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COTABATO CITY WATER DISTRICT

PREPARED BY:

LOCAL WATER UTILITIES ADMIN
ENGINEERING DEPARTMENT
PLANNING DIVISION

WITH GUIDANCE FROM:

CAMP DRESSER & McKEE INT
PROJECT CONSU

APRIL
1978

CDM

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25 April 1978

Mr. Carlos C. Leaño, Jr.
General Manager
Local Water Utilities Administration
7th Floor, NIA Building
EDSA, Quezon City

Subject: Final Report - Feasibility Study for Water Supply - Cotabato City Water District

Dear Mr. Leaño:

In accordance with the contract between Local Water Utilities Administration (LWUA) and Camp Dresser & McKee International Inc. (CDM) dated 14 October 1974, and amended on 10 August 1976, we take pleasure in submitting this report.

This report is presented in two volumes: Volume I which contains the recommended plan and detailed analysis, and Volume II which contains the support information common to all urban areas covered in the contract.

Extensive improvements and additions to the present water supply system are needed to overcome current deficiencies and to meet future requirements. The recommended plan is the result of detailed alternative studies and extensive cost optimization work. While the cost of the recommended long-range water system facilities is substantial, we consider it within the people's ability-to-pay.

The feasibility studies were done primarily by the LWUA staff assigned to CDM for on-the-job training for the duration of the contract. After guiding the counterpart staff and reviewing this work, we are of the opinion that the planning group has now acquired the necessary technical skills to carry on feasibility studies on their own.

Principal Office:
One Center Plaza, Boston, Massachusetts 02108 USA

We wish to extend our thanks to the LWUA Board, all the members of the LWUA staff, the COT-WD staff and the officials of various agencies of the Government of the Philippines, who so generously assisted us during the course of our study.

Very truly yours,

CAMP DRESSER & McKEE INTERNATIONAL INC.

ANTONIO DE VERA
Planning Manager

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FOREWORD

This feasibility study presents the recommended plan for the upgrading and expansion of the water supply system of the Cotabato Water District (COT-WD). This study was made by the Local Water Utilities Administration (LWUA), with the technical assistance of Camp Dresser and McKee International Inc. This study is the result of many months of work in Cotabato City in Maguindanao Province, and is supported by extensive experience with other water districts in the Philippines during the First Ten Provincial Urban Areas Feasibility Studies.

This study was prepared in two volumes: Volume I, the main report, which contains the recommended plan and the methodology memoranda; and Volume II, which contains detailed background information relating to specific sections of Volume I. A complete understanding of the two volumes would require reading the previously published Water Supply Feasibility Studies Methodology Manual (Volumes I and II), a compilation of the handouts used in the six-month long training seminar conducted in 1975 by CDM during the First Ten-Area Feasibility Studies.

The recommended plan is a technically and economically feasible program for providing the COT-WD adequate water supply up to the year 2000. The plan should not be viewed as a rigid plan; every attempt was made to develop a plan compatible with the needs and desires of the water district and of the people. However, during the final engineering design of the recommended facilities, changes could still be made. Design changes would be based on more recent field data, changing priorities of the water district and more economical methods of providing the recommended facilities. Any changes considered in the final design should help to further reduce the expected financial impact of the project.

While the main objective of the Second Ten Provincial Urban Areas Feasibility Studies was the preparation of feasibility reports another important objective was the training of Filipino counterpart engineers in water supply project planning. The training program which included lectures and on-the-job training aimed to develop local planning capability for water supply projects. The Filipine engineers learned by actually doing the work, with the CDM consultants providing the necessary expertise and guidance.

The following have contributed significantly to the development of the water supply feasibility studies for COT-WD:

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The following project staff members have also contributed to the technical/non-technical work of the studies:

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The following consultants have provided the guidance during the studies:

James Arbuthnot, Chief Engineer
Eugene Rumph, Hydrogeologist
James de Young, Water Supply Engineer
Bruce Conklin, Systems Engineer

LIST OF ABBREVIATIONS

Organizations

ADB	Asian Development Bank
BAN-WD	Bangued Water District
BAY-WD	Baybay Water District
BIS-WD	Bislig Water District
CAL-WD	Calamba Water District
CDM	Camp Dresser & McKee International Inc.
COT-WD	Cotabato City Water District
DCCD	Design Consultation Construction and Development Engineering Corporation
FER-WD	San Fernando Water District
GAP-WD	Gapan Water District
IBRD	International Bank for Reconstruction and Development
LB-WD	Los Baños Water District
LWUA	Local Water Utilities Administration
MWSS	Metropolitan Waterworks and Sewerage System (formerly National Waterworks and Sewerage Authority or NWASA)
NEDA	National Economic Development Authority
NIA	National Irrigation Administration
NWRC	National Water Resources Council
OLO-WD	Olongapo City Water District
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
ROX-WD	Roxas City Water District
SIL-WD	Silay City Water District
URD-WD	Urdaneta Water District
USAID	United States Agency for International Development

Units

AC	asbestos cement
CCI	centrifugally cast iron
CI	cast iron
cm	centimeter
cum	cubic meter
cumd	cubic meter per day
cumd/ha	cubic meter per day per hectare
cum/hr/sqkm	cubic meter per hour per square kilometer
cumd/m	cubic meter per day per meter
cum/mo	cubic meter per month
cum/sqkm/yr	cubic meter per square kilometer per year
FEC	foreign exchange component
GI	galvanized iron
GS	galvanized steel

ha	hectare
HGL	hydraulic grade line
hr	hour
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
m/ha	meter per hectare
mg/l	milligram per liter
min	minute
mm	millimeter
mm/yr	millimeter per year
mo	month
m/sec	meter per second
MSL	mean sea level
%	percent
₱	Philippine peso
pH	logarithm (base 10) of the reciprocal of the hydrogen ion concentration in water, moles per liter
PVC	polyvinyl chloride
RU	revenue unit
sqkm	square kilometer
sqmd	square meter per day
$	United States dollar
yr	year

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CHAPTER I SUMMARY AND RECOMMENDATIONS

A. SUMMARY OF STUDIES

Description

The Cotabato City Water District (COT-WD) was formed on March 9, 1976 by virtue of Resolution No. 35 passed by the Sangguniang Bayan of Cotabato City. The COT-WD includes all the barrios of Cotabato City. Following its formation, the COT-WD acquired the ownership and management of the entire water system from the city government.

The City of Cotabato is situated in the northern coast portion of the Maguindanao Province on the island of Mindanao. The city consists of a poblacion and 4 barrios (Rosary Heights, Bagua, Tamontaca and Kalanganan), with a total land area of 17,600 hectares.

Cotabato City is generally low, ranging from 2 to 10 meters above mean sea level (MSL). Hills range in elevation from 50 to 100 meters above MSL.

The population of the city in 1970 was 61,184, 83 percent of which were classified as urban and 17 percent, rural.

Existing Water System

The water system of COT-WD was originally constructed in 1939 and had its major reinforcement in 1955. The sources of water from COT-WD were Dimapatoy River and 4 deep wells drilled within the city. Water from Dimapatoy River passes through the settling basin from which water flows by gravity to the ground reservoir atop Colina Hill.

A 9.5 km, 250-mm transmission line carries the water from the settling basin to the reservoir.

The storage facilities for COT-WD consist of one 750-cum concrete ground storage tank located on Colina Hill at the center of the Poblacion. The tank is not used at present.

The distribution system, first constructed in 1939, consists mostly of 100-mm lines. It was expanded in 1955 and 1972. The distribution pipes have a total length of 27 km.

Projections

The present service area of COT-WD covers only the poblacion, Barrios Rosary Heights, Tamontaca and Bagua. The service area through the year 2000 will extend to Barrio Kalanganan.

The population in the COT-WD in 1975 was 50,300 and is projected to increase to 135,650 by 2000, at an average growth rate of 4.05 percent per year. During this same period, the population served by the COT-WD is expected to increase from 13,936 to 105,520.

The per capita consumption is expected to be 198 lpcd in 1980 with a total daily average usage of 4,370 cum. The per capita usage is projected to decrease to 193 lpcd in 1990 due to improved water accountability and then increase to 199 lpcd in 2000. The average daily water usage is estimated to be 11,870 cumd in 1990 and 21,600 cumd in 2000.

Water Resources

Three potential sources of water, besides Dimapatoy River, were identified for COT-WD. Two sources are aquifers that would require wells to obtain water (deep wells beneath COT-WD and induced infiltration wells along Simuay River) and the third source is Tamuel Spring.

Deep wells in the alluvial plains of Cotabato are not suitable as a source of water supply because of excessive salinity.

Induced infiltration wells drilled along the Simuay River are the only means of tapping the Cotabato groundwater suitable for water supply. It is expected that the aquifer would provide adequate quantity of water to wells and that the aquifer has adequate recharge from the Simuay River. Such wells will produce good quality water and will require only chlorination for treatment.

Tamuel Spring emerges from a limestone formation at the foot of the Linangan Mountains. From geologic studies of the area, the spring appears to be a result of solution feed channels in a large limestone formation. The formation would require massive amounts of recharge to maintain the spring flow; the dry and wet season fluctuations in flow would be significant. There is apparently sufficient flow at the present time to supply the 1988 water requirements of COT-WD; however, careful monitoring of the spring discharge will be required to determine more accurately the minimum flow that may be expected.

Alternative Studies

Studies on alternative sources of water supply for COT-WD indicate that the development of Tamuel Spring supplemented with water from Simuay River and supply from groundwater alone were found not cost effective for COT-WD.

The requirements for the distribution system were analyzed with the aid of a computer. The resulting distribution system is described in detail in Chapter IX. Based on the analysis of the pressure requirements of the system, a single pressure zone area should be provided for COT-WD.

B. RECOMMENDATIONS

General

A water supply system utilizing first Tanuel Spring and later induced infiltration wells near the Simuay River as the sources of water through the year 2000 is recommended for COT-WD. The spring site will be developed and new transmission, distribution and administrative facilities will be constructed during the immediate improvement program and a long-term construction program divided into four phases. The main features of the recommended long-term project for COT-WD are summarized in Table I-1 and shown in Figure IX-1 (appended).

Source

Tanuel Spring will supply maximum-day demands of 12,700 cumd to COT-WD in the year 1988; the remaining water requirement to the year 2000 will be obtained from Simuay River induced infiltration wells.

During the immediate improvement program, Tanuel Spring will be developed and the existing Dimapatoy River source facilities will serve as stand-by unit. During Phase I-A the Dimapatoy River facilities will be abandoned and the 4 existing wells will serve as stand-by units. The city wells will be abandoned following 1990.

In 1988, when Tanuel Spring is fully utilized, induced infiltration wells along the Simuay River will be developed to supply the water requirement through the year 2000.

The COT-WD should apply with the National Water Resources Council for water rights on Tanuel Spring and Simuay River.

Transmission/Distribution Facilities

A new 200-mm transmission line from the Tanuel Spring to the junction at Tamontaca River will be constructed during the immediate improvement program. A new 350-mm transmission main will be constructed parallel to the 200-mm line during Phase I-A. In Phase I-B during which Simuay River induced infiltration wells will be developed, a 250-mm transmission line will be constructed from the first Simuay River induced infiltration well to the Maguindanao River Bridge. Another 250-mm pipeline will be constructed in Phase II-A and a third one in Phase II-B.

TABLE I-1

SUMMARY OF PROPOSED WATER SUPPLY IMPROVEMENTS
COTABATO CITY WATER DISTRICT

	Immediate Improvement Program	Construction Phase I-A	Construction Phase I-B	Construction Phase II-A	Construction Phase II-B
Construction Period	1978-1979	1980-1985	1986-1990	1991-1995	1996-2000
Total Project Cost (₱ x 1000)	6,345.5	21,831.1	16,536.6	14,498.7	15,854.2
Foreign Exchange Component (₱ x 1000)1/	3,198	11,686.2	7,391.7	7,462.2	8,310.9
Source Development	Obtain legal water rights, construct new intake and chlorination facilities and pumping station	Expand pumping station	Construct one well equipped with disinfection facilities, river crossing and access road	Construct two wells equipped with disinfection facilities	Construct two wells equipped with disinfection facilities
Transmission	Leakage survey and repair (see Table IX-2). New pipelines 200 mm-2.0 km	New pipeline 350 mm-6.57 km	New pipelines 250 mm-5.83 km	New pipeline 250 mm-6.83 km 200 mm- .50 km	New pipelines 250 mm-7.83 km 200 mm-0.50 km
Distribution	Leakage survey and repair (see Table IX-1) 250 mm- .39 km 150 mm-1.05 km 100 mm- .805 km Valves	See Table IX-3 350 mm-5.34 km 200 mm-2.02 km 150 mm-4.50 km 100 mm-4.50 km Valves	See Table IX-5 250 mm- .30 km 200 mm-1.81 km 150 mm-8.49 km Valves	See Table IX-7 250 mm-1.97 km 200 mm- .55 km 150 mm-4.58 km Valves	See Table IX-9 250 mm- .81 km 150 mm-5.26 km
Storage	-	New 675 cum tank	New 675 cum tank	New 675 cum tank	New 675 cum tank
Internal Network	Leakage survey and repair	202 hectares	159 hectares	203 hectares	172 hectares

1/All foreign exchange figures used in this report were synthesized from data based on actual costs in U.S. dollars. To be consistent with previous studies, these foreign exchange costs were converted to RP pesos at a rate of U.S. $1.0 = RP ₱7.00. To obtain correct current foreign exchange costs, multiply those presented in this report by the ratio of the current exchange rate and 7.0. The actual local component of costs (in pesos) is as presented herein.

TABLE I-1 (Continued)

	Immediate Improvement Program	Construction Phase I-A	Construction Phase I-B	Construction Phase II-A	Construction Phase II-B
Service Connections	Add 1,018 Convert 1,655 Repair 348	Add 2,164 Repair 1,394	Add 3,860	Add 3,821	Add 5,842
Hydrants	Repair/replace existing hydrants	417 hectares	239 hectares	253 hectares	225 hectares
Miscellaneous	Administrative building and equipment, plumbing and meter repair facilities, vehicles	Plumbing Shop and laboratory facilities	-	-	-

The distribution system will be reinforced and expanded by installing 29.3 km of pipelines of sizes ranging from 100 mm to 350 mm, by 1990. An additional 13 km of 150 to 250-mm pipelines will be installed by the year 2000 to extend water service to more consumers.

By 2000, approximately 736 hectares within COT-WD will receive internal network pipelines and 16,345 new service connections will be added. All existing and new service connections in the district will be metered.

Storage

The existing 750-cum distribution storage tank will be adequate for COT-WD during the immediate improvement program only. An additional 2,700 cum of storage will be required before the year 2000. Four 675-cum storage tanks will be constructed, one each in Phases I-A, I-B II-A and II-B.

Capital Cost Summary

The capital costs for each phase of construction, including the immediate improvement program, are summarized in Table I-2. A more detailed breakdown of costs for the immediate improvement program and Phase I-A is given in Table I-3 (July 1978 price levels).

Annual Operation and Maintenance Costs

Annual operation and maintenance costs are expenses incurred for personnel, power, chemicals, maintenance and miscellaneous expenses. Estimates of the annual operation and maintenance costs of (based on July 1978 price levels) are given in Table I-4.

Financial Feasibility

The financial feasibility analysis made for the study establishes a detailed set of guidelines that the water district management may use in making crucial decisions during the next few years. A plan has been developed to indicate the manner and time funds will be used to operate and maintain the system; implement the program; establish reserve funds; and retire the indebtedness. Water rates have been developed on the basis that the system will be financially self-supporting. These rates appear to be within the ability-to-pay of the average COT-WD householder.

TABLE I-2

CAPITAL COST SUMMARY

Construction Phase	Construction Period	Construction Cost (₱)	Project Cost (₱) Local	Foreign	Total
Immediate Improvement Program	1978-79	4,915,800	3,147,500	3,198,000	6,345,500
I-A	1980-85	17,325,400	10,144,900	11,686,200	21,831,100
I-B	1986-90	12,704,400	9,144,900	7,391,700	16,536,600
II-A	1991-95	11,744,000	7,036,500	7,462,200	14,498,700
II-B	1996-2000	12,957,100	7,543,300	8,310,900	15,854,200
Total		59,646,700	37,017,100	38,049,000	75,066,100

TABLE I-3

COST SUMMARY OF IMMEDIATE IMPROVEMENT PROGRAM AND CONSTRUCTION STAGE I PHASE A (₱ x 1000)

Item	Local	Foreign*	Total
Immediate Improvement Program			
Source Development	218,100	216,900	435,000
Transmission Facilities and Distribution Facilities	1,143,600	1,208,800	2,352,400
Service Connections	526,600	914,600	1,441,200
Administrative and Miscellaneous			
Administrative Building & Equipment	400,600	55,800	456,400
Plumbing and Meter Repair Facilities	4,500	93,300	97,800
Vehicles	60,000	60,000	120,000
Miscellaneous	5,000	8,000	13,000
Total Construction Cost	2,358,400	2,557,400	4,915,800

*US$1.00 = ₱7.00

TABLE I-3 (Continued)

Item	Local	Foreign	Total
Contingencies	324,200	334,500	658,700
Engineering	164,800	306,100	470,900
Land Costs	300,000	-	300,020
Total Project Cost	3,147,500	3,198,000	6,345,500
Stage I Phase A Construction			
Source Facilities	453,300	364,300	817,600
Pipelines and Valves	4,128,000	5,666,500	9,794,500
Storage Facilities	404,800	101,200	506,000
Internal Network	1,218,400	876,800	2,095,200
Fire Hydrants	376,700	520,800	897,500
Plumbing Shop and Laboratory Facilities	430,200	189,000	619,200
Service Connections	1,126,400	1,469,000	2,595,400
Total Construction Cost	8,137,800	9,187,600	17,325,400
Contingencies	1,164,300	1,304,700	2,469,000
Engineering	642,800	1,193,900	1,836,700
Land Costs	200,000	-	200,000
Total Project Cost	10,144,900	11,686,200	21,831,100

TABLE I-4

ANNUAL OPERATION AND MAINTENANCE COSTS

Item	1976	1980	1990	2000
Administration and Personnel	130,740	267,540	345,020	580,320
Power and Fuel	420,310	182,170	455,430	880,620
Chemicals	-	36,900	96,650	167,680
Maintenance	6,330	46,420	260,580	485,200
Miscellaneous	25,930	37,960	98,470	255,400
Total	583,310	570,990	1,256,150	2,369,220

	Rate/HU
1979-1980	₱0.75
1981-1983	1.20
1984-1986	1.50
1987-1989	1.70
1990-1992	2.00
1993-1996	2.10
1997-2000	2.20

It is recommended that the implementation of these rates follow a socialized pricing policy to make the financial burden on the consumers proportionate to their ability-to-pay. A sample socialized rate structure for 1978-1980 that would generate sufficient revenue is as follows:

Usage (per month)	Cost (per cum)
first 16 cum	₱0.85
from 17 to 24 cum	1.85
greater than 24 cum	2.45

Borrowing requirements will include ₱7.602 million from 1978 to 1981 for the immediate improvement program; ₱29.143 million from 1980 to 1985 for Phase I-A improvements; and ₱29.026 million from 1985 to 1990 for Phase I-B improvements.

Economic Feasibility

The recommended improvements to the COT-WD water supply system will bring about numerous economic benefits to the study area. Economic feasibility studies show that the benefits will exceed the costs associated with the development and operation of the water system.

Two approaches were adopted to determine economic feasibility: the benefit-cost ratio and internal economic rate of return (IERR). In both approaches, four benefits valued at 1978 prices were included and discounted at 12 percent. The benefits considered are increase in land values, health, reduction in fire damage and beneficial value of water. Analysis shows a benefit-cost ratio of 1.8 : 1 and an IERR of 56.1 percent.

CHAPTER II INTRODUCTION

A. FIRST TEN PROVINCIAL URBAN AREAS

The study contract signed by the Local Water Utilities Administration[1] (LWUA) and Camp Dresser & McKee International Inc. (CDM) on 14 October 1974 provided for the feasibility studies for the First Ten Provincial Urban Areas[2] (see Figure II-1). The feasibility studies are part of LWUA's effort to develop basic water supply plans for provincial urban areas of the Philippines.

During the first 10-area project, training seminars for LWUA engineers were conducted by the CDM staff. "The Methodology Manual for Water Supply Feasibility Studies" was also developed and printed. In addition to the 10 areas, prefeasibility studies were made for 131 cities/municipalities[3]. As of August 1976, the feasibility studies were completed and submitted to LWUA.

The studies for five of the first 10 areas -- Cebu, Zamboanga, Dagt, Ozamis and Butuan -- have been appraised by the Asian Development Bank (ADB). On the basis of the interim reports, the ADB extended a $16.8 million loan to LWUA in December 1975 to provide design engineering services to these 5 areas and to implement Phase I-1 of the recommended long-term construction program (except Cebu whose share of the loan covered only engineering services). In August 1976, the United States Agency for International Development (USAID) signed a $10 million loan with LWUA to provide engineering services and funds for the implementation of the interim improvements of selected waterworks covered by the prefeasibility studies. In April 1977, the International Bank for Reconstruction and Development (IBRD) allocated $18.8 million towards the final design and initial phase implementation of the remaining five of the first 10 areas, namely: Lipa, Lucena, Tarlac, Cabanatuan, and San Fernando (La Union).

1/ A background on LWUA is given in Volume II, Appendix D.

2/ Refer to Appendix B for summary of first 10-area feasibility studies.

3/ Refer to Appendix C for summary of prefeasibility studies on 131 cities/municipalities.

B. SECOND TEN PROVINCIAL URBAN AREAS

On 10 August 1976, LWUA and CDM signed an amendment to the original study contract, extending the feasibility studies to include the Second Ten Provincial Urban Areas.[4] These are Urdaneta, Gapan, Calamba, Bislig, Silay City, Benguet, Baybay, Roxas City, Cotabato City, San Fernando (Pampanga), Olongapo City and Los Baños (see Figure II-1). This report includes the technical, financial and economic studies for the improvement of the water supply system in Cotabato City.

The dollar component of the second 10-area feasibility studies has been financed from proceeds of a loan to the Government of the Republic of the Philippines from the United States of America through the USAID, Loan No. 492-T04001 dated 9 September 1976. The peso component of the studies, approximately 41 percent, has been funded by the Government of the Philippines.

The study contract for the second 10 areas includes the following tasks:[5]

1. Training of counterpart LWUA engineers through on-the-job assignments on various aspects of water supply feasibility studies;

2. Preparing water supply feasibility studies for 5 provincial urban areas, using the expatriate and local consultant personnel for conducting such studies;

3. Preparing water supply feasibility studies for additional 5 urban areas, with the LWUA engineers taking a dominant role in the conduct of such studies.

The studies began on 1 September 1976 for a period of 18 months. The project staff was composed of 6 US engineers and 26 Filipino personnel. The personnel of the respective water districts also assisted during the course of the studies.

C. HISTORICAL BACKGROUND OF COTABATO CITY WATER DISTRICT

The water supply system of Cotabato City was constructed in 1939, operated and managed by the provincial government of Cotabato. In 1954, the water utility was turned over to the National Waterworks and Sewerage Authority (currently the Metropolitan Waterworks and Sewerage System). In September 1973, NWASA transferred the ownership and management of the system to the city government of Cotabato City.

4/ Although the inclusion of 10 areas is stipulated in the contract, feasibility studies for 12 areas have actually been made.

5/ Refer to Appendix A, Volume II for complete Terms of Reference.

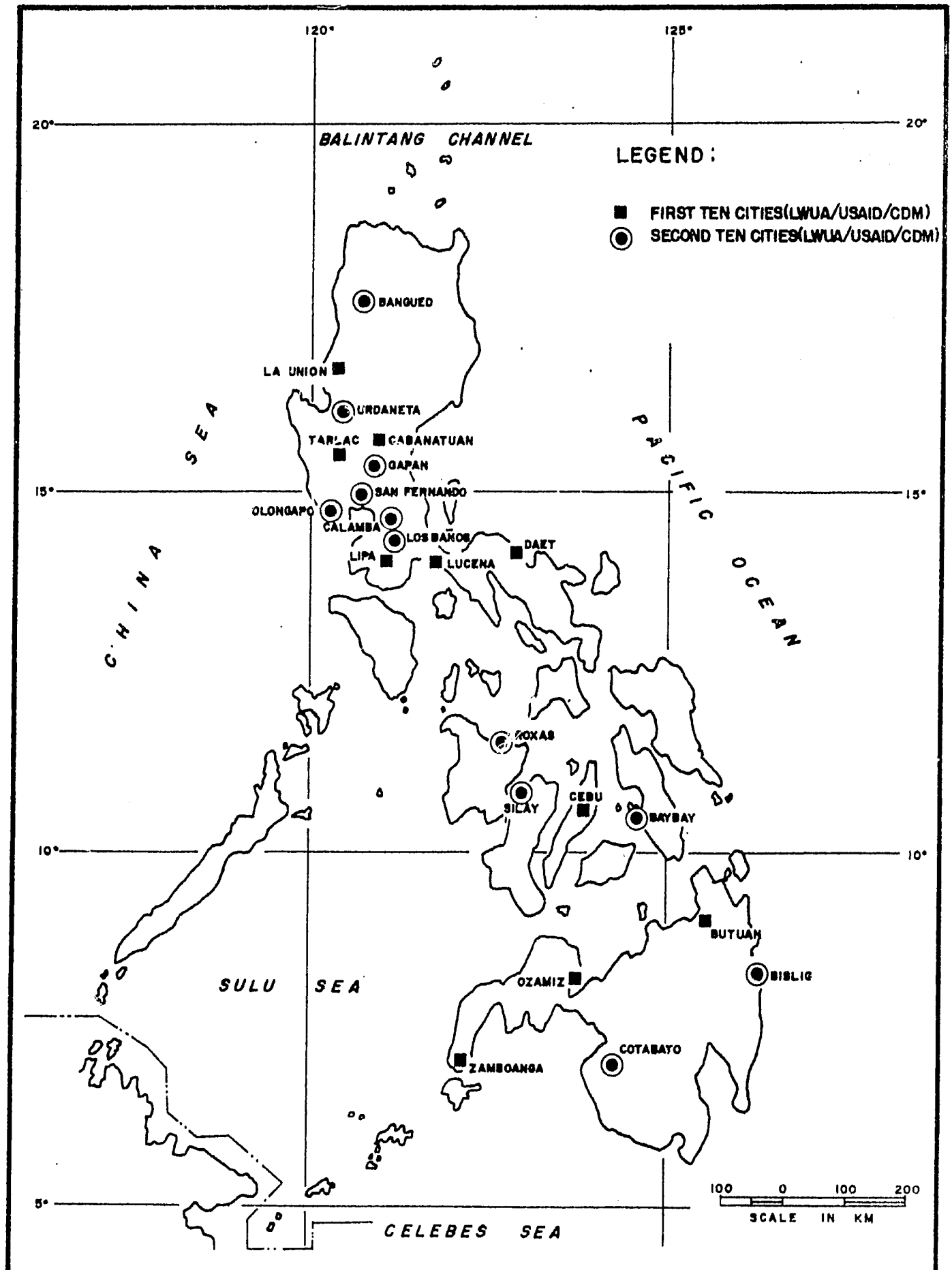

FIGURE II-1
LOCATION MAP
REPUBLIC OF THE PHILIPPINES

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

Realizing the benefits that would result from forming a water district, the city government passed Resolution No. 35 on 9 March 1976 creating the COT-WD to include the entire Cotabato City. Ownership and management of the water system were thereafter transferred to the COT-WD in accordance with Presidential Decree (PD) No. 198 (The Provincial Water Utilities Act of 1973).

