supply planning is completed. In conjunction with this, conduct an oceanographic survey of the Bohol Strait and Camotes Sea.

12. With consultation, adopt a flexible, enforceable plumbing code in anticipation of the water supply improvements and near-future sewerage/drainage system.

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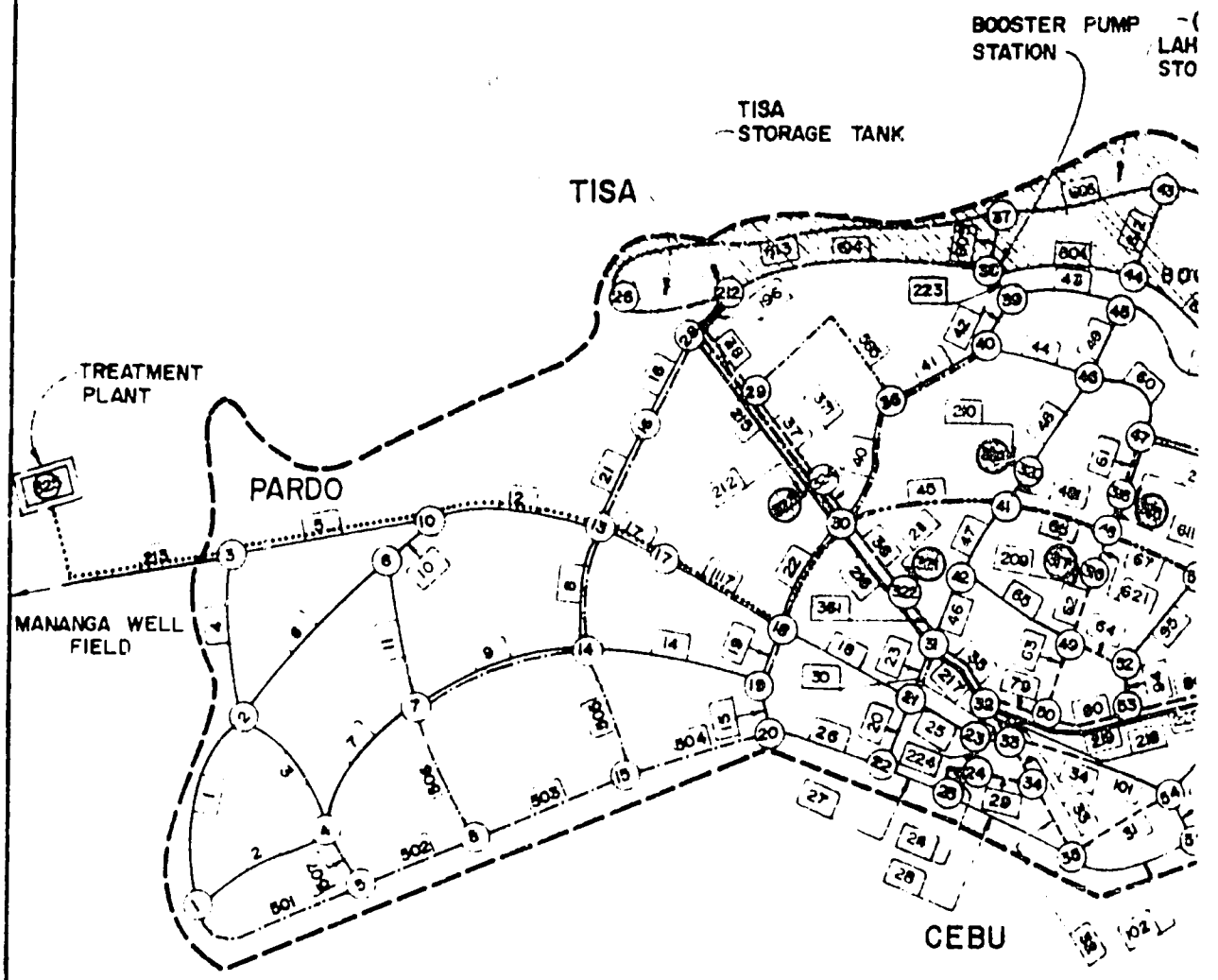

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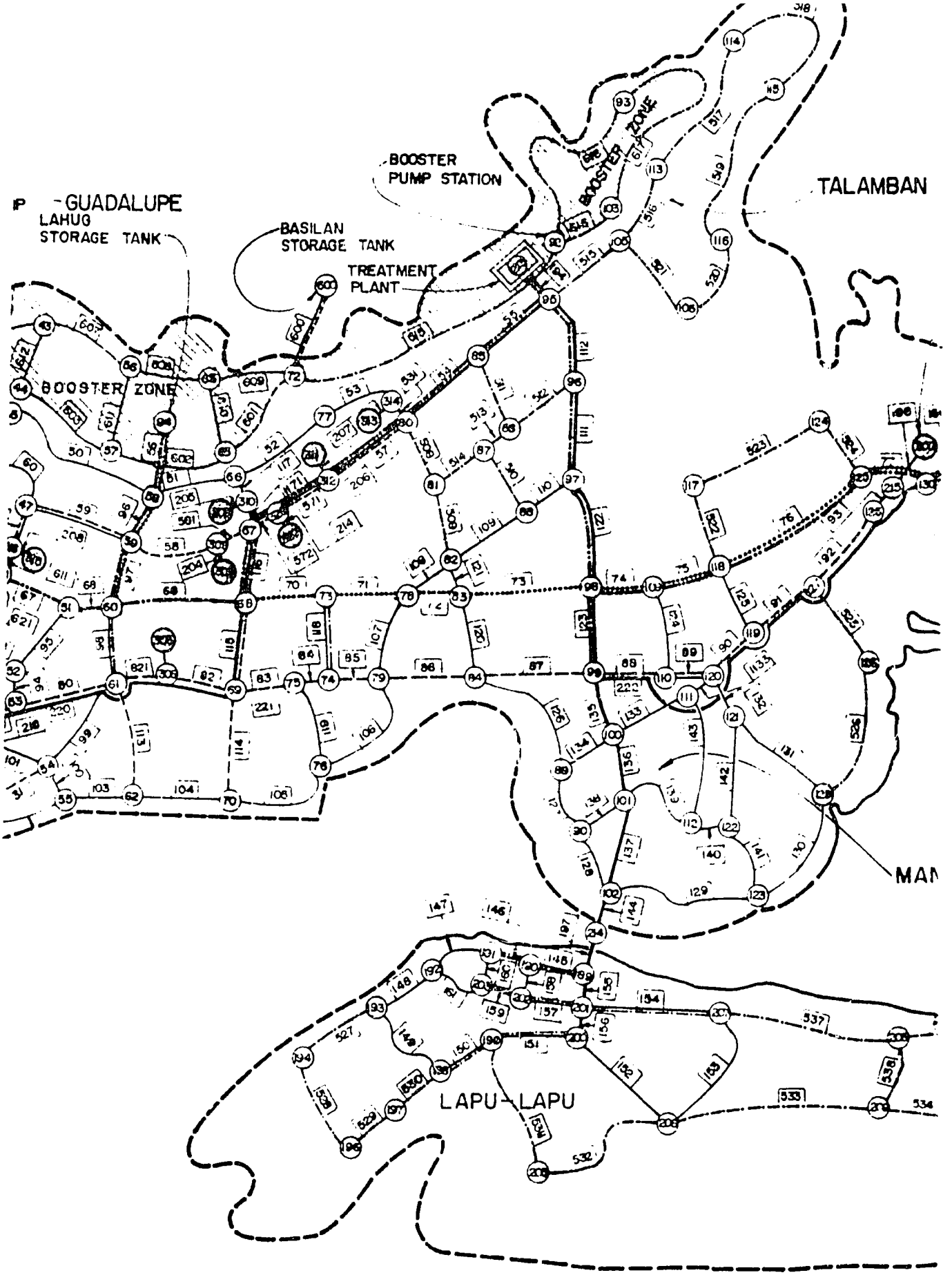

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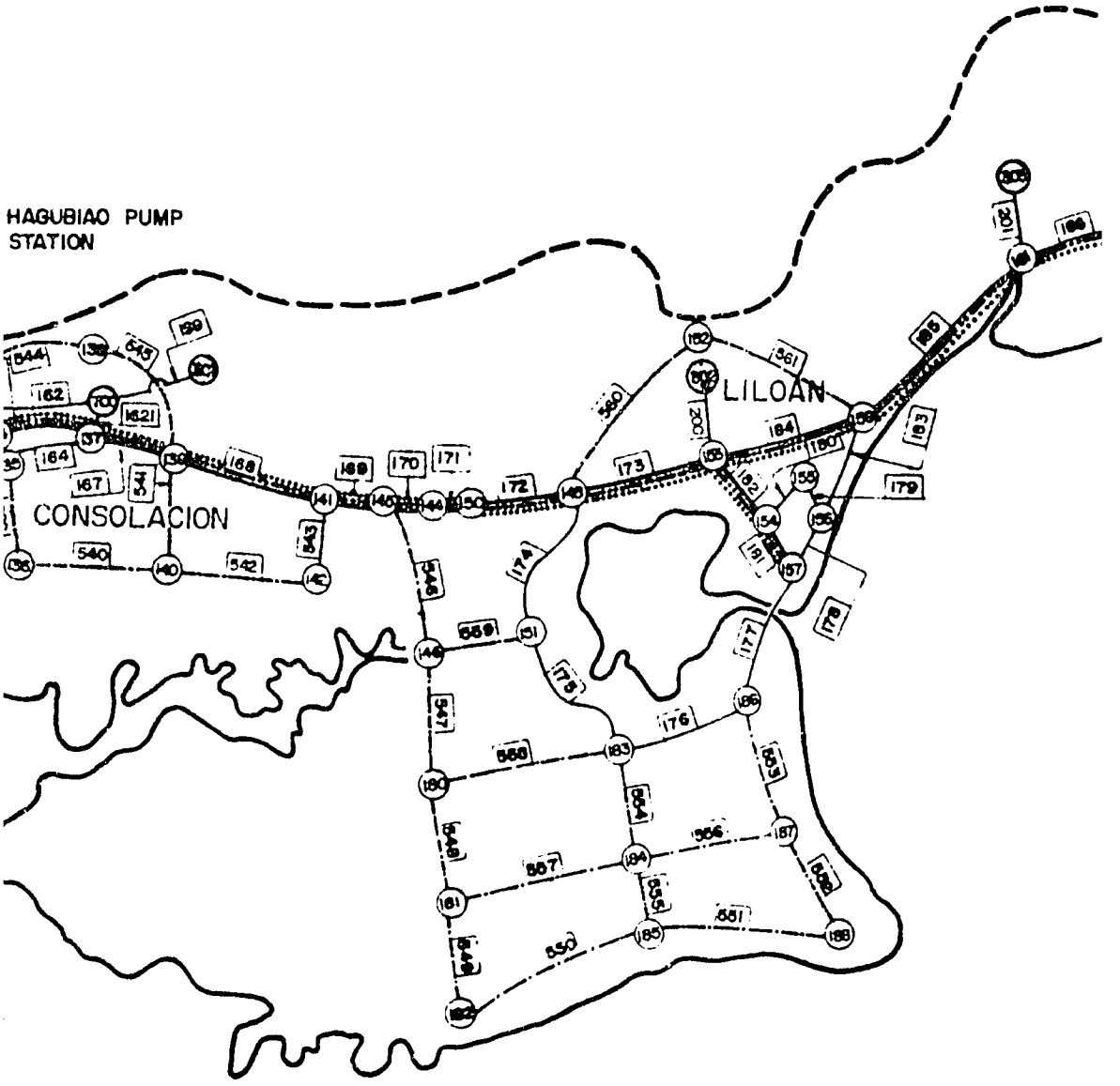

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SCALE IN METERS

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FUTURE

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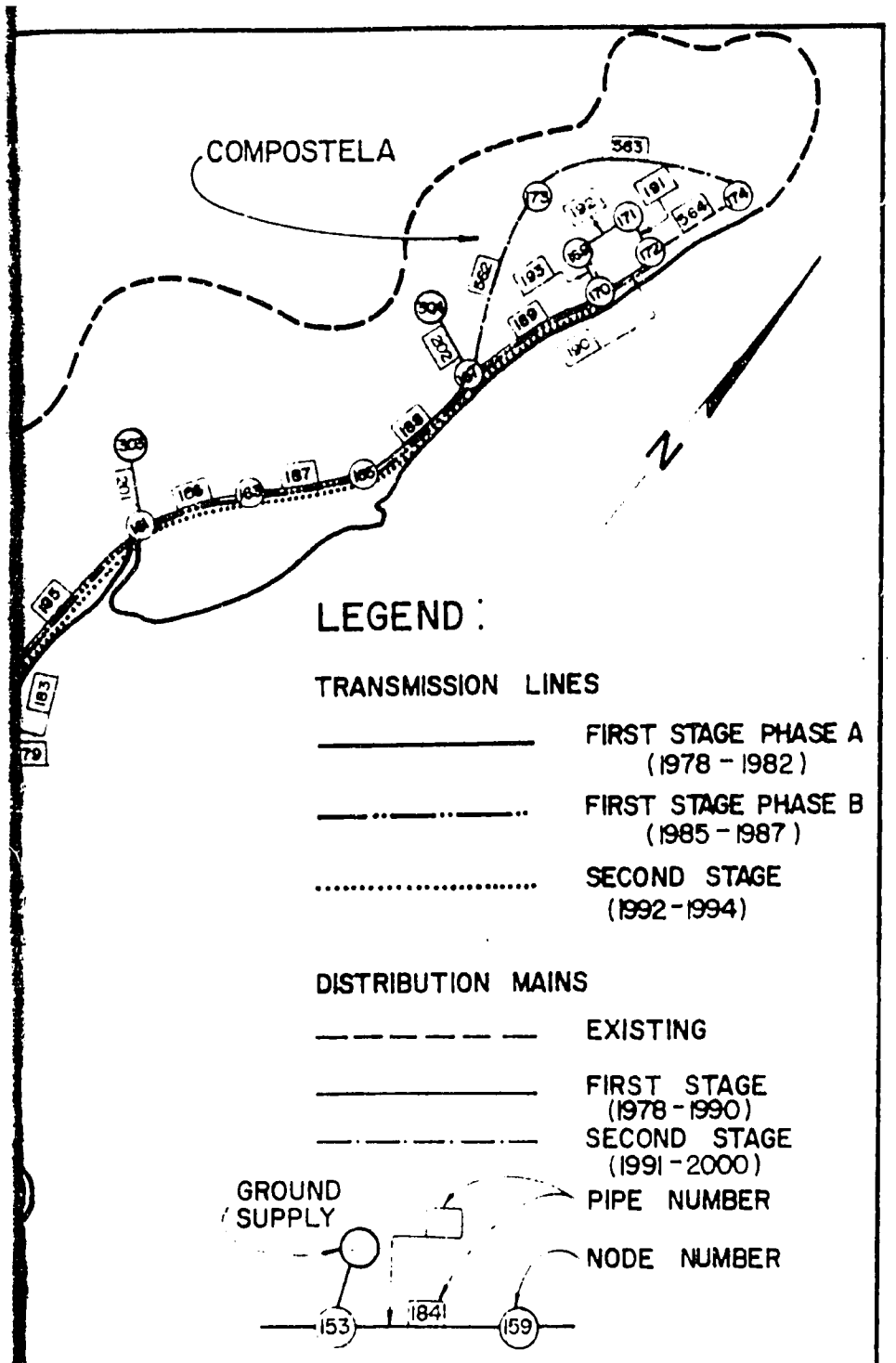

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FIGURE IX - 2
FUTURE TRANSMISSION LINES & DISTRIBUTION MAINS
SCHEMATIC PLAN

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13. Carry on with leakage and corrosion survey of the water system, identifying actual and potential cross-connections of water supply and pollutional material.

14. Initiate a jar test program at the Tisa Water Treatment Plant to maximize the use of existing facilities and optimize the use of chemicals for coagulation (in the interim period to 1982). Provide a by-pass piping to the filter to save on washwater and to eliminate back-up overflow in the sedimentation basins, during non-rainy periods; unthrottle the valve on raw water line from Buhisan to Tisa.

15. Initiate improvements to the management, engineering and operation and maintenance procedures of the Water District in accordance with the established LWUA guidelines and in anticipation of future requirements that may be imposed by loaning agencies.

Estimated construction costs and the foreign exchange components for the recommended early works are shown in Table IX-1.

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INTERIM REPORT
VOID AFTER 1 NOV 1975

TABLE IX-1

COST ESTIMATES FOR EARLY ACTION WORKS

Item	Estimated Construction Cost (₱)	Foreign Exchange Component (US $)
1. Chlorinators 2 at Tisa WTP 2 at Springs 20 at Cebu wells	845,000	95,000
2. Meter Repair Facilities (Equipment for one shop)	60,000	7,000
3. Laboratory Equipment (For one laboratory)	200,000	23,000
4. Hydrological & Meteorological Equipment (For 4 stations)	50,000	5,000
5. 15 Fire Hydrants for Lapu-Lapu	135,000	-
6. Leakage Survey	400,000	50,000
7. Land Takings * (For dam and reservoir area, WTP, storage tank, pump station, roads and pipelines)	3,000,000	-
Sub-Total	4,690,000	80,000
15% Contingencies	710,000	30,000
Total	5,400,000	210,000

* For the facilities in the Stage I construction only.

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C. INTERIM IMPROVEMENTS

During the period of 1976-1978 certain improvements may be made in the MCWD system to alleviate the water shortages until the recommended long term program is implemented.

The works considered in the interim program will include the following:

1) Improvements to the Hagubiao pump station;

2) Construction of new groundwater wells in Pardo and Mananga area;

3) Pipe cleaning and lining.

A brief description of these works is presented below:

Hagubiao Pump Station. The existing Hagubiao Spring collection chamber and pumping facilities were shown in Figure IV-3 in Chapter IV. The present total spring yield is provisionally estimated to be approximately 13,000 cumd.

Two of the four units at the Hagubiao pump station are at present inoperative due to pump and/or engine repairs. The two pumps remaining in service are inadequate to capture the full spring yield, and thus an important and readily available source of water is not fully utilized. Performance curves on all of these existing pumps are not available. However, field measurements indicate that the operating pumps (Units No. 3 and 4, Figure IX-1) together deliver about 8,700 cumd when operating against a total system head of approximately 38 meters of water. No field data are currently available to indicate how this flow is divided between the two units, which are of different pattern. In the absence of pump curves and other pertinent information on some of the existing pumps, it is difficult to estimate the aggregate discharges, heads and efficiencies of the various operating combinations of the four units. However, the following improvements which are shown in Figure IX-1 can be implemented at least on a relatively short-term interim basis.

a) Replace complete Unit No. 1 engine and pump with complete motor, pump and associated electrical controls relocated from the Mabolo booster pump station.

b) Replace complete Unit No. 2 engine and pump with new 150 HP electric motor and new 150 mm centrifugal pump now

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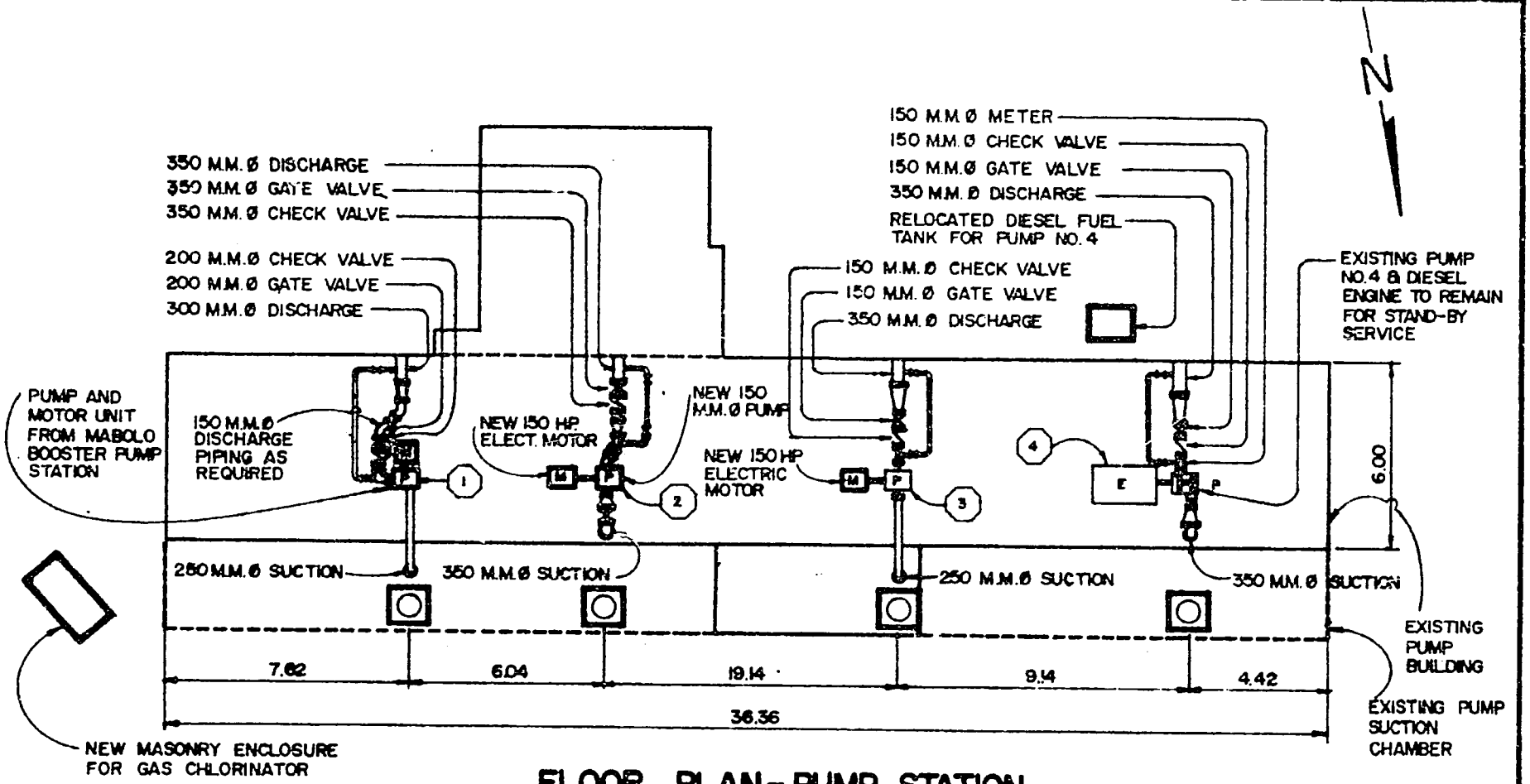

FLOOR PLAN - PUMP STATION

NOTE: INTERIM IMPROVEMENTS ALSO INCLUDE CONVERTING TEMPORARY SPRING OVERFLOW WEIR TO PERMANENT INSTALLATION.

LEGEND:

- P EXISTING
- P NEW OR RELOCATED
- (2) UNIT NO.2

1 0 1 2 3 4 5
SCALE IN METERS

FIGURE IX-1
PROPOSED INTERIM MODIFICATIONS
HAGUBIAO SPRING & PUMP STATION

FEASIBILITY STUDY FOR WATER SUPPLY OF TEN PROVINCIAL AREAS CDM-LWUA

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in MCWD stock, including new electrical service and controls as required.

c) Replace Unit No. 3 engine with the other new 150 HP electric motor now in MCWD stock, including electrical appurtenances as necessary.

d) Relocate fuel tank for Unit No. 4 engine outside the pump building. Remove from the site all other fuel tanks and associated piping which are at present within the pump building. Use Unit No. 4 for stand-by except when spring yield is in excess of what the other three units can handle.

e) Provide a masonry room for the existing chlorinator and spare full cylinders. This room can be adjacent to the pump station but no direct access should be allowed between the two rooms for safety reasons.

f) Conduct a complete house cleaning. All equipment removed in this rehabilitation, plus all existing dismantled parts, housings, castings, fittings, abandoned fuel and water piping and all other debris should be completely removed from the pump building for better operation and maintenance purposes.

g) Convert the spring overflow gaging weir to a permanent installation by constructing masonry abutments and installing a steel weir plate. Initiate a procedure for recording pump operations and spring overflows.

For incorporation of the Hagubiao pump station in the long term plan, the following permanent improvements may be necessary:

a) New pumps, if required to properly match the hydraulics of the upgraded transmission system; this may be scheduled for 1983-85. (See Stage I-B.)

b) Structural improvements to the pump building and appurtenant facilities, site drainage and flood control works, tools, maintenance and repair facilities and related rehabilitation measures to allow the station to operate efficiently over a long term service life.