The formation of the COT-WD was prompted by the need for an adequate water supply and an upgraded water system. Limited funding prevented improvement and expansion of the system. Moreover, the local officials recognized the potential role of the water district in providing sufficient, safe and potable water supply.

The COT-WD was thus formed for the purposes of acquiring, installing, improving, maintaining and operating the water supply system, as well as the wastewater collection, treatment and disposal facilities. To perform these functions, the COT-WD can obtain financial and technical assistance from LWUA. PD No. 198 provides that the water district shall operate eventually on a financially self-sufficient basis.

The COT-WD is a quasi-public corporation and is politically independent from the local government. As constituted, the water district is subject to the provisions of PD No. 198 and the rules and regulations of LWUA. The COT-WD can promulgate its own operating laws through its 5-member board of directors who are appointed by the city mayor. The district can only be dissolved through the act of this board.

On 5 November 1976, LWUA awarded the Conditional Certificate of Conformance to the COT-WD after it had complied with the minimum requirements of LWUA's certification program. This certificate entitles the COT-WD to rights and privileges authorized under PD No. 198.

CHAPTER III DESCRIPTION OF THE WATER DISTRICT[1]

A. PHYSICAL DESCRIPTION

Location

Cotabato City is located in the northern coast of the province of Maguindanao[2] on the island of Mindanao. With a total land area of 17,600 hectares, the city is divided into the poblacion[3] and 4 barrios[4].

The present service area[5] (367 hectares) of the COT-WD is situated in the central part of Cotabato City and covers the more densely populated sections of the poblacion, and the barrios of Rosario Heights, Bagua and Tamontaca. By the year 2000, the service area will also include Barrio Kalanganan. (See Figures III-1 and VI-1.)

Physical Features

Cotabato City is generally flat with elevations ranging from 2 to 10 meters above mean sea level (MSL). Situated at the center of the poblacion is the Colina Hill which is 60 meters above MSL.

The city is practically surrounded by water. It is bounded by two large rivers, Rio Grande de Mindanao on the northeast and Tamontaca River on the southwest, and Moro Gulf on the west. The rivers flow westward and empty into the Moro Gulf. Several creeks draining the city discharge into these rivers.

There are three types of soil in Cotabato City - Faraon clay, Tamontaca clay and hydrosol. Faraon clay, which is unsuitable for

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[1] The COT-WD covers all lands within the geographic boundaries of Cotabato City.

[2] In 1973, Cotabato Province was divided into three provinces, namely: North Cotabato, Maguindanao and Sultan Kudarat. The former Cotabato Province, located in the southern part of Mindanao was the largest province in the Philippines. Its boundaries were Davao Province on the east; Celebes Sea on the south and west; and Bukidnon and Lanao del Sur on the north.

[3] city proper

[4] A barrio is a political division of a city or municipality.

[5] The term "service area" refers to sections of the water distict which are currently served or intended to be served by the water system.

agriculture, is found in the vicinity of the Colina Hill. The greater part of the city is overlain by the productive Tamontaca clay. The waterlogged hydrosol covers the coastal parts of the city.

Cotabato City is classified under the Type 4 climate, with even rainfall throughout the year (see Figure III-2). The average annual rainfall for the period 1960-1969 was 2,200 mm. During the same period, average temperature ranged from 26.9°C in January to 28.1°C in May, with the annual average of 27.4°C. The climatological data are listed in Table III-1.

TABLE III-1

CLIMATOLOGICAL DATA[6]
(1960-69)

	Average Monthly Rainfall (mm)	Average Monthly Temperature (°C)
January	85.9	26.9
February	114.5	27.4
March	116.3	27.7
April	132.7	28.0
May	270.9	28.1
June	150.6	27.6
July	250.4	26.9
August	354.4	27.0
September	233.7	27.0
October	219.5	27.2
November	181.2	27.4
December	90.8	27.2
	2,200.9	
Average		27.4

B. POPULATION

The population of Cotabato City in 1970 was 61,184, an increase of 63 percent over the 1960 total of 37,499. The city had a total of 9,660 households, or an average of 6.3 members per household. The general characteristics of the population are listed in Table III-2.

C. LIVING CONDITIONS

Physical indicators showing the standard of living in Cotabato City are listed in Table III-3. These indicators include types of dwelling units, household facilities and utilities.

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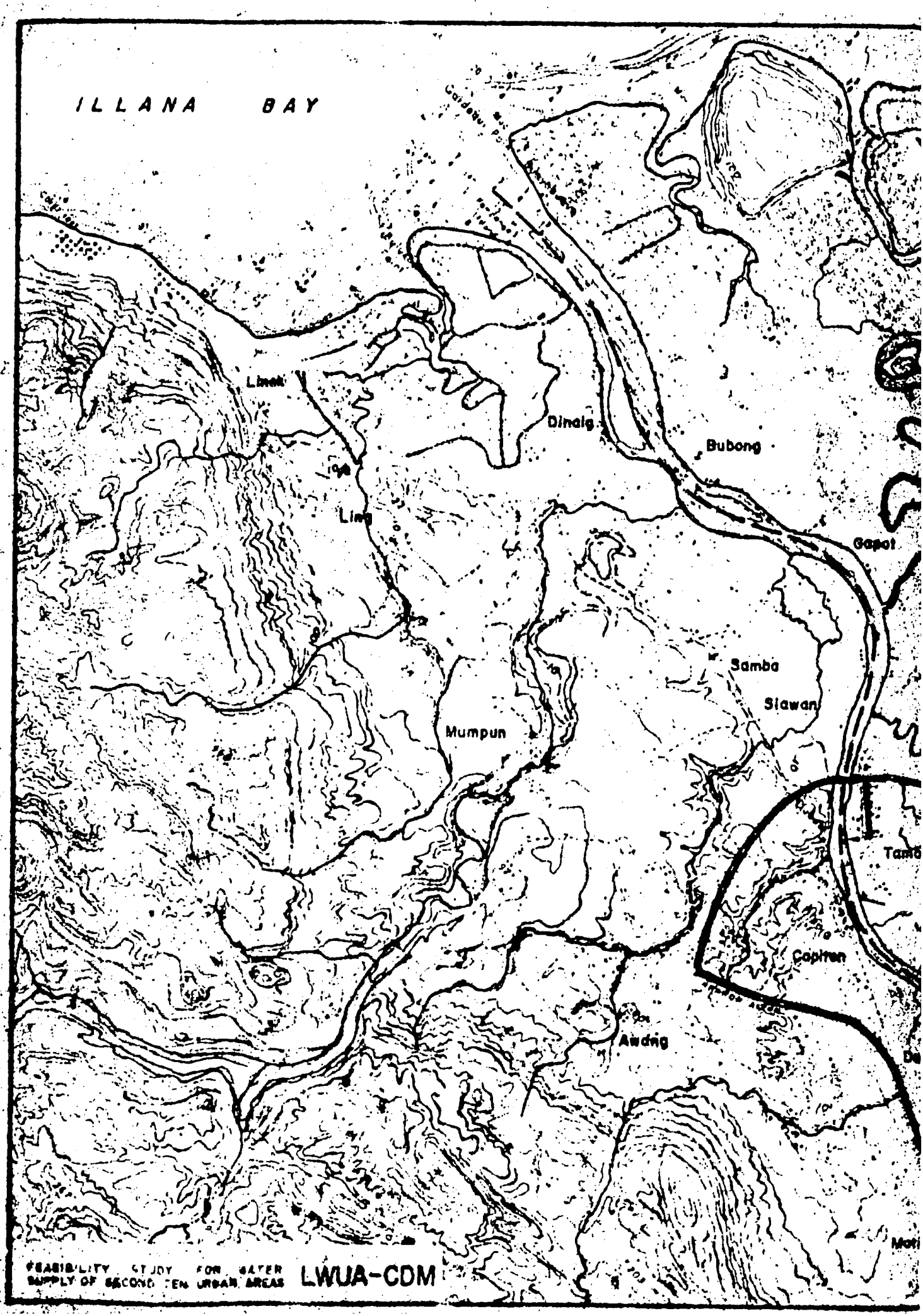
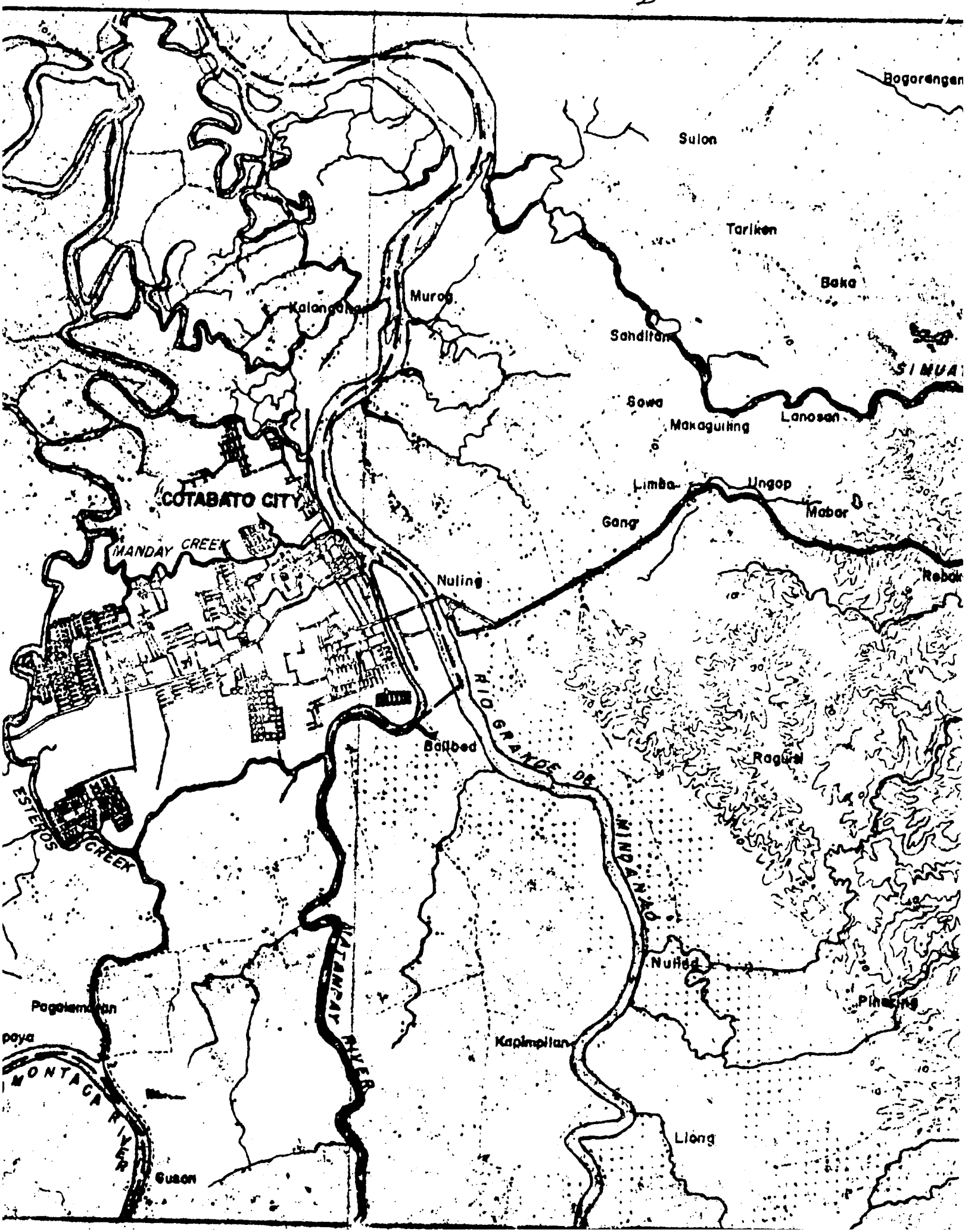
[6] Source: PAGASA station in Cotabato City.


ILLANA BAY
Linao
Dinalg
Bubong
Ling
Gapot
Samba
Siawan
Mumpun
Tamb
Capitan
Awang
FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS
LWUA-CDM


Bogorengen
Sulon
Tariken
Baka
Kalangalan
Murog
Sandilan
SIMUA
Sowa
Makaguiling
Lanosan
COTABATO CITY
Limba-
Ungop
Mabor
Gang
MANDAY CREEK
Nuling
Rebok
RIO GRANDE DE
Balbed
Ragual
ESTEROS CREEK
MINDANAO
Nulled
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MONTAGA RIVER
Liong
Guson

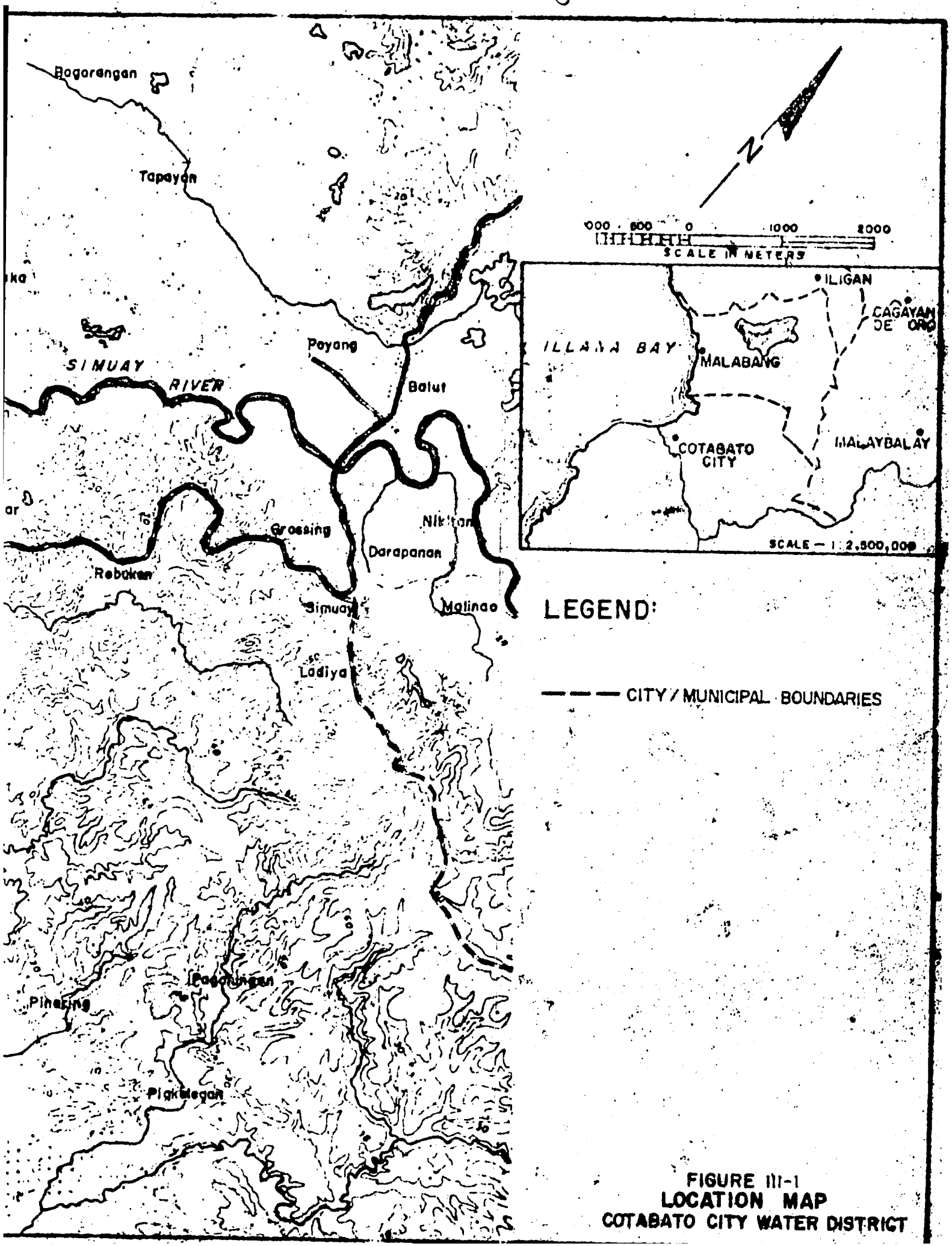
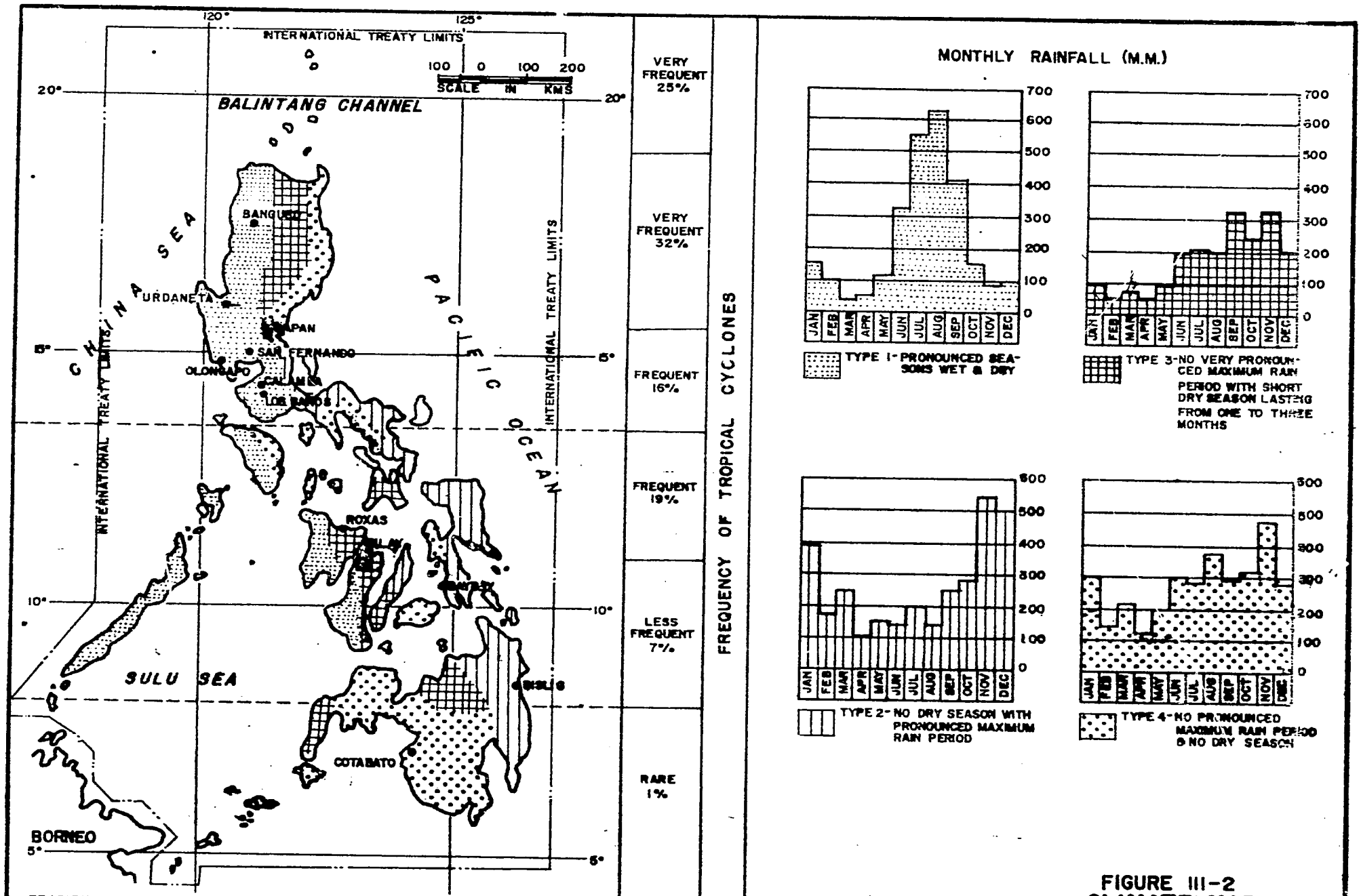


FIGURE III-1
LOCATION MAP
COTABATO CITY WATER DISTRICT



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

FIGURE III-2
CLIMATE MAP
REPUBLIC OF THE PHILIPPINES

TABLE III-2

MUNICIPAL POPULATION CHARACTERISTICS[1] (1970)

1.	Total Population	61,184
2.	Growth Rate (1960-1970)	5.0% per annum
3.	Density	3.48 persons per hectare
4.	Urban/Rural Composition	urban, 83%; rural, 17%
5.	Sex Composition	male, 49%; female, 51%
6.	Age Composition	0-14 years, 43%; 15-64 years, 55%; 65 years and over,
7.	Employment (% of those 10 years and over)	10 years and over, 41,864 employed, 46%; unemployed, 54%
	a. By class of worker (% of labor force)	wage and salary, 57%; own business, 26%; unpaid family workers, 17%
	b. By industry (% of labor force)	agriculture, forestry, fishing, 27%; manufacturing, 12%; commerce, 15%; services, 24%; construction, utilities, minor industries, 22%
8.	Education (% of those 6 years and over)	6 years and over, 49,048 literate, 72%; illiterate, 28%
	a. By attainment (% of those 25 years and over)	25 years and over, 20,533 elementary grades, 33%; high school, 20%; college, 17%; no formal education, 30%
	b. Number of Schools	elementary, 23; high school, 4; college, 2; vocational, 5
9.	Dialects	Maguindanao, 36%; Cebuano, 26%; Tagalog, 15%; Hiligaynon, 11%; others, 12%
10.	Religion	Catholic, 51%; Islam, 40%; Protestant, 2%; others, 1%

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[1] This information applies to Cotabato City as a whole.
Source: 1970 Census of Population and Housing, National Census and Statistics Office (NCSO).

TABLE III-3

CLASSIFICATION OF HOUSEHOLDS
BY TYPE OF FACILITIES[8] (1970)

1.	Total Households	9,660
2.	Average Household Size	6.3 members per household
3.	Water Facilities (% of total households)	piped water, 51%; rainwater, 25%; surface water, 14%; other sources, 10%
4.	Toilet Facilities (% of total households)	flush/water sealed, 29%; closed pit, 37%; open pit, 17%; no facilities, 17%
5.	Lighting Facilities (% of total households)	electricity, 56%; kerosene, 42%; others, 2%
6.	Appliances (% of total households)	radio, 63%; TV, 1%; refrigerator, 12%
7.	Cooking Fuel (% of total households)	electricity, 1%; kerosene, 12%; LPG, 11%; wood, 75%; others, 1%
8.	Total Dwelling Units	9,182
	a. Type of Dwelling Unit (% of total units)	single type, 75%; duplex, 10%; apartment/accesoria, 11%; barong-barong (makeshift houses), commercial, industrial, etc., 4%
	b. Roofing Material (% of total units)	durable materials (aluminum/galvanized iron, asbestos, tile/concrete), 66%; non-durable materials (cogon, nipa, others) 34%

[8] This information applies to Cotabato City as a whole.
Source: 1970 Census of Population and Housing, NCSO.

Health

Water-borne diseases occur particularly in the more densely populated sections of the city. Public health authorities recognize the correlation between the lack of safe water supply and sewerage facilities and the incidence of water-borne diseases. Table III-4 shows the recorded morbidity and mortality rates per 100,000 population due to water-borne diseases in Cotabato City from 1964 to 1974. During this period, the average morbidity of 1,305.6 in this province was about twice the national average of 666.5; the average mortality of 61.5 was also higher than the national average of 48.1.

TABLE III-4

REPORTED MORBIDITY AND MORTALITY
DUE TO WATER-BORNE DISEASES[9] (1964-1974)
(per 100,000 population)

Year	Cotabato		Philippines	
	Morbidity	Mortality	Morbidity	Mortality
1964	1,067.8	50.9	846.3	60.2
1965	1,336.3	71.8	715.8	51.6
1966	2,110.9	80.2	715.1	61.9
1967	1,250.0	71.4	572.1	47.6
1968	1,191.0	71.1	564.8	46.5
1969	1,241.5	62.8	706.9	46.0
1970	1,000.7	39.0	612.8	39.0
1971	341.0	21.5	422.5	35.8
1972	1,067.7	34.6	743.4	49.4
1973	2,060.9	111.5	768.4	50.4
1974	1,693.7	61.6	663.8	40.4
Total	14,361.5	676.4	7,331.9	528.8
Average	1,305.6	61.5	666.5	48.1

Medical services are provided by 3 hospitals, clinics and rural health units located throughout the city.

9/ Source: Disease Intelligence Center, Department of Health, Manila.

The water-borne diseases, of which records are available, include typhoid, cholera, dysentery, and gastro-enteritis.

D. ECONOMY[10]

Family Income[11]

In 1975, the province of Cotabato was estimated to have 71,450 families, with a combined annual income of ₱266.2 million. The average family income of ₱3,725 was lower than the country's average of ₱5,840. About 63 percent of families constituted the below-average income (₱1,000-₱3,999) group. The average income (₱4,000-₱9,999) group included 35 percent of the families; the upper middle income (₱10,000-₱19,999) group, 1.5 percent; and the high-income (₱20,000-and over) group, .5 percent.

City Income

Based on records of the city government, the income of Cotabato City progressively increased from ₱1.3 million in fiscal year 1964-1965 to ₱4.9 million in 1973-1974. In fiscal year 1974-1975, however, income decreased by almost ₱800,000. The decrease in income coincided with the decline in business activity resulting from the deteriorating peace and order condition in the area. The largest sources of income were city licenses and receipts from the operation of the waterworks and the public market. The largest expenditure items during the same period were maintenance and operation of the market and slaughterhouse and police services. The following are the city incomes for the period 1964-1975.

Fiscal Year	Income	Increase	Decrease
1964-1965	₱1,271,935.12	-	-
1965-1966	1,405,658.77	133,723.65	-
1966-1967	1,633,758.68	228,099.91	-
1967-1968	1,743,667.46	109,908.78	-
1968-1969	2,262,811.03	519,143.57	-
1969-1970	2,420,663.78	157,852.75	-
1970-1971	2,543,109.63	122,445.85	-
1971-1972	3,075,983.68	532,874.05	-
1972-1973	3,886,903.14	810,919.46	-
1973-1974	4,894,996.85	1,008,093.71	-
1974-1975	4,100,976.97	-	₱794,019.88

Agriculture

Agriculture is the most important activity in Cotabato City, with about 60 percent of its total land area used for farming. The major crops are rice, copra, corn and fruits. The city serves as an outlet for farm protection and center of technical and credit facilities for agricultural development in the Cotabato area.

10/ The Philippine economy from 1946 to 1976 is discussed in Appendix F.

11/ Only provincial data are available at the NCSO.

The city also serves as a major fishing port of Cotabato area. About 2,800 hectares of swampy area has been developed into fishponds. Another important fishing area is Illana Bay, west of Cotabato City.

Commerce and Industry

In 1975, Cotabato City had about 1,850 commercial establishments, 54 percent of which were engaged in the wholesale and retail trade. Goods being traded were largely agricultural products.

In the same year, there were 116 manufacturing establishments, mostly agriculture-based. These are grain mills, sawmills and cottage industries.

Transportation and Communication

The city can be reached by sea, air and land transportation. It has an airport located in Awang for local travel and a port in Rio Grande, servicing light passenger and cargo vessels. The road system has a total length of about 45 kilometers, of which 48 percent is concrete or asphalt pavement.

Communication facilities include 11 telegraph stations, a telephone system, 4 radio stations, 4 postal and messengerial services, and a local weekly newspaper.

Electric power service is provided by the privately owned Cotabato Light and Power Company. The following is the schedule of power rates: (a) residential - ₱0.6718/kwhr for the first 60 kwhr/mo; ₱0.6018/kwhr for the next 40 kwhr/mo; and ₱0.4418 kwhr for consumption over 100 kwhr/mo; (b) commercial - ₱0.6718/kwhr for the first 100 kwhr/mo; ₱0.5918/kwhr for the next 300 kwhr/mo; ₱0.5218 for consumption over 400 kwhr/mo; (c) industrial - ₱0.4818/kwhr for the first 30-hour use; ₱0.4318/kwhr for the next 70-hour use; ₱0.3868/kwhr for the next 200-hour use; and ₱0.3668/kwhr for consumption over 300-hour use in a month. The city government and a number of households are charged flat rates.

CHAPTER IV EXISTING WATER SUPPLY FACILITIES

A. GENERAL

The original water system of COT-WD was constructed in 1939 with Dimapatoy River as its water source. A concrete dam was constructed across the stream of Dimapatoy River about 15 km south of the poblacion. From the dam, water flowed by gravity to a reservoir constructed on top of Colina Hill at the center of the poblacion through a 125-mm pipeline.

In 1955, a settling basin was constructed 5.5 km downstream from the dam and connected to the existing 125-mm line. A 5.5 km of 200-mm pipeline was constructed parallel to the existing 125-mm transmission line from the dam to the settling basin. The same year, the existing 125-mm transmission line from the settling basin to the city was replaced with a 250-mm pipeline.

In 1962, the source facilities of the system were reinforced with the construction of a pumping station about 300 meters downhill from the settling basin. It pumped raw water directly from the river to the settling basin or directly to the distribution system.

In 1974, four wells were drilled in the city but only two wells were made operational - the General Luna well and the Santos well.

In August 1976, an earthquake severely damaged the transmission line from the dam to the settling basin, putting the Dimapatoy Dam out of operation.

In December 1976, the other two wells drilled in 1974 were reactivated and connected to the system. They were made operational in March 1977. At present, COT-WD has a total of 1,742 service connections. Schematic diagram of the water system is shown in Figure IV-1.

B. WATERWORKS FACILITIES

Source Facilities

The COT-WD obtains its water supply from the Dimapatoy River, via the Dimapatoy pump station, and the four wells located in Barrio Rosary Heights. Dimapatoy dam is not operational at present because of severe damage to the transmission pipeline from the dam to the settling basin, caused by the 1976 earthquake. The water from the River is pumped from an intake box, built beside the Dimapatoy River, to the settling basin. The present total water supply is 6,080 cumd, 40 percent (2,390 cumd) of which is provided by the Dimapatoy pump station and the remaining 60 percent (3,690 cumd) provided by the four wells.

Treatment Facilities

There are two treatment facilities in the Cotabato City water system - a 2,840-cum sedimentation basin and concrete solution feed tankfor hypochlorination which is not presently used.

The sedimentation basin (Figure IV-2) was designed for plain sedimentation of water from the Dimapatoy River which is usually clear and for meeting storage requirement of the system.

Since August 1976, when the supply from the Dimapatoy dam was discontinued, the basin is being supplied with water from Dimapatoy pumping station. The basin cannot be filled because the capacity of the pump station is less than the capacity of the transmission line to the city when the basin level is high. Withdrawal is controlled by throttling the outflow valve. During night time, the outflow valve is closed; it is re-opened early in the morning.

When water in the river is turbid, supply to the basin is discontinued.

Storage Facilities

The existing system has one storage facility - a 750-cum reinforced concrete, cylindrical ground-level reservoir constructed in 1939. Located on top of Colina Hill, the reservoir has bottom and overflow elevations of 46 and 53 meters above MSL, respectively. However, due to the inability of the system to fill the reservoir because of low system pressure, the military forces have utilized it for their water supply using water from their own well.

Transmission Facilities

Since 1955, water has been conveyed from the dam to the settling basin by 125 and 200-mm CCI transmission pipes, about 5.5 km in length, and from the settling to the distribution system by a 9.5 km, 250-mm CCI transmission line. Since August 1976, when an earthquake severely damaged the pipelines from the dam to the settling basin, the settling basin has been supplied with water taken directly from the river through Dimapatoy pumping station. The 9.5 km pipeline from the settling basin to the distribution system and 200 and 150-mm CCI pipelines (both 300 meters long) from the pumping station to the settling basin are presently utilized. Transmission lines are described by size, material, length and year of construction in Figure -1.

Distribution System

With the establishment of the water system in 1939, about 5.7 km km of 100-mm CCI distribution lines was constructed. In 1955, an

TRANSMISSION LINES

DIAMETER (MM)	TYPE	LENGTH (M) AND YEAR INSTALLED			
		1939	1955	1962	TOTAL
250	CCI		9,500		9,500
200	CCI		5,500	300	5,800
150	CCI			300	300
125	CCI	5,500			5,500
SUB-TOTAL		5,500	15,000	600	21,100

DISTRIBUTION SYSTEM

DIAMETER (MM)	TYPE	LENGTH (M) AND YEAR INSTALLED			
		1939	1955	1960	TOTAL
250	CCI		2,800		2,800
200	CCI		500		500
150	CCI		900		900
125	CCI		8,700		8,700
100	CI & ACP	5,700			5,700
75	CI		1,400		1,400
50	GI		3,640		3,640
37	GI			3,520	3,520
SUB-TOTAL		5,700	17,940	3,520	27,160

APPURTENANCES , DECEMBER 1976

	SIZE (MM)	NUMBER	REMARKS
VALVES	50 75 100 125 150 200 250 300	2 3 10 16 2 3 1 1	90 PERCENT OPERATIONAL THOUGH SOME ARE LEAKING.
HYDRANTS	75	4	3 DISCONNECTED 1 OPERATIONAL
PUBLIC FAUCETS	12	3	DISCONNECTED

SERVICE CONNECTIONS , DECEMBER 1976

TYPE	METERED	FLAT-RATE	TOTAL
DOMESTIC	63	1614	1677
COMMERCIAL	20	36	56
INDUSTRIAL	4	5	9
INSTITUTIONAL			
TOTAL	87	1655	1742

DIMAPATOY

- 21 M WIDE
- CONCRETE
- ELEVATION
- NOT PRESI

DIMAPATOY

- R.C. INTAK
- PUMPING U
  - WESTIN 125HP,
  - AURORA 1910 CU
- PUMPING
  - ELECTR 125 HP,
  - AURORA 2730 C
- PUMPING
  - ELECTR
  - AURORA 1910 CU

SETTLING

- 2840 CUM
- ELEVATION
- 30 M x 40

TREATMEN

- NO TREATM THE 2840

SYSTEM F

- SATISFACT LOW AT E HIGHER E

DIMAPATOY DAM (1939)

- 21 M WIDE, 5 M HIGH
- CONCRETE DAM
- ELEVATION 120 M ABOVE MSL
- NOT PRESENTLY USED

REINFORCED CONCRETE GROUND RESER

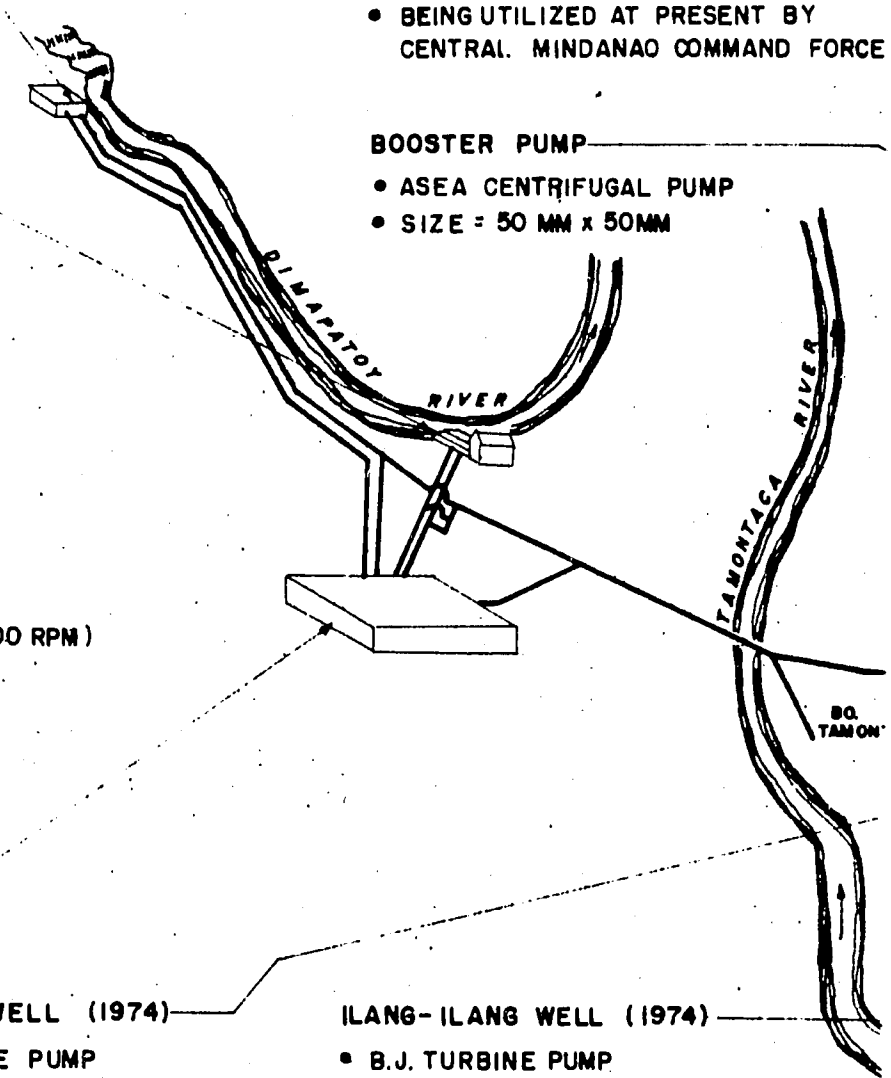
- 750 CUM CAPACITY
- DIAMETER = 11.75 M
- HEIGHT = 7.00 M
- ELEVATION 46 M (BOTTOM)
- BEING UTILIZED AT PRESENT BY CENTRAL MINDANAO COMMAND FORCE

BOOSTER PUMP

- ASEA CENTRIFUGAL PUMP
- SIZE = 50 MM x 50MM

DIMAPATOY PUMP STATION (1962)

- R.C. INTAKE BOX, 4.2 x 14.5 x 1.5 M.
- PUMPING UNIT 1
  - WESTINGHOUSE ELECTRIC MOTOR 125HP, 440V, 60 CYCLES, 1800 RPM
  - AURORA CENTRIFUGAL PUMP 1910 CUMD, 350 M TDH.
- PUMPING UNIT 2
  - ELECTRIC MOTOR 125 HP, 3 PHASE, 440 V (1800 RPM)
  - AURORA CENTRIFUGAL PUMP 2730 CUMD, 350 M TDH.
- PUMPING UNIT 3 (UNDER REPAIR)
  - ELECTRIC MOTOR, 60 HP, 3 PHASE (1800 RPM)
  - AURORA CENTRIFUGAL PUMP 1910 CUMD, 350 M TDH.



SETTLING BASIN (1955)

- 2840 CUM CAPACITY
- ELEVATION 93 M ABOVE MSL
- 30 M x 40 M x 3 M

ORTOUSTE WELL (1974)

- B.J. TURBINE PUMP
- 20 HP HIGGS ELECTRIC MOTOR
- CASING DIAMETER = 200 MM
- WELL DEPTH = 19.8 M
- DISCHARGE = 907 CUMD
- CONNECTED TO SYSTEM MARCH 1977

ILANG-ILANG WELL (1974)

- B.J. TURBINE PUMP
- 25 HP HIGGS ELECTRIC MOTOR
- CASING DIAMETER = 200 MM
- WELL DEPTH = 24.4 M
- DISCHARGE = 1175 CUMD
- DISCHARGE PRESSURE = 4.01 KG/SQ CI
- PUMPS TO DISTRIBUTION SYSTEM
- CONNECTED TO SYSTEM MARCH 1977

TREATMENT

- NO TREATMENT FACILITIES EXCEPT THE 2840 CUM SETTLING BASIN.

SYSTEM PRESSURES

- SATISFACTORY IN AREAS NEAR SOURCE BUT LOW AT EXTREMITIES AND IN AREAS WITH HIGHER ELEVATIONS.

SERVICE AREA OPERATION

- WATER FROM THE WELLS IS PUM DIRECTLY TO THE SYSTEM FOR 24
- WATER FROM DIMAPATOY PUMP STAT PUMPED DIRECTLY TO THE SETTLI FOR 24 HOURS.
- WATER FROM SETTLING BASIN IS C TO THE DISTRIBUTION SYSTEM BY FOR 24 HOURS WITH OUTFLOW VA

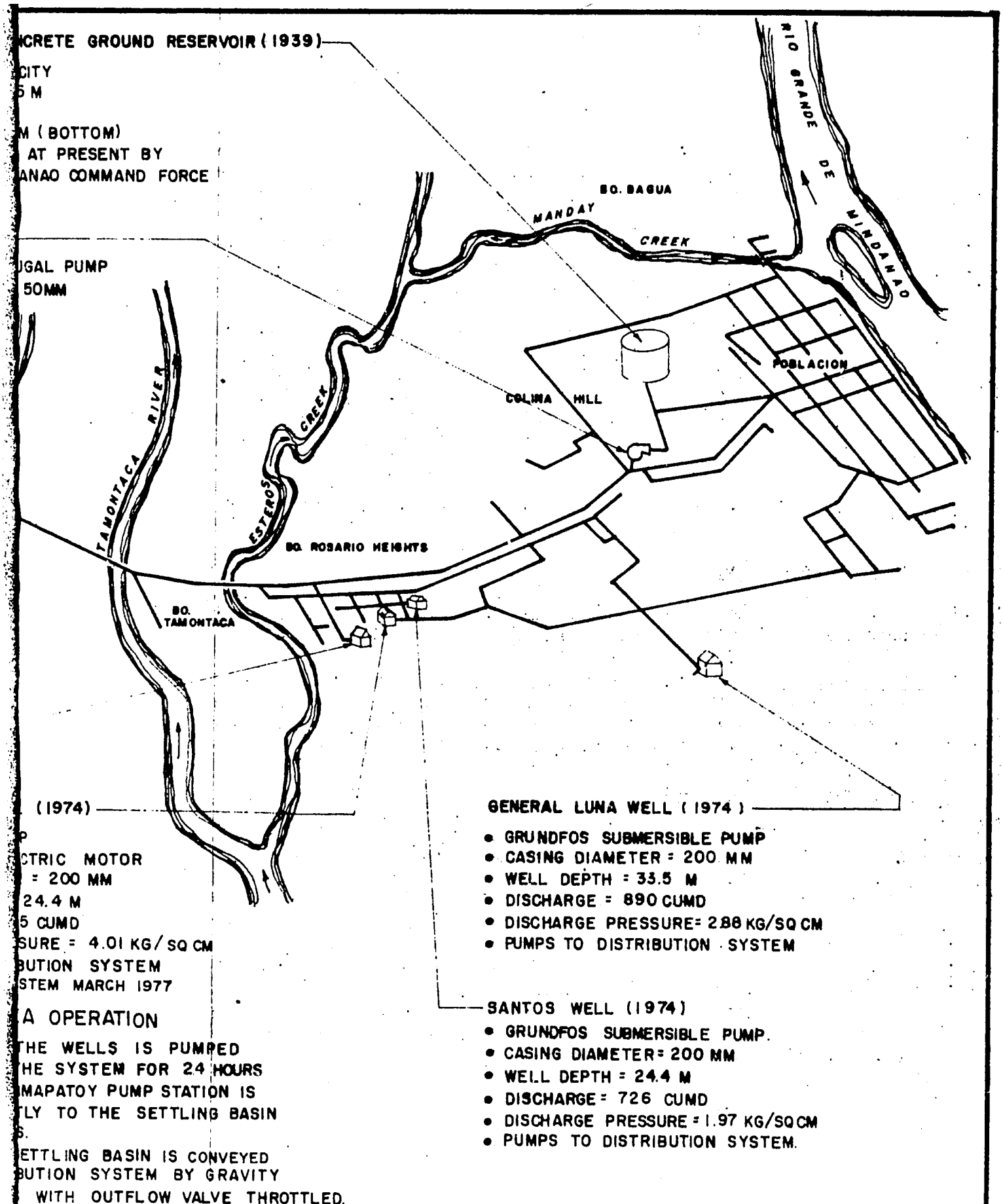
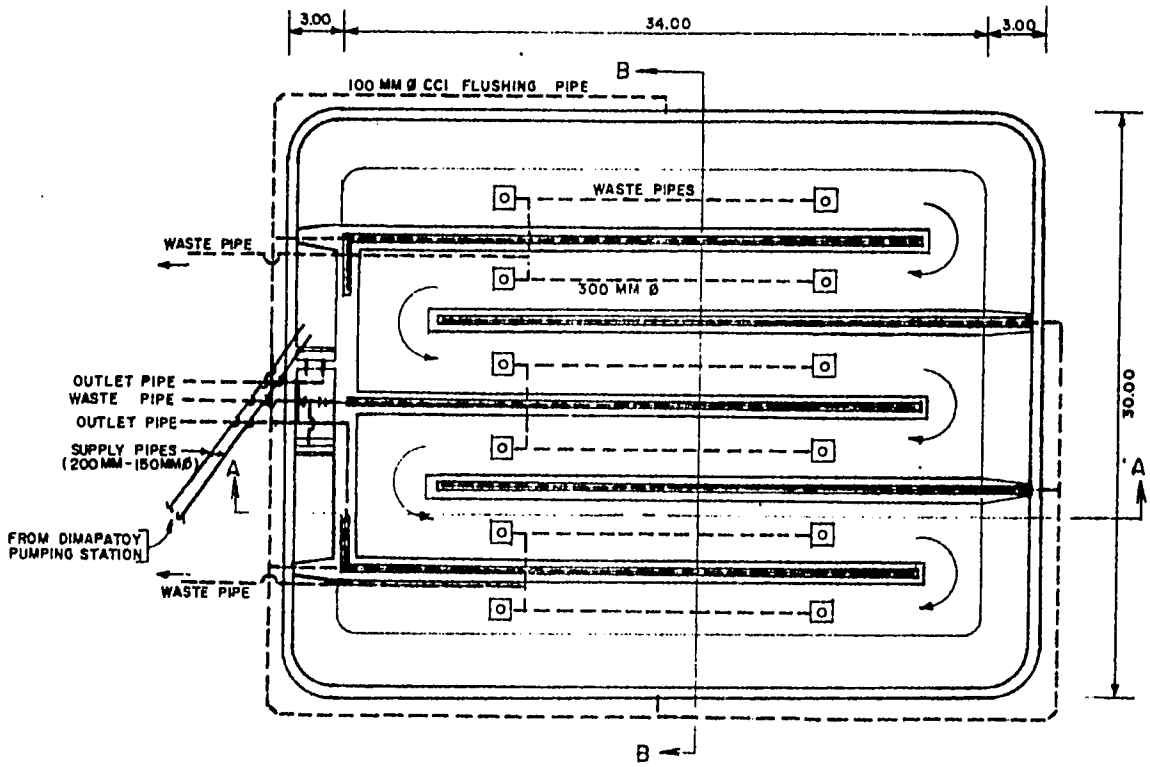
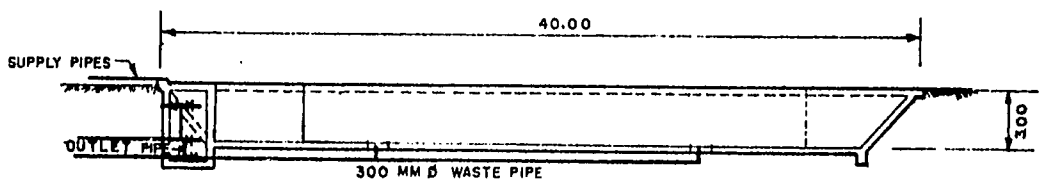


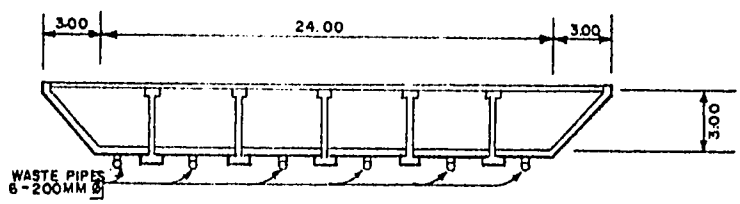
FIGURE IV-1
EXISTING FACILITIES
COTABATO CITY WATER DISTRICT



SETTLING BASIN PLAN
SCALE 1:400 M



SECTION A-A
SCALE 1:400 M



SECTION B-B
SCALE 1:400 M

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

FIGURE IV-2
EXISTING SETTLING BASIN
SCHEMATIC DIAGRAM
COTABATO CITY WATER DISTRICT

additional 17.9 km of CCI and GI pipelines, ranging from 50 to 250 mm in diameter, was constructed within the system. New pipelines, with a total length of 3.5 km, were laid in 1960 (see Figure IV-3).

At present, the distribution system has some 27.1 km of piping ranging in size from 37 to 250 mm. The pipes are classified by size, material, length and date of construction in Figure IV-1. Fifty three percent of the piping is 100 mm in diameter and smaller. About half of all installed piping is made of centrifugally cast iron.

Valves and Hydrants. As reported by water district staff, the COT-WD has 38 valves, varying in size from 50 to 300 mm, and 4 hydrants. Only one hydrant, however, is operational and its usefulness is limited by inadequate pressure in the system.

Service Connections. As of December 1976, the COT-WD had 1,742 registered service connections, of which only 87 (5 percent) were metered. Figure IV-1 shows the number of service connections by consumer category and basis of billing. Information on the number of connections by size was not available. About 20 percent of the total service connections reportedly need repair or replacement.

Operation and Maintenance

The COT-WD operates and maintains the water sources, pumping stations and treatment, transmission and distribution system. The operation and maintenance staff includes one engineering operations chief, one construction and maintenance chief, one production chief, two pump operators, one operator-mechanic, and two watershed attendants.

The operation program consists mainly of manipulating the valves for scheduling water service and operating the pumps. The present system is operated according to the following schedule (as of February 1977). Refer to Figure IV-3 for location of pump stations.

1. Santos pump station serves the Gutierrez Subdivision (the pilot area) and some portions in the north 24 hours daily.

2. Ilang-Ilang and Gen. Luna wells serve the northeastern portion of the system 24 hours daily.

3. The Dimapatoy River source supplies certain areas according to the following schedule:

    a. Monday, Tuesday and Friday - the downtown area is served 24 hours through the 200-mm distribution line connected to the 250-mm main. All valves along Sinsuat Avenue are closed, except those which direct the flow into the 200-mm line.

b. Wednesday and Saturday - All valves along Sinsuat Avenue and at the junction of Quezon Avenue are closed. When sufficient pressure has been built up along the 250-mm line (usually by 1:00 p.m.), water supply is distributed to concessionaires along PC Hill Road.

c. Thursday and Sunday - All valves are closed, except those along Sinsuat Avenue corner Sausa Street. The flow is directed to the western portion of the system along Sausa and San Vicente Streets.

The maintenance program consists of servicing the pumps, service connections, settling basin, repairing leaks in pipelines and valves and safeguarding the watershed area against kaingineros and intruders.

C. WATER QUALITY

Two water samples were taken from the Dimapatoy River (Dimapatoy dam and Dimapatoy pump station), and four from the operating COT-WD wells. Results of analyses of the surface water show that, except for manganese content, the chemical constituents are within the permissible limits set by the Philippine National Standards for Drinking Water. The manganese concentration (0.2 mg/l) of the Dimapatoy pump station sample is less than the excessive limit of 0.3 mg/l. The samples taken from wells are generally above, or near, the permissible limits with respect to total dissolved solids, total hardness, calcium, magnesium, and manganese concentration. Although three of the four well water samples analyzed contained manganese in excess of the permissible limit, only the sample from the Ortouste Well exceeded the excessive limit. In addition, the Ortouste Well sample was turbid beyond the permissible limit. The results of these analyses are listed in Table IV-1.