Pardo-Mananga Wells. A well testing program is underway in downstream gravel beds of the Mananga River to determine the well and pump characteristics, well spacing and number of wells required for an estimated total yield of 22,000 cumd. Most of the proposed wells will be located at the Mananga downstream near Tabunoc and

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Lawaan for relatively shallow depths but the well field will be extended to the Bulacao and Pardo areas along the northern part of C. Padilla Street. The wells will be equipped with suitable pump and motors for supplying water to the downtown Cebu. A new 300 mm diameter and about 9.0 km long pipeline will convey the water along the C. Padilla Street up to the existing 250 mm pipe near the Tres de Abril Street intersection.

In the long term plan, supply from the Pardo-Mananga wells to MCWD will be reduced as water demands in Talisay and the surrounding communities will increase. The proposed pipeline, at that time, will serve as transmission line to the Pardo area, by conveying water from the long term sources.

Pipe Cleaning and Lining. Field investigations showed most of the existing transmission lines, which have been in service more than 50 years, have lost about 25 per cent of their total hydraulic capacity. When pipe internal wall surface deterioration reaches this level, it is usually economical to clean and line it. However, this should be done without interrupting the service. Therefore, almost all of the major pipelines can be cleaned and lined after new supply lines are put into service. No field checking was performed on 150 mm diameter distribution mains. Assuming that hydraulic capacity losses of these lines are in the same level of transmission lines, an early cleaning and lining of about 7.0 km long 150 mm diameter mains would be economical and practical as service interruptions along these lines would not be as significant as the transmission lines. However, a field checking of the pipe "C" valves should be worthwhile before contracting this work out. Cleaning and lining of pipes, in diameter smaller than 150 mm, may not be economically justified and therefore, not recommended.

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INTERIM REPORT
VOID AFTER 1 NOV 1975

TABLE IX-2

COST ESTIMATES FOR INTERIM IMPROVEMENTS

Item	Estimated Construction Cost (₱)	Foreign Exchange Component (US $)
1. Hagubiao Pump Station	100,000 *	-
2. Pardo-Mananga Wells		
Wells & Pumps	3,080,000	260,000
Pipeline **	4,950,000	190,000
3. Pipe cleaning & Lining (150 mm - 7.0 km)	525,000	11,000
Sub-Total	8,655,000	461,000
25% Engineering & Contingencies	2,165,000	115,000
Total Project Cost	10,820,000	576,000

* Based on usage of the available units in stock and in-house work.

** This pipeline will be incorporated in the long term plan.

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D. FIRST STAGE OF LONG TERM (TENTATIVE) PROGRAM

First stage of the recommended program which includes source development, treatment, transmission and distribution facilities, will be implemented in three construction phases.

Construction Phase A (1978-82)

Source Development. The preliminary investigations show that with construction of an 82 m high dam, located on a narrow gorge, near Barrio Lusaran, the Balamban River flows may be regulated for an estimated potential safe yield of 154,000 cumd. The selected dam site was considered for an impoundment reservoir in the past. Access to the dam site can be from east either by going through the Cebu City-Talamban Road which ends at Barrio Guba, or going over Canamucan-Dapdap Road north of Compostela. In either way, no road exists for the remaining about 10 km distance to the site. The dam site can also be reached from the west, through the municipality of Balamban with a feeder road along the Balamban River. However, from the end of the road, the dam site is still more than 15 km away. For moving heavy construction equipment to the site, it will be necessary to construct a 12 km long all weather road together with at least two major bridges. In addition, improvement on the Cebu City-Talamban Road to Barrio Guba will also be necessary, assuming this route will be selected as it is along or near the proposed raw water conduit.

General geologic setting and the foundation materials at the proposed dam and reservoir site were discussed in Chapter VII. The Lusaran dam site is suitable for a rockfill dam with impervious clay core protected with filter material on both sides. Geological studies show the availability of good andesite rock to be quarried and sand and clay borrow areas within short haul distances. The dam embankment will have a length of about 215 m at the crest and the side slopes of 2.5:1 on the upstream and 2:1 on the downstream face. When the dam is built the reservoir will inundate an area of about 255 ha, which will require relocation of Barrio Lusaran.

The spillway and diversion tunnel can be located at either left or right abutment, both being in the massive andesite formation. The regular spillway will be a concrete chute type, designed for an estimated 100-year peak outflow of 600 cum/sec. An emergency spillway, excavated through the andesite formations, will provide safety to the dam for the greater but less frequent floods.

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For temporary diversion works during the construction, 2 tunnels, each having a diameter of about 5.0 m and a length of about 450 m and a cofferdam will be constructed.

The raw water system will consist of a reinforced concrete intake structure, 2.5 m diameter and 7.5 km long gravity flow transmission tunnel and 900 mm diameter and 7.1 km long pipeline, as shown in Figure VIII-3. Flows into the raw water intake will be regulated at the multiple level gated inlet ports. Minimum water surface elevation in the reservoir will be at about 155 m.

Water Treatment Plant. The proposed water treatment plant for the Lusaran system will be a conventional type with chemical mixing, coagulation and flocculation, sedimentation, filtration and disinfection. It will be located at elevation 70-75 m, near Barrio Talamban. Initial capacity of the plant will be about 121,000 cumd and provision will be made in the layout to expand this capacity to 185,000 cumd, considering a maximum day to average day demand up to factor of 1.2. A minimum land area of 15 ha will be required at this site. General site work and chemical and administrative building will be designed and constructed for the ultimate capacity but the remaining process units may be completed in two stages.

Transmission Facilities. The treated water from the Talamban Water Treatment Plant will be conveyed into the distribution system through the transmission pipelines as shown in Figure VIII-3 and IX-2. A summary of those lines is shown in the following table:

Transmission Lines and Valves in Stage I - Phase A

Location	Size (mm)	Length (m)	Number of Valves
WTP to Tisa Storage Tank	1,400	11,450	3
WTP to Mandaue	700	4,000	2
Mandaue to Consolacion	500	3,800	2
Consolacion to Node 153	350	5,200	2
Node 153 to Liloan	250	1,000	2
Liloan to Compostela	250	6,400	5
Mandaue to Lapu-Lapu	500	4,100	2

The transmission lines are designed for maximum daily demands as supplementary flows during the peak demand hours will be drawn from the distribution storage. During the Phase A of Construction Stage I, a storage tank with a capacity of 32,000 cumd will be constructed at Tisa. A minimum land area of about 2.5 hectares should be secured at this site for this and future storage units.

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Distribution System. In 1978 the MCWD will begin making significant improvements to the existing distribution system. Table IX-3 lists the recommended improvements and Figure IX-2 is a schematic plan of the improved system. The first improvements will be in the central city area of Cebu. This will consist of laying 200 mm and 250 mm distribution mains and replacing and reinforcing internal network pipes. New fire hydrants will be installed and all pipes 100 mm or less which connect to a hydrant will be replaced by a minimum 150 mm line.

During 1980 and 1981 improvements will be made in Mandaue and Lapu-Lapu. For Mandaue, new 200 mm and 250 mm distribution mains will be installed as well as improvements to the internal network. New 150 mm and 200 mm lines will be installed in Lapu-Lapu in preparation for the transmission line which will be laid along the Mactan Bridge in 1982. Additional lines will be installed in Cebu to improve service in the areas near Guadalupe, the Capitol and Lahug which are lower than 50 m in elevation. The areas in Guadalupe and Lahug higher than 50 m should be valved off from the main distribution system obtaining water supply from the existing wells in these areas.

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INTERIM REPORT
VOID AFTER 1 NOV 1975

TABLE IX-8

COST SUMMARY OF CONSTRUCTION
STAGE I - PHASE C (1986-89)

Item	Construction Period	Construction Cost (₱)	Foreign Exchange Component (US$)
Distribution Mains	1986-89	9,727,000	392,000
Internal Network	1986-89	23,075,000	617,000
Service Connections	1986-89	6,423,000	254,000
Pipe Cleaning & Lining	1986-87	420,000	9,000
Sub-Total		39,645,000	1,272,000
Engineering & Contingencies 25%		9,911,000	318,000
Sub-Total		49,556,000	1,590,000
Land Costs		-	-
Administrative & Legal Fees 3%		1,487,000	-
		51,043,000	1,590,000
Interest during Construction			
18%		7,272,000	227,000
6%		32,000	1,000
Total Project Cost		58,647,000	1,818,000

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150

E. SECOND STAGE OF LONG TERM (TENTATIVE) PROGRAM

Second stage of the recommended program will include a new source development, the Mananga dam and appurtenances, a new raw water system, treatment works, treated water transmission lines and expansion of distribution system. These works will be implemented in two phases.

Construction Phase A (1989-94)

Source Development. To meet the year 2000 demands in MCWD and in Talisay area, a 72 m high rockfill dam will be constructed with appurtenances, including diversion works during the construction and the regular and emergency spillways. The reservoir created with this dam will inundate a land area of about 140 ha, which will require replacement of a 5 km section of an existing road along the Mananga River and relocation of Barrios Jaclupan and Maghaway.

Dam site geology, foundation and construction materials were discussed in Chapter VII.

The Mananga reservoir safe yield studies are based on an extrapolation with the Balamban River lows. These safe yield analyses should be reviewed after several years of stream flow gaging in both streams.

The raw water system will consist of a reinforced concrete intake structure and 1,000 mm diameter and about 6.0 km long transmission line, as shown in Figure VIII-3. The minimum water surface elevation in the reservoir is estimated to be about 81 m.

Water Treatment Plant. The proposed water treatment plant for the Mananga system will be a conventional type, similar to the Talamban plant for the Lusaran system. Design capacity of this plant will be 82,000 cumd. A minimum land area of 10 ha will be necessary at this site.

Transmission Facilities. Transmission pipeline locations and sizes are shown in Figures VIII-3 and IX-2. A summary of these lines is as follows:

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Transmission Lines and Valves
in Stage II - Phase A

Location	Size (mm)	Length (m)	Number of Valves
Cebu City to Mandaue	700	5,500	2
Mandaue to Consolacion	500	3,800	2
Consolacion to Node 153	450	5,200	2
Node 153 to Liloan	200	1,000	2
Liloan to Compostela	250	6,400	3
Node 60 to Lahug	1,000	2,000	2
Mananga WTP to Node 30	1,200	7,700	3

The distribution storage capacity will be increased by the construction of an additional 17,000 cum storage unit at Lahug.

Distribution System. During the period 1990-94 parallel lines will be installed in some areas of Cebu to reinforce lines laid in the early years of the improvements program. The lines are listed in Table IX-9 along with other lines to be constructed between 1990 and year 2000. Areas receiving water service in the period 1990-1994 will be the reclaimed area between Pardo and Cebu, the area between Mandaue and Talamban, portions of Lapu-Lapu, Consolacion and Liloan.

In 1993 and 1994 a 15,000 cum storage facility will be added to the site at Lahug. This will bring the total distribution storage to 62,000 cum.

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TABLE IX-9

STAGE II - PHASE A CONSTRUCTION PROGRAM
FOR DISTRIBUTION SYSTEM (1990 - 1994)

Construction Period	Description	Pipe Number	Node From	Node To	Pipe Size (mm)	Pipe Length (m)
1990-94	Cebu - Reinforcement of Stage I Lines	16	28	16	400	550
		21	16	13	400	1,350
		22	30	18	350	950
		23	31	21	300	450
		19	18	19	300	300
		8	13	14	200	1,080
		9	14	7	250	1,050
1990-94	Cebu - New Area	501	5	1	200	1,500
		502	8	5	300	1,040
		503	15	8	300	1,050
		504	20	15	300	1,300
		505	15	14	250	1,000
		506	8	7	250	1,000
		507	5	4	250	960
1990-94	Lapu-Lapu New Area	5,311	199	205	250	1,300
		532	205	206	200	1,450
		533	206	209	250	1,600
		534	209	211	200	500
		535	210	211	150	500
		536	208	210	200	600
		537	207	208	200	1,100
		538	209	208	150	500
		527	193	194	200	950
		528	196	194	150	1,150
		529	197	196	200	350
		530	198	197	200	400
1990-94	Mandaue New Area	508	80	81	200	650
		509	82	81	200	850
		510	88	87	200	850
		511	86	85	200	700
		512	86	96	150	950
		513	87	86	150	300
		514	81	87	150	700
1990-94	Consolacion New Area	539	135	136	200	700
		540	140	136	150	1,000
		541	139	140	200	800
1990-94	Liloan New Area	560	148	152	200	1,400
		561	152	159	200	1,400
		546	145	146	250	1,100
		547	146	180	250	300
		558	180	183	200	1,200
		559	146	151	200	600

No pipe cleaning and lining are scheduled at this phase.

BEST AVAILABLE DOCUMENT

INTERIM REPORT
VOID AFTER 1 NOV 1975

TABLE IX-10

COST SUMMARY OF CONSTRUCTION
STAGE II - PHASE A (1989-94)

Item	Construction Period	Construction Cost (₱)	Foreign Exchange Component (US$)
Mananga Dam and Appurtenances	1989-93	123,300,000	2,642,000
Raw Water System	1991-93	17,520,000	980,000
Water Treatment Plant	1990-93	37,000,000	1,850,000
Transmission Facilities	1991-93	59,327,000	3,010,000
Distribution Mains	1990-94	14,652,000	568,000
Internal Network	1990-94	25,470,000	716,000
Service Connections	1990-94	14,380,000	570,000
Sub-Total		291,649,000	10,336,000
Engineering & Contingencies 25%		72,912,000	2,584,000
		364,561,000	12,920,000
Land Costs		2,150,000	-
Sub-Total		366,711,000	12,920,000
Administrative & Legal Fees 3%		11,001,000	-
		377,712,000	12,920,000
Interest during Construction			
24%		43,952,000	1,349,000
18%		8,574,000	416,000
12%		11,873,000	599,000
Total Project Cost		442,111,000	15,284,000

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Construction Stage II - Phase B (1995-99)

The proposed source development, raw water system, the water treatment plant and the transmission facilities during the construction Stage II - Phase A are adequate until the target design year 2000. Therefore, during the Phase B construction, improvements to the distribution system only will be necessary.

Distribution System. In 1995 it is expected that demand in the Talamban area will warrant extension of both low pressure and high pressure service to customers in the area. A booster pump station will be constructed to serve the area. A line will be laid to connect the Talamban and Guadalupe booster zones as well as to serve the higher areas between the two booster zones. Further booster zone extensions will be made to the Tisa area.

Reinforcement of distribution main will be made in Lapu-Lapu with the construction of parallel lines. New areas of Mandaue, Liloan, Consolacion and Compostela will be extended service.

Internal network will also be expanded in accordance with the service area growth.

The distribution pipelines proposed for this phase of construction are shown in Table IX-11.

BEST AVAILABLE DOCUMENT

TABLE IX-11

STAGE II - PHASE B CONSTRUCTION PROGRAM
FOR DISTRIBUTION SYSTEM (1995 - 99)

Construction Period	Description	Pipe Number	Node From	Node To	Pipe Size (mm)	Pipe Length (m)
1995-99	Cebu - Reinforcement of Stage I Lines	40	30	36	250	1,000
		41	36	40	250	700
		118	73	74	300	860
		98	60	61	300	950
1995-99	Booster Zone Extension	613	37	36	200	3,100
		614	38	26	200	3,000
		615	92	72	250	3,000
		616	92	103	200	1,100
		617	103	93	200	2,200
		618	92	93	200	2,300
		566	95	92	350	500
1995-99	Lapu-Lapu Reinforcement of Stage I Lines	145	189	190	250	700
		146	190	191	250	520
		150	199	198	250	550
		151	200	199	250	1,000
		154	201	207	250	1,100
		1,156	201	200	400	450
		157	201	202	250	1,000
		159	202	203	250	620
1995-99	Mandaue New Area	522	118	117	200	1,300
		523	124	117	200	550
		524	125	124	200	1,050
		525	127	128	250	700
		526	128	129	250	1,100
1995-99	Consolacion New Area	542	142	140	150	1,100
		543	141	142	200	600
		544	138	133	150	1,000
		545	139	138	150	1,100
1995-99	Liloan New Area	548	180	181	250	600
		549	181	182	250	1,100
		550	182	185	200	1,400
		551	185	188	200	1,250
		552	187	188	200	750
		553	186	187	200	1,250
		554	183	184	150	800
		556	184	187	200	1,100
		557	181	184	200	1,340
		555	184	185	150	900

BEST AVAILABLE DOCUMENT

TABLE IX-11

STAGE II - PHASE B CONSTRUCTION PROGRAM
FOR DISTRIBUTION SYSTEM (1995 - 99)

Construction Period	Description	Pipe Number	Node From	Node To	Pipe Size (mm)	Pipe Length (m)
1995-99	Compostela New Area	562	167	173	150	1,400
		563	173	174	150	1,500
		564	174	172	150	400
		190	170	172	200	700
		193	170	169	200	360
1995-99	Cebu New Area near Talamban	515	95	105	300	700
		516	105	113	250	600
		517	113	114	200	1,400
		518	114	115	200	1,500
		519	116	115	250	1,700
		520	106	116	250	700
		521	105	106	250	900
		565	29	36	200	1,500

About 5,630 m of 150 mm and 4,500 m long 200 mm diameter existing pipelines are scheduled for cleaning and lining during this phase of construction.

BEST AVAILABLE DOCUMENT

INTERIM REPORT
VOID AFTER 1 NOV 1975

TABLE IX - 11

COST SUMMARY OF CONSTRUCTION
STAGE II - PHASE B (1995-99)

Item	Construction Period	Construction Cost (₱)	Foreign Exchange Component (US$)
Talamban Booster Station	1994-96	1,350,000	94,000
Distribution Mains	1995-99	19,052,000	678,000
Internal Network	1995-99	29,712,000	724,000
Service Connections	1995-99	14,380,000	570,000
Pipe Cleaning & Lining	1994-96	870,000	19,000
Sub-Total		65,364,000	2,085,000
Engineering & Contingencies 25%		16,341,000	521,000
Sub-Total		81,705,000	2,606,000
Land Costs		-	-
Administrative & Legal Fees 3%		2,451,000	-
		84,156,000	2,606,000
Interest during Construction			
12%		343,000	17,000
24%		19,511,000	473,000
Total Project Cost		104,010,000	3,096,000

BEST AVAILABLE DOCUMENT

158

F. CAPITAL COST SUMMARY

Capital costs of each phase of construction including the "Early Action Works" and the "Interim Improvements" are summarized in Table IX-12. Land costs for the Stage I facilities are included in the "Early Action Program". The total project cost shown in this table, in general, includes estimated construction cost of facility, engineering and contingencies, cost of land and easements, administrative and legal fees and interest during construction. As indicated previously, construction cost estimates of the proposed improvements are based on the projected July 1976 unit prices. Foreign exchange component of total project cost which is also shown in Table IX-12, includes cost of direct and/or indirect import items.

The water supply and demand chart in Figure IX-3 indicates timing of the construction stages for the source development in relation to the maximum daily water demand curve for the project area.

G. ANNUAL OPERATIONAL AND MAINTENANCE COSTS

Annual operational and maintenance costs include personnel, power, chemicals, maintenance, rentals, repayments of loans incurred in the past, and other miscellaneous expenses which are necessary to run the overall water system. The total annual cost of the existing system in 1975 was P3,343,000. Following implementation of the recommended improvements, the present annual cost will increase due to additional personnel, power, chemicals and maintenance costs. The annual costs discussed here exclude the annual repayment of the loan for construction of the new facilities.

The annual costs of operating the water district facilities are estimated to be about P6,850,000 in 1982. These costs will increase to P9,020,000 in 1990 and P13,020,000 in 2000. (See Table IX-13.)

BEST AVAILABLE DOCUMENT

TABLE IX-3

STAGE I - PHASE A CONSTRUCTION PROGRAM
FOR DISTRIBUTION SYSTEM (1978 - 1981)

Construction Period	Description	Pipe Number	Node From	Node To	Pipe Size (mm)	Pipe Length (m)
1978 - 79	Core City of Cebu Reinforcing Feeder Mains	224	23	24	250	200
		30	33	23	250	150
		28	35	25	250	1,050
		102	55	35	250	1,120
		100	55	54	250	500
		101	33	54	250	280
		99	61	54	300	1,200
		61	316	47	250	500
		611	316	48	250	300
		94	53	52	200	300
		65	42	49	200	1,000
		46	31	42	200	620
		59	47	59	200	1,100
		24	24	25	250	400
1980 - 81	Lapu-Lapu Core City Reinforcement	145	189	190	200	700
		146	190	191	200	520
		159	202	203	200	620
		160	191	203	150	300
		158	190	202	150	430
		147	191	192	200	860
		161	203	192	200	760
		157	201	202	200	650
1980 - 81	Core City of Mandaue Reinforcing Mains	134	100	89	200	540
		138	90	101	200	850
		139	112	101	200	660
		143	111	112	200	1,700
		127	89	90	250	1,000
		128	90	102	250	940
		133	111	100	250	900
		126	84	89	250	1.300
1980 - 81	Cebu City Reinforcing Existing Service Area	47	41	42	200	600
		95	51	52	200	900
		98	60	61	200	350
		97	60	59	250	600
		48	320	46	250	700
		481	41	320	250	200
		60	47	46	300	680
		49	45	46	250	560
		23	31	21	300	450
		19	18	19	250	300
		22	30	18	350	950

BEST AVAILABLE DOCUMENT

INTERIM REPORT
VOID AFTER 1 NOV 1975

TABLE IX-4

COST SUMMARY OF CONSTRUCTION
STAGE I - PHASE A (1978 - 82)

Item	Construction Period	Construction Cost (₱)	Foreign Exchange Component (US$)
Imsaran Dam & Appurtenances	1978-82	167,800,000	3,596,000
Raw Water System	1978-82	94,756,000	3,524,000
Water Treatment Plant	1978-82	51,500,000	2,500,000
Transmission Facilities *	1979-82	88,812,000	4,924,000
Distribution Mains	1978-81	10,531,000	372,000
Internal Network	1978-81	22,734,000	613,000
Service Connections	1978-81	6,423,000	254,000
Sub-Total		442,556,000	15,783,000
Engineering & Contingencies 25%		110,639,000	3,947,000
Sub-Total		553,195,000	19,730,000
Land Costs **		-	-
Administrative and Legal Fees 3%		16,595,000	-
		569,790,000	19,730,000
Interest during Construction 24% ***		97,043,000	2,310,000
18% ***		29,697,000	1,110,000
Total Project Cost		696,530,000	23,150,000

* Include transmission line to Lapu-Lapu.

** Land costs are included under the "Early Action Works".

*** Average interest during construction of corresponding facilities.

BEST AVAILABLE DOCUMENT

Construction Phase B (1982-87)

Source Development. The raw water transmission line capacity will be increased to 185,000 cumd by installation of 800 mm diameter and 7.1 km long pipeline from the downstream end of the transmission tunnel to the water treatment plant at Talamban.

Water Treatment Plant. Capacity of the plant will be increased to the full capacity (185,000 cumd) of the Lusaran system by adding new process units. This capacity will be adequate (including 40,000 cumd from the groundwater) for MCWD until the year 1993.

Transmission Facilities. New transmission lines will be constructed as shown in Figures VIII-3 and IX-2. A summary of these lines is presented in the following table:

Transmission Lines and Valves in Stage I - Phase B

Location	Size (mm)	Length (m)	Number of Valves
WTP to Tisa Storage Tank	1,000	10,720	3
WTP to Mandaue	800	4,000	2
Mandaue to Consolacion	450	3,800	2
Consolacion to Node 153	400	5,200	2
Node 153 to Liloan	200	1,000	2
Liloan to Compostela	200	6,400	3
Node 60 to Lahug Storage	700	2,000	2

A new storage tank will be built at Lahug, with an initial capacity of 8,000 cum. A minimum land area of 2 ha should be taken at this site to accommodate this storage tank and future expansion units.

An additional 5,000 cum storage unit will be constructed at the Tisa site. A booster pump station at Guadalupe will be put into operation for serving high level areas.

Distribution System. By mid-1982 the new surface water source will be brought into service along with the transmission line from the water treatment plant. This will significantly increase the water supply to the MCWD customers. To provide better pressure distribution during peak hours, a new 32,000 cum storage tank will be constructed near Tisa. The new transmission line will pass through Consolacion enabling service to be extended to customers in this area with very little incremental cost. The municipalities of Liloan

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162

and Compostela will be served by a transmission line laid along the National Road. The existing systems in each municipality must be reinforced to provide adequate pressures during peak-hour and fire flow periods.

In 1982-83, 250 mm lines will be laid along the waterfront in Cebu and connections made to existing distribution mains as well as the transmission line from the new source. Service will be extended to the reclaimed area in Cebu and Mandaue. Feeder mains in Pardo and a loop will be completed in the low pressure zone between Lahug and Guadalupe.

By 1984-85 the feeder main system will be extended to the limits of the low pressure zone. A booster pump station will be installed to provide improved service to areas in Guadalupe and Lahug above 50 m in ground elevation. New distribution main will be laid to serve the booster zone and the Basilan storage tank will be used for booster zone storage. Also, the service area will be extended in Pardo, Lahug (toward Talamban) and Lapu-Lapu.

Table IX-5 shows a summary of the proposed distribution mains.

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TABLE IX-5

STAGE I - PHASE B CONSTRUCTION PROGRAM
FOR DISTRIBUTION SYSTEM (1982-85)

Construction Period	Description	Pipe Number	Node From	Node To	Pipe Size (mm)	Pipe Length (m)
1982-83	Liloan	182	153	154	200	400
		181	154	157	200	600
		178	157	156	150	830
		179	155	156	150	400
		180	154	155	150	480
		183	156	159	150	800
1982-83	Compostela	191	172	171	150	350
		192	169	171	150	660
		193	170	169	150	360
1982-83	Mandaue Service Area Extension	140	122	112	200	1,120
		141	122	123	200	640
		142	121	122	200	1,000
		132	120	121	250	480
		129	123	102	250	1,800
1982-83	Cebu Service Area Extension Along Waterfront North	103	62	55	250	680
		104	70	62	250	940
		105	76	70	250	950
		106	79	76	250	1,450
		119	75	76	200	820
1982-83	Service Area Extension Along Waterfront South	26	22	20	250	600
		27	26	22	250	400
		20	21	22	200	580
		15	20	19	250	380
1982-83	Pardo	4	3	2	250	1,100
		10	10	6	250	500
		6	6	2	200	1,200
1982-83	Lahug Area	51	66	58	200	900
		50	45	58	200	1,680
1982-83	Lapu-Lapu	152	200	206	250	820
		156	201	200	300	460
1984-85	Booster Zone Network Near Guadalupe & Lahug	602	57	65	250	1,100
		603	44	57	250	1,050
		604	38	44	250	1,300
		605	37	38	250	500
		606	43	37	250	1,350
		607	56	43	250	1,200
		608	63	56	250	700
		609	72	63	250	500
		610	63	65	200	550
		611	56	57	200	800
		612	43	44	200	1,000
		223	38	39	300	320

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TABLE IX-5 (Cont'd)

STAGE I - PHASE B CONSTRUCTION PROGRAM
FOR DISTRIBUTION SYSTEM (1982 - 85)

Construction Period	Description	Pipe Number	Node From	Node To	Pipe Size (mm)	Pipe Length (m)
1984-85	Lapu-Lapu Service Area Extension	154	201	207	200	1,100
		153	206	207	200	1,140
1984-85	Cebu Service Area Extension to Booster Pump Station	40	30	36	300	1,000
		41	36	40	300	700
		44	46	40	300	850
		42	40	39	350	820
		43	45	39	250	1,000
1984-85	North of Lahug Service Area Extension	52	77	66	200	600
		53	314	77	200	850
		531	80	314	200	350
1984-85	Pardo Industrial Area	3	4	2	250	680
		7	7	4	200	1,020
		11	6	7	250	1,100
		9	14	7	200	1,050
		8	13	14	250	1,080
		14	19	14	250	1,600
		21	28	13	400	1,900

The following existing distribution pipelines will need cleaning and lining during this phase of construction:

Existing Pipeline	Diameter (mm)	Length (m)
Hagubiao Line	350	11,100
Tisa Line	400	4,000
	350	630
Steel pipes laid in 1974, '75	300	2,450
	250	2,790
Distribution Mains	250	2,270
" "	200	2,270

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165

INTERIM REPORT
VOID AFTER 1 NOV 1975

TABLE IX - 6

COST SUMMARY OF CONSTRUCTION
STAGE 1 - PHASE B (1982 - 87)

Item	Construction Period	Construction Cost (₱)	Foreign Exchange Component (US$)
Raw Water System	1984-86	14,484,000	731,000
WTP Expansion	1985-87	8,500,000	1,000,000
Transmission Facilities	1985-87	55,429,000	2,603,000
Guadalupe Pump Station	1983-85	1,650,000	120,000
Hagubiao Pump Station	1983-85	280,000	31,000
Distribution Mains	1982-85	20,220,000	739,000
Internal Network	1982-85	23,274,000	616,000
Service Connections	1982-85	6,423,000	254,000
Pipe Cleaning & Lining	1983-86	5,820,000	125,000
Sub-Total		136,080,000	6,219,000
Engineering & Contingencies 25%		34,020,000	1,555,000
Sub-Total		170,100,000	7,774,000
Land Costs*		-	-
Administrative & Legal Fees 3%		5,103,000	
Sub-Total		175,203,000	7,774,000
Interest during Construction:			
12%		12,413,000	538,000
18%		10,334,000	208,000
Total Project Cost		197,950,000	8,520,000

* Land costs are included under "Early Action Works".

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Construction Phase C (1986-89)

No additional works will be required at this phase for the source development, water treatment plant and treated water transmission facilities.

Distribution System. In 1986-87 new storage facilities will be added to the distribution. The Tisa storage site will be expanded with the addition of another 5,000 cum storage facility. A new site will be developed in Lahug with the construction of a 10,000 cum storage tank.

Significant expansion of the service will be made in the area between Cebu and Mandaue in 1986-89. This will be done in conjunction with a new transmission line between these cities. The MCWD will extend service to new areas north of the main highway from Mabolo to Hagubiao. Other system expansion is expected to occur in Lapu-Lapu, Consolacion and Liloan.

The proposed distribution pipelines in this phase are shown in Table IX-7.

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TABLE IX-7

STAGE I - PHASE C CONSTRUCTION PROGRAM
FOR DISTRIBUTION SYSTEM (1986 - 1989)

Construction Period	Description	Pipe Number	Node From	Node To	Pipe Size (mm)	Pipe Length (m)
1986 - 89	Lapu-Lapu	148	192	193	200	400
		149	193	198	150	860
		150	199	198	200	550
		151	200	199	200	1,000
1986-89	Consolacion	162	137	133	150	740
		164	137	135	150	670
		165	134	135	150	100
		166	134	133	150	100
1986-89	Liloan	174	148	151	200	1,200
		175	151	183	200	1,200
		176	183	186	200	800
		177	157	186	200	1,150
1986-89	Pardo	1	1	2	200	1,300
		2	4	1	200	960
1986-89	Mandaue Service Area Extension	131	121	129	250	1,300
		130	129	123	250	1,200
		108	82	78	250	800
		109	88	82	250	570
		110	97	88	250	600
		121	83	82	200	640
		124	109	110	150	860
		125	118	119	150	450
		107	78	79	250	780
		118	73	74	200	860
		120	83	84	200	560
		122	98	97	400	1,000
		111	97	96	400	1,230
		112	96	95	400	850
		55	85	95	300	1,240
		54	80	85	300	1,300

Cleaning and lining of the existing old 150 mm diameter distribution mains were included in the interim improvements program. Cleaning and lining of 50 per cent (5,630 m) of more recently laid existing 150 mm diameter pipelines will be done during this phase of the recommended construction program.

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DESCRIPTIVE DATA

WELL NO. (CDM) CBU-41
(OTHER) NWASA 18-66-07
LOCATION WEST SIDE OF PROV. ROAD NEAR BULACAO BRIDGE, TABUNOC
CITY
PROVINCE TALISAY, CEBU
CONST. BY NWASA
DRILLER P. GOMEZ
STARTED
COMPLETED 15 AUGUST 1966
OWNER
STATUS
CASING DIAMETER 200 MM

DRILLER'S TEST DATA:
DATE 15 AUGUST 1966
STATIC WATER LEVEL 12.2 M
PUMPING WATER LEVEL
TEST PUMP YIELD 37.9 LPS

REMARKS:
PERFORATED CASING 15.2 M, 200 MM

GRAPHIC LOG

DEPTH (M)	DEPTH (FT.)	CASING	STRATIFICATION
			GROUND SURFACE
2.5	8		BROWN SANDY CLAY
			HARD LIMESTONE
12.2	40		
15.2	50		BROWN STICKY CLAY
			BOULDERS
21.3	70		
24.4	80		SOLID BOULDER
			BOULDERS
29.0	95		
31.4	103		SOLID BOULDER
44.2	145		BOULDERS
59.5	195		
64.0	210		

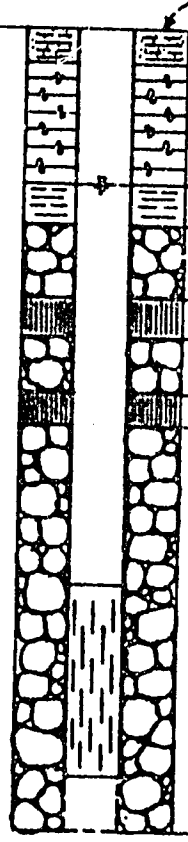

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FIGURE VII-B-1
WELL DATA SHEET
WELL CBU-41

TABLE VII-B-2

CHLORIDE CONTENT OF WELL WATER
METROPOLITAN CEBU WATER DISTRICT

Well Location	Year	Chloride[1] (ppm)	Year	Chloride (ppm)	Pump
Ong Res. - Casal Mabolo	1969	17.4	1975	24.0	Power
Go Thong Res.- Jasmin, Capital	1969	20.6	1975	29.0	Power
Lu Do Res. - Ramos St.	1969	20.6	1975	30.0	Power
70 Hipodromo St., Mabolo	1970	22.9	1975	39.0	Hand
U.S.C. Res. - Lab., P. del Rosario St.	1970	45.3	1975	1,978.0	Power
134 V. Rama St.	1970	87.3	1975	104.0	Hand
Cebu Health Dept., Sikatuna St.	1970	146.9	1975	274.0	Hand
Provincial Jail	1970	200.9	1975	784.0	Hand
170 Manalili St.	1970	201.4	1975	704.0	Hand
110 Villagonzalo St.	1970	1,044	1975	2,200	Power
Southern Motors	1970	2,328	1975	2,390	Power

[1] Wilhelm Bruell, Intrusion of Sea Water Into the Groundwater of Cebu City, The Philippine Scientist, 1973.

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DESCRIPTIVE DATA

WELL NO. (CDM) CBU-64
(OTHER)
LOCATION BARRIO NAWANAO, MANDAWE CITY

CITY
PROVINCE CEBU
CONST. BY
DRILLER
STARTED
COMPLETED SEPTEMBER 1955
OWNER

STATUS

CASING DIAMETER 150 MM

DRILLER'S TEST DATA:
DATE
STATIC WATER LEVEL 12.2 M

PUMPING WATER LEVEL 12.2 M

TEST PUMP YIELD 1.3 LPS

WATER QUALITY DATA:
WATER IS FRESH AND CLEAR AFTER 48 HOURS OF PUMPING.

REMARKS:
WATER LEVELS WERE STRUCK AT 14.3 M BELOW GROUND SURFACE AND AT 33.8 M BELOW GROUND SURFACE.

GRAPHIC LOG

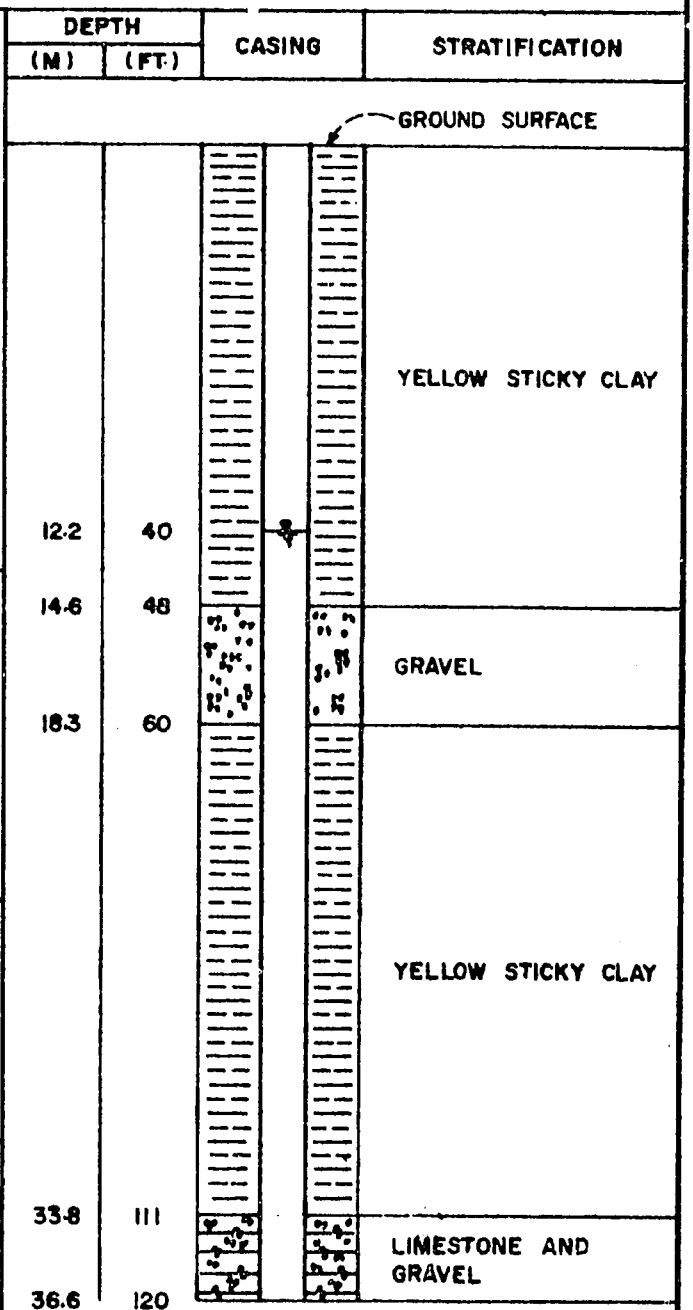

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FIGURE VII-B-2
WELL DATA SHEET
WELL CBU-64

FEASIBILITY STUDY FOR WATER SUPPLY OF TEN PROVINCIAL AREAS CDM-LWUA

DESCRIPTIVE DATA

WELL NO. (CDM) CBU-71
(OTHER)
LOCATION SOUTH ILAYA, BO. COTCOT
LILO-AN
CITY
PROVINCE CEBU
CONST. BY
DRILLER
STARTED
COMPLETED JULY 1963
OWNER
STATUS
CASING DIAMETER 100 MM

DRILLER'S TEST DATA:
DATE
STATIC WATER LEVEL 7.6 M
PUMPING WATER LEVEL 9.1 M
TEST PUMP YIELD 0.6 LPS

WATER QUALITY DATA:
pH = 7.4
ODOR = UNOBJECTIONABLE
COLOR = 5 UNITS
TASTE = UNOBJECTIONABLE
TURBIDITY = 5 UNITS
ALKALINITY = 119
BICARBONATE = 145.18
ACIDITY = 20
FREE CO_2 = 17.6
CHLORIDES = 16
IRON = 0.15
$CaCO_3$ = 293
GOOD FOR DRINKING, LAUNDRY AND BOILER. EXAMINED – JULY 8, 1963

REMARKS:
LENGTH OF SUCTION 14.3 M
PERFORATION 3.4 M
SPECIFIC CAPACITY 0.9 LPS/M

GRAPHIC LOG

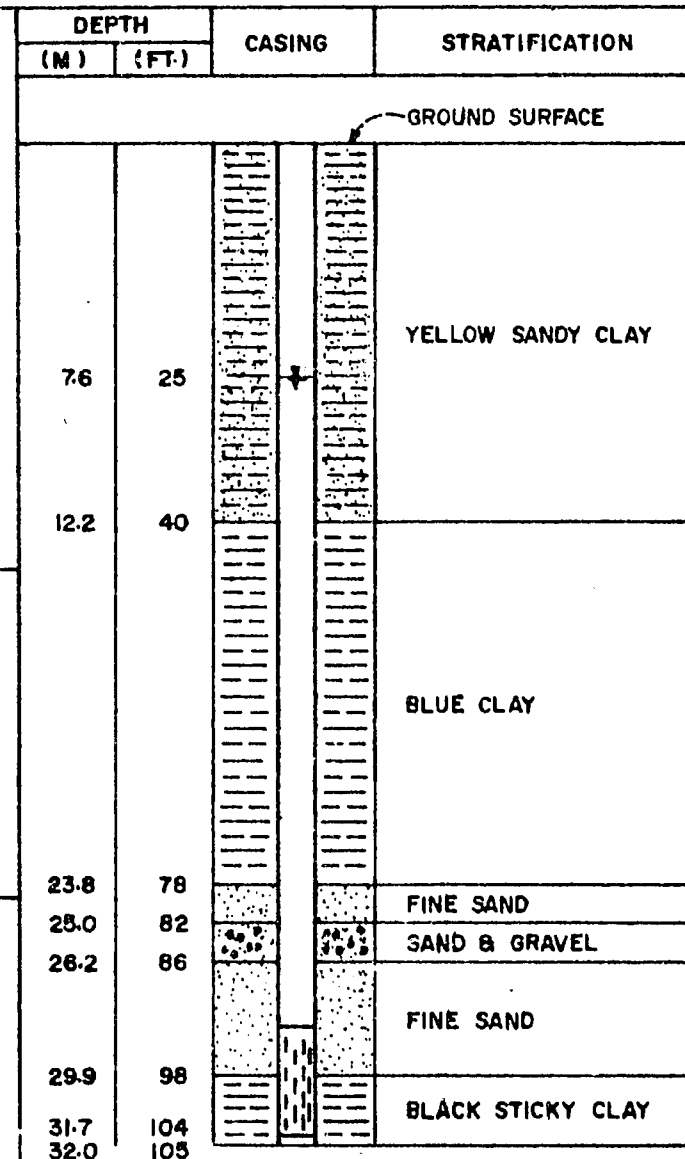

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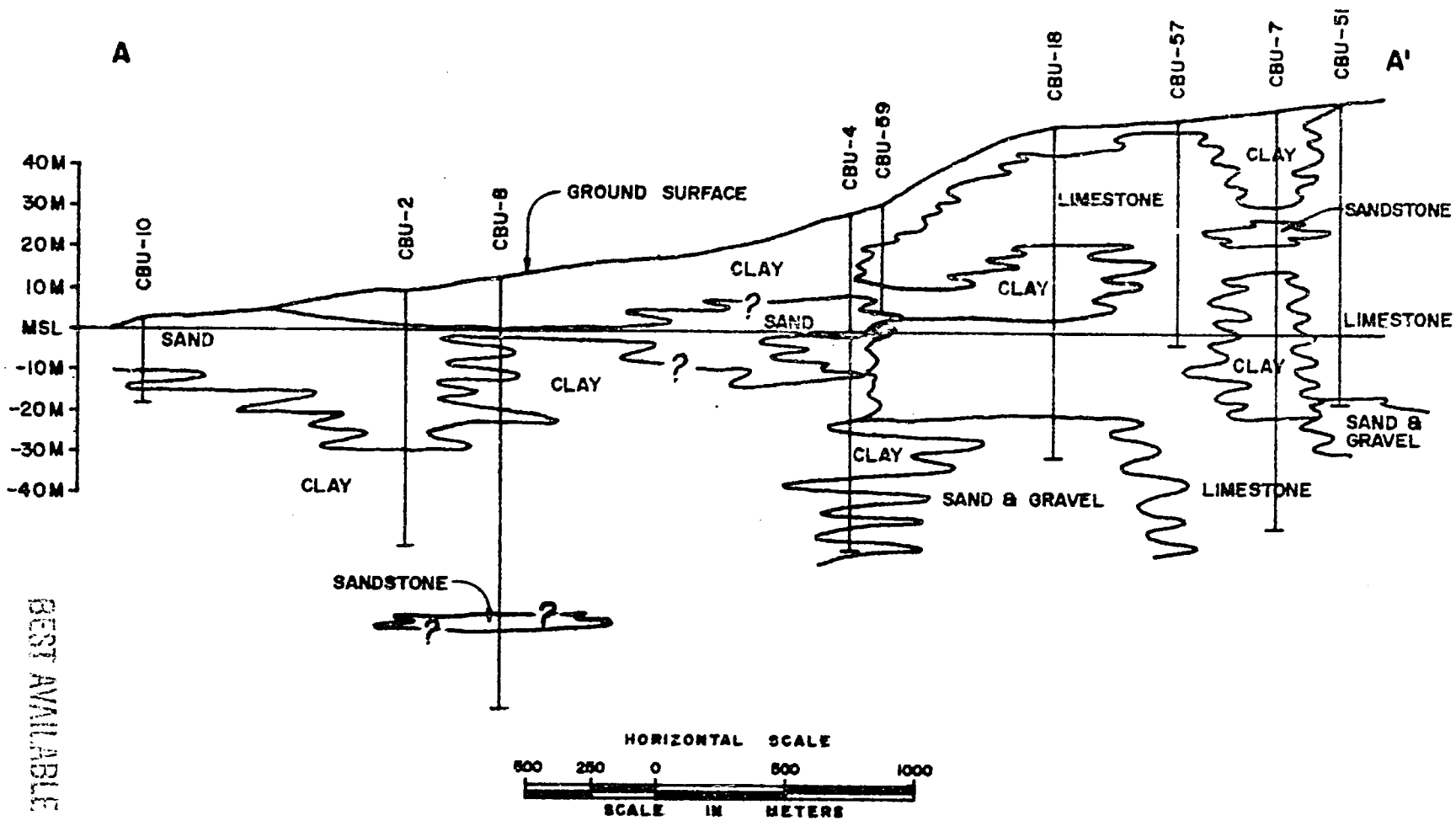
FIGURE VII-B-3
WELL DATA SHEET
WELL CBU-71

FEASIBILITY STUDY FOR WATER SUPPLY OF TEN PROVINCIAL AREAS CDM-LWUA



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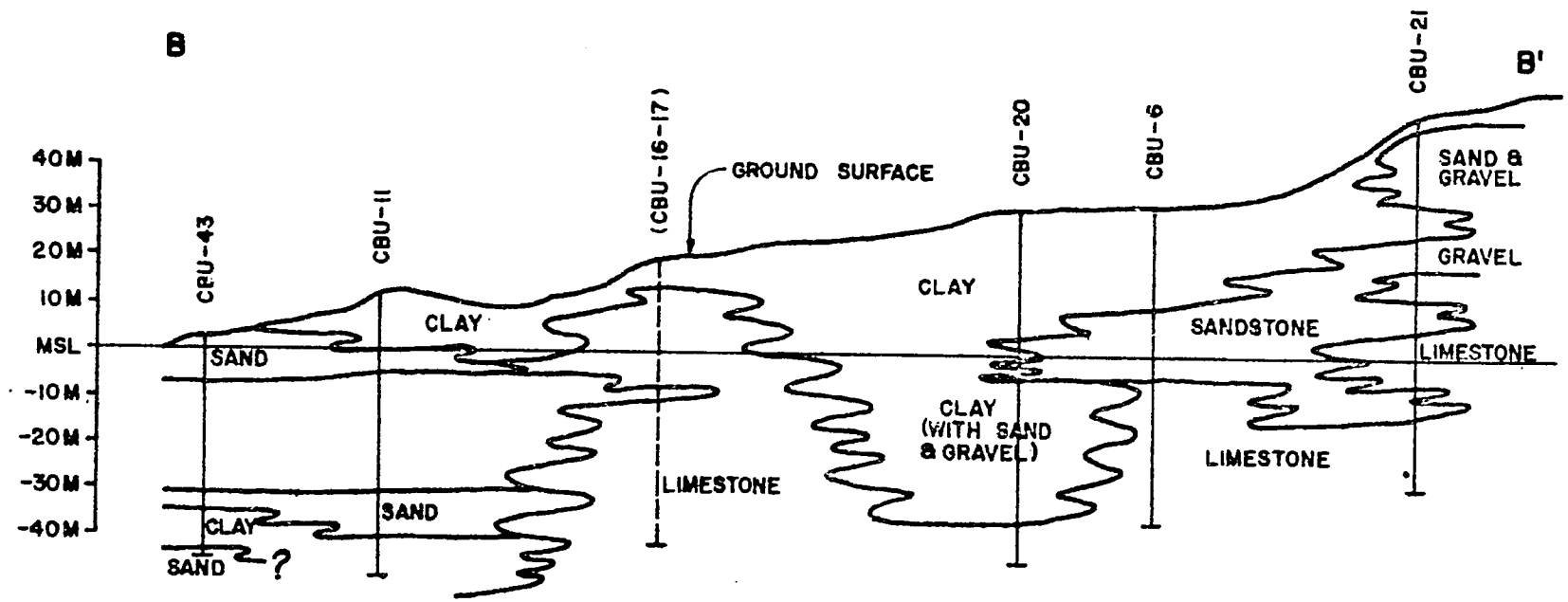
FEASIBILITY STUDY FOR WATER SUPPLY OF TEN PROVINCIAL AREAS CDM-LWUA