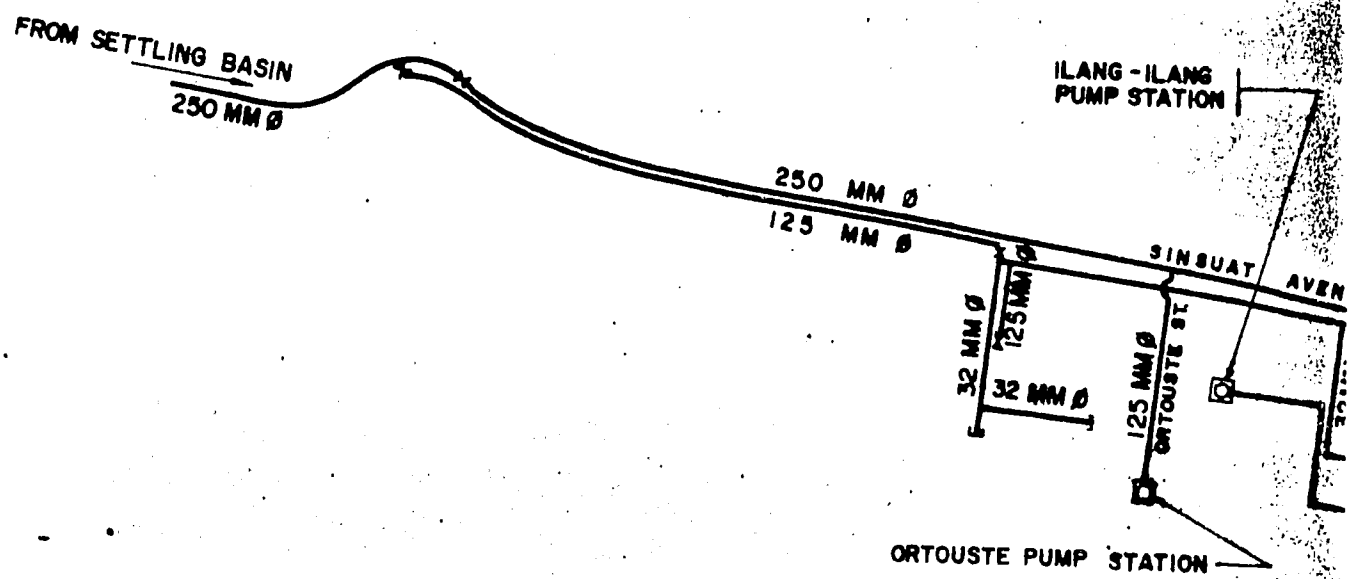
D. WATER USE PROFILE

General

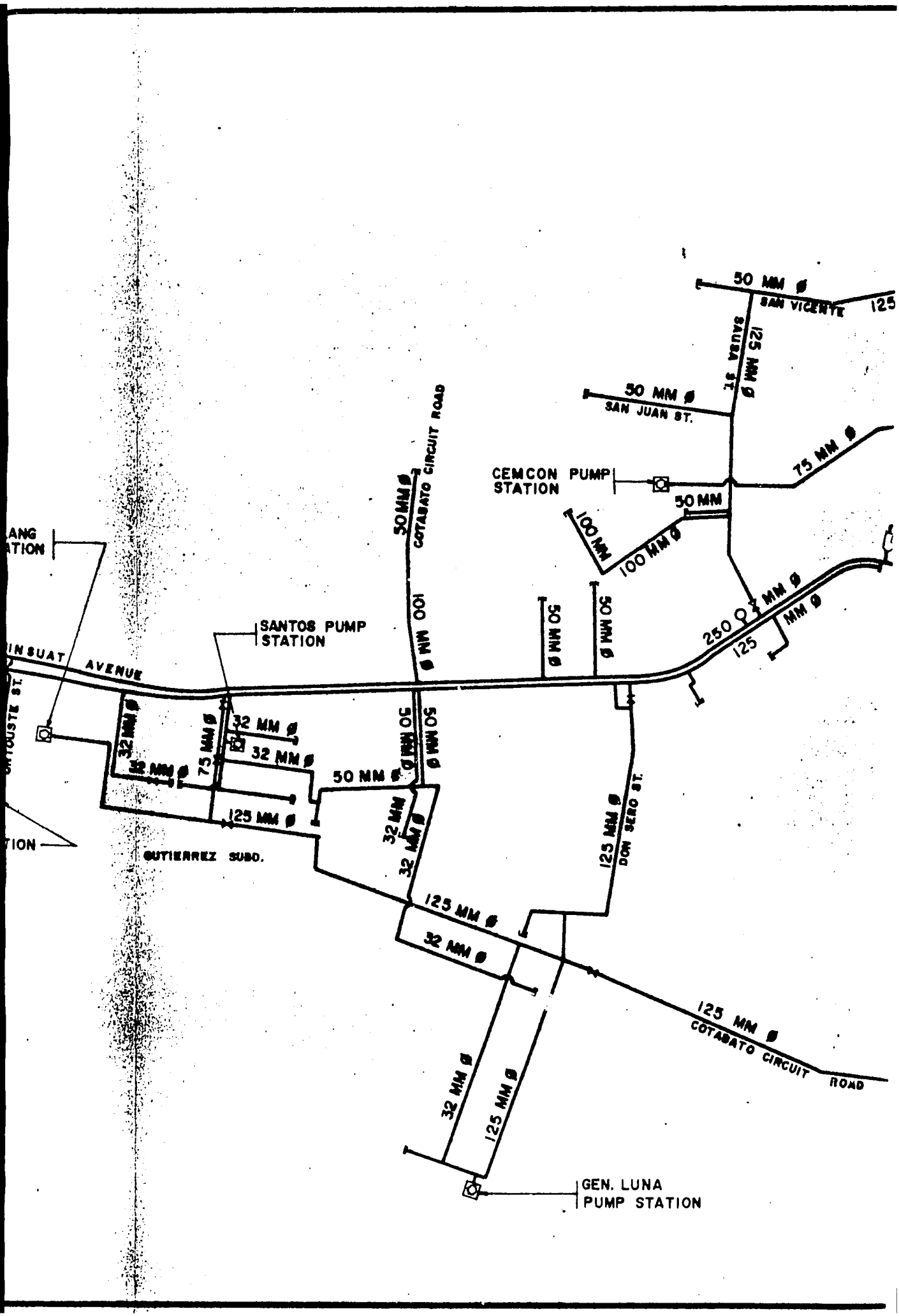
The current water demands of COT-WD have been analyzed to project future water requirements. Data on metered connections and revenue-producing water were obtained from water district records. To supplement these data, a pilot area survey was made. (See Annex IV-D and Methodology Memoranda No. 1 and 2). These data have been used to establish the present water use profile.

Pilot Area Survey

The pilot area, about 13.8 hectares, is located in Gutierrez Subdivision in Barrio Rosary Heights. It is bounded by Sinsuat Avenue



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM


50 MM ø
SAN VICENTE
125
125 MM ø
SAUDA ST.
50 MM ø
SAN JUAN ST.
75 MM ø
CEMCON PUMP STATION
50 MM
100 MM
100 MM ø
50 MM ø
COTABATO CIRCUIT ROAD
100 MM ø
50 MM ø
50 MM ø
250
125
MM ø
MM ø
SANTOS PUMP STATION
INSUAT AVENUE
32 MM ø
32 MM ø
32 MM ø
75 MM ø
32 MM ø
50 MM ø
50 MM ø
50 MM ø
125 MM ø
32 MM ø
32 MM ø
125 MM ø
DON SERO ST.
GUTIERREZ SUBD.
125 MM ø
32 MM ø
125 MM ø
COTABATO CIRCUIT ROAD
32 MM ø
125 MM ø
GEN. LUNA PUMP STATION

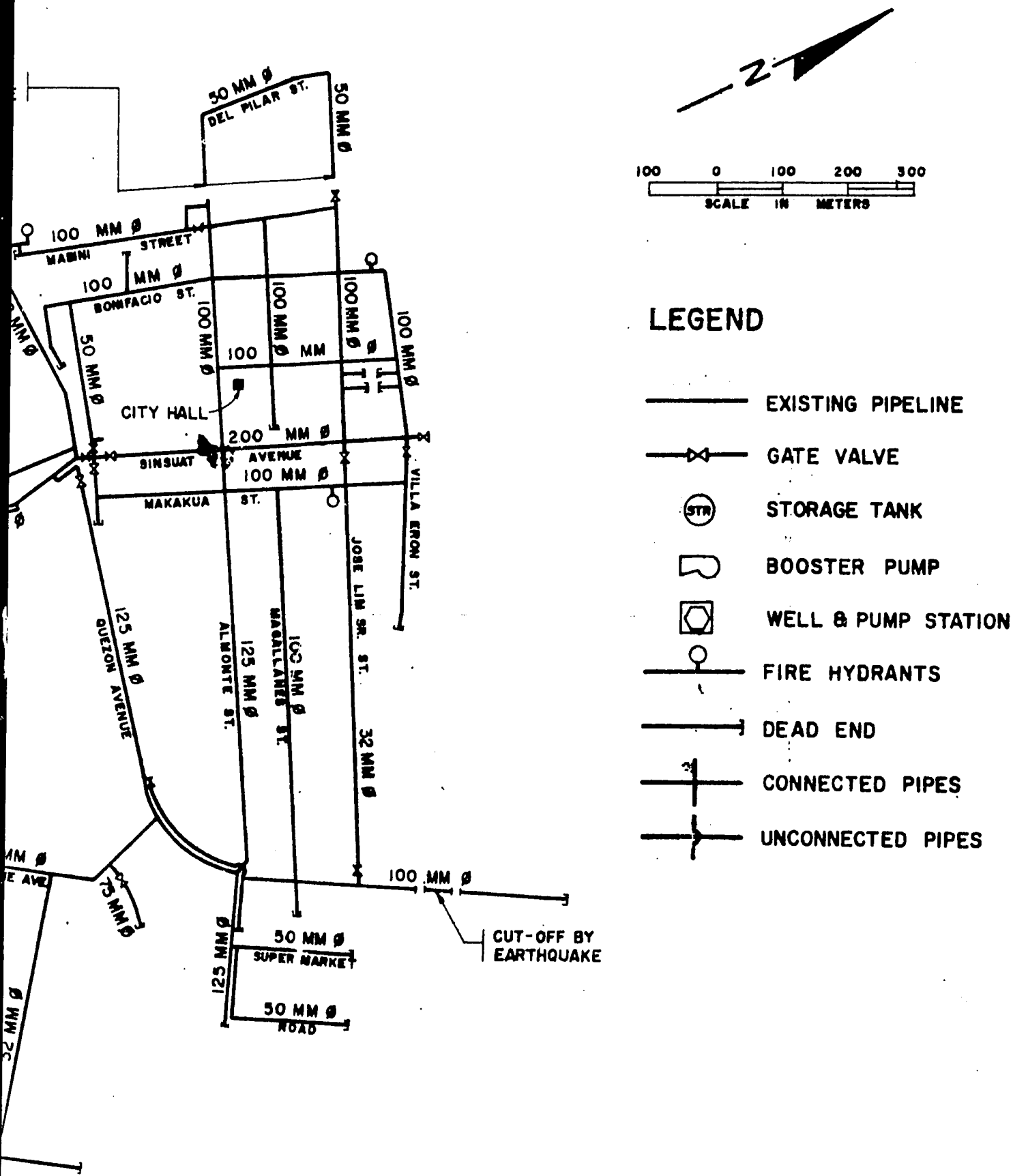


FIGURE IV- 3

EXISTING WATER DISTRIBUTION SYSTEM

COTABATO CITY WATER DISTRICT

TABLE IV-1

WATER QUALITY TEST RESULTS
COTABATO CITY WATER DISTRICT

Test	Unit	Permissible Limits	Dimapatoy Dam Bo. Dimapatoy, Dinaig 27 Nov 76	Dimapatoy Pumping Station Bo. Dimapatoy, Dinaig 27 Nov 76	Ortouste Well Bo. Rosary Heights 21 Feb 77	Ilang-ilang Well Bo. Rosary Heights 25 Nov 76	Santos Well Bo. Rosary Heights 25 Nov 76	Gen. Luna Well Bo. Rosary Heights 21 Feb 77
Physical								
Color	APHA	15	5	5	10	5	5	5
Turbidity	FTU	5	3	3	15*	2	5	2
Total Dissolved Solids**	mg/l	500	195	218	1,328*	878*	780*	1,390*
Conductivity	micromhos/cm	-	300	335	1,540	1,350	1,200	1,600
Chemical								
pH		7-8.5	7.95	7.80	7.15	7.65	7.45	7.20
Total Alkalinity	mg/l CaCO3	-	180	195	380	430	420	365
Phenolpthalein Alkalinity	mg/l CaCO3	-	0	0	0	0	0	0
Total Hardness***	mg/l CaCO3	400	177	181	554*	351	463	518
Calcium	mg/l	75	60.4	64.4	86*	77*	132*	114*
Magnesium	mg/l	50	6.24	4.8	81.3*	38	32	56*
Total Iron	mg/l	0.3	.125	.10	3.68*	nil	nil	0.08
Fluoride	mg/l	1.5	.435	.435	.83	.620	.485	0.7
Chloride	mg/l	200	0	2.44	108	146	82	173
Sulfate	mg/l	200	nil	nil	109	48	25	78
Nitrate	mg/l	100	10.2	10.2	9.9	8.1	12.0	4.16
Manganese	mg/l	0.1	0.1	0.2*	.75*	0.3*	0.2*	0.05

*Exceeds the permissible limits set by the Philippine National Standards for Drinking Water.
**Calculated as 65% of conductivity.
***Inferred from permissible limits for individual metals contributing to hardness.

on the west, Rosal Street on the east, Gutierrez Road on the south, and Sero Elementary School on the north. It has a total population of 1,470, consisting of 183 households with an average of 8 persons per household. The overall density is 106 persons/hectare. Based on interviews, 154 households are registered concessionaires of the water district, 21 households are "borrowers" from registered concessionaires; 4 have their own hand pumps or private wells; 3 are "borrowers" from private wells; and 1 household has an unregistered connection.

Users of water from the COT-WD water system are classified as primary users (registered concessionaires) and secondary users (borrowers). Based on the pilot study data, the total number of households dependent on the system is 1,988. Household borrowers total 239, of whom 11 are borrowers from metered connections and 228 households are borrowers from unmetered connections. Assuming 8 persons per household, total users of water from the COT-WD system are estimated to be 15,900, of whom 13,990 are primary users and 1,910 are secondary users.

The data on the estimated daily consumption of each household and the number of persons per household, as given in the survey, have been used to estimate unit water consumption. The per capita consumption per day based on a record of 4 metered connections in the pilot area was computed to be 123 liters. Based on interviews with flat-rate concessionaires, borrowers and households with their own hand pumps, their consumptions were estimated to be 37, 32 and 57 lpcd, respectively. However, these figures are probably understated either because of the strict rules of the water district or poor estimates of the respondents. The only reliable consumption rate is the per capita consumption at the 4 metered connections. Available data are not sufficient to estimate the different categories of consumption (domestic, commercial, institutional and industrial).

Accounted-for-Water

Accounted-for-water is the sum of metered consumption and the water consumption assumed at flat-rate connections. The accounted-for-water is revenue-producing water for the water district. Metered consumption is estimated to be 4,071 cumd/mo, while estimated flat-rate consumption, 45,844 cum/mo. The total of 49,915 cum/mo represents 30 percent of total water production of 164,672 cum/mo.

Unaccounted-for-Water

Unaccounted-for-water, or unbilled water, does not generate revenue for the water district. It can be divided into several categories; leakage, wastage at flat-rate connections, usage of borrowers from

flat-rate connections and other uses. The estimated total unaccounted-for-water is 114,758 cum/mo or 70 percent of total water production.

Underestimated Flat-Rate Use. Analysis of metered water consumption and flat-rate billing indicates that underestimated flat-rate use is 33,596 cum/mo or 20.4 percent of the total production. This represents potential revenue if flat rates would be increased.

Borrowers' Usage from Flat-Rate Connections. This is the consumption of households who obtain their water supply from their neighbors with flat-rate service connections. The pilot area survey shows that the consumption of these borrowers is 1,751 cum/mo which corresponds to 1.1 percent of the total production. Borrowers' consumption would be revenue-producing if all connections were metered.

Usage from Unregistered Connections. Based on pilot area survey data, there are 11 unregistered connections in the COT-WD water system. Consumption at these connections is estimated to be 528 cum/mo (less than 1 percent of total water production).

Wastage, Leakage and Other Uses. Water is lost due to leaks in the transmission lines, distribution mains and service connections. Leakage in the transmission lines and distribution mains exists due to the prevalence of old corroded pipes, poor jointing techniques (e.g. bell and spigot joints are made of cold lead or cement, mortar), high pressure (in some areas) and displacement of pipes due to earthquakes.

Water for public use (fire-fighting, main flushing, and street cleaning), meter under-registration and unauthorized use are grouped together under the category of other uses. Leakage and other uses are estimated to be 78,882 cum/mo or 48 percent of total production.

Summary of Water Accountability

A summary of water accountability is presented in Table IV-2. The accounted-for-water, based on the February 1976 billing record, is about 30 percent of total production. The accounted-for-water is the sum of the metered consumption and estimated consumption at unmetered (flat-rate) connections. The unaccounted-for-water represents about 70 percent of production. A portion of the unaccounted-for-water can be considered consumed water and potentially billable water which includes underestimated flat-rate use, borrowers' usage from flat-rate connections, and usage from unregistered connections. Wastage, leakage and other uses combined represent 48 percent of total production. Pressure would probably rise if leaks and flat-rate connections were eliminated. A program to reduce leakage and to install meters on flat-rate connections would significantly increase water accountability and the revenue of the district.

TABLE IV-2

SUMMARY OF WATER ACCOUNTABILITY
COTABATO CITY WATER DISTRICT

Category	Amount of Water (cum/mo)	Percentage of Production
1. Accounted-for-water		
a) Metered consumption at 83 connections	4,071	2.5 %
b) Inferred flat-rate use at 1,655 connections	45,844	27.8
Sub-total	49,915	30.3
2. Unaccounted-for-Water		
a) Potentially billable water		
- Underestimated flat-rate use	33,596	20.4
- Usage from illegal connections	528	.3
- Borrowers' usage from flat-rate connections	1,751	1.1
b) Wastage, Leakage and Other Uses	78,882	47.9
Sub-total	114,758	69.7
Total	164,670*	100.0%

*This does not include production of Ortouste well. During the survey, Ortouste well was not yet operational.

E. HYDRAULIC SURVEY DATA

Field measurements to obtain hydraulic data on the COT-WD facilities were conducted during the period 2-20 February 1977. These included measurement of the volume of water being pumped from the Dimapatoy River and the four existing wells; an investigation of the condition of Dimapatoy pumping station transmission mains; water accountability along these lines; determination of the pressure distribution throughout the system; and a "water use" study on a selected pilot area. The purpose of field studies was to provide data for a computer model of the existing system and to isolate areas with major operational problems.

Flow and Pressure Test Points

Test points for flow and pressure measurements were established (see Figure IV-E-1) to determine the Dimapatoy pump station production, the condition of pump discharge lines and the 250-mm transmission main, and the water lost along these lines. Data obtained for these test points are shown in Annex Table IV-E-1.

Water Accountability Analyses

Test data show differences in flow of 8.9 lps and 8.2 lps, between TP-1 and TP-3 and between TP-2 and TP-4, respectively. This flow discrepancy, however, is not due to leakage along the lines alone. Part of it is attributed to water leaking through the "closed" bypass valves as evidenced by a flow greater at TP-6 than at TP-5. A portion of the measured flow difference (about 5 lps) leaks through the bypass valves. Thus, the remainder, about 12 lps of water or 25 percent of the total pump output (48.4 lps), is lost in leaks along the parallel pipelines between the pump station and settling basin.

The test data likewise indicate a difference of 17 lps in the measured flow between TP-6 and TP-7. Since there are 42 connections serving Barrio Tamontaca, with 8 persons per connection, assuming 160 lpcd demand, about 0.6 lps goes to the distribution line serving the barrio. Thus, leakage along this 9-km transmission main is about 16 lps. Total leakage along the 250-mm mainline between the settling basin and TP-7 accounts for about 58 percent of total pump production.

HGL and C-Value

The hydraulic gradeline from the Dimapatoy station to Barrio Rosary Heights (TP-7) is shown in Figure IV-E-2. Estimated C-values of pipelines, based on test data, are shown in Table IV-3.

TABLE IV-3

PIPE C-VALUES

Pipe	Location	C-Values
200-mm CCI	TP-1 to TP-3	50
150-mm CCI	TP-2 to TP-4	40
250-mm CCI	TP-5 to TP-6	100
250-mm CCI	TP-6 to TP-7	75
250-mm CCI	TP-7 to TP-8	67

Observed high headlosses along the parallel Dimapatoy discharge lines result from low pipeline C-values, as evidenced by thick encrustation on the inner surfaces of the 200-mm and 150-mm pipes. The low calculated C-value of the 250-mm pipe between TP-7 and TP-8 is the result of the combined effects of leakage along the pipeline and the high headloss induced by the poor internal condition of the pipeline.

Field data for C-value computation in the distribution mains were not obtained due to very low pressures in the distribution system, particularly in the poblacion area.

Well Pump Stations

Small wood/concrete structures with galvanized sheet roofs, enclosing the main switch boxes and motor starters, were built beside the Santos, Ilang-Ilang and Ortouste wells. The General Luna well pump station is equipped with a structure which encloses the well, pumpset motor and accessories.

A 24-hour pressure recorder installed at General Luna pump station on 5-6 February 1977 showed the pump to have automatically stopped and started 21 times on that date and about 20 times on 8-9 February 1977. This pumpset is equipped with an automatic level cut-out device, which is manually by-passed during periods of peak demand.

The pumpsets generally appear to be in good condition and operate with little vibration. Pump tests were conducted at the Santos, Ilang-Ilang, General Luna and Ortouste pumping stations to determine the head-capacity curves for existing pumps (see Figures IV-E-3 through IV-E-6). Annex Tables IV-E-2 through IV-E-5 show the recorded pump test data.

System Pressures

Automatic pressure recorders were installed at the Santos, Ilang-Ilang and General Luna wells to determine system pressure for a 24-hour period within Barrio Rosary Heights.

Pressures varied from 1.59 to 2.31 kg/sqcm during the test period (7-8 February) at Santos pump station while pressures ranged from 3.0 to 4.48 kg/sqcm at Ilang-Ilang pump station for the same period. At General Luna pump station, pressures varied from 2.4 to 3.27 kg/sqcm (8-9 February), and at TP-7, from 1.04 to 1.76 kg/sqcm (10-11 February). Figures IV-E-7 through IV-E-10 show the 24-hour pressure recordings.

Pressure in the northern part of the distribution system, particularly the poblacion area, is practically zero. Water is supplied in this area 3 times a week by manipulation of valves located along Sinsuat Avenue. Concessionaires have to use hand pumps installed on distribution pipes to get water from the system.

Pilot Area Flow Measurements

The selected pilot area is being served by Santos pump station. Flow measurements were made at two test points, TP-9 and TP-10 (see Figure IV-E-11), to determine the volume of water entering the pilot area. The purpose of these field measurements was to provide data which could serve as a basis for estimating water accountability in the entire distribution system. Annex Table IV-E-6 shows flow data obtained on 8 February 1977 and Figure IV-E-11 illustrates flow data as plotted and the "total water use", graphically. This curve roughly indicates the day-time consumption pattern on an hourly basis, assuming that leakage and wastage did not vary much during the observation period.

F. COMPUTER STUDIES

The purpose of conducting computer studies on the existing system is to duplicate, to the greatest extent practicable, the hydraulic conditions observed in the field. The impact of improvements could be more accurately evaluated after a model of existing system has been made.

However, computer studies on the existing system of COT-WD could not be made for several reasons. Field data gathered indicate that the existing system has generally low or negligible pressure. Water is rationed to different areas by valve manipulations. A major earthquake in the city damaged the transmission pipelines, causing major leakage and loss of pressure. The distribution system must be free from major leakage or otherwise be under reasonable pressure in order to model the system on the computer.

The portions of the existing system that could be utilized for the future have been retained and included in the computer studies for the future system. The data for these facilities have been based on visual inspection of the existing facilities.

G. DEFICIENCIES OF THE EXISTING SYSTEM

The COT-WD has a low level of water service. Most of the consumers receive water only 3 to 4 days a week on a part-time basis. Some of the consumers in the poblacion use pumps directly connected to the service lines to increase water supply. Only 5 percent of the 1,742 service connections are metered.

The surface water supply coming from the Dimapatoy pumping station is turbid following heavy rains in the catchment area. No treatment or disinfection chemicals are currently used in the system. The water district has no water quality control laboratory facilities. The wells within the city are shallow, ranging from 20 to 34 meters in depth, and have low capacities. The water produced is highly saline; conductivity ranges from 1,200 to 1,600 micromhos/cm.

The existing ground storage tank on Colina Hill is not currently used. Because of low pressure in the distribution mains, the storage tank cannot be filled, even during off-peak hours.

Transmission lines from the Dimapatoy dam to the settling basin were severely damaged and have become useless after the August 1976 earthquake. The transmission main from the settling basin to the poblacion produces considerable head losses due to old age and encrustation.

Fire protection is virtually non-existent because of low water pressure and the presence of only one operational hydrant.

Distribution mains in the poblacion are laid 2 to 3 meters under concrete pavement, making tapping and maintenance work very difficult and costly.

Preventive maintenance is severely lacking. Galvanized thin wall pipe is used for service lines. Plumbing equipment for proper operation and maintenance is inadequate.

ANNEX IV-E

HYDRAULIC SURVEY DATA

ANNEX TABLE IV-E-1

FLOW AND PRESSURE DATA

Test Point[1/]	Flow (lps)	Pressure (kg/sqcm)	Date of Test	Remarks
TP-1	32.3	6.20	6 February 1977	
	30.9	6.12	7 February 1977	
TP-2	17.5	7.74	7 February 1977	
TP-3	22.0	0	7 February 1977	Flow into the settling basin through the 200-mm line.
TP-4	9.3	0	7 February 1977	Flow into the settling basin through the 150-mm line.
TP-5	33.6	.56	8 February 1977	Settling basin discharge valve in normally throttled position.
	42.7	.53	10 February 1977	Settling basin valve fully open.
TP-6	39.0	5.77	8 February 1977	Settling basin valve throttled.
	47.7	5.98	10 February 1977	Settling basin valve fully open.
	39.2	5.42	10 February 1977	Settling basin valve fully closed and bypass valves fully open.
TP-7	30.7	1.65	9 February 1977	Settling basin valve fully open.
	30.5	1.62	10 February 1977	Settling basin valve fully open.
TP-8	12.6	.43	9 February 1977	Hydrant flow with the 250-mm transmission main isolated; that is, all valves to distribution mains closed.

1/ See Figure IV-E-1 for proper identification.

ANNEX TABLE IV-E-2

TEST DATA AT SANTOS PUMP STATION

Flow (lps)	Pressure (kg/sqcm)	Pumping Water Level (m)	Total Head (m)
10.32	.211	13.5	15.61
10.4	.704	10.36	17.40
9.36	1.408	8.74	22.82
8.80	2.112	8.23	29.35
8.25	1.816	7.91	36.07
7.00	3.520	8.33	43.53
6.45	4.224	8.74	50.98
5.44	4.928	8.84	58.12
4.84	5.632	7.77	64.10
4.29	6.336	8.63	72.00
3.49	7.040	8.36	78.76
2.76	7.744	8.60	86.04
1.36	8.449	15.24	99.72

ANNEX TABLE IV-E-3

TEST DATA AT GENERAL LUNA PUMP STATION

Flow (lps)	Pressure (kg/sqcm)	Pumping Water Level (m)	Total Head (m)
11.99	0	26.49	26.49
11.48	.704	26.49	33.53
11.10	1.408	26.26	40.34
10.85	2.112	26.06	47.18
10.22	2.887	25.85	54.72
9.97	3.520	25.65	60.85
9.40	4.365	25.40	69.05
8.83	4.999	25.04	75.03
8.33	5.632	24.79	81.11
7.95	6.336	24.66	88.02
7.51	6.900	24.43	93.43
4.73	9.152	23.42	114.94

ANNEX TABLE IV-E-4

TEST DATA AT ILANG-ILANG PUMP STATION

Flow (lps)	Pressure (kg/sqcm)	Pumping Water Level (m)	Total Head (m)
14.26	.211	11.32	13.43
13.38	.774	11.26	19.00
13.50	1.408	11.11	25.11
13.88	2.112	11.05	32.17
13.75	2.887	11.05	39.92
14.07	3.520	11.06	46.26
13.88	4.224	11.01	53.25
11.86	4.928	10.48	59.76
8.90	5.632	9.79	66.11
8.96	6.407	10.41	74.48
5.05	6.900	8.53	77.53
0	7.252	8.05	80.57

ANNEX TABLE IV-E-5

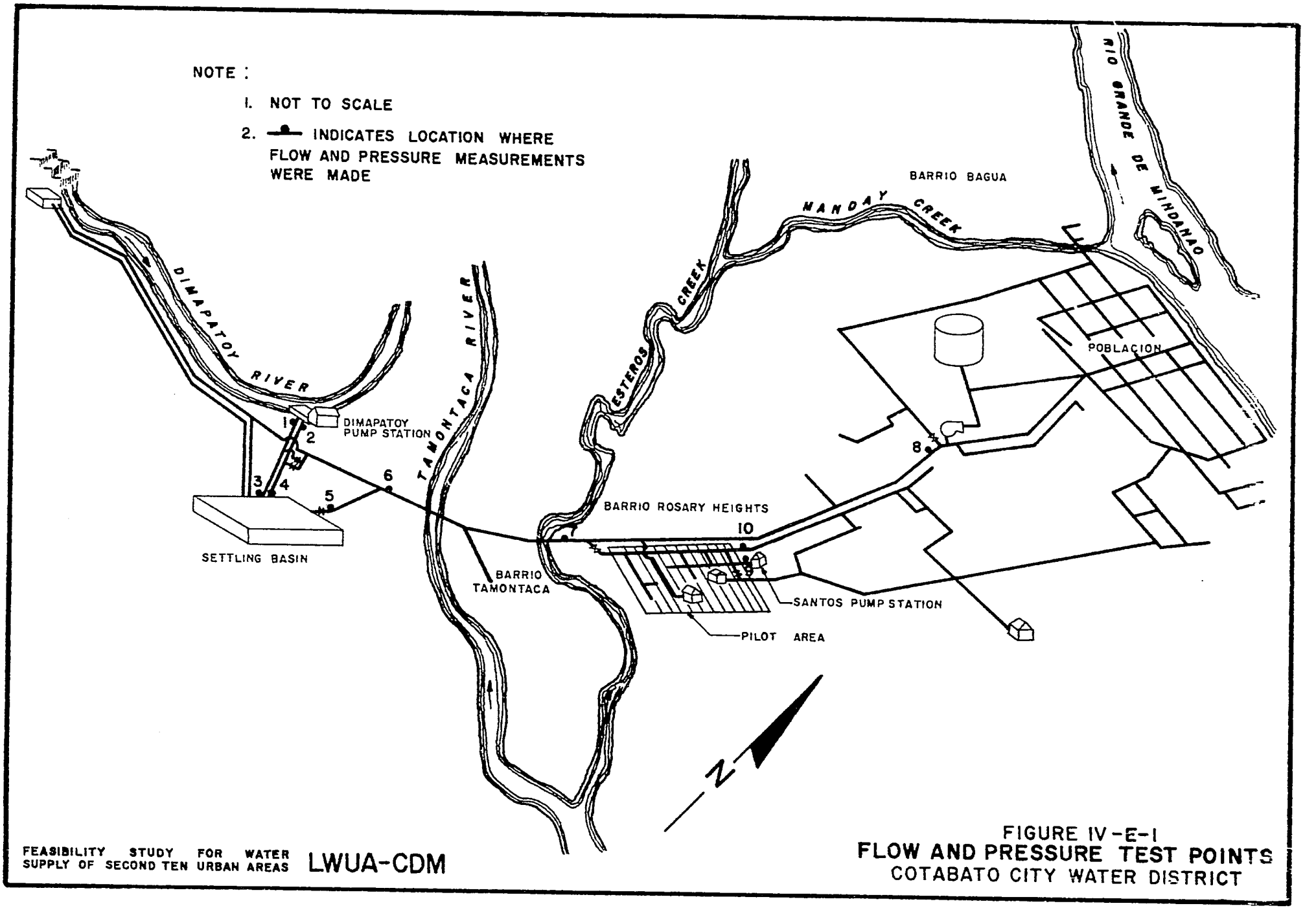
TEST DATA AT ORTOUSTE PUMP STATION

Flow (lps)	Pressure (kg/sqcm)	Pumping Water Level (m)	Total Head (m)
14.38	0	14.10	14.10
13.94	.845	13.98	22.43
13.38	1.408	13.96	28.04
13.19	2.112	13.88	42.04
13.06	2.816	13.88	42.04
12.62	3.520	13.69	48.89
11.86	4.224	13.33	55.57
9.65	4.928	12.82	62.10
5.68	5.632	12.36	68.68
0	6.196	12.29	74.25

ANNEX TABLE IV-E-6

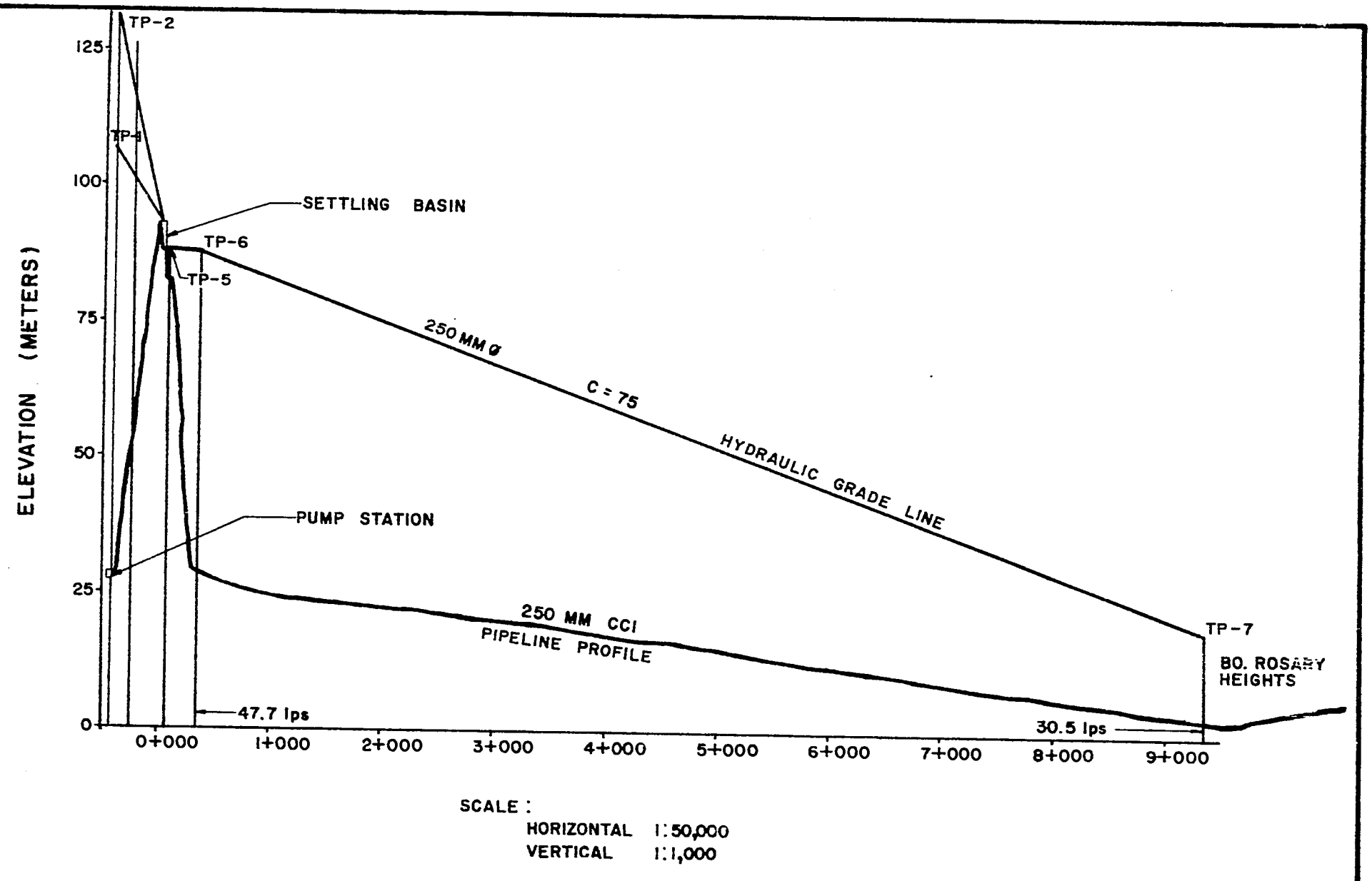
PILOT AREA FLOW DATA

TP - 9			TP - 10		
Time	Flow (lps)	Pressure (kg/sqcm)	Time	Flow (lps)	Pressure (kg/sqcm)
8:40 am	11.18	1.69	9:10 am	4.68	1.02
9:30 am	8.41	1.55	10:20 am	4.58	0.81
10:45 am	12.22	1.55	11:10 am	4.11	0.92
11:35 am	12.28	1.58	12:00 noon	3.98	0.92
2:15 pm	10.59	1.83	2:45 pm	5.09	1.51
3:15 pm	10.65	1.90	3:40 pm	4.49	1.48
4:05 pm	10.93	1.97	4:30 pm	4.11	1.41
4:55 pm	11.22	1.83	5:15 pm	4.66	1.20



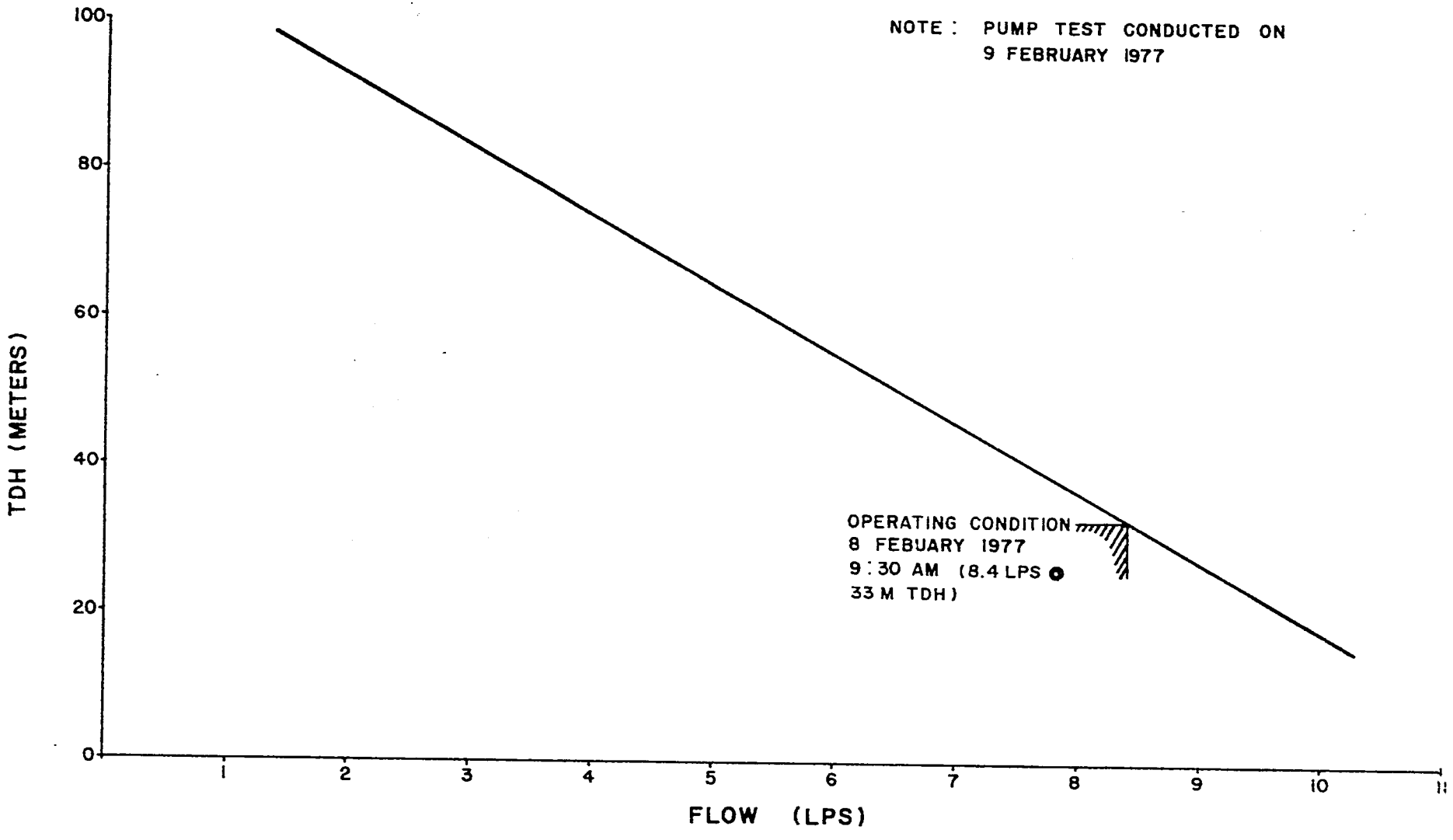
FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

FIGURE IV-E-1
FLOW AND PRESSURE TEST POINTS
COTABATO CITY WATER DISTRICT



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

FIGURE IV-E-2
DIMAPATOY PUMP STATION TO BO. ROSARY HEIGHTS
HYDRAULIC GRADE LINE
COTABATO CITY WATER DISTRICT



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

FIGURE IV-E-3
SANTOS PUMP H-Q CURVE
COTABATO CITY WATER DISTRICT

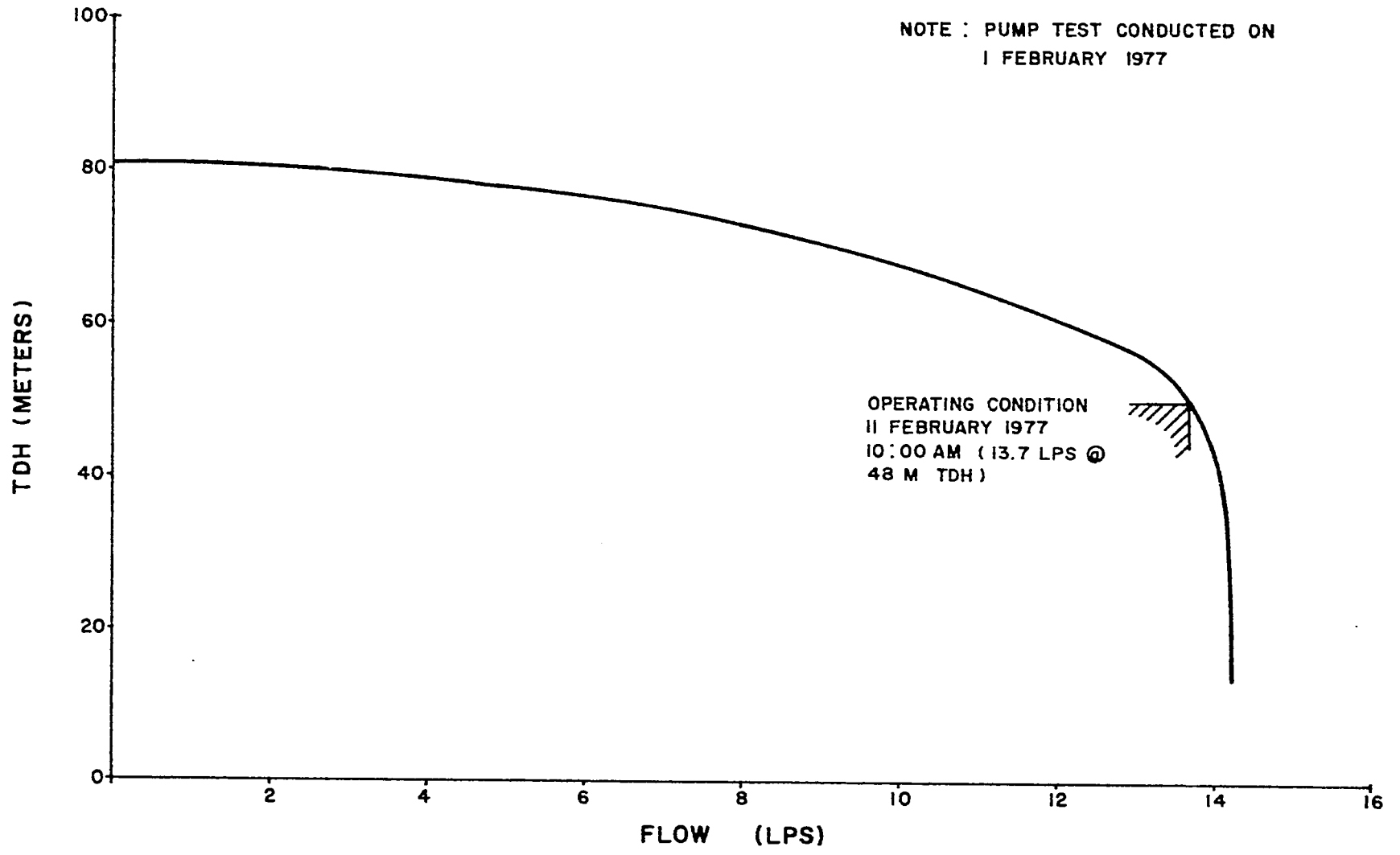
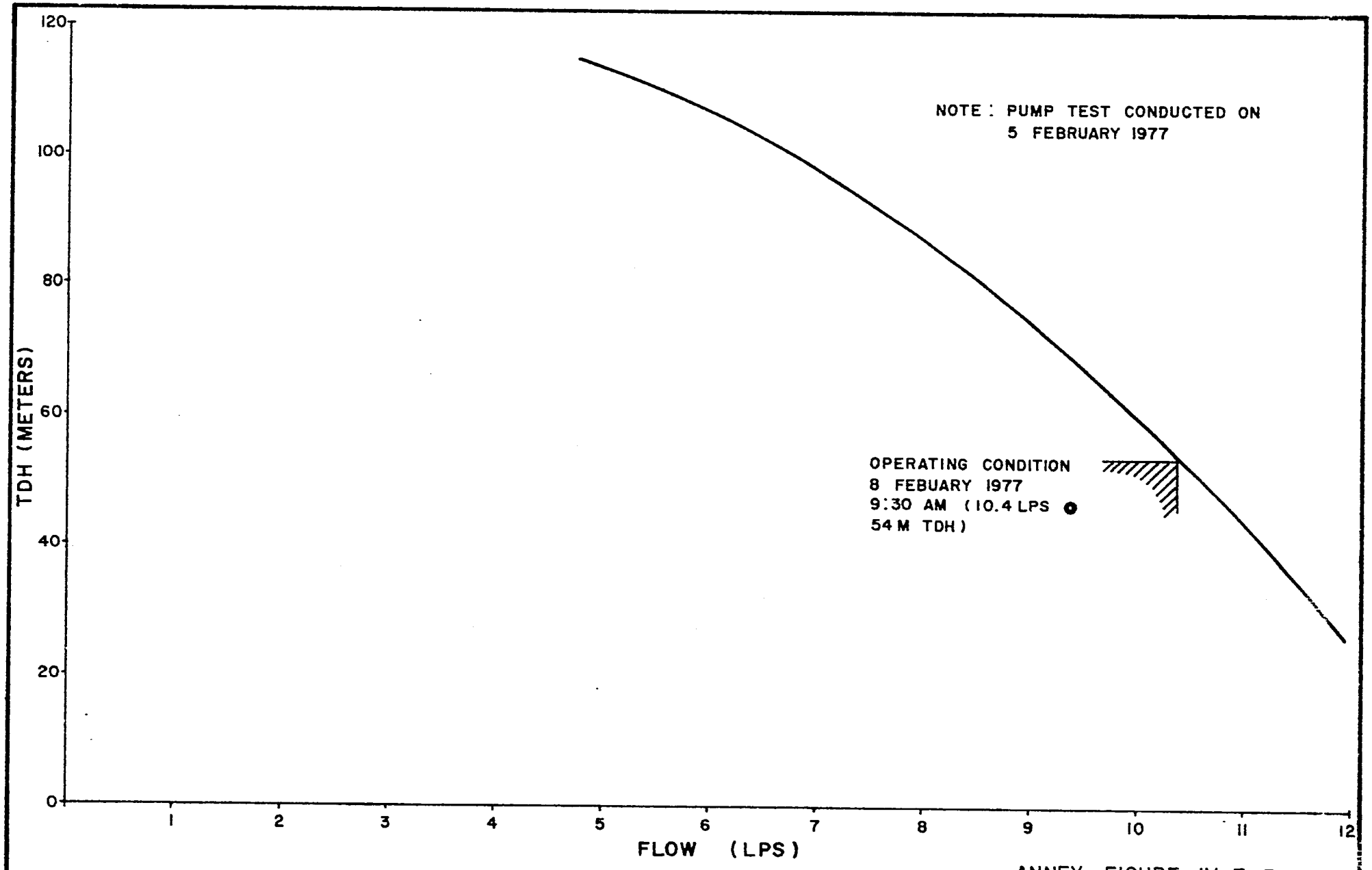


FIGURE IV-E-4
ILANG-ILANG PUMP H-Q CURVE
COTABATO CITY WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

ANNEX FIGURE IV-E-5
GENERAL LUNA PUMP H-Q CURVE
COTABATO CITY WATER DISTRICT

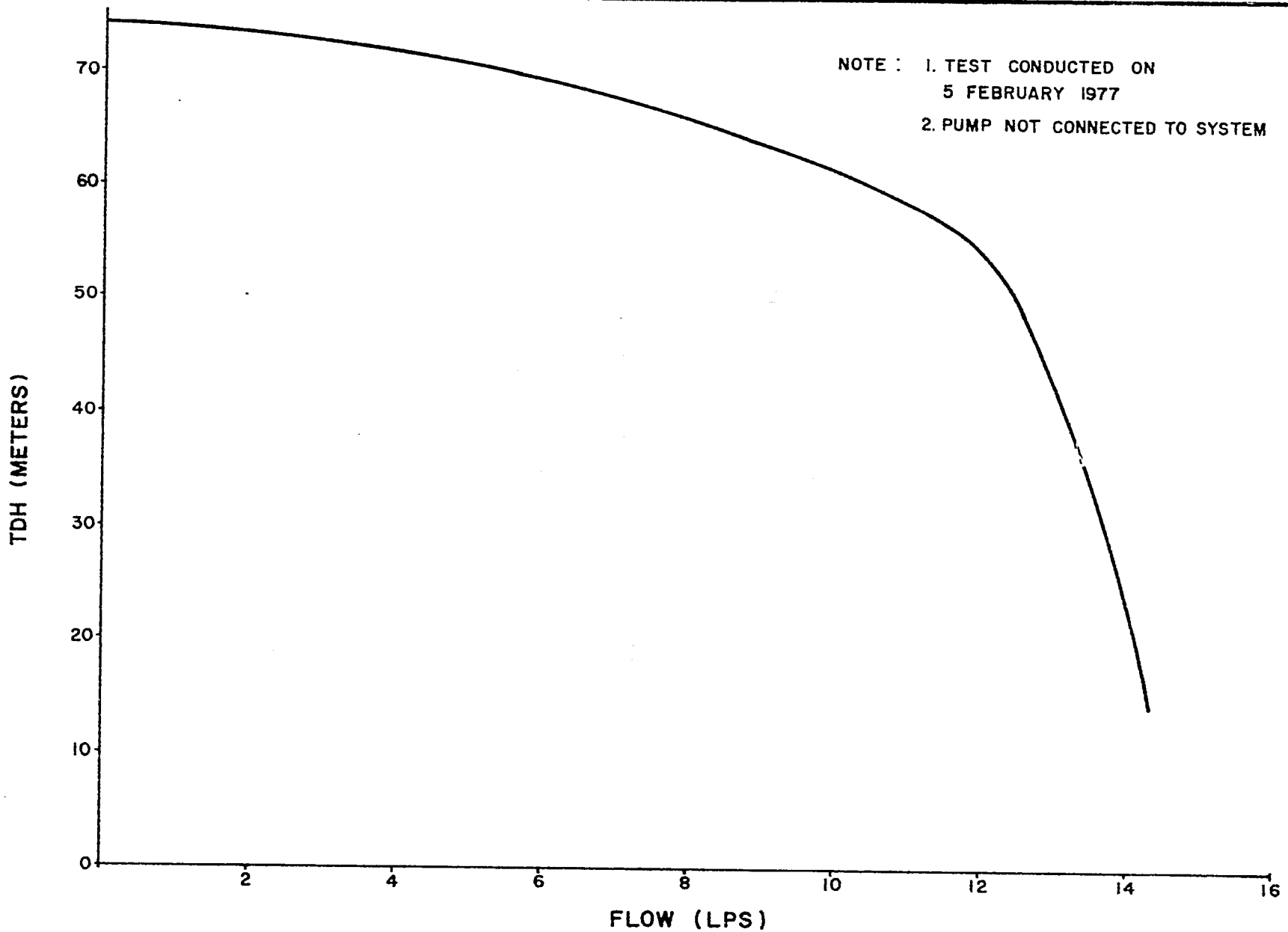
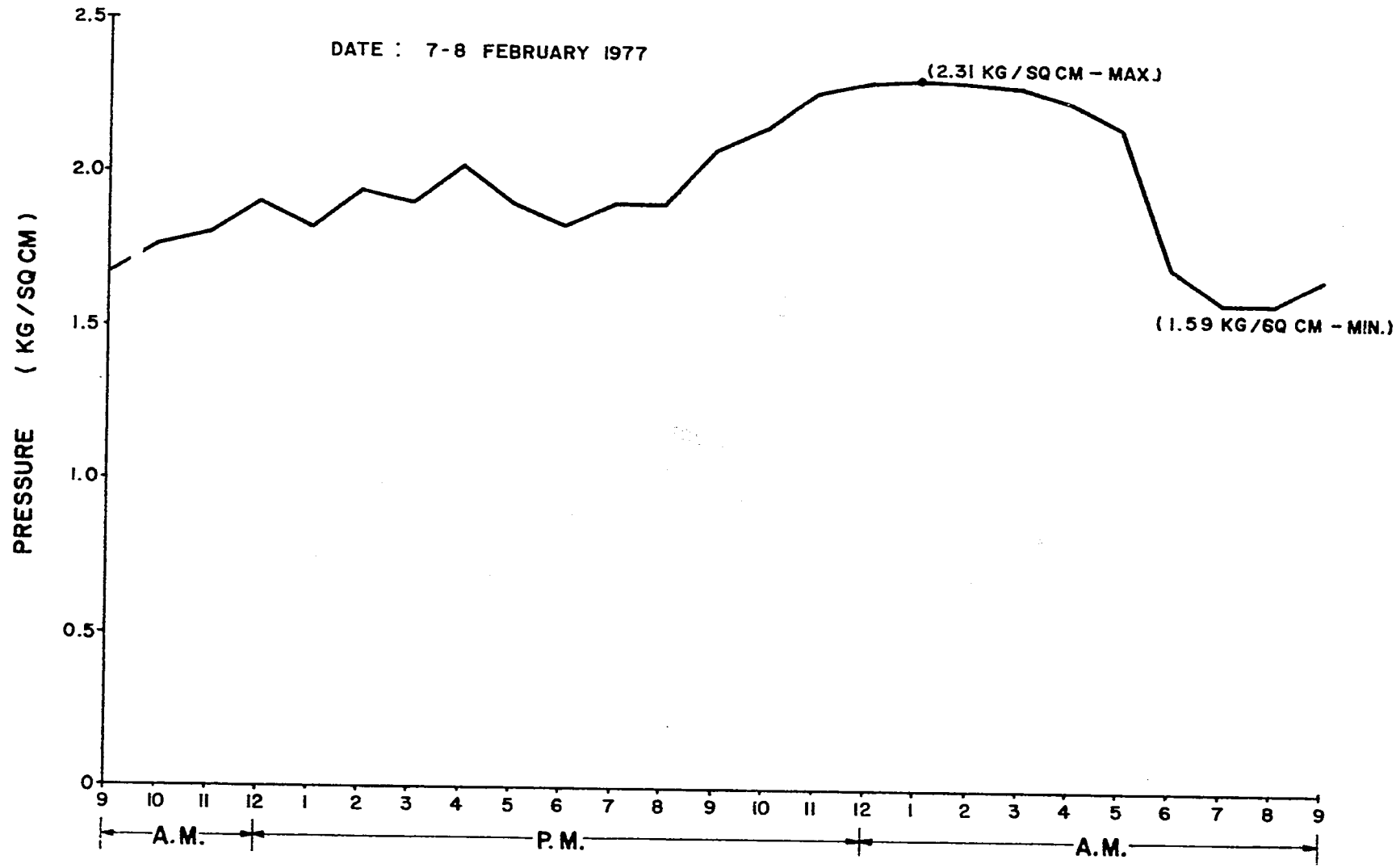