FIGURE VII-B-4
GEOLOGIC CROSS-SECTION A-A'
CEBU CITY AREA



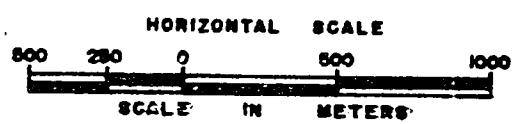


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FIGURE VII-B-5
GEOLOGIC CROSS-SECTION B-B'
CEBU CITY AREA

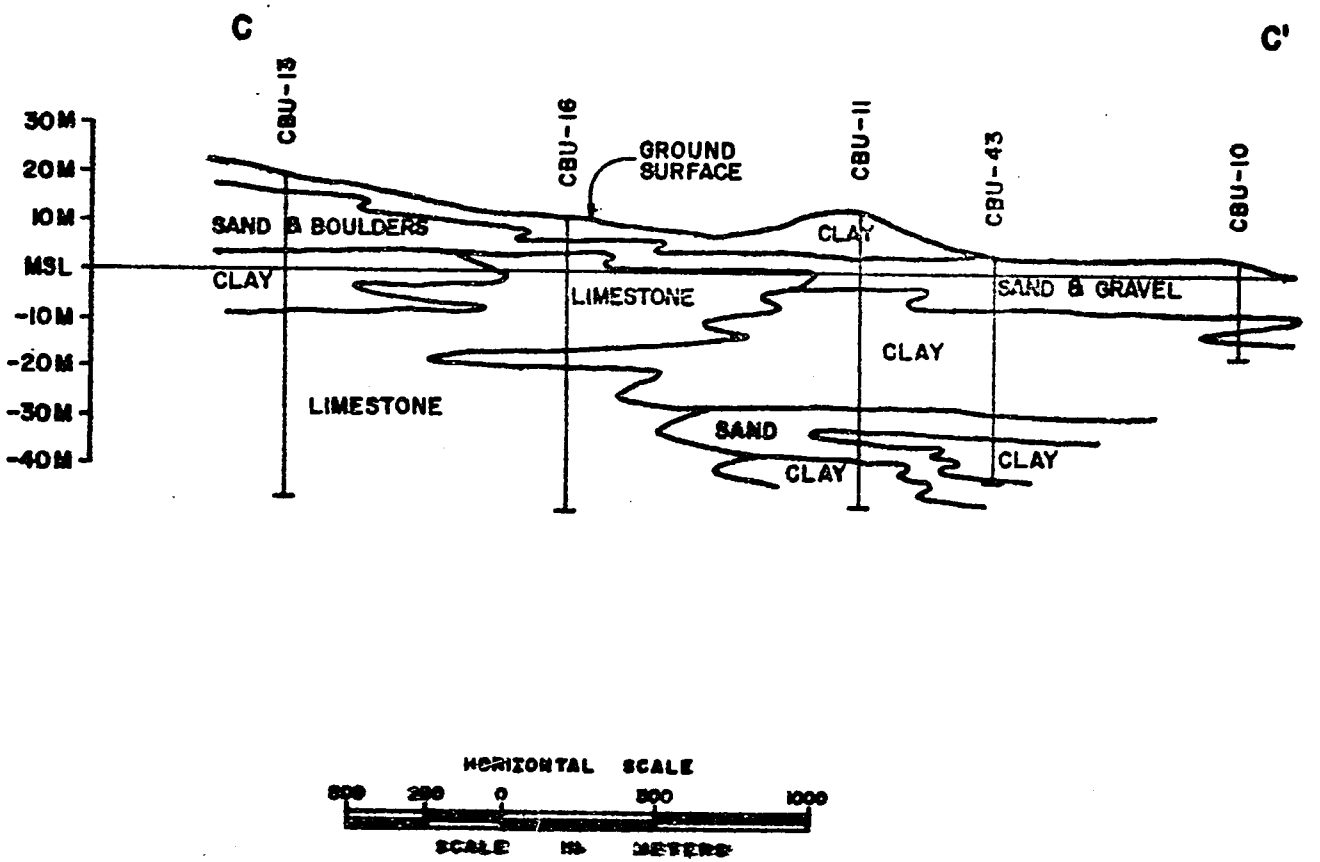

FIGURE VI-B-6
GEOLOGIC CROSS-SECTION C-C'
CEBU CITY AREA

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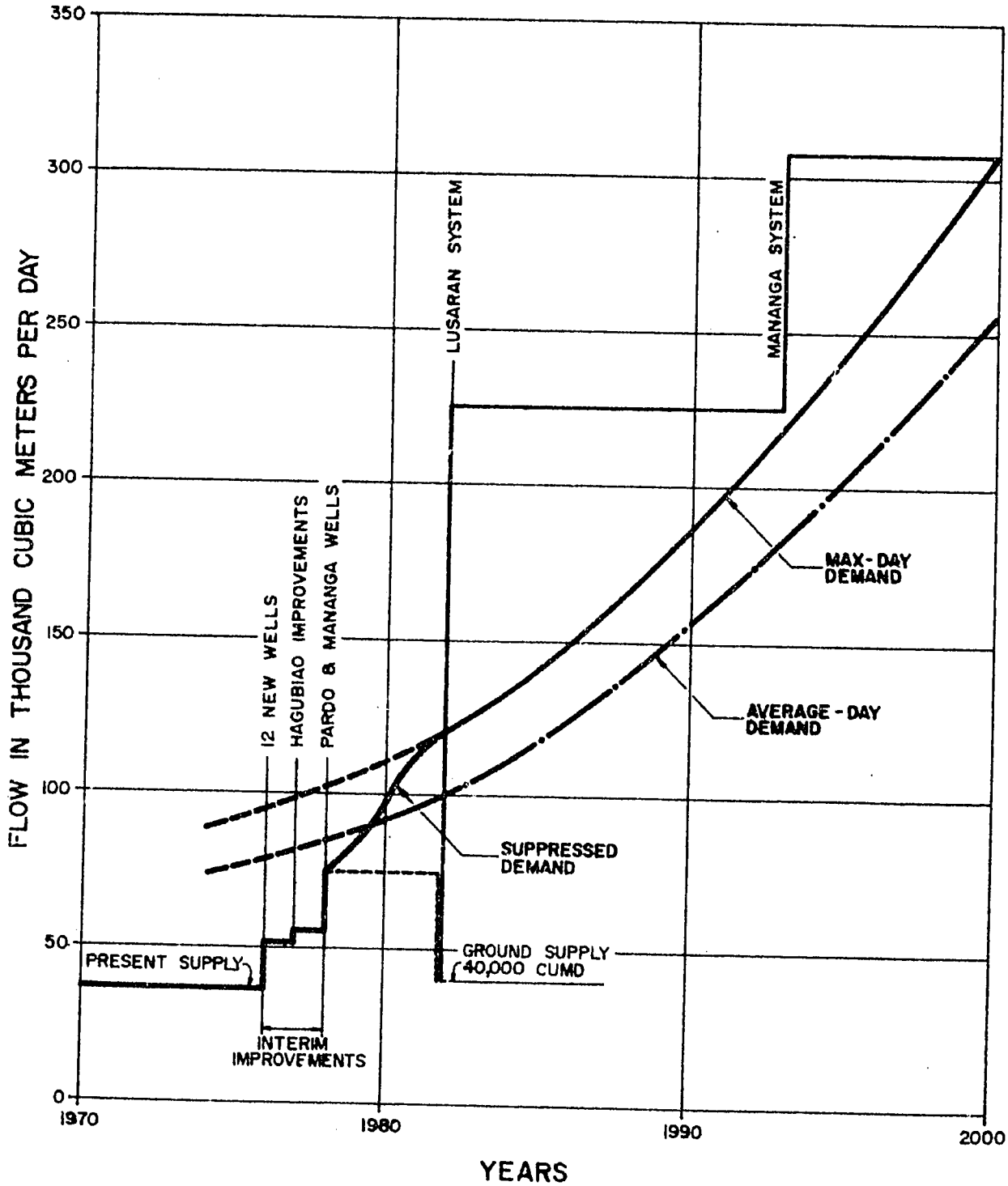

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FEASIBILITY STUDY FOR WATER SUPPLY OF TEN PROVINCIAL AREAS CDM-LWUA

FIGURE IX-3
WATER SUPPLY-DEMAND CHART

INTERIM REPORT
VOID AFTER 1 NOV 1975

TABLE IX-12

CAPITAL COST SUMMARY

Construction Stage/Phase	Period	Construction Cost (₱)	Total Project Cost (₱)	Foreign Exchange Component (US$)
Early Action Works	1976-77	4,690,000	5,400,000	210,000
Interim Improvements	1976-78	8,655,000	10,820,000	576,000
I - A	1978-82	442,556,000	696,530,000	23,150,000
B	1982-87	136,080,000	197,950,000	8,520,000
C	1986-89	39,645,000	58,647,000	1,818,000
II - A	1989-94	291,649,000	442,111,000	15,284,000
B	1995-99	65,364,000	104,010,000	3,096,000

TABLE IX-13

ANNUAL OPERATION AND MAINTENANCE COSTS

Item	Annual Costs (₱) 1982	1990	2000
1. Source Facilities	2,690,000	2,760,000	3,480,000
2. Water Treatment	1,990,000	2,710,000	4,320,000
3. Transmission & Distribution	1,170,000	2,350,000	3,820,000
4. Administration	800,000	900,000	1,000,000
5. Miscellaneous	200,000	300,000	400,000
Totals	6,850,000	9,020,000	13,020,000

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H. SEWERAGE/DRAINAGE CONCEPTS

General

All the communities in MCWD lie along the shores of Bohol Strait or the Camotes Sea. Lapu-Lapu City is nearly flat, with very gradual slopes from the shoreline to a maximum elevation of about 10 m above mean sea level in the center of the island. All of the other municipalities in the MCWD are in coastal settings, with altitudes varying from near sea level at the shore to 50 m or more in the more inland portions.

Existing Drainage System

There are no adequate sewerage and drainage facilities for any of the cities in the MCWD service area. Many residences and establishments have septic tanks with effluent being discharged to open drains and storm drainage conduits, which ultimately drain into the Bohol Strait and Camotes Sea. Except for Cebu and Mandaue, piped drainage systems of any type are limited to small gravity-flow storm drain systems in the central market and commercial areas of each community. Though nominally restricted to storm water runoff, these systems all receive substantial sanitary sewage and effluent from septic tanks, through many direct connections or seepage from overloaded subsurface disposal facilities.

In Compostela, Consolacion, Liloan and Lapu-Lapu open ditches and swales on grade convey runoff to local chanuels draining to the bay. Relative to the densely-developed urbanized area of Cebu-Mandaue, the smaller communities have less general tendency toward flooding, as paved areas are relatively smaller in extent. Also, surficial soils are generally more granular in the outlying communities, so that a greater percentage of rainfall percolates into the ground. In the Cebu City area the upper soil cover is clayey in nature, tending to make surface runoff larger.

Many principal streets in the central section of the urban area of Cebu City have a piped storm drainage system. These drains discharge to the 3 major natural watercourses passing through the city (the Subangdako, Guadalupe and Kinalumsano Rivers) and directly to the Bohol Strait along the shoreline. However, most areas in the City are drained by open ditches and earth channels. The City has considerable topographic relief in the areas to the west of the downtown commercial zone, but the older section of the poblacion, the port, and other land reclaimed from the harbor are

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all very flat. All the drainage arrangements rely on gravity flow. During and immediately following periods of intense rainfall, brief flooding is experienced in these low-lying commercial areas, especially when severe storms coincide with high tides in the receiving waters.

Portions of the river channels passing through the urban area are essentially dry in the dry season. This is especially true in the area to the west of the commercial center of the city, as these waterways are at higher elevations and are characterized by steep channel gradient toward the shoreline. In the flat low-lying areas along the shore however, these rivers are sluggish, and very objectionable nuisance conditions prevail, due to the large amount of wastes conveyed.

Except for Lapu-Lapu, topography of the MCWD area slopes steeply toward the shore, and flooding does not appear as serious as in many other cities in the Philippines. However, existing facilities are inadequate and floods of short duration do occur, with most of the attendant damage occurring in the low-lying areas. With sanitary sewage (wastewater) being discharged into the storm drains, contamination of the environment is prevalent, creating serious health hazards and conditions conducive to breeding mosquitoes and for the propagation of water-borne diseases. Since gradient of many drains in the low areas is flat, the conduits and channels are often plugged with soil and debris adding to the polluted conditions. There is also potential for polluted waters to percolate into the subsoil, contaminating the groundwater in the vicinity of these waterways.

The Central Cebu piped drainage system suffers from lack of planning. For many years, there has been no coordinated drainage master plan; available drainage facilities are not put to optimum use.

Available drawings of Cebu drainage facilities are very incomplete, both in regard to area covered by the system, and with respect to many details of facilities which have been constructed. Drawings indicate a basic Cebu City drainage system was designed in 1940, including about 50 km of concrete pipe ranging from 150 mm to 1,100 mm in diameter with gravity flow outfalls to Bohol Strait in the port area. Existing drainage system inlets, manholes and appurtenant structures are seen throughout the central area of Cebu, encompassing the entire area for which the 1940 design was prepared. However, records do not indicate whether or not this original system was constructed in substantive conformance with the design intent on these recorded drawings.

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Numerous additions were made to this system over the years.

The Bureau of Public Works Manila design office prepared a master plan for drainage in a portion of Cebu City in 1956, but available records suggest there has been no updating of the concept and detail for many years.

Relationships with Infrastructure and Other Engineering and Economic Factors

The provision of sewerage and drainage facilities in these MCWD communities has a significant impact on water supply and other infrastructure. On the other hand, economics (that is, "ability to pay") and public health affect the feasibility of providing sewerage/drainage either on a separate or a combined basis. Because of its location, any system of public sewerage in this coastal area will include some form of discharge, treated or otherwise into either the Bohol Strait or the Camotes Sea.

As stated before, alternatives for water supply sources in the MCWD area include groundwater from deep wells. Discharge of sewage and surface run off into the open channels and creeks may have potential for pollution of wells in proximity to such discharges to a greater degree than is usual, due to local geology and well construction practice. Existing MCWD wells in the Cebu City area tap a fundamental limestone complex which forms an extensive mantle overlying the basement structure beneath the city. This limestone series is in turn blanketed with surficial sediments which are stiff clays and sandy clays varying from about 6 m to 25 m in thickness over the core city area. Local well drilling has almost exclusively been done with cable-tool percussion equipment. In most cases there is neither a surface casing nor grout seal of the inner casing in the clay layer which exists between the ground surface and the top of the aquifer. Well completion has customarily consisted of pouring a concrete collar around the top of the casing at ground level, with a slab on grade. There is potential pollution of those wells which are immediately adjacent to drainage ditches conveying wastewaters. This pollutional threat is expected to increase as the water supply availability improves.

Because of the common topography and relationship with the bay, any form of centralized wastewater disposal in MCWD will necessarily involve discharge of effluent, treated or otherwise, into the bay. It is therefore immediately apparent that oceanographic investigation of the bay will be necessary to determine

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its ability to absorb these wastes, as this ability has very great impact on whether or not treatment will be necessary, and if so when and what degree will likely be needed.

The 1970 census reported 32 per cent of the households in the MCWD had flush toilets. However, such plumbing is concentrated in the Cebu-Mandaue urban area, as shown in the following table.

Community	Total No. of Households	Households with flush toilets	Ratio (%)
Cebu City	56,032	23,172	41
Mandaue City	9,658	2,347	24
Lapu-Lapu City	11,781	1,153	10
Liloan	4,123	711	17
Consolacion	3,120	343	11
Compostela	2,588	218	8
MCWD Overall	87,302	27,944	32

Experience has shown that, as a general rule for core city areas where population densities exceed 35 to 50 persons/ha a public sewer system may be economically justifiable as opposed to septic tank systems.

By 1980, the core city area of Cebu and Mandaue will have densities much more than that of Lapu-Lapu, over 50 persons/ha; while Consolacion, Liloan and Compostela will have overall densities less than 25 persons/ha. At that time Cebu, Mandaue and Lapu-Lapu may be able to justify a public sewer system while the rest may have to wait a while to increase densities and homes with water-borne closets.

Projected Wastewater Volumes

Wastewater production, like water supply demand, tends to be concentrated in the core city area of Cebu, where the density of structures with water-borne waste disposal systems is higher. This core city area largely coincides with the area served with the existing piped storm drainage system. For this central Cebu City area, estimated potential connections for a sanitary sewerage system have been projected to be as follows:

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Design Year	% Sewered of Water Connections	Wastewater, cumd: Domestic Com./Inst.	Industrial	Allowance for Infiltration	Total
1990	9	5,200	3,700	1,300	10,200
2005	24	22,200	4,300	6,000	32,500
2025	47	73,000	9,000	18,000	100,000

Alternatives Available

Before decisions can be made on the implementation of drainage and/or sewerage facilities, it must be decided whether the works should be designed on the basis of separate piping for storm and sanitary wastewater as a combined system. Although the studies necessary to determine the most economical system (or combinations) have not yet been undertaken in Cebu, experience elsewhere in urban Asian communities of similar size and economic development indicates that it is unlikely that such a low percentage of modern toilets would justify economically an immediate or early sewering program, particularly on a separate basis. The rationale for the provision of wastewater collection facilities has traditionally been based on aesthetics and public health benefits. In addition, provision of a financially self-supporting sewerage system is seldom achieved even in developed countries. It is likely that MCWD will be no exception to this experience.

At the present, there is a distinct water supply shortage in the MCWD. As the water supply problem is resolved, wastewater volumes will increase. Related public health and aesthetic problems will in turn compound and aggravate the wastewater problem. Taking into account the area's ability to pay and its needs, implementation of infrastructure facilities appears to be in the following order: 1) water supply, 2) drainage of surface runoff, and 3) wastewater.

Optimum layout of trunk sewers and drains is greatly affected by topography, with pipes ideally following the natural drainage slope of the ground to minimize sewer depth and need for pumping. However, in urbanized coastal areas such as that between Talisay and Mandaue along the Bohol Strait, it is important to select trunk sewer alignments conforming to a long-range plan. This is especially true in view of the configuration of the Strait which may restrict the natural flushing action of the tides. The minimum-investment scheme initially may be a trunk sewer and separate outfall in each major drainage basin in each community. Oceanographic studies will help define the total wastewater load which

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can be assimilated in the bay water concerned with minimal effect on aquatic life, or nuisance and public health problems of a degree which would not be tolerable to the communities. Such studies, coupled with more detailed projections of the volume and nature of the wastewater produced, will permit definition of the time and locations at which some degree of treatment will be required. In densely developed contiguous urbanized areas, such as Cebu-Mandaue, when high degree treatment may be required it is often found more economical to treat the wastes at a single location. It is thus important that trunk mains and outfalls be so located that wherever possible they may be readily adapted to conveying waste to a central disposal plant if such becomes necessary in the long-term future.

Very preliminary conceptual trunk sewer basins, pump stations, and outfalls for the Talisay-Mandaue stretch of Bohol Strait are shown on Figure

Treatment requirements cannot be defined until a drainage and sewerage master plan, including assessment of the waste-absorbing potential of the Strait, is complete.

Planning concepts should be guided by the following:

1) Minimum cost (with the absolute limit of the ability of the District to build and operate the system within the resources likely to be available).

2) Optimum economic staging of combined and separate sewers. At some (or all) stages the most economic systems may include both types, or combinations.

3) Maximum use of the natural ability of the Bohol Strait to assimilate untreated wastes, and to minimize the complexity and cost of any treatment which is required. Oceanographic studies will be necessary to determine this.

4) Minimize number of pumping stations required.

5) Make greatest possible use of the existing drainage system piping.

6) Define land requirements of important rights-of-way, pumping stations and treatment units, to enable the District to acquire land well in advance of the time when design of each successive element is undertaken.

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7) Develop viable financing plans for each stage of the works, including measures to equitably distribute costs between domestic, commercial, institutional and industrial properties served and the general public.

Capital cost of even first stage improvements to the sewerage/drainage arrangements in the Cebu-Mandaue core city area will be substantial. While the detailed planning for these works is beyond the intent of this report, several alternatives which should be evaluated in a master plan are apparent.

1) Combined or separate system. Population density in this area, at present, is on the order of 200 persons/ha, predicted to increase to near 300 by the year 2000. It is thus apparent that no type of subsurface disposal systems will be workable at this density, with the clayey surface soils common in the area. Optimum systems should be determined for:

   (a) Areas with piped storm drainage.
   (b) Areas without piped storm drainage.

2) Gravity flow or pumped outfalls;

3) Location, sequence and size of pump stations and interceptor sewers which may in time become necessary;

4) More complete treatment with short bay outfall versus very minimum (i.e., screening of coarse solids, etc.) treatment with longer ocean outfalls;

5) Effect of storms on adapting existing combined sewers to an improved system involving pumping stations and/or treatment units. Impact of storm runoff on receiving waters under these conditions;

6) Flood control in the high-value commercial districts. Evaluation of existing drainage system, to include preparation of accurate and comprehensive as-built drawings of the existing piping.

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Recommendations

As soon as the first phase water supply program is underway, a comprehensive sewerage/drainage feasibility study should be undertaken. This study must address the issue of combined vs. separate sewers. It should incorporate oceanographic studies relative to marine disposal of wastewaters into the Butuan Bay. It should also update the population and water demand projections of this water supply study.

Once the decision has been made to use either the combined or separate system, the water district must embark as expediently as possible, into a street sewering[1] and house connection program.

A plumbing code should be developed by the MCWD to coordinate plumbing requirements for water, wastewater and surface runoff facilities. This code becomes very important and meaningful particularly when a separate system of sewers is adopted.

In the meantime, a house-to-house survey should be conducted to inventory existing wastewater and toilet facilities. As-built drainage of storm drains and peripheral canals must be compiled and accurately recorded in preparation for the sewerage/drainage feasibility study.

For residence and establishments that currently lack waste disposal facilities and are financially unable to provide the modern flush toilet with septic tank, considerations may be given to an inexpensive water seal squat type toilet, developed by the Department of Health (Division of Environmental Sanitation).

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[1]The rate of sewering is influenced by the following factors:

1. the limited rate local street sewers can physically be constructed by available forces within acceptable traffic dislocation.

2. the administrative and social constraints on the rate at which premises can actually be connected to the sewer system.

3. the availability of funds.

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I. MANAGEMENT OF GROUNDWATER SOURCES

The basic problem of groundwater management in the MCWD is t provide as much water as possible, before surface water becomes available. No further MCWD wells should be allowed in the areas of heavy pumping in Cebu City and Mandaue and those wells that show marked increase in salinity should be permanently retired to inhibit the salinization effect in the local aquifer. Necessary additional water for replacement of that from saline wells may be obtained from the Mananga River and Kotkot River areas.

All operating wells should be monitored to provide records of time and rate of pumping, quantity pumped, pumping water levels, static water levels, and water quality, to aid in refining predictions of safe yield and to determine the progress of salinization of the aquifer.

The period immediately after surface water supply is available to MCWD provides the opportunity to temporarily remove some wells from service. This step will save the expense of well operation and permit the full groundwater recharge to flow through the areas of heavy pumping in order to restore the artificially lowered water table (or piezometric head) and to flush the salinized aquifer out with fresh water. In order to extend this rejuvenation period as long as possible (when it becomes necessary to use again groundwater to supplement surface water due to demand increases), the wells distant from the core city should be reactivated first and phased into the system again. During the period of well shutdown, the pumping units and all equipment and facilities must be carefully maintained so as to minimize deterioration. Each pump should be given routine operating tests as part of preventive maintenance.