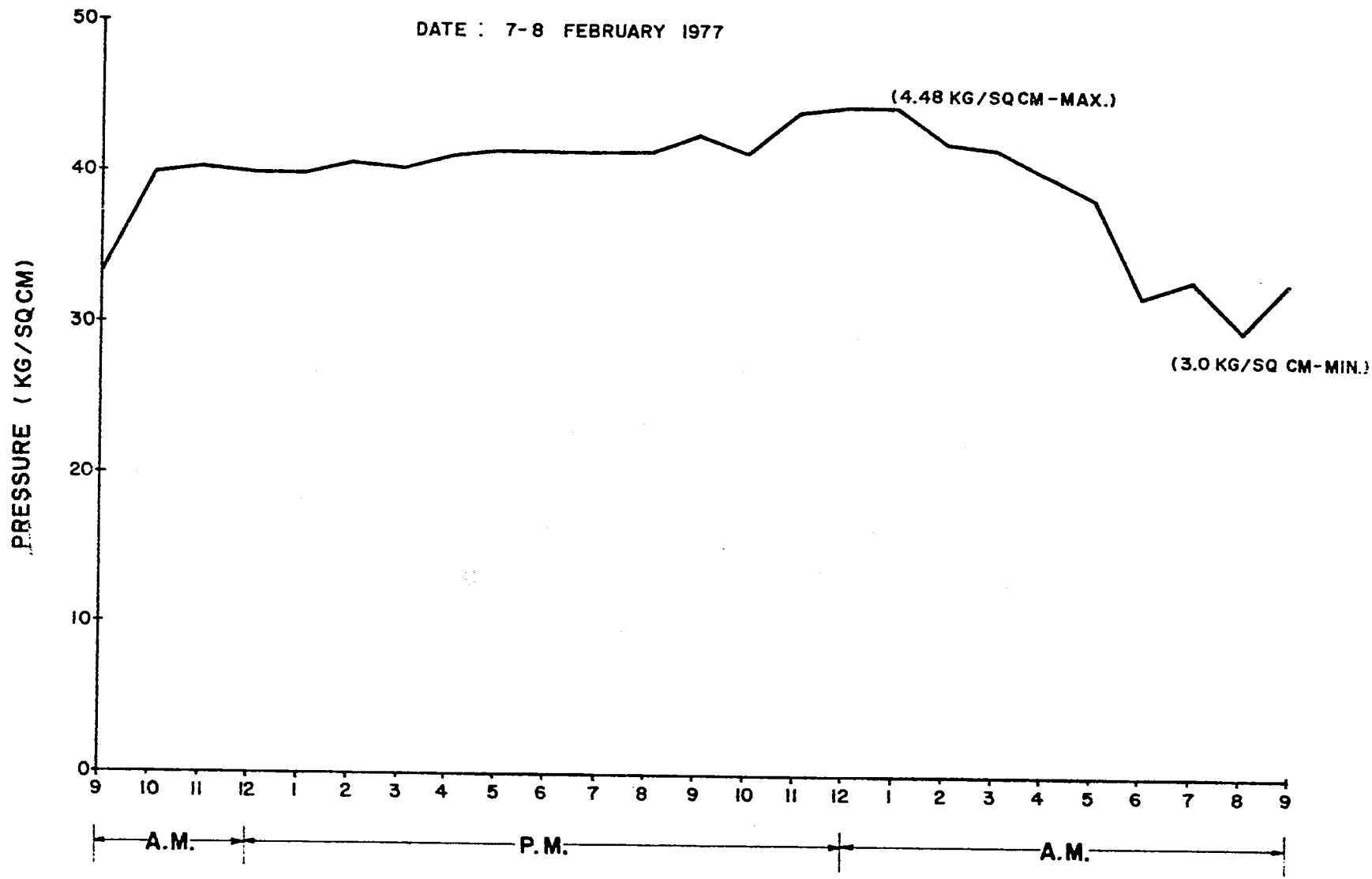
FIGURE IV-E-6
ORTUOSTE PUMP H-Q CURVE
COTABATO CITY WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS **LWUA-CDM**



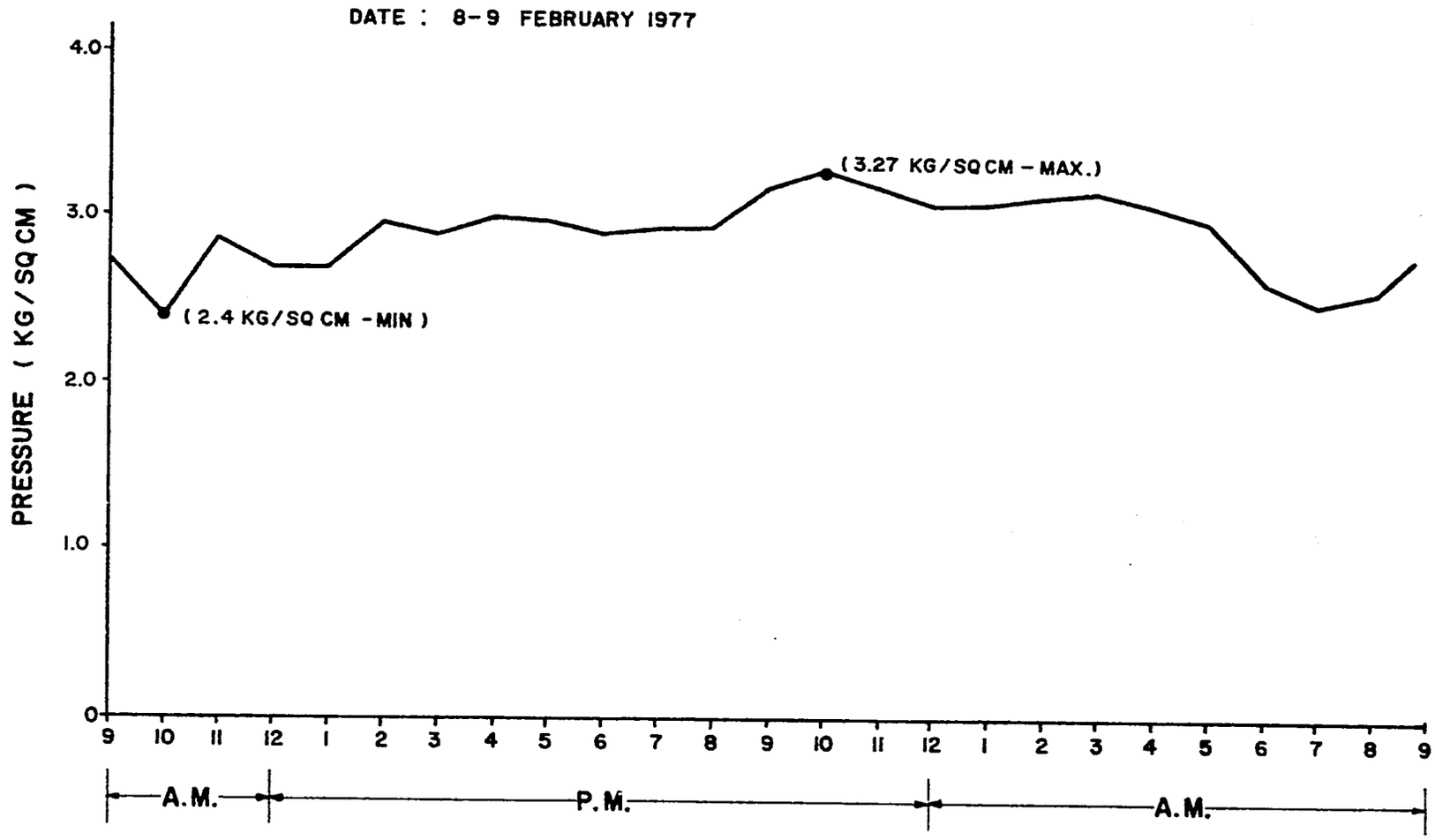
ANNEX FIGURE IV-E-7
24-HOUR DISCHARGE PRESSURE
AT SANTOS PUMP STATION
COTABATO CITY WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM



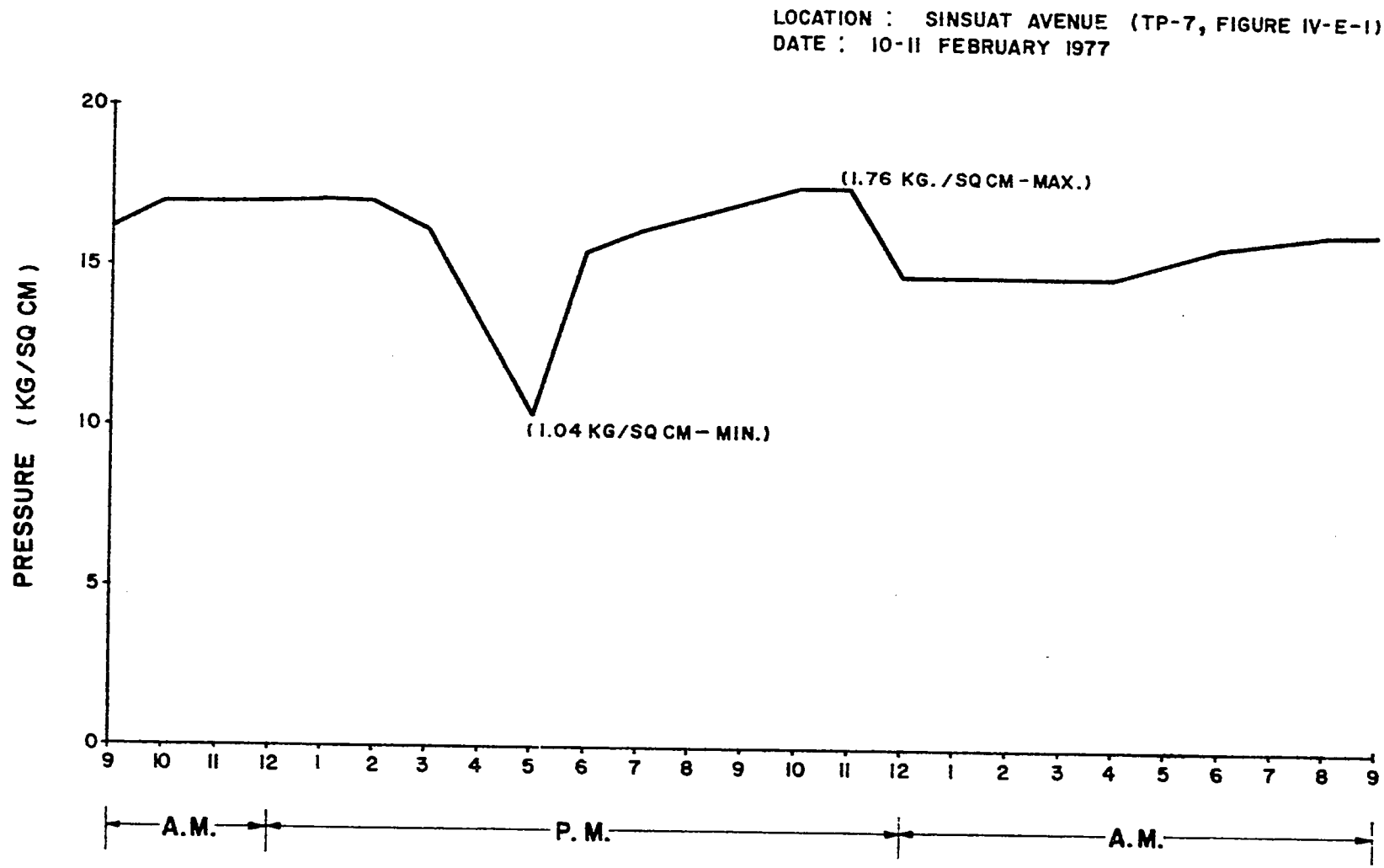
FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

ANNEX FIGURE IV-E-8
24-HOUR DISCHARGE PRESSURE
AT ILANG-ILANG PUMP STATION
COTABATO CITY WATER DISTRICT



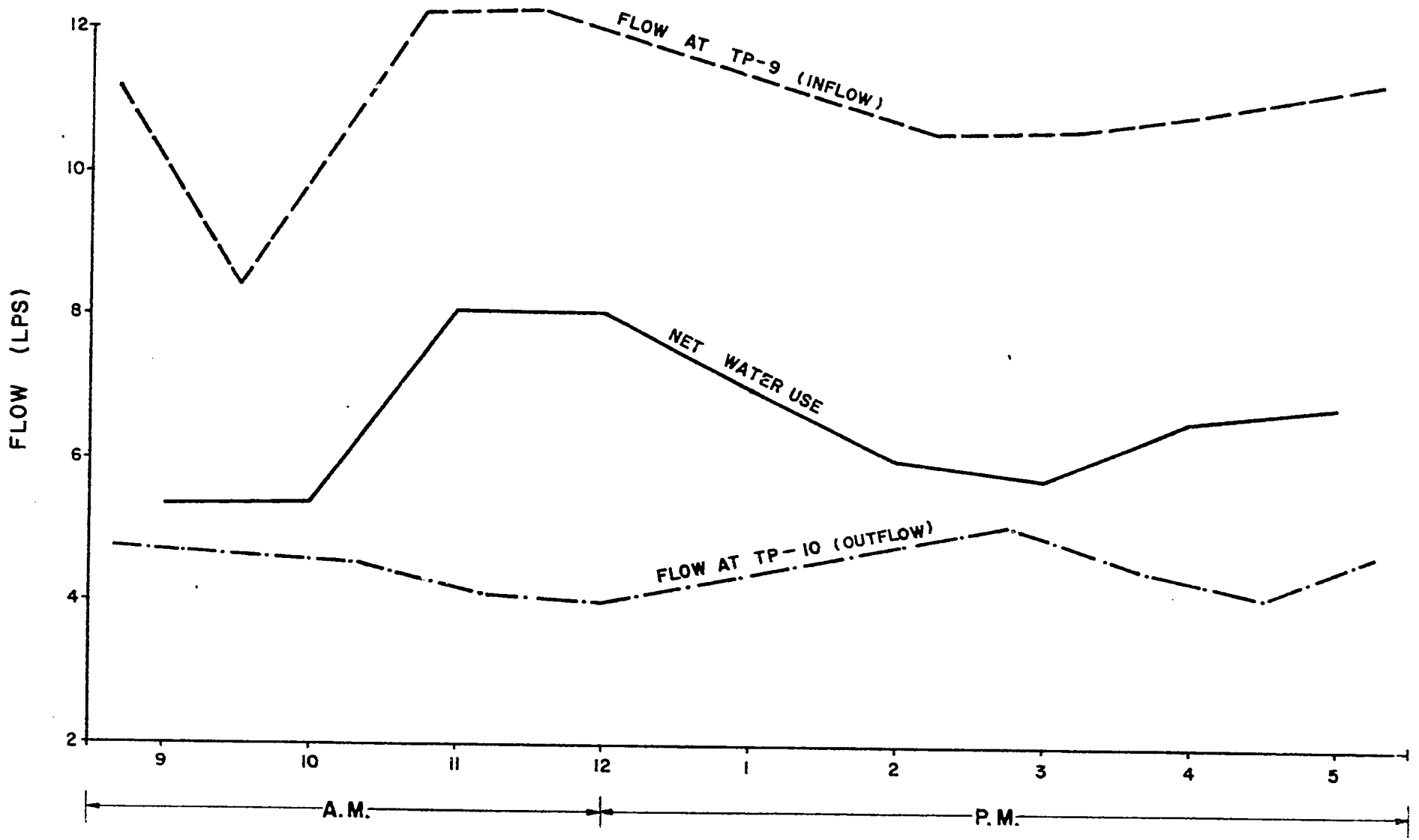
ANNEX FIGURE IV-E-9
24-HOUR DISCHARGE PRESSURE
AT GEN. LUNA PUMP STATION
COTABATO CITY WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

ANNEX FIGURE IV-E-10
24-HOUR SYSTEM PRESSURE
AT TEST POINT NO.7
COTABATO CITY WATER DISTRICT



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

FIGURE IV-E-II
PILOT AREA WATER USE CURVE
COTABATO CITY WATER DISTRICT

CHAPTER V FEASIBILITY STUDY CRITERIA

A. GENERAL

The planning, design, economic, and financial criteria used in the water supply feasibility studies have been derived from studies of local conditions, accepted practices, standards and methods developed in the First Ten Provincial Urban Areas Feasibility studies. These criteria, together with the developed basis of cost estimates have been utilized to evaluate and compare the various alternatives identified in the course of the study.

In the analysis and evaluation of alternatives, feasibility study criteria need not be as refined as those used in the detailed development of the recommended scheme. Consistency is, however, essential. As long as each alternative to be analyzed is judged by similar criteria (or rules), the choice of alternatives will 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 listed in order of importance):

1. Areawide Approach: Planning of facilities has been done on a regional or areawide basis taking into account the present district service boundaries and the logical long-term service areas beyond present district or political boundaries.

2. Source of Water: Groundwater and surface water have been given equal consideration as potential sources of water. However, based on the first 10 feasibility studies, disinfected groundwater derived from deep wells, when available, is expected generally to be more economical than conventionally treated surface water.

2. Self-Sufficiency: The recommended plan has been developed to provide the highest quality of water service within the "ability-to-pay" of the consumers.

4. Conservation: In the selection among alternative plans, water, power, chemicals and foreign exchange are considered valuable resources which must be conserved to the greatest extent possible.

5. Stage Development: The recommended long-range construction program has been divided into several stages, each of which satisfies the projected requirements for a specific design year.

Stage	Start Construction by Calendar Year	Target Design Year
Immediate Improvement	1978	1980
Phase I-A	1980	1985
Phase I-B	1986	1990
Phase II-A	1991	1995
Phase II-B	1996	2000

6. Alternative Plan Screening and Selection: From an array of identified plan alternatives, the recommended plan has been selected on the basis of least (present worth) cost and other non-economic parameters. The selected plan has been tested for economic/financial feasibility.

7. Skilled Manpower Shortage: The recommended plan has recognized, in the short term, the apparent shortage in skilled, technical and managerial expertise. Emphasis has been given on the need for district personnel training and certification.

8. Water Quality: The feasibility study has identified present and future water quality problems and includes recommendations for providing a water supply that is safe, healthful and wholesome.

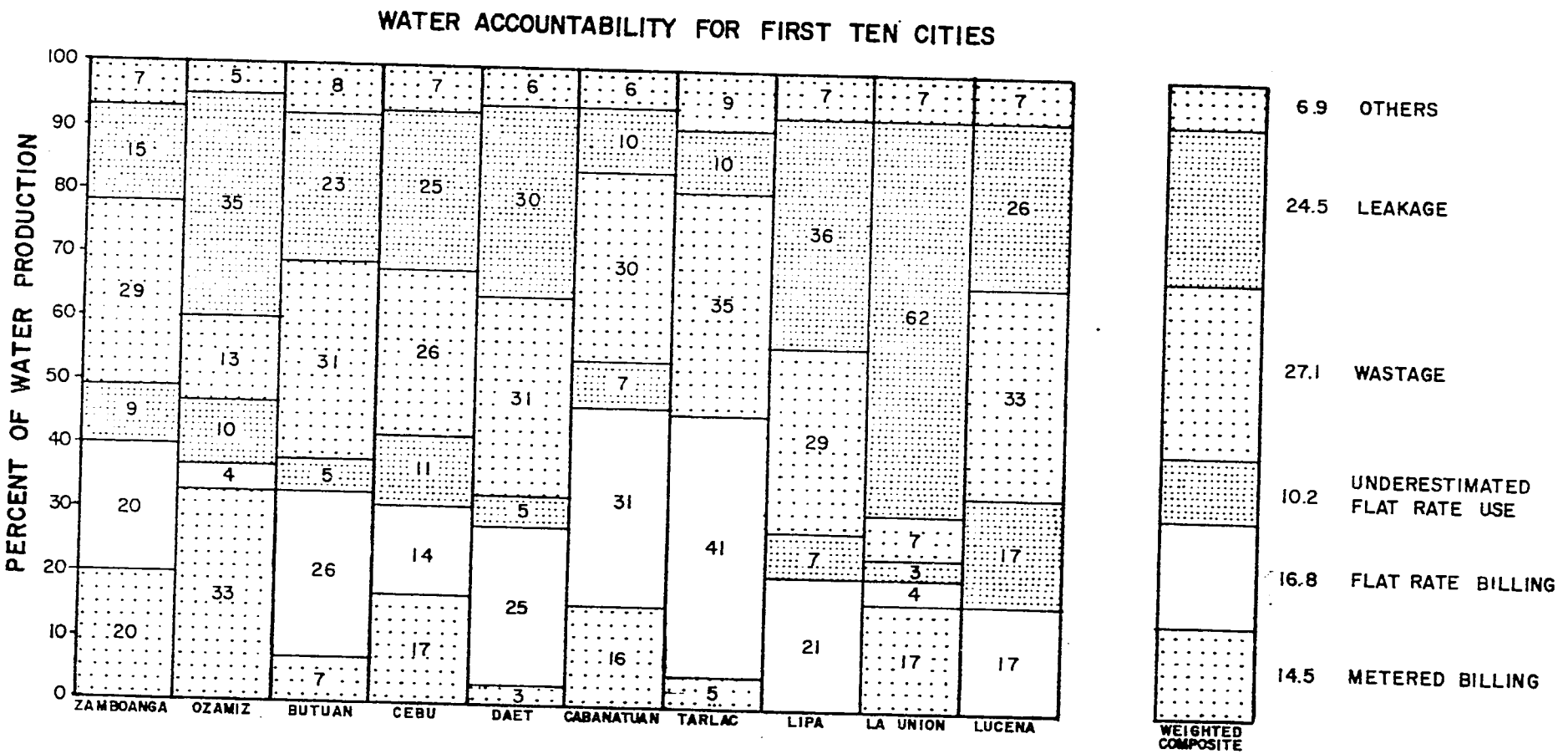
9. Social Soundness: The successful completion of any project must take into account the social acceptability of its recommended programs (Appendix S, Volume II).

C. DESIGN CRITERIA

The basis of design for these feasibility studies is presented in detail in Appendix F, Volume II of this Report. The design criteria are basically similar to those utilized in the First Ten Provincial Urban Areas feasibility studies. Minor improvements/modifications have been made as indicated in the Methodology Memoranda attached herein in Volume I.

Water Accountability

As much as possible, water accountability has been determined through field testing and measurement procedures, augmented by data gathered in the pilot area study surveys (see Methodology Memoranda No. 1 and 2). Where field data were not available and the pilot area study survey results were not conclusive, the weighted average of the water accountability results in the First Ten Provincial Areas was used (see Figure V-1).



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

FIGURE V-1
WATER ACCOUNTABILITY
FIRST 10 CITIES

The breakdown of the water accountability is as follows:

	Percent of Water Production
Metered Billing	14.5
Flat-Rate Billing	16.8
Underestimated Flat-Rate Use	10.2
Wastage	27.1
Leakage	24.5
Others	6.9
	100.0

Water Demand Grouping

A procedure has been developed to classify communities in the Philippines into one of 5 groups for purposes of water demand projections. Available data on population, population growth, housing, income and other economic and technical parameters are used in the classification, with a system of weighting (see Methodology Memorandum No. 3). In general, the water demand requirements per capita through the period 1980-2000 are as follows:

Group 1	261 - 273 lpcd
Group 2	220 - 230 lpcd
Group 3	193 - 199 lpcd
Group 4	174 - 181 lpcd
Group 5	157 - 165 lpcd

The above values include domestic water needs; allowances for nominal commercial, industrial and institutional use; and a decreasing percentage of unaccounted-for-water in time.

For the analysis of existing conditions, actual metered (or connected) customers and "borrowers" are considered separately (see Methodology Memorandum No. 2). However, for short- and long-range planning, it has been assumed that "borrowers" would eventually become metered consumers. Per capita domestic use has been increased each year to account for economic growth within the community. Institutional and commercial water demands have been estimated as a percentage of domestic demand (see Methodology Memorandum No. 3).

Demand Variation

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

maximum-day to average-day ratio = 1.2:1
peak-hour to average-day ratio = 1.5:1 - 1.75:1

D. ECONOMIC AND FINANCIAL CRITERIA

Discount Rate

The opportunity cost of capital or discount rate used in this feasibility study is 12 percent. The discount rate has been used for economic screening of the technically viable alternatives (see Chapter IX, Methodology Manual on Water Supply Feasibility Studies, Volume I).

Inflationary Trends

The national economy of the Philippines is discussed in Appendix E, Volume II.