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APPENDIX FOR CHAPTER VII

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TABLE VII-B-1

WATER WELL DATA SUMMARY

METROPOLITAN CEBU WATER DISTRICT

Number	Location	Nominal Diameter (mm)	Depth Total	from Ground Surface (m) Cased	SWL[1]	Test PWL[2]	Test Yield (lps)	Specific Capacity (lps/m)	Year Completed	Remarks
CBU-1	Kinasang-an Pardo	250-200	30	23	4.6					MCWD
CBU-2	Jones Ave., Abellana	250	62	46	15.5	28.0	31.5	2.5		MCWD
CBU-3	Capitol	250	74	65	25.3	34.1	12.5	1.4	1956	MCWD
CBU-4	Camputhaw	250-150	82	66	24.4				1963	Throttled MCWD
CBU-5	F. Ramos	200	76	63	27.7		6.6		1957	Abandoned MCWD
CBU-6	Guadalupe CFD	200	68	60	18.3				1958	Throttled MCWD
CBU-7	Lahug Rotonda	200	102	89	42.4				1958	Throttled MCWD
CBU-8	Ramos Super-market	200	104	92	14.6		25.2		1959	MCWD
CBU-9	Parian	200	53	47	12.2					MCWD
CBU-10	Warwick Barracks	200	20	18	3.0				1964	MCWD
CBU-11	V. Rama	250	61	49	13.1	32.3	17.7	0.9	1964	Throttled MCWD
CBU-12	Bulacao Pardo	250	64	48	7.3		15.8		1964	Out of Service MCWD
CBU-13	F. Llamas	200	67	64	9.4		15.8		1965	MCWD
CBU-14	Pelaez Girl Scouts	200	64?	61?	12.2					Abandoned high Cl MCWD
CBU-15	Sikatuna Zapatera	200	61	56	5.5	8.5	26.4	8.8		MCWD

[1]Static water level.

[2]Pump water level.

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TABLE VII-B-1 (Cont'd)

Number	Location	Nominal Diameter (mm)	Depth Total	from Ground Surface(m) Cased	SWL	Test PWL	Test Yield (lps)	Specific Capacity (lps/m)	Year Completed	Remarks
CBU-16	Natipuman Labangon	200	61	53	3.4		46.0		1965	MCWD
CBU-17	Adelfa	200	62	58	20.7					MCWD
CBU-18	Lahug Laboratory	200	81	71	38.1	50.6	5.7	0.5	1964	Throttled MCWD
CBU-19	Lahug III MA	200	101	80	40.5	43.6	12.5	4.0		MCWD
CBU-20	M. Velez	200	78	62	24.4				1964	MCWD
CBU-21	Guadalupe Church	150	79	62	36.6		10.1		1965	No pump MCWD
CBU-22	Sangciangoo	200	52	37	7.0	12.5	15.4	2.8		MCWD
CBU-23	Don Jose Avila	200	75	61	64.0					No discharge MCWD
CBU-24	Gen. Maxilom (USC)	200	75	60	17.1	30.2	7.2	0.5	1964	MCWD
CBU-25	South Expressway	200	76	73	6.1?					No discharge MCWD
CBU-26	Talamban (Tacoan)	112	8.5	7.3	4.9		0.6		1956	MCWD
CBU-27	Cebu Royal Plant	200	61	61	5.7				1972	
CBU-28	Pepsi Cola Plant	200	30	30	12.2	15.8			1964	
CBU-29	SSS Bld, Jones Ave.	100	43	43	8.8	11.0			1971	
CBU-30	First Engine Rebuilder	200	17	17	6.1	6.4			1974	
CBU-31	Paradise Vil., Banilad	200	76	76	25.9	29.6			1965	
CBU-32	Silver Hills	200	92	92	47.2	51.2			1974	
CBU-33	Rozen Bldg.		46	46	9.1	10.1			1974	

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TABLE VII-B-1 (Cont'd)

Number	Location	Nominal Diameter (mm)	Depth Total	from Ground Surface (m) Cased	SWL	Test PWL	Test Yield (lps)	Specific Capacity (lps/m)	Year Completed	Remarks
CBU-34	San Miguel Complex		114	114	6.1	9.6	15.4	4.4	1967	
CBU-35	San Miguel Complex		114	114	14.0	18.9	13.3	2.7	1967	
CBU-36	San Miguel Complex		107	107	17.3	18.7	12.0	8.6	1967	
CBU-37	San Miguel Complex		111	111	8.3	10.5	10.7	4.9	1967	
CBU-38	San Miguel Complex		136	136	19.4	23.1	15.8	4.3	1970	
CBU-39	Bonifacio St., Mandaue		122	122	13.6	22.0	15.0	1.8	1974	
CBU-40	Herman Cortes St., Cabancalan		122	122	16.8	26.1	29.8	3.2	1974	
CBU-41	Tabunoc, Talisay	200	64	59	14.9		37.9		1966	
CBU-42	Gen. Maxilom & Gen. Echaves	200	91	81	10.7		12.6		1964	
CBU-43	San Nicolas, Plaza	200	46	41	2.7				1961	
CBU-44	Lapu-Lapu City						12.4-14.6			2 wells, high Cl
CBU-45	Campar, Pardo	100	21	16	9.8	13.7	0.6	0.2	1971	NWASA
CBU-46	Bo. Catahu-an, Talamban	112	29	24	12.5		1.3		1957	NWASA
CBU-47	Bo. Banilad, Mabolo		37	30	22.9				1957	NWASA
CBU-48	Upper Banilad	100	33	30	27.1		0.5		1957	NWASA
CBU-49	Quiat, Pardo	100	22	20	9.8	10.7	0.5	0.6	1957	NWASA
CBU-50	So. Majon, Tisa	100	30	29	16.8	17.4	1.1	1.8	1958	NWASA

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TABLE VII-B-1 (Cont'd)

Number	Location	Nominal Diameter (mm)	Depth Total	from Ground Surface(m) Cased	SWL	Test PWL	Test Yield (lps)	Specific Capacity (lps/m)	Year Completed	Remarks
CBU-51	Camp Lapu-Lapu	200	73	72	32.9	34.7	3.8	2.1	1958	NWASA
CBU-52	Bo. Nasipit	100	49	47	25.9		1.1		1958	NWASA
CBU-53	So. Caduloy, Tisa	100	23	22	14.9	15.5	1.1	1.8	1957	NWASA
CBU-54	Camp Lapu-Lapu	75	65		42.7		1.3		1955	NWASA
CBU-55	Lahug	150	49	48	33.5	34.4	1.1	1.2	1955	NWASA
CBU-56	Mambaling, San Nicolas	200	35	35	2.1	10.1	6.3	0.8	1958	NWASA
CBU-57	Lahug	150	55	46	33.5	36.6	1.3	0.4	1955	NWASA
CBU-58	Binaliw	100	46	37	27.4	29.0	0.3	0.2	1953	NWASA
CBU-59	Camputhao, Lahug	100	28	21	19.2				1957	NWASA
CBU-60	Camacho Res., Capitol	75	50	49	35.7	36.6	0.3	0.3	1968	
CBU-61	Near Capitol		91							NWASA
CBU-62	Bo. Pardo	250	26	20	4.6					NWASA
CBU-63	Bo. Guizo, Mandaue	150	34	33	13.7		1.3		1955	NWASA
CBU-64	Bo. Nawanao, Mandaue	150	37	34	12.2		1.3		1955	NWASA
CBU-65	Bo. Cabangkalan, Mandaue	150	22	21	10.7	11.0	1.6	5.3	1954	NWASA
CBU-66	Bo. Poo, Mandaue	150	30	30	10.7	11.0	1.6	5.3	1954	NWASA
CBU-67	Bo. Casili, Consolacion	150	17	15	10.7		1.3		1955	NWASA
CBU-68	Bo. Tugbungan, Consolacion	100	29	23	16.8				1957	
CBU-69	Bo. Lamak, Liloan	150	27	22	12.2		1.3		1955	NWASA
CBU-70	Bo. Catarman, Liloan	150	20	20	15.2	16.2	1.3	1.3	1954	NWASA

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TABLE VII-B-1 (Cont'd)

Number	Location	Nominal Diameter (mm)	Depth Total	from Ground Surface (m) Cased	SWL	Test PWL	Test Yield (lps)	Specific Capacity (lps/m)	Year Completed	Remarks
CBU-71	Ilaya, Cot Cot. Liloan	100	32	32	7.6	9.1	0.6	0.4	1963	NWASA
CBU-72	Tayud, Liloan	100	24	22	12.8	13.4	0.4	0.7	1963	NWASA
CBU-73	Bo. Canamucan, Compostela	150	43	37	9.1	10.7	0.9	0.6	1955	NWASA
CBU-74	Tabunao, Talisay	200	52		14.3					
CBU-75	Bo. Lug	250	107	107	25.0				1974	Municipal
CBU-76	Home for Blind Banilad	250	123	117	27.4				1974	Municipal
CBU-77	Salinas Dr., Lahug	250	123	122	33.5				1975	Municipal
CBU-78	Nurses Home	250	76	76	25.9	28.0	7.6	3.6	1975	Municipal
CBU-79	Bezak Elem. School	250	67	66	4.6	41.1	6.3	0.2	1975	Municipal
CBU-80	Labangan Elem. School	250-150	76	76?	9.1				1975	Municipal
CBU-81	Hipodromo	250	76		12.2				1975	Municipal
CBU-82	Country Club	250	113	113	25.0				1975	Municipal
CBU-83	Guadalupe Church	250	122						1975	Municipal
CBU-84	Tisa	250							1975	Municipal
CBU-85	V. Rama	250							1975	Municipal
CBU-86	Lahug Runway Tip	250	122						1975	Municipal
CBU-87	San Miguel Brewery									Abandoned high Cl
CBU-88	San Miguel Brewery									
CBU-90	Power Plant SCU	150	24	18	8.8				1956	1,978 ppm Cl
CBU-91	Fathers Quarters SCU	150	30	30					1961	1,098 ppm Cl

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TABLE VII-B-1 (Cont'd)

Number	Location	Nominal Diameter (mm)	Depth Total	from Ground Surface (m) Cased	SWL	Test PWL	Test Yield (lps)	Specific Capacity (lps/m)	Year Completed	Remarks
CBU-92	Near Perpetual Succor Hospital									32 ppm Cl
CBU-93	F. Jaca St., Pardo									98 ppm Cl
CBU-94	Int. Cebu So. Expressway near Basak Elem. School									35 ppm Cl
CBU-95	Punta Princesa									16 ppm Cl
CBU-96	J.M. Basa, Cañete Side, CIT									156 ppm Cl
CBU-97	Tisa Kapakulan Sta. Ana I									34 ppm Cl
CBU-98	B. Rodriguez,Sr.									40 ppm Cl
CBU-99	T. Villa									719 ppm Cl
CBU-100	Hippodromo									50 ppm Cl
CBU-101	Barrio Luz									19 ppm Cl
CBU-102	Labangon Elem.School									23 ppm Cl

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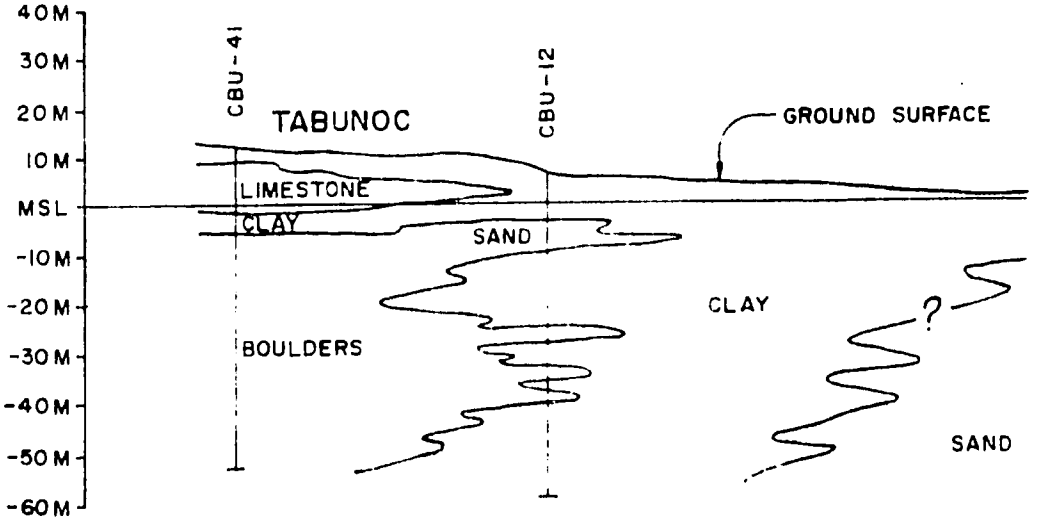

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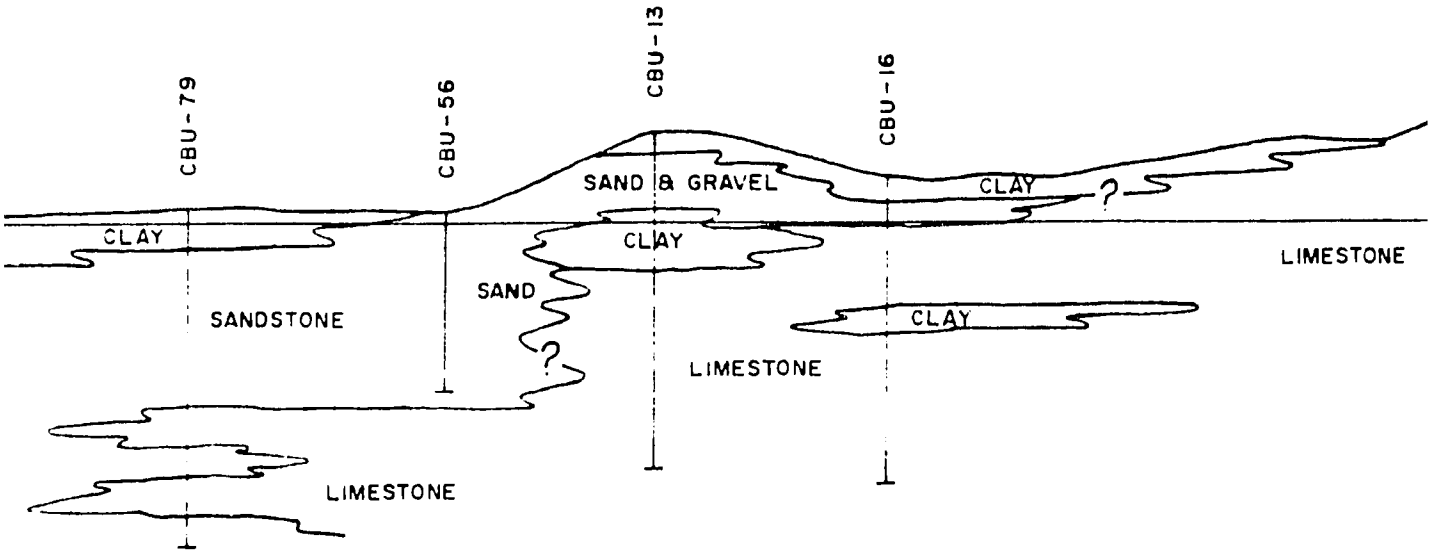

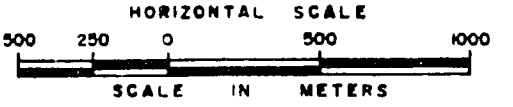

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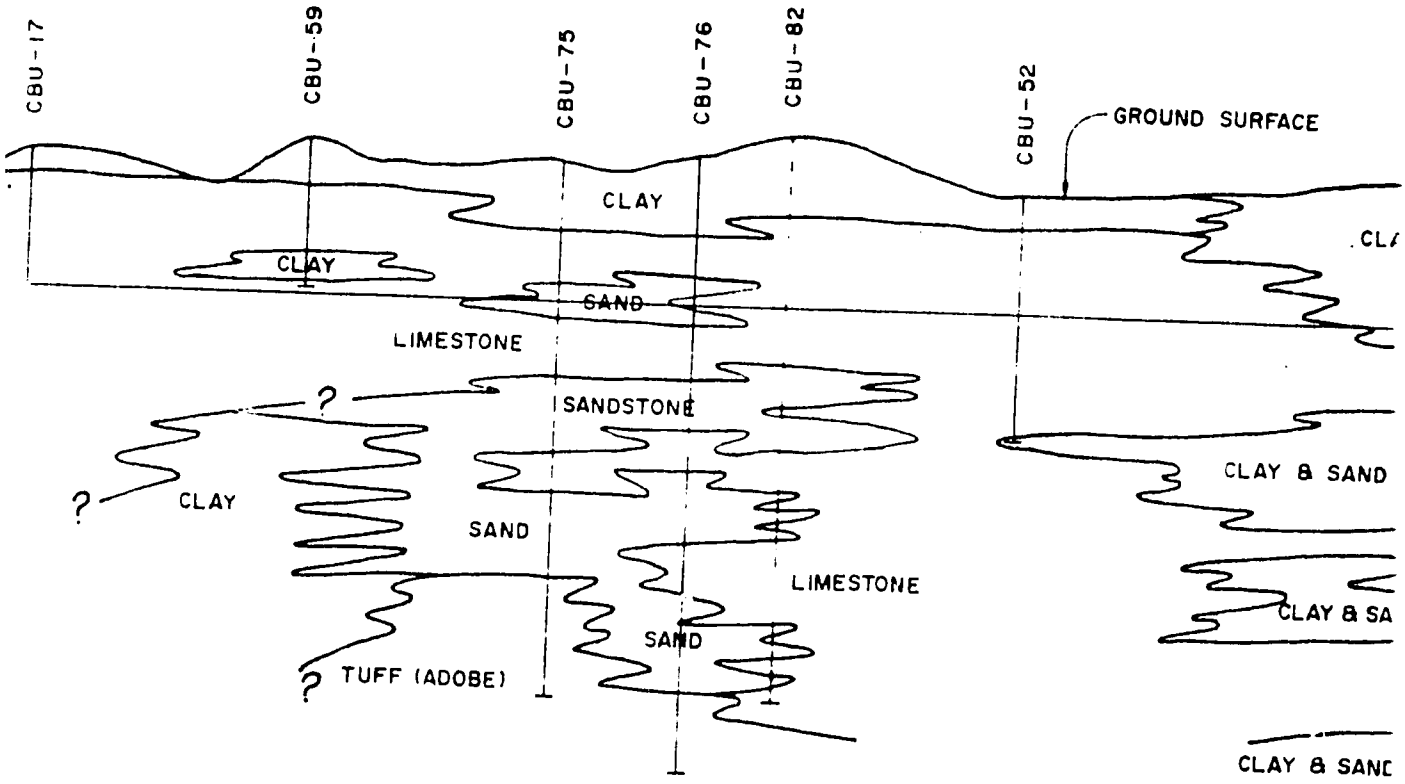

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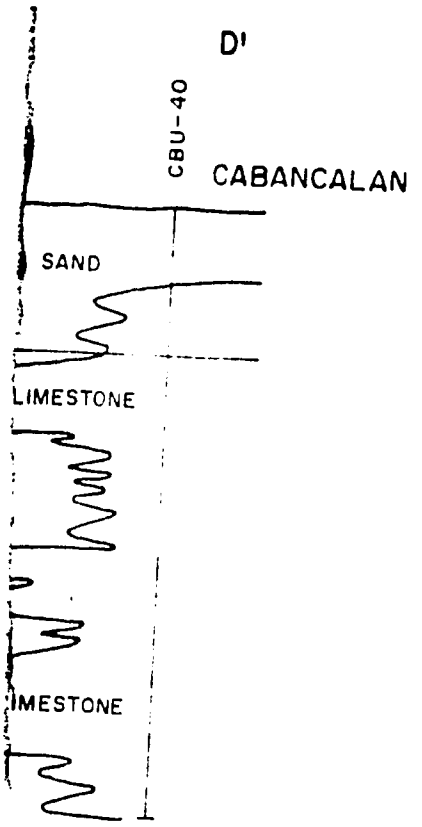

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FIGURE VII-B-7
OGIC CROSS-SECTION D-D'
CEBU CITY AREA

TABLE VII-C-1

METEOROLOGICAL STATIONS

Type	Location	Station	Type of Record	Period of Record
Streamflow[1]	Balamban River	Liki, Cebu	Recorder	1956-57
	Balamban River	Lusaran, Cebu	Recorder	1957-69
	Kotkot River	Malao, Cebu	Staff gage	1957-61
	Pitogo River	Consolacion, Cebu	Staff gage	1955-77
	Carcar River	Carcar, Cebu	Staff gage	1955-66
	Sapangdaco River	Toledo, Cebu	Staff gage	1955-66
	Basak River	Badian, Cebu	Staff gage	1955-56
	Mantayupan River	Barili, Cebu	Staff gage	1956-56
Rainfall[2]	Cebu	Cebu	Non recording	1920-40 1966-74
		Lahug	Non recording	1956-74
		Montalongan	Non recording	1956-74
		Minglanilla	Non recording	1966-74
		Medellin	Non recording	1966-74
		Talisay	Non recording	1928-40
		Barili	Non recording	1956-59
Evaporation[1]	Luzon	Quezon City	Pan	1965-68
		Manila	Pan	1963-65
	Samar	Catarman	Pan	1966-72
	Samar	Quinapondon	Pan	1961-65
	Negros	Dellimen	Pan	1961-65
		Tagbac	Pan	1964-65
		Orang	Pan	1961-65
		Dahile	Pan	1964-65
	Cotabato	Gen. Santos	Pan	1961-65
	Agusan del Sur	Bunawan	Pan	1961-65

[1] From the Bureau of Public Works.

[2] From records of Philippine Atmospheric, Geophysical and Astronomical Services Administration.