Projections made in this feasibility study assume a general cost escalation rate of 10 percent for the period 1978 through 1980; 8 percent for the period 1981-1985; and 6 percent thereafter. The cost of maintenance and operation is assumed to escalate at 8 percent per annum.

Economic Justification

The economic feasibility of this water supply project is based on 2 parameters: benefit-cost ratio (B/C) and the internal economic rate of return (IERR). These parameters are discussed in Chapter XI.

Financial Criteria

The financial justification of this project is based on the district customers' ability-to-pay (see Chapters XX and XXI, Methodology Manual) and a suggested socialized pricing scheme, based on increasing unit cost of water with increasing consumption (see Chapter X).

E. BASIS OF COST ESTIMATES

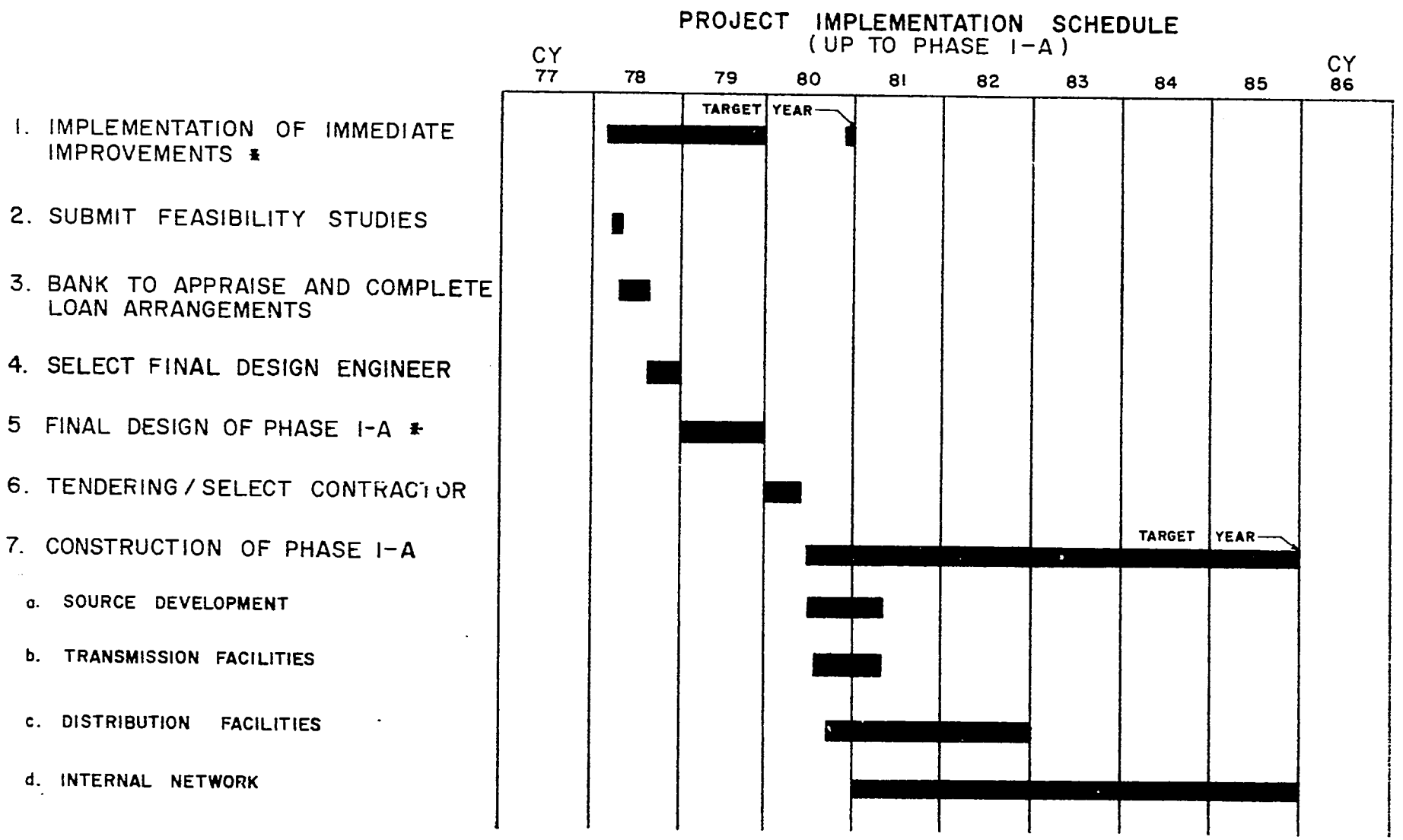
Construction cost curves have been developed for inplace costs of pipelines, deep wells, water treatment plants, pump stations, and storage reservoirs. These cost curves have been used for estimating the relative cost magnitudes of alternative water supply plans. Escalation factors used in calculating the capital cost of recommended improvements in July 1978 prices, as well as the above unit costs, are presented in Appendix G, Volume II.

F. IMPLEMENTATION SCHEDULE

For purposes of feasibility study and economic/financial analyses, an implementation schedule has been assumed. Figure V-2 shows the probable time-table which covers the planning, design, and implementation of the immediate improvement program and Phase I-A. It is assumed in these feasibility studies that the recommended immediate improvement program is to be fully implemented by the LWUA Interim Demonstration Program by 1979.

Estimated Phase I-A Schedule

Final Report Submission	February	1978
Select Final Design Engineer	September	1978
Start Final Design	January	1979
Complete Final Design	January	1980
Start Construction	July	1980
Complete Construction:		
a) Source	Early	1981
b) Distribution	Early	1982
c) Internal Network	Late	1985



* PHASE I-A ASSUMES THE FULL IMPLEMENTATION OF THE IMMEDIATE IMPROVEMENT PROGRAM

FIGURE V-2
PROJECT IMPLEMENTATION SCHEDULE
COTABATO CITY WATER DISTRICT

CHAPTER VI POPULATION AND WATER DEMAND PROJECTIONS

A. GENERAL

A necessary step in developing the preliminary design of a water system is the projection of future population and water demand for the delineated service area. These projections have a significant impact on facility layouts and sizes, construction staging and cost of the project. The population and water demand projections for the COTWD are discussed in this chapter.

B. POPULATION PROJECTIONS

The population growth of Cotabato City for the period 1948-75 shows decreasing annual growth rates from 5.20 to 1.76 percent. From 1948 to 1970, the average annual growth rates of Cotabato were 2 percent higher than the national rates. For 1970-75, the growth rates of Cotabato were lower than the national growth rates. The following table presents a comparison of these growth rates as well as the population of Cotabato from 1948 to 1975.

Year	Population	Annual Growth Rate (%)	National Growth Rate (%)
1948	20,407		
1960	37,499	5.20 (1948-1960)	3.1
1970	61,184	5.01 (1960-1970)	3.0
1975	66,756	1.76 (1970-1975)	2.6

The significant decrease in the growth rate of Cotabato City in 1970-75 was presumably caused by the deteriorating peace and order condition in the area. During this period, people were evacuating to other municipalities and provinces. In contrast, during the previous years, people from different provinces were migrating to Cotabato City in response to a vigorous resettlement campaign of the government. At present the government is taking all possible steps to normalize the peace and order situation and the development of the city.

The primary factors that will affect the future growth in the COTWD service area are: the resumption of normal growth with the restoration of peace and order; the continuing development of the city as a commercial center of Maguindanao province; the expected expansion of the universities; the migration from other provinces, cities and municipalities to the city; the development of housing facilities; and the accessibility by air, water and land transportation.

Since the past average national growth rates varied from 3.0 to 2.6 percent annually, it is assumed that Cotabato will have a growth rate of 2.5 percent for 1975-80, considering no abrupt change from

the rate of 1.76 percent in 1970-75. It is also assumed that for 1980-90, the growth rate of Cotabato Will further increase to 4.0 percent, with greater migration to the city resulting from an improving peace and order situation.

On the basis of field inspection, observation and discussion with the water district and local officials, and the city development plan, Figure VI-1 has been developed to indicate present, immediate, projected 1990 and 2000 service areas of COT-WD. By the year 2000, the COT-WD is expected to serve the entire poblacion, Rosary Heights, and the principal portions of barrios Bagua, Tamontaca, and Kalanganan.

The methodology used in projecting the population included applying the ratio method and the growth rates for the province, city, poblacion and barrios in the service area derived through field observations and discussions with local officials/citizens. Growth rates were determined and adjusted, based on engineering judgment and field condition. NEDA-POPCOM projections were not used because they were much higher than the actual city population count (for example, the actual 1975 city population was lower by about 12,000 than the NEDA-POPCOM medium assumption projection); however, the NEDA growth rates were used to check LWUA-CDM projections for 1990-2000.

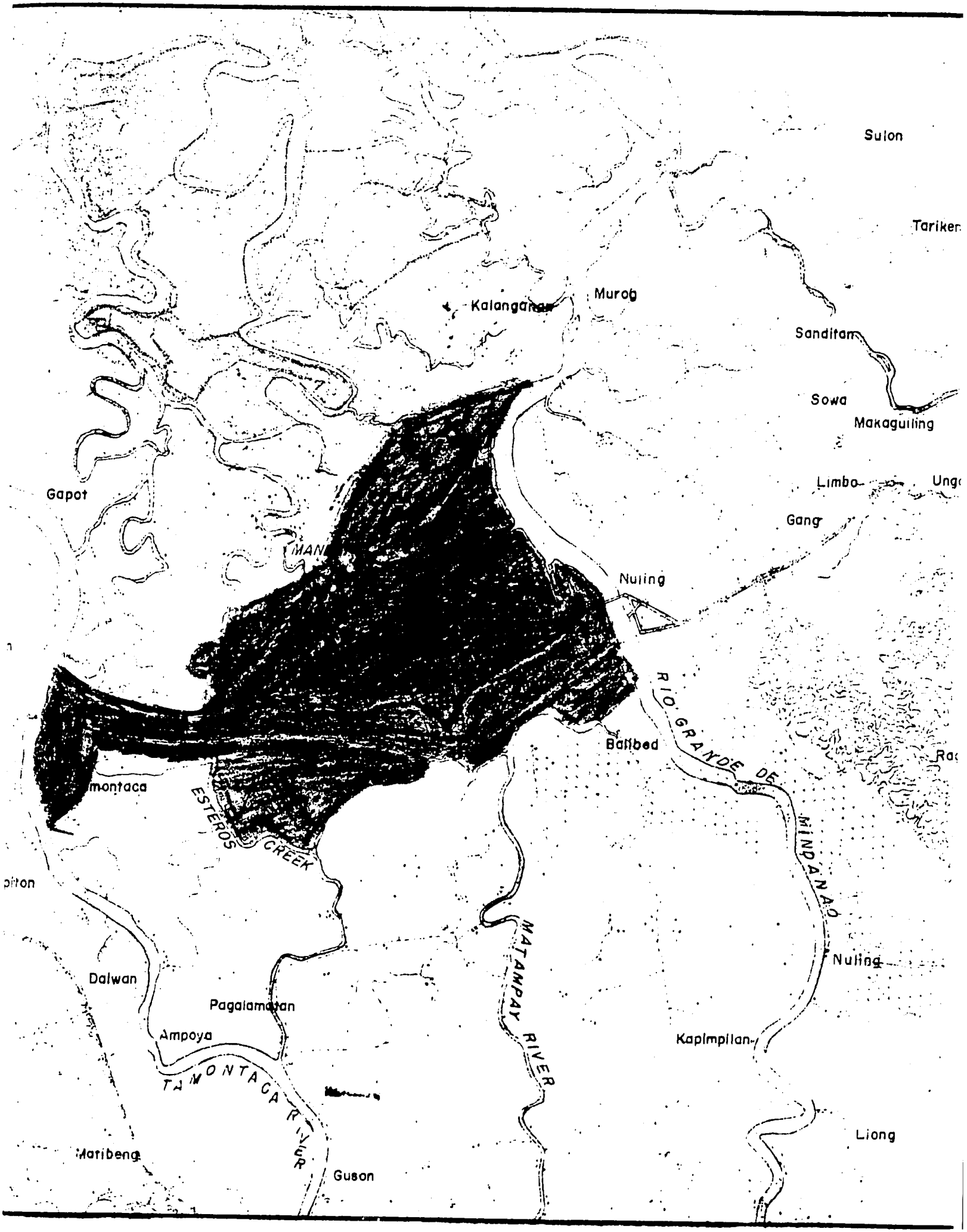
Service area population projections are shown in Table VI-1 and are summarized below:

Year	Population[1/]	Overall Annual Growth Rate(%)	Population in Service Area	Service Area(ha)	Overall Density in Service Area (person/ha)
1975(Present)	66,756		50,300	367	137
1980(Immediate)	75,530	2.5(1975-1980)	55,170	367	150
1990	111,320	4.0(1980-1990)	87,840	813	108
2000	157,560	3.5(1990-2000)	135,650	1,319	103

The analysis shows that the population in the service area (Figure VI-2) will increase from 50,300 in 1975 to 135,650 in the year 2000. Average densities in the service area will vary from 103 to 150 persons per hectare. The total population of the poblacion and other barrios will increase from 66,756 to 157,560 in the year 2000. Overall annual growth rates in this area will average 3.5 percent for the period 1975-2000.

[1/] Of poblacion and other barrios

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM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Sowa
Makaguiling
Limbo
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Gapot
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Balibed
montaca
ESTEROS CREEK
MATAMPAY RIVER
Nuling
Dalwan
Pagalamatan
Ampoya
Kapimpilan
TAMONTACA RIVER
Liong
Matibeng
Guson

Kalangangan
Murog
Sandiman
Sowa
Makaguling
Limbo
Gang
Gapot
COTABATO
Nuling
RIO GRANDE DE MINDANAO
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ESTERO
MATAMPAY RIVER
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Dalwan
Pagalamutan
Ampaya
Kalimbian
Gusan

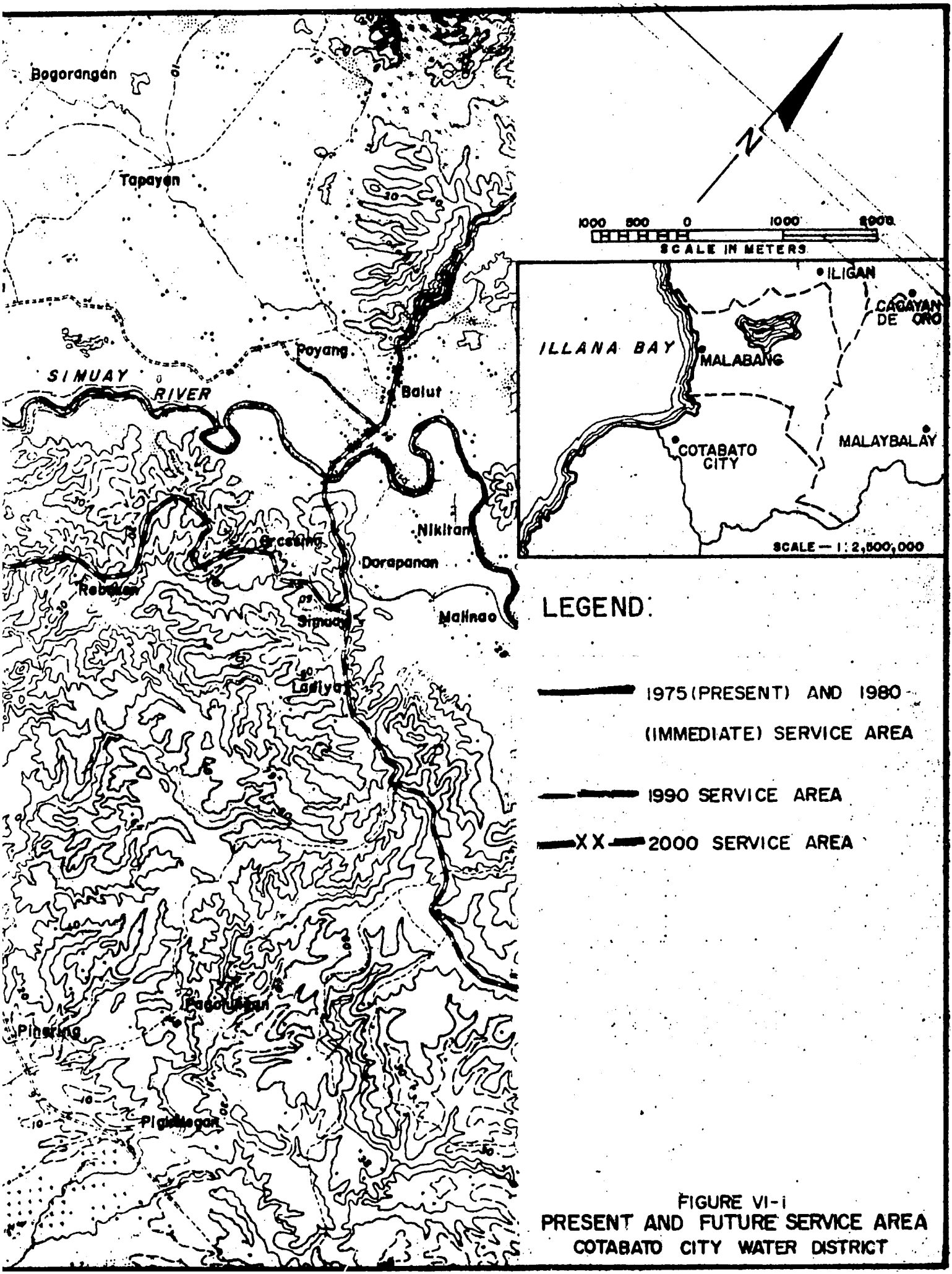

FIGURE VI-1
PRESENT AND FUTURE SERVICE AREA
COTABATO CITY WATER DISTRICT

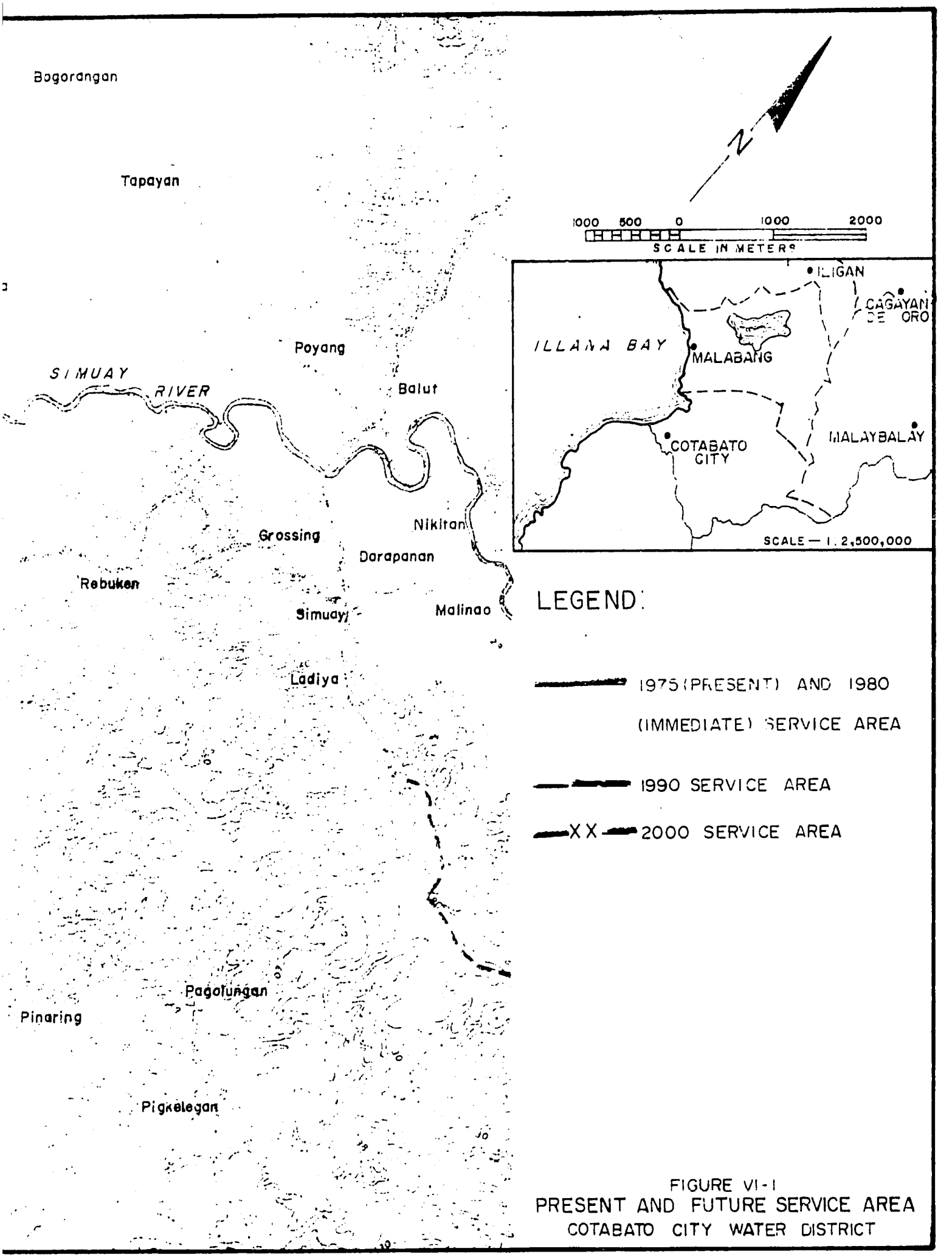

FIGURE VI-1
PRESENT AND FUTURE SERVICE AREA
COTABATO CITY WATER DISTRICT

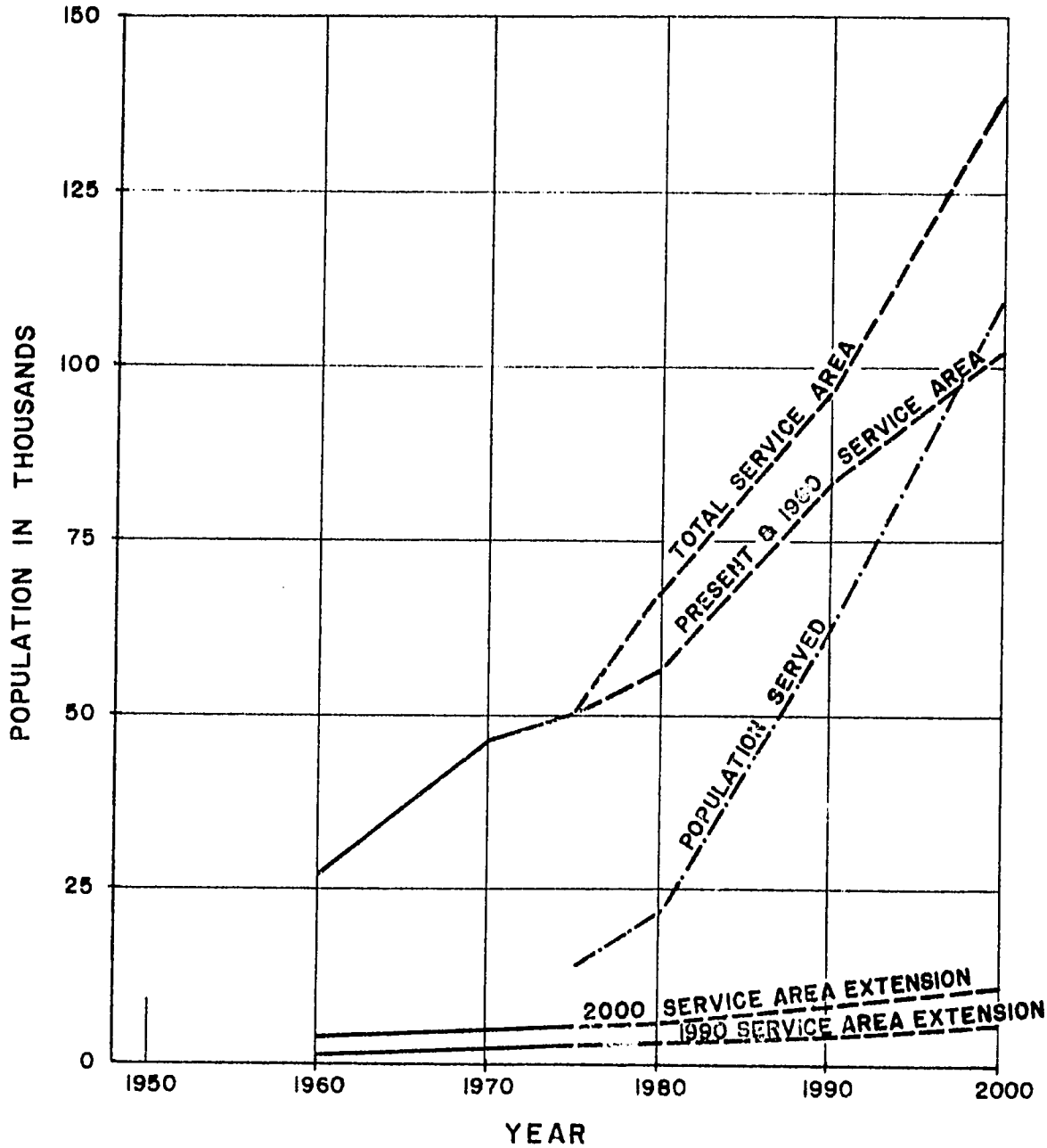

FIGURE VI-2
SERVICE AREA
POPULATION PROJECTION
COTABATO CITY WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

TABLE VI-1

POPULATION PROJECTIONS
COTABATO CITY WATER DISTRICT

		Present Service Area			Immediate Service Area			1990 Service Area			2000 Service Area		
	Population 1975	Population In Service Area	Service Area(ha)	Density (Persons/ha)	Population In Service Area	Service Area(ha)	Density (Persons/ha)	Population In Service Area	Service Area(ha)	Density In (Persons/ha)	Population In Service Area	Service Area(ha)	Density (Persons/ha)
Poblacion	28,758	25,880	98	264	29,150	98	297	39,230	174	225	55,800	217	257
Bagua	6,841	2,050	13.5	152	3,030	13.5	224	6,420	42	153	12,070	143	84
Rosary Heights	21,256	21,260	236	90	21,760	236	92	39,450	507	78	61,260	782	78
Tamontaca	5,547	1,110	19.5	57	1,230	19.5	63	2,740	90	30	5,300	145	36
Kalanganan	4,354	0	0	-	0	0	-	0	0	-	1,220	32	38
Sub-Total	66,756	50,300	367	137	55,170	367	150	87,840	813	108	135,650	1,319	103

C. PROJECTIONS OF SERVED POPULATION

Served population in COT-WD has been projected to increase significantly in the next two decades. The increase will be a result of:

1) The desire of the residents in the COT-WD to partake of the benefits of a modern piped water system;

2) The intense campaign of COT-WD to connect and reconnect many customers;

3) The increase in population and in geographical coverage of COT-WD.