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TABLE VII-C-2

RAINFALL RECORDS

STATIONS IN CEBU

(in millimeters)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL ANNUAL
CEBU CITY													
1920	-	58.8	103.2	15.5	93.9	79.3	62.1	32	251.8	131.2	212.5	53.7	-
1921	11.4	165.4	82.3	24.7	235.5	208.5	211.1	328.7	259.7	146.3	272.3	98.9	2147.4
1922	26.0	74.8	96.9	56.8	192.7	187.1	227.6	50.2	131.3	25.6	143.5	15.7	1833.9
1923	212.5	14.0	91.3	84.9	15.3	69	116.2	150.5	83.3	194.5	141.6	29.6	1340.4
1924	96.3	13.8	54.2	13.8	13.4	216.7	132.7	19.6	178.4	259.9	254.9	326.6	2001.5
1925	147.9	200.5	51.8	101.4	-	-	-	-	132.9	173.9	150.5	61	-
1926	126.6	43.4	37.9	4.3	89.8	124.8	228.3	309.2	242.7	149.7	110.5	19.2	138.3
1927	-	-	-	-	-	-	-	-	-	-	-	-	-
1928	171.1	194.4	56.1	-	178.8	150.3	249.4	104.3	45.4	126.6	216	119.2	-
1929	125.9	13.3	59.6	113.9	158.3	162.8	231.8	128.7	68.7	-	88.3	143.5	-
1930	63.8	-	22.6	51.1	69.7	166.1	82	109.9	179.7	71.6	145.4	129.6	-
1931	94.8	28.8	36.2	2.4	70.9	143.2	208.4	82.1	207.4	297.4	259.1	113.3	1544.0
1932	86.3	43.4	12.1	14.1	88.5	154	217.3	106.8	236.3	94.8	215.8	86.8	1356.2
1933	-	122.9	6.1	-	62.0	212.8	177.9	249.4	-	303.6	-	76.0	-
1934	44.8	218.1	81.8	107.8	200.7	72.5	202.8	323.5	125.5	87.6	165.2	210.3	1840.6
1935	-	15.7	14.3	58.4	217.2	177.9	156.5	73.3	172.8	155.9	73.7	42	-
1936	139.5	23.5	54.3	39.9	88.9	180.7	117.9	115.5	113.2	116.3	52	-	-
1937	73.2	17.8	100.9	89.7	93.1	100.3	339.3	170.3	281.8	118.9	135.1	55.1	1575.5

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TABLE VII-G- 2 (continued)
RAINFALL RECORDS
STATIONS IN CEBU
(in millimeters)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL ANNUAL
1938	-	68.2	117.9	221.7	197.9	388	135	66.9	237.2	292.9	171.6	91.0	-
1939	262.4	91.3	66.8	24.8	209.7	246.5	137.6	67.9	128.8	161.4	169.4	267.3	1828.9
1940	56.6	32.4	12.4	76.4	83.4	169.3	141.2	199	-	-	-	-	-
1966	70.3	38.4	8.0	24.5	271.8	125.2	305.2	214.8	142.5	202.1	208.9	161.8	1773.5
1967	463.7	73.5	77.8	12.4	57.7	187.9	180.4	98.5	113.0	107.1	139.3	59.6	1570.9
1968	57.1	56.4	58.1	32.6	5.1	144.6	115.7	134.9	177.3	147.6	265.8	41.1	1236.3
1969	11.5	4.8	26.5	5.5	54.5	172.5	103.7	181.5	141.3	89.0	47.5	66.2	904.5
1970	51.8	22.8	17.6	17.0	43.8	239.6	238.7	182.0	98.1	197.5	231.[illegible]	152.0	1492.0
1971	84.1	53.5	21.4	86.0	194.0	301.5	137.0	96.1	253.4	295.1	138.4	77.7	1728.2
1972	253.2	16.8	83.7	82.7	126.7	166.3	86.8	194.6	249.1	100.3	100.2	70.5	1530.9
1973	12.3	70.0	20.4	10.8	28.4	154.1	234.4	172.1	315.5	109.7	480.3	112.8	1720.8
1974	67.6	137.5	113.4	35.2	-	-	-	-	-	-	-	-	-

BEST AVAILABLE DOCUMENT

TABLE VII-C-2 (continued)

RAINFALL RECORDS

STATIONS IN CEBU

(in millimeters)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL ANNUAL
LAHUG													
1940	83.3	47.6	21.2	119.8	80.6	235.4	173.5	255.2	-	-	-	-	-
1956	56.4	11.2	49.5	174.0	262.9	164.6	91.2	160.0	89.7	158.0	134.9	229.9	1582.3
1957	69.6	143.5	48.5	51.3	11.2	158.0	200.7	142.0	73.2	146.0	104.9	20.6	1169.5
1958	160.3	36.1	117.9	40.4	126.8	60.4	139.7	209.3	105.4	152.4	73.7	97.8	1320.2
1959	-	51.4	57.7	41.9	49.5	70.1	227.6	258.3	2550.0	133.1	155.4	130.0	-
1960	62.7	48.5	78.0	175.8	48.8	216.9	247.1	242.1	290.8	134.6	172.2	19.0	1736.5
1961	43.4	36.6	29.0	56.9	99.3	147.6	222.5	97.5	160.8	261.4	141.2	96.5	1397.7
1962	47.5	193.8	73.2	18.8	130.3	199.4	195.8	367.5	148.8	155.7	172.0	43.9	1746.7
1963	67.6	24.1	74.9	89.2	20.6	117.4	229.1	186.2	290.8	241.0	102.6	45.5	1613.1
1964	67.3	145.5	38.6	97.8	221.0	227.1	256.8	65.3	194.8	272.5	381.0	69.6	2037.3
1965	79.5	104.4	177.3	63.5	23.4	233.9	95.0	223.5	127.2	279.6	127.8	132.3	1667.4
1966	79.5	35.8	8.4	29.3	315.2	117.6	370.1	231.9	162.3	241.2	275.9	204.2	2081.6
1967	460.3	73.1	69.7	25.0	52.4	171.4	174.1	88.5	140.8	175.3	142.3	77.8	1650.7
1968	59.3	18.0	60.5	19.3	6.1	116.6	132.0	24.8	25.9	5.0	363.7	62.1	893.3
1969	11.5	5.1	51.4	56.7	82.5	236.5	105.4	164.7	201.6	95.6	52.9	97.6	1161.5
1970	60.1	39.0	24.9	14.0	65.6	275.2	254.6	217.6	98.6	256.2	249.4	132.7	1687.9
1971	106.8	56.3	26.2	55.7	126.6	342.6	141.8	134.0	326.7	300.4	132.3	108.4	1857.8
1972	298.1	15.0	87.7	75.7	131.8	202.1	59.4	265.4	238.9	107.2	116.4	79.3	1677.5
1973	15.1	75.5	23.9	9.1	29.6	181.0	285.6	195.5	-	105.4	568.7	128.3	-
1974	52.4	128.3											

BEST AVAILABLE DOCUMENT

TABLE VII-C-2 (continued)

RAINFALL RECORDS

STATIONS IN CEBU

(in millimeters)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL ANNUAL
MONTALONGAN													
1932	-	106.4	112.2	15.7	186.9	286.7	205.9	72.3	-	392.8	170.3	166.3	-
1933	-	178.8	37.1	-	112.5	253.2	294.2	94.6	319.6	408	329.1	269	-
1938	-	-	-	253.2	167.5	306.4	297.1	140.6	296.1	277.5	247.5	127.9	-
1940	-	131.7	20.6	113.9	14.6	165.7	225.5	288.2	-	-	-	-	-
1956	149.1	39.9	131.3	198.1	305.8	123.7	364.7	198.6	178.1	414.5	84.8	589.5	2778.1
1957	159.0	119.9	68.3	80.0	59.7	171.7	300.7	166.6	63.2	134.6	51.6	38.1	1413.4
1958	98.8	125.2	98.8	67.6	113.8	152.1	109.7	122.7	88.6	237.2	266.2	51.8	1532.5
1959	119.8	105.4	124.5	106.2	241.3	231.4	150.9	253.0	237.7	154.2	119.1	203.9	2047.2
1960	184.9	126.2	55.9	97.3	129.0	231.4	179.1	128.5	103.9	181.1	203.7	59.7	1680.7
1961	111.5	78.0	48.3	91.4	239.3	162.0	149.6	110.5	113.8	210.8	130.6	127.5	1573.3
1962	28.2	164.8	148.8	105.7	85.6	288.3	353.6	290.1	215.4	147.6	354.1	126.0	2308.3
1963	123.2	90.9	227.6	19.6	77.0	96.0	211.3	314.9	182.1	303.5	88.9	114.0	1849.0
1964	209.8	272.6	34.0	212.6	254.3	307.8	213.1	67.3	184.4	197.1	437.7	38.7	2502.3
1965	175.8	159.8	234.2	226.6	131.8	231.1	247.6	151.4	215.9	255.3	220.5	167.9	2417.12
1966	118.0	77.1	46.1	31.2	219.2	127.5	303.8	154.2	154.9	219.0	49.9	46.3	1547.2
1967	105.3	14.7	78.3	8.3	32.4	21.3	87.4	63.2	53.8	99.2	107.6	48.2	769.7
1968	45.8	34.4	18.0	8.4	40.2	67.5	23.1	6.0	37.2	33.3	116.1	47.2	473.2
1969	21.7	6.1	33.0	10.4	23.8	51.3	43.6	90.2	89.9	74.8	28.3	62.6	535.7

BEST AVAILABLE DOCUMENT

TABLE VII-C-2 (continued)

RAINFALL RECORDS

STATIONS IN CEBU

(in millimeters)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL ANNUAL
MONTALONGAN													
1970	53.4	45.5	17.8	13.9	61.6	87.7	82.8	47.0	53.5	209.2	230.1	107.3	1009.8
1971	147.6	282.2	93.8	114.9	94.6	316.5	203.6	164.5	129.2	252.6	185.5	95.2	2080.2
1972	175.0	45.8	111.2	69.6	68.3	218.8	31.8	185.0	183.9	74.9	127.6	223.9	1515.8
1973	34.9	94.7	45.7	13.0	6.2	145.8	357.9	212.4	-	212.3	412.2	66.9	-
1974	150.4	112.1	109.5	26.6	161.9	219.4	203.1	154.1	103.8	340.5	-	-	-
MINGLANILLA													
1938	-	-	-	-	-	-	-	-	22.9	713.7	241.9	151.9	-
1939	134.9	114.7	131.6	10.7	434.8	263.5	89.1	105.6	207.1	284.2	290.2	518.6	2585.0
1940	53.2	35.2	39.6	79.4	164.1	192.6	220.7	153.5	-	-	-	-	-
1966	64.1	44.6	15.0	46.0	390.4	1406.0	313.9	206.0	130.3	272.5	201.0	167.3	3257.1
1967	326.9	89.3	107.1	38.3	56.4	30.7	26.4	10.8	27.9	37.0	115.5	63.5	960.0
1968	90.1	20.2	2.3	2.0	2.9	67.4	9.6	83.6	125.2	29.6	55.0	27.4	515.3
1969	29.3	12.7	100.3	114.3	99.6	62.7	200.8	161.3	99.0	180.4	71.2	86.4	1218.0
1970	35.8	86.4	45.7	0	0	310.0	187.9	175.3	172.1	274.4	0	203.1	1490.7
1971	123.2	81.2	60.9	185.5	154.9	193.1	223.5	220.9	244.0	364.0	101.4	180.4	2133.0
1972	-	48.2	129.4	11.5	118.4	114.3	-	30.4	211.0	121.8	-	27.0	-
1973	-	-	-	-	-	-	-	-	-	-	-	156.7	-
1974	45.5	111.5	-	60.7	259.9	308.2	112.9	74.8	98.9	319.4	-	-	-

BEST AVAILABLE DOCUMENT

TABLE VII-A-2 (continued)

RAINFALL RECORDS

STATIONS IN CEBU

(in millimeters)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL ANNUAL
MEDELLIN													
1932	-	53.1	57.8	39.4	221.2	302.1	221.2	-	266.8	157.5	199.4	92.5	-
1933	132.7	36.3	0.8	28	55.6	307.2	121.2	125.2	179.9	290.3	219.8	153.8	1643.8
1938	57.9	49.6	62.3	141.7	124.9	105.8	156.5	112	203.2	212.1	191.9	236.2	1654.1
1966	33.6	33.2	10.3	10.2	409.2	156.5	412.5	285.2	153.9	168.2	76.2	248.7	1997.7
1967	75.2	134.8	51.3	17.6	54.8	64.0	97.3	228.6	145.8	247.4	190.5	29.5	1636.8
1968	15.2	17.3	40.9	28.2	36.8	98.6	180.3	114.9	128.5	149.1	295.1	25.1	1160.0
1969	21.3	1.3	3.0	29.5	37.9	320.5	248.9	241.6	169.9	120.9	82.8	96.0	1373.6
1970	12.5	67.8	60.0	0	29.5	344.6	350.0	60.4	193.5	384.3	252.0	85.3	1859.7
1971	87.9	32.5	40.1	224.3	273.8	418.3	457.0	122.7	317.0	316.7	138.7	61.7	2494.7
1972	506.2	11.7	56.9	67.5	95.3	214.3	56.4	520.9	486.9	70.6	298.9	146.2	2558.8
1973	20.6	68.6	45.7	18.3	37.0	149.5	169.6	195.6	272.4	113.6	246.3	186.2	1523.4
1974	77.7	-	36.9	37.3	138.0	84.9	-	63.8	66.5	444.9	-	-	-
TALISAY													
1928	-	-	-	-	216.5	214.6	123.3	106.7	84.7	208.5	269.7	145.9	-
1929	109.6	5.1	57	41.1	225.4	77.4	171.4	138.3	77.2	-	85.2	14.3	-
1930	46.5	-	20.2	66.3	131.4	140.7	81.1	95.6	122.4	40.8	112.6	96.1	-
1931	121.6	35.1	28.9	10.2	43.5	139.4	241.4	59.1	101.7	291.8	296.4	74.2	1446.3
1932	83.7	41.8	16.6	5.4	179.3	206.1	192.2	150.3	286.4	139	233.2	83.3	1617.3

BEST AVAILABLE DOCUMENT

TABLE VII-C-2 (continued)

RAINFALL RECORDS

STATIONS IN CEBU

(in millimeters)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL ANNUAL
TALISAY													
1933	142.3	100.6	9.2		109.2	284.4	284.4	151.7	219.8	324.9	-	84.9	-
1934	71.2	246.3	53.4	119.1	209.5	80.4	244.8	295.3	148.8	122.7	320.8	246.4	2158.7
1935	-	20.8	32.3	27.6	162.6	161.2	205.8	25.8	159.9	256.2	71.7	62.2	-
1936	143.1	25.5	48.1	27.6	140.8	279.5	272.3	20.5	109.4	185.4	110.9	-	-
1937	82.4	30.9	99.5	47.6	161.2	97.9	176.8	145.8	121.4	104.8	209.8	39.6	311.8
1938	-	48.6	123.9	145.2	219.2	324.5	222.4	112.7	119.6	288.2	160.1	141.2	-
1939	230.8	81.7	61.6	13.7	134.6	17.9	145.3	43.1	191.4	147.8	248.4	232.5	1709.9
1940	59.5	34.0	3.9	124.8	81.8	175.1	154.7	149.5	-	-	-	-	-
BARILI													
1940	-	46.5	32.9	207.6	21.9	142.2	67.9	194.4	-	-	-	-	-
1956	183.1	91.7	129.3	277.1	355.8	375.9	261.6	231.6	145.5	173.5	127.8	206.5	2559.4
1957	88.4	64.8	58.2	49.8	31.2	47.0	202.4	122.9	76.7	82.3	66.5	17.8	908
1958	50.8	12.7	39.4	12.2	48.3	81.8	31.8	122.9	26.9	100.1	151.4	167.4	845.7
1959	49.5	19.0	-	-	-	-	-	-	15.2	-	-	-	-

BEST AVAILABLE DOCUMENT

TABLE VII-C-3

EVAPORATION RECORDS

STATIONS IN THE PHILIPPINES

(in centimeters)

YEAR	EVAPORATION STATION									
	NEGROS OCCIDENTAL				SAMAR		QUEZON CITY	MANILA	COTABATO	AGUSAN DEL NORTE
	SILLIMAN	TAGBAC	ORONG	DAHILE	GUINAPONDAN	CATARMAN	DILIMAN	PORT AREA	GEN. SANTOS	BUENAVAN
1961	200.0	-	173.	-	167	-	-	-	204	128
1962	191	-	174	-	163	-	-	-	218	131
1963	201	-	171	-	165	-	-	195	245	-
1964	197	200	162	154	157	-	-	176	286	145
1965	188	164	155	136	152	-	165	194	-	143
1966	-	-	-	-	-	166	182	-	-	-
1967	-	-	-	-	-	174	178	-	-	-
1968	-	-	-	-	-	180	194	-	-	-
1969	-	-	-	-	-	175	-	-	-	-
1970	-	-	-	-	-	151	-	-	-	-
1971	-	-	-	-	-	139	-	-	-	-
1972	-	-	-	-	-	143	-	-	-	-
1973	-	-	-	-	-	149	-	-	-	-
AVE.	195.4	182	167	145	160.8	151.6	179.8	189.3	238.2	136.8

Note: All records from open rim type evaporation pans.

BEST AVAILABLE DOCUMENT

TABLE VII-C-4

TOTAL MONTHLY STREAM FLOW RECORD

STREAM FLOW GAGING STATIONS IN CEBU

(in million cubic meters/month)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL ANNUAL
BALAMBAN RIVER AT LIKI (watershed area = 11 sqkm)													
1956	-	-	-	-	-	13.80	5.80	4.30	4.10	5.60	5.70	8.30	
1957	9.10	2.20	1.44	1.10	1.20	1.10	2.10	-	-	-	-		
BALAMBAN RIVER AT LUSARAN (watershed area = 49 sqkm)													
1957	-	-	-	-	-	-	-	2.80	1.20	1.50	1.90	.80	-
1958	.61	.40	.50	.40	1.90	1.60	2.00	1.40	.60	7.20	9.60	17.50	43.70
1959	5.50	4.60	5.10	5.20	5.60	4.40	14.20	7.10	3.40	3.90	1.70	2.70	63.40
1960	2.20	4.50	2.30	5.30	2.20	5.00	3.20	1.60	3.50	3.80	6.30	3.10	43.00
1961	2.20	1.80	1.60	1.20	2.80	5.60	3.60	1.60	3.20	9.20	5.80	2.90	41.50
1962	1.40	7.70	3.70	2.00	3.50	15.00	9.30	11.10	14.20	6.30	22.60	5.30	100.20
1963	5.40	2.90	2.80	1.50	1.30	1.00	1.20	8.70	6.60	4.90	5.00	4.00	45.30
1964	2.75	3.94	2.36	4.75	14.46	5.56	12.67	0.93	1.50	6.21	39.76	1.07	96.30
1965	6.90	1.40	6.90	2.10	2.10	10.70	4.60	3.70	5.80	7.70	5.80	8.60	66.30
1966	3.20	1.75	1.60	1.10	15.90	1.70	8.10	8.80	2.80	5.70	3.40	7.00	61.05
1967	23.03	9.17	11.84	5.94	5.06	4.15	4.90	1.34	1.14	1.90	5.26	1.93	75.69
1968	2.59	1.72	1.31	.83	.75	1.22	1.87	1.21	.96	-	-	2.97	-
1969	1.26	.63	.64	.47	.86	1.17	3.54	.29	5.88	5.22	2.26	2.92	25.14
KOTKOT RIVER AT MALUO (watershed area = 55 sqkm)													
1957	-	-	-	-	-	-	-	-	.20	2.05	.32	.16	-

BEST AVAILABLE DOCUMENT

TABLE VII-C-4 (continued)

TOTAL MONTHLY STREAM FLOW RECORD

STREAM FLOW GAGING STATIONS IN CEBU

(in million cubic meters/month)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL ANNUAL
KOTKOT RIVER AT MALUO (watershed area = 55 sqkm)													
1958	.07	.04	.03	.01	.27	.12	.24	.73	.45	2.05	2.45	2.20	8.66
1959	.49	.22	.13	.12	.33	.65	2.51	5.30	2.10	1.60	.75	1.50	15.70
1960	.30	.30	1.20	2.30	.30	2.30	1.50	.70	3.50	5.00	3.20	1.80	22.40
1961	1.30	1.10	.70	.60	2.50	2.50	6.90	4.60	5.20	9.80	10.60	9.50	55.30
PITOGO RIVER AT CONSOLACION (watershed area = 40 sqkm)													
1955	-	.60	.40	.40	.60	.60	.60	.60	.70	.90	1.30	1.20	-
1956	.80	.70	.70	.80	1.00	1.30	1.90	1.50	.70	.90	.80	1.30	12.40
1957	.10	.50	.50	.45	.40	.95	.40	.35	.20	.60	.20	.20	5.40
1958	.25	.20	.35	.65	.55	.20	.45	.30	.30	.35	.30	.25	4.20
1959	.20	.20	.20	.20	.20	.25	.35	3.50	2.20	1.40	.30	.45	9.40
1960	.40	.40	1.00	5.60	.30	5.50	1.70	1.10	1.80	5.20	8.70	.40	32.10
1961	.40	.30	.30	.30	.60	.30	.90	.90	1.20	2.30	.30	.40	8.20
1962	.40	1.60	.40	.30	.30	1.20	.90	9.60	14.40	6.30	1.10	.47	37.00
1963	1.10	.29	.29	.29	.30	.29	.61	19.40	.91	10.30	5.80	.27	39.80
1964	.29	1.50	1.10	.27	10.20	4.40	10.10	.46	3.30	4.10	6.30	.87	42.90
1965	.68	.94	2.80	.38	.46	2.40	.49	7.60	1.50	.70	.64	2.80	21.90
1966	.88	.69	.65	.33	1.20	.43	1.90	2.60	.40	.81	.85	.98	11.70
CARCAR RIVER AT CARCAR (watershed area = 31 sqkm)													
1955	-	1.20	1.10	1.20	1.40	1.20	1.00	.90	1.50	.90	5.00	2.60	-

BEST AVAILABLE DOCUMENT

TABLE VII-C-4 (continued)

TOTAL MONTHLY STREAM FLOW RECORD

STREAMFLOW GAGING STATIONS IN CEBU

(in million cubic meters/month)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL ANNUAL
MANTAYUPAN RIVER AT BARILI (watershed area =sqkm)													
1955	-	-	-	-	-	1.50	1.40	1.40	1.90	1.70	2.80	2.20	-
1956	1.70	1.40	1.50	1.50	1.80	1.70	1.90	1.60	1.30	1.40	1.40	2.20	19.40

BEST AVAILABLE DOCUMENT

TABLE VII-C-5

TOTAL MONTHLY STREAM FLOW

BALAMBAN RIVER AT LUSARAN GAGE

WATERSHED AREA 49.0 SQKM

(in million cubic meters/month)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL ANNUAL
1957	-	-	-	-	-	-	-	2.80	1.20	1.50	1.10	.80	-
1958	.61	.40	.50	.48	1.90	1.60	2.00	1.40	.60	7.20	9.60	17.50	43.71
1959	5.50	4.60	5.10	5.20	5.60	4.40	14.20	7.20	3.40	3.90	1.70	2.70	63.40
1960	2.20	4.50	2.30	5.30	2.20	5.00	3.20	1.60	3.50	3.80	6.30	3.10	43.00
1961	2.20	1.80	1.60	1.20	2.80	5.60	3.60	1.60	3.20	9.20	5.80	9.90	48.50
1962	1.40	7.70	3.70	2.00	3.50	15.00	8.30	11.10	14.20	6.30	22.60	5.30	102.20
1963	5.40	2.90	2.80	1.50	1.30	1.00	1.20	8.70	6.60	4.90	5.00	4.00	45.30
1964	1.00	2.70	1.10	1.00	1.30	3.80	6.20	1.60	1.10	1.60	39.14	1.06	61.60
1965	6.90	1.40	6.90	2.10	2.10	10.70	4.60	3.70	5.80	7.70	5.80	8.60	66.30
1966	3.20	1.75	1.60	1.10	15.90	1.70	8.10	8.80	2.80	5.70	3.40	7.00	61.05
1967	23.03	9.17	11.84	5.94	5.06	4.15	4.90	1.34	1.14	1.90	5.26	1.93	75.66
1968	2.59	1.72	1.31	.83	.75	1.22	1.87	1.21	.96	5.15	38.01	2.97	58.59
1969	1.26	.63	.64	.47	.86	1.17	3.54	2.92	5.88	5.22	2.26	2.92	25.14
1970	1.74	1.36	1.30	1.30	1.61	5.77	5.77	4.28	2.51	4.62	5.55	3.60	39.41
1971	2.26	1.77	1.36	2.29	4.56	7.66	3.26	2.48	6.17	7.44	3.29	2.14	44.68
1972	6.17	1.30	2.23	2.23	3.07	3.91	2.32	4.56	6.08	2.54	2.54	2.02	38.97
1973	1.89	2.02	1.33	1.24	1.43	3.60	5.61	4.03	8.12	2.73	15.00	2.79	49.77
1974	1.98	3.29	2.79	1.49	3.60	3.98	4.34	3.79	4.17	4.30	5.53	3.18	42.44
Mean	**4.08**	**2.88**	**2.85**	**2.09**	**3.39**	**4.72**	**4.94**	**3.92**	**4.30**	**4.76**	**9.88**	**4.53**	**53.51**

Note: Data 1957 to 1969 are from record. Data for 1970 to 1974 are developed by rainfall correlation.

BEST AVAILABLE DOCUMENT

TABLE VII-C-6

TOTAL MONTHLY STREAM FLOW

BALAMBAN RIVER AT LUSARAN DAMSITE

WATERSHED AREA 63.2 SQKM

(in million cubic meters/month)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL ANNUAL
1957	-	-	-	-	-	-	-	3.61	1.55	1.94	1.42	1.03	
1958	0.79	0.52	0.65	0.62	2.45	2.06	2.58	1.81	0.77	9.29	12.38	22.57	56.39
1959	7.09	5.93	6.58	6.71	7.22	5.68	18.32	9.29	4.39	5.03	2.19	3.48	81.91
1960	2.84	5.80	2.97	6.84	2.84	6.45	4.13	2.06	4.51	4.90	8.13	4.00	55.47
1961	2.84	2.32	2.06	1.55	3.61	7.22	4.64	2.06	4.13	11.87	7.48	12.77	62.55
1962	1.81	9.93	4.77	2.58	4.51	19.35	12.00	14.32	18.32	8.13	29.15	6.84	131.71
1963	6.97	3.74	3.61	1.94	1.68	1.29	1.55	11.22	8.51	6.32	6.45	5.16	58.44
1964	1.29	3.48	1.42	1.29	1.68	4.90	8.00	2.06	1.42	2.06	50.48	1.37	79.45
1965	8.90	1.81	8.90	2.71	2.71	13.80	5.93	4.77	7.48	9.93	7.48	11.09	85.51
1966	4.13	2.26	2.06	1.42	20.51	2.45	10.45	11.35	3.61	7.35	4.39	9.03	79.01
1967	29.70	11.83	15.27	7.66	6.53	5.35	6.32	1.73	1.47	2.45	6.78	2.49	97.58
1968	3.34	2.22	1.69	1.07	0.97	1.57	2.41	1.56	1.24	6.64	49.03	3.83	75.57
1969	1.63	0.81	0.83	0.61	1.11	1.51	4.57	3.76	7.58	6.73	2.92	3.77	35.83
1970	2.24	1.75	1.68	1.68	2.08	7.44	7.44	5.52	3.24	5.96	7.16	4.64	50.83
1971	2.92	2.28	1.75	2.95	5.88	9.88	4.21	3.20	7.96	9.60	4.24	2.76	57.63
1972	7.96	1.68	2.88	2.88	3.96	5.04	2.99	5.88	7.84	3.28	3.28	2.61	50.28
1973	2.44	2.61	1.72	1.60	1.84	4.64	7.24	5.20	10.47	3.52	19.35	3.60	64.23
1974	2.55	4.24	3.60	1.92	4.64	5.13	5.60	4.89	5.38	5.55	7.13	4.10	54.73
MEAN	5.26	3.72	3.67	2.70	4.37	6.10	6.38	5.05	5.55	6.14	12.75	5.84	67.53

NOTE: Developed from Stream Flow Record of Balamban River Gage of Lusaran. (Watershed 49 sqkm)

BEST AVAILABLE DOCUMENT

TABLE VII-C-7

TOTAL MONTHLY STREAM FLOW

MANANGA RIVER DAMSITE

WATERSHED AREA 67.5 SQKM

(in million cubic meters/month)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL ANNUAL
1957	-	-	-	-	-	-	-	3.86	1.65	2.07	1.52	1.10	-
1958	.84	.55	.69	0.66	2.62	2.20	2.76	1.93	.83	9.92	13.23	24.11	60.25
1959	7.58	6.34	7.03	7.16	7.71	6.96	19.56	9.92	4.68	5.37	2.34	3.72	87.47
1960	3.03	6.20	3.17	7.30	3.03	6.89	4.41	2.20	4.82	5.24	8.68	4.27	39.24
1961	3.03	2.48	2.20	1.65	3.86	7.71	4.96	2.20	4.41	12.67	7.99	13.64	66.20
1962	1.93	10.61	5.10	2.76	4.82	20.66	12.81	15.29	19.56	8.68	31.13	7.30	140.65
1963	7.44	4.00	3.86	2.07	1.79	1.38	1.65	11.99	9.09	6.75	6.89	5.51	62.42
1964	1.38	3.72	1.52	1.38	1.79	5.24	8.54	2.20	1.52	2.20	53.52	1.46	84.87
1965	9.51	1.03	9.51	2.89	2.89	14.74	6.34	5.10	7.99	10.61	7.99	11.85	91.35
1966	4.42	2.42	2.20	1.52	21.90	2.34	11.16	12.12	3.86	7.85	4.68	9.64	84.09
1967	31.73	12.63	16.31	8.18	6.97	5.72	6.75	1.85	1.50	2.62	7.23	2.66	104.17
1968	3.57	2.37	1.81	1.14	1.03	1.68	2.58	1.67	1.32	7.09	52.36	4.09	80.71
1969	1.74	.87	.88	.65	1.19	1.61	4.88	4.02	8.1	7.19	3.11	4.02	34.64
1970	2.40	1.87	1.79	1.79	2.22	7.95	7.95	5.90	3.46	6.36	7.65	4.96	54.30
1971	3.11	2.44	1.07	3.15	6.28	10.55	4.49	3.42	8.50	10.25	4.53	2.95	61.54
1972	8.50	1.79	3.07	3.07	4.23	5.37	3.20	6.28	8.38	3.50	3.50	2.78	53.67
1973	2.60	2.78	1.83	1.71	1.97	4.36	7.73	5.55	11.19	3.76	20.66	3.84	68.95
1974	2.73	4.53	3.84	2.05	4.96	5.48	5.98	5.22	5.74	5.92	7.62	4.38	58.45
MEAN	5.62	3.97	3.92	2.88	4.66	6.50	6.81	5.4	5.92	6.56	13.61	6.24	72.09

NOTE: Developed from Stream Flow Record of Balamban River Gage at Lusaran. (Watershed 49 sqkm)

BEST AVAILABLE DOCUMENT

TABLE VII-C-8

TOTAL MONTHLY STREAM FLOW
KOTKOT RIVER-MULAO GAGING STATION
WATERSHED AREA = 55.0 SQKM
(in million cubic meters/month)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total Annual
1940	1.50	0.95	0.55	2.05	1.50	3.75	2.85	4.05	2.64*	3.31*	3.47*	2.18*	28.80
1956	1.10	0.40	0.95	2.85	4.20	2.70	1.60	2.65	1.55	2.60	2.25	3.70	26.55
1957	1.30	2.40	0.95	1.00	0.40	2.6	3.25	2.35	0.20	2.04	0.33	0.16	16.98
1958	0.07	0.04	0.03	0.01	0.27	.12	0.24	0.73	0.45	2.05	2.45	2.20	8.66
1959	0.49	0.22	0.13	0.12	.33	.65	2.51	5.30	2.10	1.60	0.75	1.50	15.70
1960	0.30	0.30	1.20	2.30	0.30	2.30	1.50	0.70	3.50	5.00	3.20	1.80	22.40
1961	1.30	1.10	0.70	0.60	2.50	2.50	6.90	4.60	5.20	9.20	10.60	9.50	55.30
1962	0.95	3.15	1.30	0.50	2.20	3.25	3.15	5.75	2.50	2.60	2.80	0.90	29.05
1963	1.25	0.60	1.35	1.55	0.55	2.0	3.70	3.00	4.60	3.85	1.75	0.90	25.10
1964	1.25	2.40	0.80	1.70	3.55	3.65	4.1	1.20	3.15	4.35	5.95	1.25	33.35
1965	1.40	1.80	2.90	1.20	0.55	3.75	1.65	3.60	2.15	4.45	2.15	2.25	27.85
1966	1.40	0.75	0.35	0.65	4.95	2.0	5.75	3.70	2.65	3.85	4.40	3.30	33.75
1967	7.10	1.35	1.25	0.60	1.00	2.8	2.85	1.55	2.35	2.85	2.35	1.40	27.45
1968	1.10	0.5	1.20	0.50	0.30	2	2.20	0.60	0.60	0.30	5.65	1.15	16.10
1969	0.40	0.3	1.00	1.05	1.45	3.8	1.80	2.70	3.25	1.65	1.00	1.70	20.10
1970	1.15	0.8	0.6	0.45	1.20	4.35	4.05	3.50	1.70	4.10	3.95	2.20	28.05
1971	1.85	1.05	0.6	1.05	2.10	5.35	2.35	2.25	5.10	4.75	2.20	1.85	30.50
1972	4.70	0.45	1.55	1.35	2.20	3.3	1.10	4.20	3.80	1.85	2.00	1.40	27.90
1973	0.45	1.35	0.55	0.35	0.65	2.95	4.50	3.15	2.64	1.80	8.70	2.15	29.24
Mean	1.53	1.05	0.95	1.05	1.59	2.83	2.95	2.93	2.64	3.31	3.47	2.18	26.40

* Estimated

BEST AVAILABLE DOCUMENT

TABLE VII-C-9

TOTAL MONTHLY STREAM FLOW
PITOGO RIVER - CONSOLACION GAGING STATION
WATERSHED AREA = 40.0 SQKM
(in million cubic meters/month)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total Annual
1940	0.60	0.40	0.30	0.85	0.55	2.10	1.35	2.35					
1955	0.50	0.60	0.40	0.40	0.60	0.60	0.60	0.60	0.70	0.90	1.30	1.20	8.40
1956	0.80	0.70	0.70	0.80	1.00	1.30	1.90	1.50	0.70	0.90	0.80	1.30	12.40
1957	0.10	0.50	0.50	0.45	0.40	0.95	0.40	0.35	0.20	0.60	0.20	0.20	4.85
1958	0.25	0.22	0.35	0.65	0.55	0.20	0.45	0.30	0.30	0.35	0.30	0.25	4.15
1959	0.20	0.20	0.20	0.20	0.20	0.25	0.35	3.50	2.20	1.40	0.30	0.45	9.45
1960	0.42	0.40	1.00	5.60	0.30	5.50	1.70	1.10	1.80	5.20	8.70	0.40	32.10
1961	0.40	0.30	0.30	0.30	0.60	0.30	0.90	0.90	1.20	2.30	0.30	0.40	8.20
1962	0.40	1.60	0.40	0.30	0.30	1.20	0.90	9.60	14.40	6.30	1.10	0.47	36.97
1963	1.10	0.29	0.29	0.29	0.30	0.29	0.61	19.40	0.91	10.30	5.80	0.27	39.85
1964	0.29	1.50	1.10	0.27	10.20	4.40	10.10	0.46	3.30	4.10	6.30	0.87	42.89
1965	0.68	0.94	2.80	0.38	0.46	2.40	0.49	7.60	1.50	0.70	0.64	2.80	21.39
1966	0.88	0.69	0.65	0.33	1.20	0.43	1.90	2.60	0.40	0.81	0.85	0.98	11.72
1967	6.45	0.55	0.50	0.30	0.40	1.35	1.35	0.60	1.05	1.35	1.05	0.55	15.50
1968	0.45	0.30	0.45	0.30	0.25	0.85	0.95	0.30	0.30	0.25	4.30	0.45	9.15
1969	0.30	0.25	0.40	0.45	0.60	2.10	0.75	1.25	1.65	0.70	0.40	0.70	9.55
1970	0.45	0.35	0.30	0.30	0.50	2.70	2.35	1.85	0.70	2.40	2.30	0.95	15.15
1971	0.75	0.45	0.30	0.45	0.90	3.85	1.05	1.00	3.55	3.10	0.95	0.80	17.15
1972	3.65	0.30	0.60	0.55	0.95	1.65	0.45	2.55	2.15	0.80	0.85	0.55	14.45
1973	0.30	0.55	0.30	0.30	0.30	1.45	2.85	1.55	2.06*	0.75	9.54	0.95	20.90
1974	0.40	0.95											
Mean	0.89	0.57	0.59	0.67	1.03	1.69	1.57	2.97	2.06	2.27	2.42	0.77	17.50

* Estimated

BEST AVAILABLE DOCUMENT

TABLE VII-C-10

TOTAL MONTHLY STREAM FLOW
KOTKOT RIVER AT UPPER DAMSITE
WATERSHED AREA 38.5 SQKM
(in million cubic meters/month)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total Annual
1956	0.77	0.28	0.67	2.00	2.94	1.89	1.12	1.86	1.09	1.82	1.58	2.59	18.56
1957	0.91	1.68	0.67	0.70	0.28	1.82	2.28	1.65	0.14	1.43	0.23	0.11	11.90
1958	0.05	0.03	0.02	0.01	0.19	0.08	0.17	0.73	0.32	1.44	1.72	1.54	6.30
1959	0.34	0.15	0.09	0.08	0.23	0.46	1.76	3.71	2.10	1.12	0.53	1.05	11.62
1960	0.21	0.21	0.84	1.61	0.21	1.61	1.05	0.49	2.45	3.5	2.24	1.26	15.68
1961	0.91	0.77	0.49	0.42	1.75	1.75	4.83	3.22	3.64	6.86	7.42	6.65	38.71
1962	0.67	2.21	0.91	0.35	1.54	2.28	2.21	4.03	1.75	1.82	1.96	0.63	20.36
1963	0.88	0.42	0.95	1.09	0.39	1.40	2.59	2.10	3.22	2.70	1.23	0.63	17.60
1964	0.88	1.68	0.56	1.19	2.49	2.56	2.87	0.84	2.21	3.05	4.17	0.88	23.38
1965	0.98	1.26	2.03	0.84	0.39	2.63	1.16	2.52	1.51	3.12	1.51	1.58	19.53
1966	0.98	0.53	0.25	0.46	3.47	1.40	4.03	2.59	1.86	2.70	3.08	2.31	23.66
1967	4.97	0.95	0.88	0.42	0.70	1.96	2.00	1.09	1.65	2.00	1.65	0.98	19.25
1968	0.77	0.35	0.84	0.35	0.21	1.40	1.54	0.42	0.42	0.21	3.96	0.81	11.28
1969	0.28	0.21	0.70	0.74	1.02	2.66	1.26	1.89	2.28	1.16	0.70	1.19	14.09
1970	0.81	0.56	0.42	0.32	0.84	3.05	2.84	2.45	1.19	2.87	2.77	1.54	19.66
1971	1.30	0.74	0.42	0.74	1.47	3.75	1.65	1.58	3.57	3.33	1.54	1.30	21.39
1972	3.29	0.32	1.09	0.95	1.54	2.31	0.77	2.94	2.66	1.30	1.40	0.98	19.55
1973	0.32	0.95	0.39	0.25	0.46	2.07	3.15	2.21	1.89*	1.26	6.09	1.51	20.55
Mean	1.07	0.74	0.68	0.70	1.12	1.95	2.07	2.02	1.89	2.32	2.43	1.53	18.52

* Estimated

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TABLE VII-C-11

TOTAL MONTHLY STREAM FLOW
KOTKOT RIVER AT MIDDLE DAMSITE
WATERSHED AREA 60.3 SQKM
(in million cubic meters/month)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total Annual
1956	1.21	0.44	1.04	3.12	4.60	2.96	1.75	2.91	1.70	2.85	2.47	4.06	29.11
1957	1.43	2.63	1.04	1.10	0.44	2.85	3.56	2.58	0.22	2.24	0.36	0.18	18.63
1958	0.08	0.04	0.03	0.01	0.30	0.13	0.26	0.80	0.49	2.25	2.69	2.41	9.49
1959	0.54	0.24	0.14	0.13	0.36	0.71	2.75	5.81	2.30	1.75	0.82	1.64	17.19
1960	0.33	0.33	1.32	2.52	0.33	2.52	1.64	0.77	3.84	5.48	3.51	1.97	24.56
1961	1.43	1.21	0.77	0.66	2.74	2.74	7.56	5.04	5.70	10.74	11.62	10.42	60.63
1962	1.04	3.45	1.43	0.55	2.41	3.56	3.45	6.30	2.74	2.85	3.07	0.99	31.84
1963	1.37	0.66	1.48	1.70	0.60	2.19	4.06	3.29	5.04	4.22	1.92	0.99	27.52
1964	1.37	2.63	0.88	1.86	3.89	4.00	4.50	1.32	3.45	4.77	6.52	1.37	36.56
1965	1.53	1.97	3.18	1.32	0.60	4.11	1.81	3.95	2.36	4.88	2.36	2.47	30.54
1966	1.53	0.82	0.38	0.71	5.43	2.19	6.30	4.06	2.91	4.22	4.82	3.62	36.99
1967	7.78	1.48	1.37	0.66	1.10	3.07	3.12	1.70	2.58	3.12	2.58	1.53	30.09
1968	1.21	0.55	1.32	0.55	0.33	2.19	2.41	0.66	0.66	0.33	6.19	1.26	17.66
1969	0.44	0.33	1.10	1.15	1.59	4.17	1.97	2.96	3.56	1.81	1.10	1.86	22.04
1970	1.26	0.88	0.66	0.49	1.32	4.77	4.44	3.84	1.86	4.50	4.33	2.41	30.76
1971	2.03	1.15	0.66	1.15	2.30	5.87	2.58	2.47	5.59	5.21	2.41	2.03	33.47
1972	5.15	0.49	1.70	1.48	2.41	3.62	1.21	4.60	4.17	2.03	2.19	1.53	30.58
1973	0.49	1.48	0.60	0.38	0.71	3.23	4.93	3.45	2.89*	1.97	9.54	2.36	32.03
1974													
Mean	1.68	1.15	1.06	1.09	1.75	3.05	3.24	3.14	2.89	3.62	3.81	2.39	28.87

* Estimated

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TABLE VII-C-12

TOTAL MONTHLY STREAM FLOW
KOTKOT RIVER AT LOWER DAMSITE
WATERSHED AREA 67.15 SQKM
(in million cubic meters/month)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total Annual
1956	1.34	0.49	1.16	3.48	5.13	3.30	1.95	3.24	1.89	3.17	2.75	4.52	32.42
1957	1.59	2.93	1.16	1.22	0.49	3.17	3.97	2.87	0.24	2.49	0.40	0.20	20.73
1958	0.09	0.05	0.04	0.01	0.33	0.15	0.29	0.89	0.55	2.50	2.99	2.69	10.58
1959	0.60	0.27	0.16	0.15	0.40	0.79	3.06	6.47	2.56	1.95	0.92	1.83	19.16
1960	0.37	0.37	1.47	2.81	0.37	2.81	1.83	0.85	4.27	6.10	3.91	2.20	27.36
1961	1.59	1.34	0.85	0.73	3.05	3.05	8.42	5.62	6.35	11.96	12.94	11.60	67.50
1962	1.16	3.85	1.59	0.61	2.69	3.97	3.85	7.02	3.05	3.17	3.42	1.10	35.48
1963	1.53	0.73	1.65	1.89	0.67	2.44	4.52	3.66	5.62	4.70	2.14	1.10	30.65
1964	1.53	2.93	0.98	2.08	4.33	4.46	5.01	1.47	3.85	5.31	7.26	1.53	40.74
1965	1.71	2.20	3.54	1.47	0.67	4.58	2.01	4.40	2.62	5.43	2.62	2.75	34.00
1966	1.71	0.92	0.43	0.79	6.04	2.44	7.02	4.52	3.24	4.70	4.40	4.03	40.24
1967	8.67	1.65	1.53	0.73	1.22	3.42	3.48	1.89	2.87	3.48	2.87	1.71	33.52
1968	1.34	0.61	1.47	0.61	0.37	2.44	2.69	0.73	0.73	0.37	6.90	1.40	19.66
1969	0.49	0.37	1.22	1.28	1.77	4.64	2.20	3.30	3.97	2.01	1.22	3.08	24.55
1970	1.40	0.98	0.73	0.55	1.47	5.31	4.94	4.27	2.08	5.01	4.82	2.69	34.25
1971	2.22	1.28	0.73	1.28	2.56	6.53	2.89	2.75	6.23	5.80	2.69	2.26	37.22
1972	5.74	0.55	1.89	1.65	2.69	4.03	1.34	5.13	4.64	2.26	2.44	1.71	34.07
1973	0.55	1.65	0.67	0.43	0.79	3.60	5.49	3.85	3.22*	2.20	10.62	2.62	35.69
1974													
Mean	1.87	1.29	1.18	1.21	1.95	3.40	3.61	3.50	3.22	4.03	4.18	2.67	32.10

* Estimated

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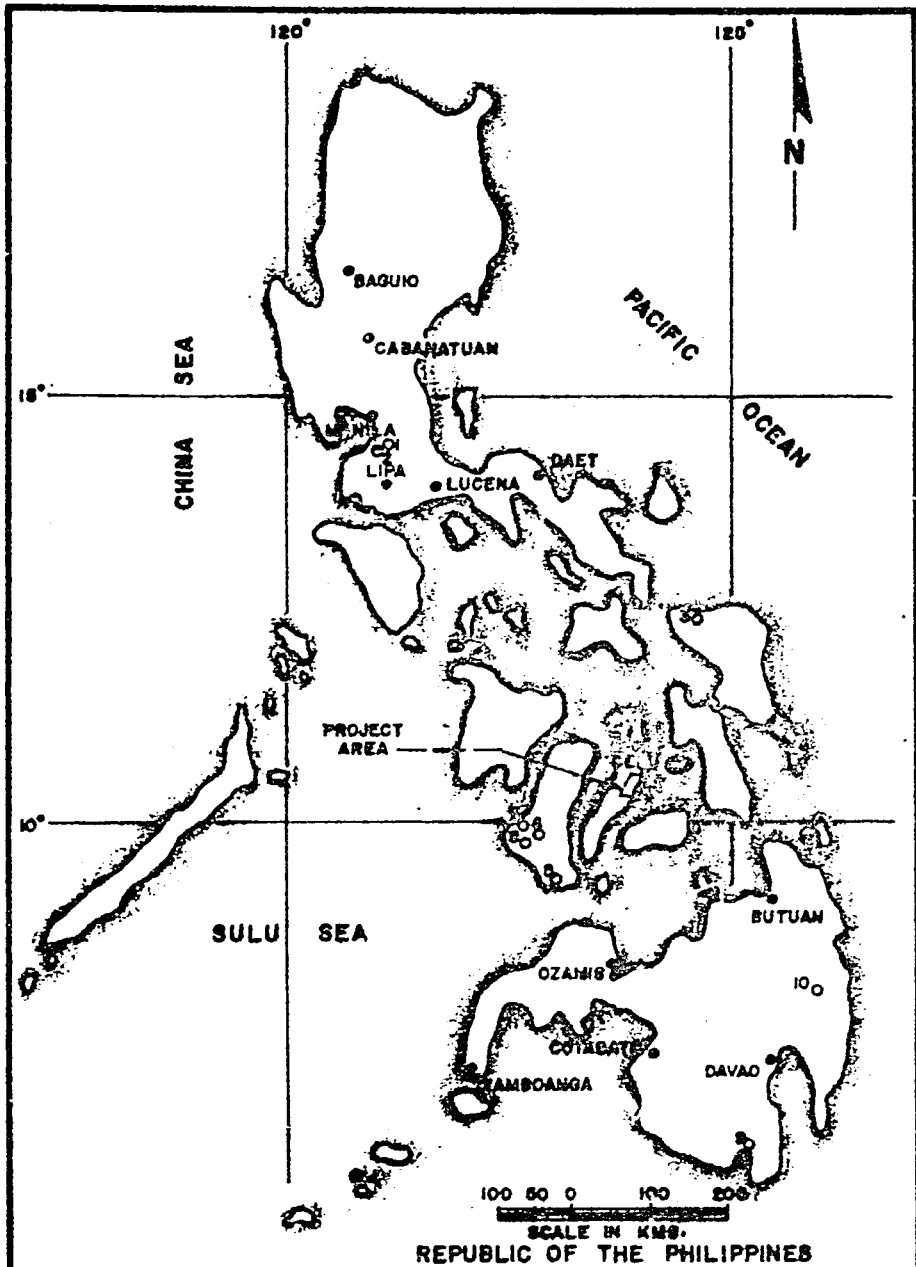
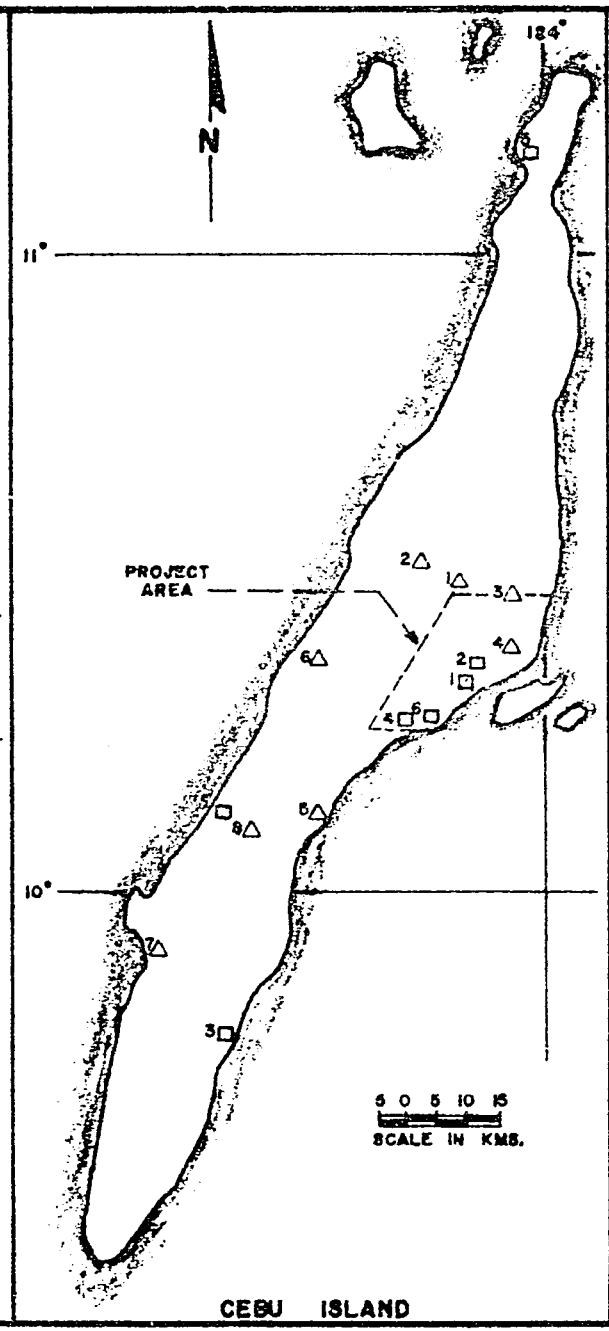


REPUBLIC OF THE PHILIPPINES

FEASIBILITY STUDY FOR WATER SUPPLY OF TEN PROVINCIAL AREAS CDM-LWUA



CEBU ISLAND

LEGEND:

CITIES ..... ●
STREAMFLOW STATION ..... △
RAINFALL STATION ..... □
EVAPORATION STATION .... ○

STREAMFLOW STATIONS

1. BALAMBAN RIVER, LUSARAN, CEBU
2. BALAMBAN RIVER, LIPA, CEBU
3. KOTKOT RIVER, MALAO, CEBU
4. PITOGO RIVER, CONSOLACION, CEBU
5. CARCAR RIVER, CARCAR, CEBU
6. SAPANGDACO RIVER, TOLEDO, CEBU
7. BASAT RIVER, BADIAN, CEBU
8. MANTAYUPAN RIVER, BARILI, CEBU

RAINFALL STATIONS

1. CEBU CITY
2. LAHUG, CEBU
3. MONTALONGAN, CEBU
4. MINGLANILLA, CEBU
5. MEDALLIN, CEBU
6. TALISAY, CEBU
7. BARILI, CEBU

EVAPORATION STATIONS

1. QUEZON CITY
2. MANILA
3. CATARMAN, SAMAR
4. QUINAPONDAN, SAMAR
5. SILLIMAN, NEGROS
6. TAGBAC, NEGROS
7. ORONG, NEGROS
8. DANILE, NEGROS
9. GEN. SANTOS, COTABATO
10. BUNAWAN, AGUSAN DEL NORTE

FIGURE VII-C-1
GENERAL LOCATION MAP CLIMATOLOGICAL GAGING STATION

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215

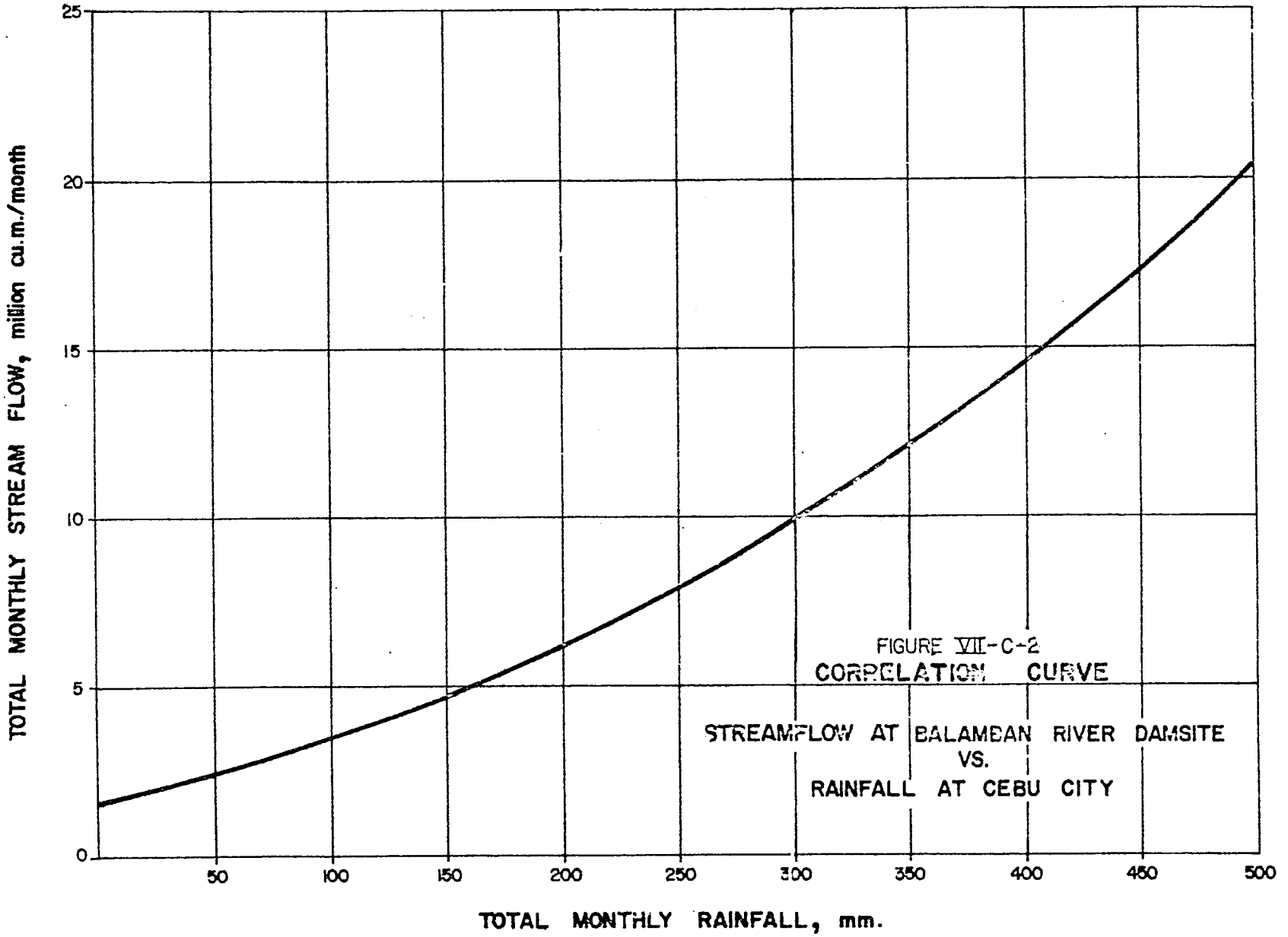

FIGURE VII-C-2
CORRELATION CURVE

STREAMFLOW AT BALAMBAN RIVER DAMSITE
VS.
RAINFALL AT CEBU CITY

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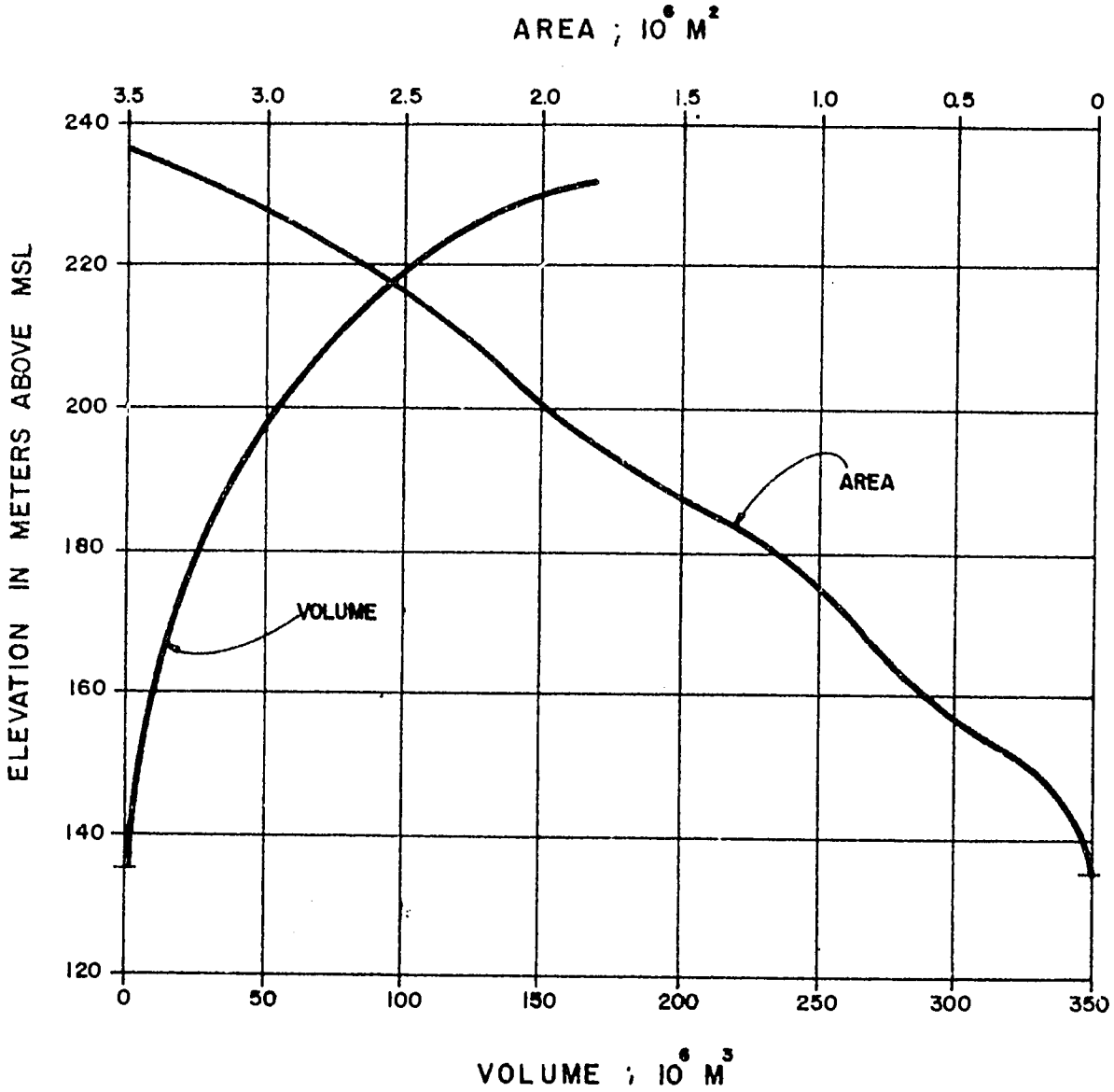

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FIGURE VII-C-3
AREA - CAPACITY CURVES
LUSARAN DAM SITE

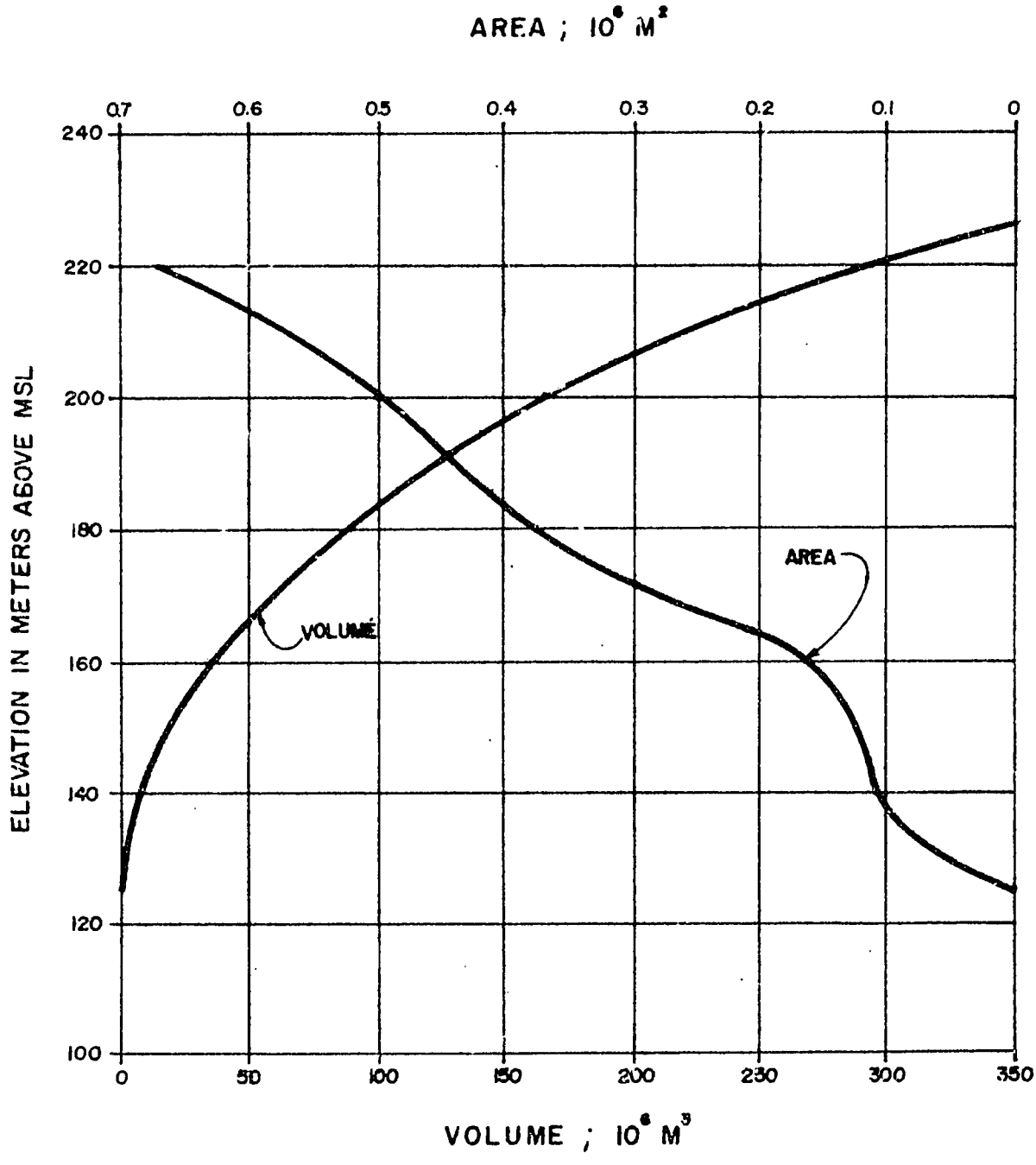

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FIGURE VII-C-4
AREA - CAPACITY CURVES
UPPER KOTKOT DAM SITE

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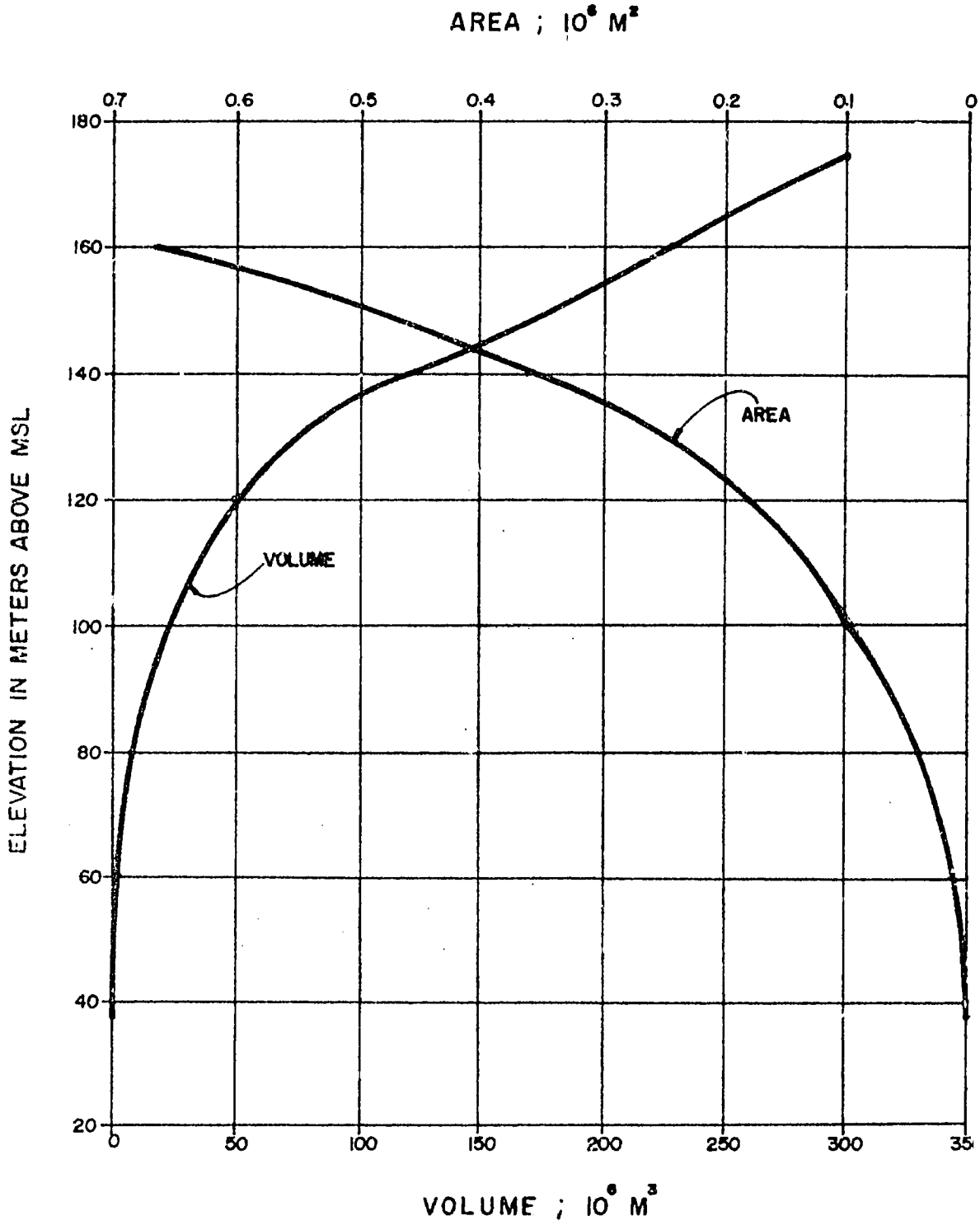

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FIGURE VII-C-5.
AREA - CAPACITY CURVES
MIDDLE KOTKOT DAM SITE

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219

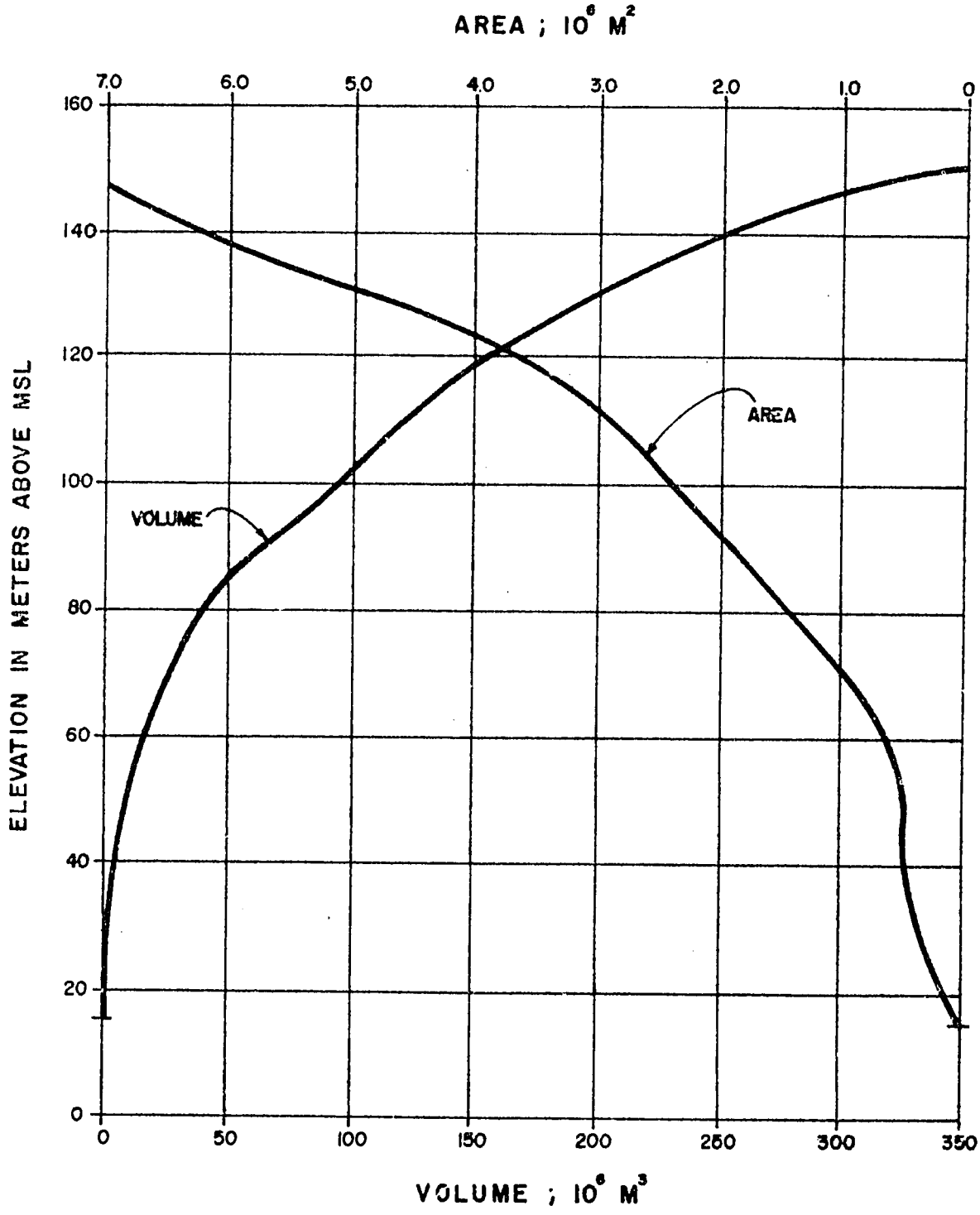

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FIGURE VII-C-6
AREA - CAPACITY CURVES
LOWER KOTKOT DAM SITE

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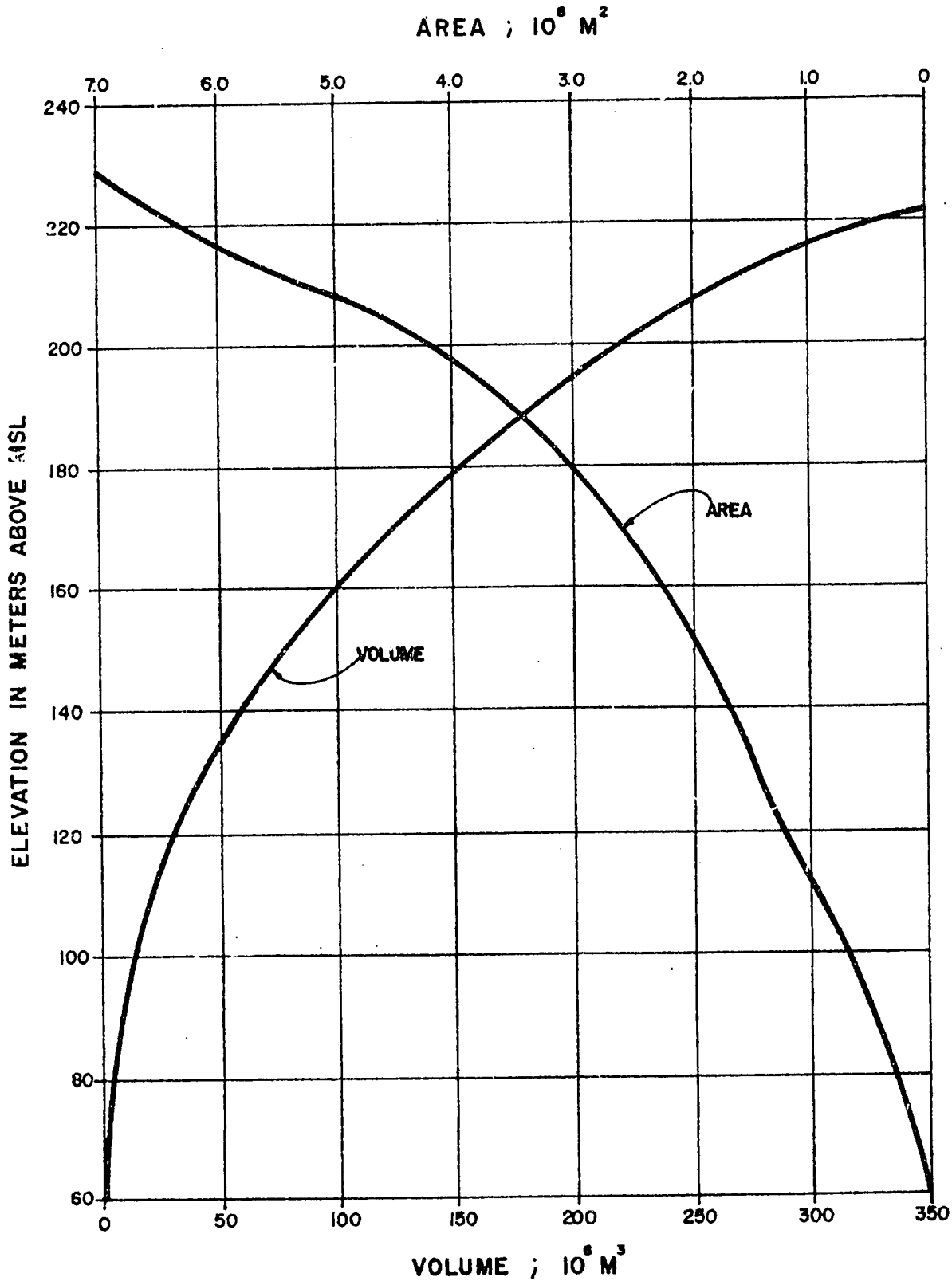

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FIGURE VII-C-7

AREA - CAPACITY CURVES

MANANGA DAM SITE

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