Table VI-2 shows the detailed breakdown of the served population projections for the poblacion and barrios in COT-WD service area. These are summarized below:

Year	Served Population	Population in Service Area	Percent Served
1975 (Present)	13,936	50,300	28
1980 (Immediate)	22,080	55,170	40
1990	61,490	87,840	70
2000	108,520	135,650	80

Table VI-3 shows the year-by-year projections of served population from 1975 to 2000.

D. WATER DEMAND PROJECTIONS

The water demand of COT-WD has been projected to increase significantly as a result of continued growth of the served population. Per capita domestic use, commercial/industrial/institutional use, as well as unaccounted-for-water (expressed as percent of production), have been estimated for the years 1980, 1990 and 2000 for the service area. Based on analyses, COT-WD has been classified under Group III, with the following water use parameters (see Methodology Memorandum No. 3):

TABLE VI-2

SERVED POPULATION PROJECTIONS
COTABATO CITY WATER DISTRICT

	Present Service Area	1980 Immediate Service Area	1990 Service Area	2000 Service Area
I. Poblacion				
a. Population in Service Area	25,880	29,150	39,230	55,800
b. Number of Service Connections	774	1,275	3,920	7,440
c. Connected Population	6,192	10,200	27,440	44,640
d. Percent Connected	24	35	70	80
II. Rosary Heights				
a. Population in Service Area	21,256	21,760	39,450	61,260
b. Number of Service Connections	779	1,199	3,950	8,170
c. Connected Population	6,232	9,592	27,650	49,010
d. Percent Connected	29	44	70	80
III. Bagua				
a. Population in Service Area	2,052	3,030	6,420	12,070
b. Number of Service Connections	150	224	640	1,610
c. Connected Population	1,200	1,792	4,480	9,656
d. Percent Connected	58	59	70	80
IV. Tamontaca				
a. Population in Service Area	1,110	1,230	2,740	5,300
b. Number of Service Connections	39	62	274	707
c. Connected Population	312	496	1,920	4,240
d. Percent Connected	28	40	70	80
V. Kalanganan				
a. Population in Service Area	-	0	0	1,220
b. Number of Service Connections	-			160
c. Connected Population	-			974
d. Percent Connected	-			80
Total Number of Connections	1,742	2,760	8,784	18,087
Total Population	50,300	55,170	87,840	135,650
Total Population Served	13,936	22,080	61,490	108,520
Percent Served Population	28	40	70	80

	1980	1990	2000
Domestic use (lpcd)	105	120	135
Commercial/industrial/institutional, lpcd	14	19	24
Accounted-for-water (lpcd)	119	139	159
Percent unaccounted-for-water	40	28	20
Unaccounted-for-water (lpcd)	79	54	40
Total Water Demand (lpcd)	198	193	199

Using the above water demand parameters and the projected served population, the water demands for the design years 1980, 1990 and 2000 are as follows (see Table VI-3 and Figure VI-3):

	1980	1990	2000
Water demand (lpcd)	198	193	199
Served population	22,080	61,490	108,520
Average daily water demand (cumd)	4,370	11,870	21,600
Maximum-day water demand[2] (cumd)	5,240	14,240	25,920
Peak-hour demand[3] (cumd)	7,650	20,770	37,800

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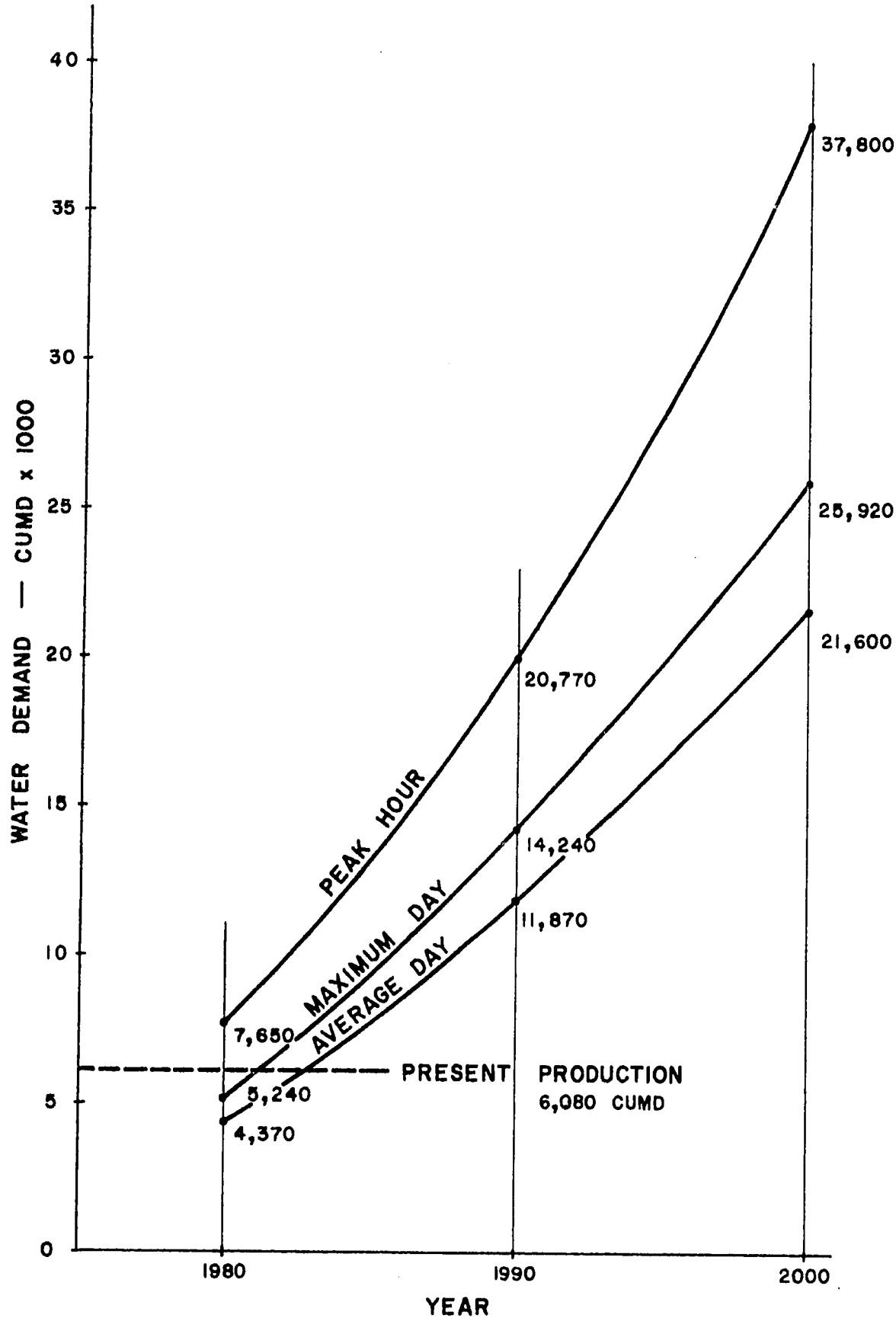
[2] Based on 1.2 times average daily water demand

[3] Based on 1.75 times average daily water demand

TABLE VI-3

YEAR-BY-YEAR SERVED POPULATION AND WATER DEMAND PROJECTIONS

Year	Served Population	Water Demand		
		Average Day	Maximum-Day	Peak-Hour
1978	18,788	3,795	4,555	6,640
1979	20,540	4,110	4,930	7,190
1980	22,080	4,370	5,240	7,650
1981	24,460	4,830	5,800	8,450
1982	27,100	5,340	6,410	9,340
1983	30,020	5,900	7,080	10,320
1984	33,260	6,520	7,820	11,410
1985	36,850	7,200	8,640	12,610
1986	40,820	7,960	9,550	13,930
1987	45,223	8,800	10,560	15,390
1988	50,100	9,720	11,660	17,010
1989	55,500	10,740	12,890	18,800
1990	61,490	11,870	14,240	20,770
1991	65,080	12,600	15,120	22,050
1992	68,890	13,380	16,050	23,410
1993	72,920	14,200	17,050	24,860
1994	77,180	15,080	18,100	26,390
1995	81,690	16,010	19,210	28,020
1996	86,460	17,000	20,400	29,750
1997	91,520	18,050	21,660	31,580
1998	96,870	19,160	22,990	33,530
1999	102,530	20,340	24,410	35,600
2000	108,520	21,600	25,920	37,800



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

FIGURE VI-3
PROJECTED WATER DEMAND
COTABATO CITY WATER DISTRICT

CHAPTER VII WATER RESOURCES

A. GENERAL

The COT-WD obtains water from four wells located within city limits and from surface water pumped directly from the Dimapatoy River into a settling basin located 8 km southwest of Cotabato City. Prior to August 1976, the primary water source of Cotabato City was surface water impounded by a dam on the same river located further upstream of the present intake facilities. This surface water source was later abandoned due to severe damages to the transmission lines caused by an earthquake in August 1976. The present water sources of COT-WD supply approximately 6,000 cumd of water which is sufficient to meet the maximum-day water demand of the COT-WD just beyond 1980. COT-WD will need 25,920 cumd of water (see Chapter VI, Section C) to supply the maximum-day water requirements of its consumers in the year 2000. Additional water resources to supply the growing water needs of the COT-WD must be identified.

The problem of deteriorating water supply for the COT-WD is compounded by the poor quality of the groundwater within the Cotabato City area due to high salinity of subsurface water in the aquifer underlying the city. The COT-WD is in immediate need of supplemental water supply sources that will produce water of good quality and sufficient quantity.

Possible additional sources of water for COT-WD are springs, wells in the floodplains of non-saline rivers (induced infiltration wells) and surface water from rivers in the area. Rehabilitating the Dimapatoy River dam and reservoir would also relieve the long-term water supply problem of the COT-WD.

B. GROUNDWATER RESOURCES

Along the western shore of the central portion of Mindanao Island, Cotabato City is located in the flat delta at the mouth of the vast drainage basin of the Rio Grande de Mindanao and Tamontaca River, with an area of about 19,000 sqkm. Annex Figure VII-B-33 is a relief map of Mindanao showing general land elevations in the area and the Cotabato drainage basin. A steep-fronted mountain mass, generally about 500 meters high, lies about 7 km south and southwest and a low range of hills with mountains beyond lies about 4 km northeast of the city. The shore of Moro Gulf is 7 km west of the city. The topography of the outwash plain where Cotabato City is located is very flat with ground elevations ranging from 0 at the shoreline to 10 meters above mean sea level approximately 4-5 km north and south of the core city and

about 25 km to the east. Most of the city itself is located on a low ridge about 10 meters above the surrounding valley floor with a small, 60-meter high limestone hill at the north end. This ridge is probably the remnant of a coral island during a goelogic period when the sea level was relatively higher. Perennial marshes, ponds and rivers dominate the topography within the plain around Cotabato City and extending far to the east. The Mindanao (Rio Grande de Mindanao) and the Tamontaoa River drain this vast plain and water shed area and empty into the Moro Gulf.

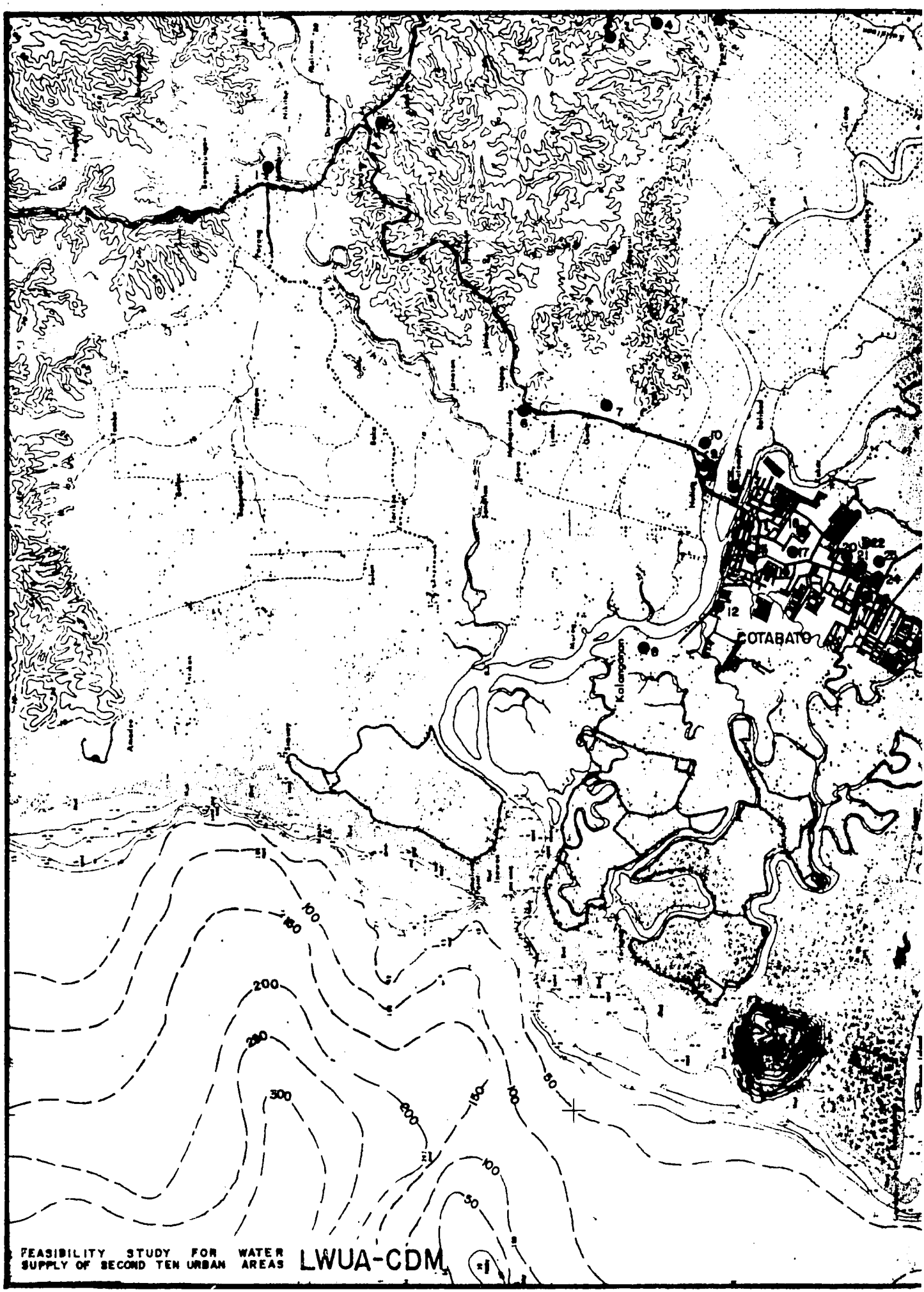
The topographic map shows that the slope of the Moro Gulf bottom offshore of Cotabato City is very steep reaching 700 meters about 7 km offshore in one place and 180 meters in most places within 1 or 2 km ofshore (see Figure VII-1).

Geology

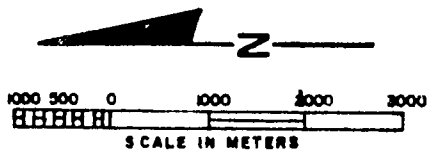
The expansive outwash plain of the Mindanao River where Cotabato City is located is made up of Recent alluvium, primarily composed of beach deposits, sand, gravel and clay. Occasional hills of raised coral reefs, basically limestone and probably remnants of coral islands during an earlier period when the sea level was relatively higher, are located within this flat valley. In part, this indicates that the area was once a waterway connected to the Moro Gulf which recently receded and was filled by alluvium. This alluvial valley is surrounded on three sides at varying distances by relatively high mountain ranges chiefly composed of limestones and volcanic rocks. Marine clastics and tuffaceous rocks form the lower hills. The mountain mass about 7 km south of the poblacion is the exposed remnant of a large limestone reef complex which probably developed around a volcanic island core. Limestone rubble in fairly steeply dipping beds, typical of the seaward side of a high reef, is exposed in a quarry on this mountain. Much of the limestone mass appears to be very permeable as a result of solution by groundwater.

Springs

Springs occur whenever an aquifer is intersected by 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 and at the foot of steep slopes.


COTABATO
Kalanganan
Amas
4
7
8
10
11
12
20
21
22
24
100
150
200
250
300
50
FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS
LWUA-CDM

MINDANAO RIVER
TAVIRAN SPRINGS
MARQUEZ SPRINGS
TAMUEL SPRINGS
COTABATO
SIAWAN SPRINGS
BUDACON SPRINGS
MAGONG SPRINGS
TAMBANON
LIONG SPRINGS
SIRINGANAN SPRINGS



LEGEND:

WELLS

SPRINGS

50
100
150
SEA BED TOPOGRAPHY IN FATHOMS

FIGURE VII-1
SPRING AND WELL LOCATION MAP
COTABATO CITY WATER DISTRICT

In the Philippines, large springs are commonly found in areas of limestone mountains for several reasons. The mountains frequently tend to cause higher than average rainfall on their upper slopes and flanks; the limestone rocks are frequently very porous and permeable because of solution effects on fractures and original openings; and consequently, infiltration rates are high. The high infiltration rates result in the limestone aquifers being saturated to a high elevation which, in combination with the large topographic relief of the limestone areas, causes springs and seeps where the land surface intersects the aquifers. The high permeability of some of the limestone aquifer zones and the prevalence of fractures and other natural conduits enlarged by solution result in many of these springs producing large flows.

Most large springs in the Cotabato area are in the mountains south of Cotabato City. Figure VII-1 shows approximate locations of the springs. Almost all the springs located during various spring exploration programs conducted along the slopes of Mt. Cabalalaan and the Linangan Mountains produce from intrinsic rock fractures and solution-affected channels in the limestones. The springs are located at elevations of 3 to 420 meters with the largest springs located along the foot of the mountains. If these large springs are ever used for water supply of COT-WD, pumping will be required to deliver spring water to Cotabato City due to their low elevation. Intake structures will also be required to collect the water and protect it from external pollution.

Tanuel Spring. This spring produces from a limestone formation at the foot of a spur of the Linangan Mountains. It is located about 8 km south of Cotabato City on the south shoulder of the Cotabato City - South Cotabato Highway at an elevation of about 5 meters above MSL. Spring water flows from several limestone channel outlets to collect in a 10-meter diameter circular groundsurface pool immediately beside the outlets. Except when used for occasional washing and laundering, the spring discharge goes to waste and flows through a stream feeding the Tamontaca River located 2 km north of Tanuel Spring. Spring capacity was measured on several occasions and average flow is about 21,300 cumd (see Table VII-1).

Water from Tanuel Spring will have to be pumped to raise water to the reservoir elevation in Cotabato City and to offset transmission losses. Facilities to effectively collect the total production of the spring and to protect water against contamination will also be necessary.

Marquez Spring. This is one of the many springs originating from the limestone spurs of the Linangan Mountains. It fills a pond, measuring about 13 meters in diameter and probably 5 meters deep, from underwater openings. The pond is a deep natural basin that is closed

except for a narrow exit stream flowing north into Tamontaca River. Because of the blue coloration of the water, caused probably by the presence of algae and/or other discoloring micro-organisms, the local residents call the pond "Blue Lagoon." The total production of Marquez Spring, measured at 4,350 cumd, flows as waste into Tamontaca River. At present, Blue Lagoon serves as a swimming and bathing resort for local residents.

Marquez Spring is located about 11.5 km southeast of Cotabato City a short distance off the left shoulder of the Cotabato City - South Cotabato highway at an estimated elevation of about 3 meters. Use of Marquez Spring for urban water supply is not particularly attractive because either spring collection facilities would have to be installed under the surface of the pond to collect the water before it becomes exposed and contaminated or the pond water would have to be used but would require extensive treatment to make it suitable for domestic water supply. Also the spring is topographically low, thus, subject to contamination from river flooding. In addition, the low elevation and great distance of the spring from the poblacion would make pumping and transmission costs high.

Taviran Spring. This spring is located about 14 km southeast of Cotabato City on the same mountain front as Tanuel and Marquez Springs. Situated at an elevation of 8 meters above MSL, Taviran Spring produces from a limestone formation basically similar to that supplying Marquez and Tanuel Springs. Taviran Spring consists of a number of separate flows occurring from fissures and cracks at the base of a steep limestone face low on the flank of a foothill of Linangan Mountain immediately below the north shoulder of the Cotabato City - South Cotabato highway. The individual springs discharge into s shallow pool drained by a small stream into rice fields for irrigation purposes. Total spring capacity was measured to be 4,300 cumd.

Taviran Spring will be relatively difficult to collect as a water supply source without contamination because it is frequently under high flood water from Tamontaca River on account of its very low elevation. The low elevation and great distance from the poblacion will also make pumping and transmission costs high.

Tambanon Springs. This spring, which is the source of a minor tributary of the Dimapatoy River, is located approximately 16 km southwest of Cotabato City at an elevation of 250 meters above MSL. The main spring complex consists of spring seepages appearing from fissures and openings on the limestone slope at a foothill of Mt. Tobo. The total capacity of the spring was measured as 6,040 cumd, which totally goes to waste. Another group of springs is located approximately 10 meters downstream of the main spring group and appears from similar large limestone cracks and fissures in the hill face of Mt. Tobo, obviously producing from the same source bed as the main spring group.

Facilities to collectively tap the separate seepages making up the Tambanon Spring complex will be required if the spring is to be used for the city water supply. Although Tambanon Spring will not require a pumping installation to deliver water to the service areas because of its high elevation, a long transmission pipeline passing through fairly rugged terrain will be necessary.

Budacan Spring. This spring is located along the western slope of the Dimapatoy River Valley in the Linangan Mountains at an elevation of 70 meters above MSL and about 12 km south-southwest of Cotabato City. Similar to most of the springs found within the area, Budacan Spring produces from rock fractures and discharges directly into Dimapatoy River. The Budacan Spring complex consists of several fairly large seeps producing a total capacity of 2,580 cumd. Budacan Spring results from the Dimapatoy river channel outting through the high water table of the mountains. The springs are just above the water surface of Dimapatoy River and are constantly submerged during high river flows.

Several other springs located within the Linangan Mountains are shown in Figure VII-1. Data on these springs are shown in Table VII-1. Basically, all the springs identified and located along the flanks of the Linangan Mountains produce from either solution channels in limestone or fractures in other rocks which compose the mountain mass. The permeable rocks of these mountains collect a large volume of direct recharge from precipitation and runoff which is eventually discharged in large quantities through springs considered natural water outlets. On this account, all of the springs in these mountains are expected to be adversely affected by the seasonal change from wet to dry conditions within the Cotabato area. Major, and perhaps, abrupt fluctuations in spring production must be anticipated. Monitoring of spring flows is necessary. In the absence of extensive flow records of all springs located in Cotabato, it is recommended that 70 percent of the measured spring capacity be used for purposes of cost estimates.

Wells

Wells are common sources of water supply for domestic and industrial supply in Cotabato City. The Bureau of Public Works (BPW) drilled a large number of wells within the area. BPW records of depth, static and pumping water level, casing diameter, test yield and specific capacity for 40 of these wells are presented in Table VII-2; only 31 wells have records of stratigraphic logs. The locations of these wells are plotted in Figure VII-1, and stratigraphic logs describing the geologic formations penetrated by such wells are shown in Annex Figures VII-B-1 to VII-B-31. It should be noted that the terminology used by the BPW drillers in identifying the geologic formations penetrated by these wells is vague and too generalized to describe clearly the formations underlying the Cotabato area. Terms such as

TABLE VII - 1

SPRING DATA

Name of Spring	Location	Elevation Above Mean Sea Level	Spring Capacity (cumd)	Date of Measurement	Approximate Distance from Cotabato City (km)	Remarks
Tamuel Spring	Dinaig, Maguindanao	5 m	23,630 20,650 18,140	20 May 1977 28 May 1977 23 June 1977	8 SSE	Untapped
Marquez Spring (Blue Lagoon)	Dinaig, Maguindanao	3 m	4,350	17 Feb 1977	11.5 SE	Blue colored water possibly caused by the presence of algae or micro-organisms. Serves as a swimming resort.
Taviran Spring	Dinaig, Maguindanao	8 m	4,300	17 Feb 1977	14 SE	Being used for local water supply and irrigation.
Tambanon Spring	Dinaig, Maguindanao	250 m	6,400	20 May 1977	16 SW	Untapped
Budacan Spring	Dinaig, Maguindanao	70 m	2,580*	13 April 1977	12 SSW	Untapped
Siawan Spring	Dinaig, Maguindanao	90 m	520*	14 April 1977	10 SSW	Untapped
Biasong Spring	Dinaig, Maguindanao	420 m	1,630*	15 April 1977	12 SW	Untapped
Liong Spring	Dinaig, Maguindanao	10 m	3,100*	18 April 1977	11.5 SW	Untapped
Siringanan Spring	Dinaig, Maguindanao	50 m	2,200*	18 April 1977	13 WSW	Untapped

* Approximate spring capacity; not verified by the use of current meter.

TABLE VII-2

WATER WELL DATA SUMMARY
COTABATO CITY WATER DISTRICT

CDM Well Number	BPW Well Number	Location	Nominal Diameter (mm)	Depth from Ground Surface In Meters: Total	Cased	Static Water Level	Pumping Water Level	Test Yield (lps)	Specific Capacity (lps/m)	Year Completed
1	10513	Macabiso, Sultan Kudarat	150	39.0	38.4	-	- 3.4	0.63	-	1956
2	6136	Crossing, Sultan Kudarat	150	26.2	25.6	-10.7	-11.3	1.58	2.63	1954
3	16221	Pagalongan, Sultan Kudarat	112	61.0	53.5	-47.3	-48.8	0.95	0.63	1957
4	7475	Pagalungan, Sultan Kudarat	150	11.3	10.1	- 0.9	- 3.0	0.95	0.45	1956
5	15425	Pigcalagan, Sultan Kudarat	100	29.6	19.2	-12.2	-13.7	0.63	0.42	1957
6	20310	Bo. Makaquiling	150	8.5	3.7	- 3.1	-	0.63	-	-
7	20311	Bo. Gang, Sultan Kudarat	100	12.2	10.0	- 2.1	-	0.63	-	-
8	16230	Kalanganan, Sultan Kudarat	100	7.6	7.3	- 1.2	- 2.4	0.63	0.53	1957
9	15427	Leprosarium, Hospital, Sultan Kudarat	150	30.5	22.0	-17.4	-18.9	0.94	0.63	1957
10	15426	Almada, Sultan Kudarat	100	17.1	13.1	-10.4	-12.2	0.95	0.53	1957
11*		Matampay, Cotabato City	100	13.7	13.1	- 0.6	-	-	-	1960
12	195912	Bagua, Cotabato City	100	18.0	16.9	- 1.5	- 1.8	0.32	1.07	1959
13		Cotabato City High School Cotabato City	200	30.5	30.5	-13.7	Abandoned			1973
14	20351	Lambayong Institute	150	25.9	25.9	- 1.5	- 2.4	0.94	1.05	1957
15	196021	Cotabato City High School	200	27.4	26.5	-15.2	-19.5	3.40	0.79	1960
16*	-	CEMCOM - Poblacion	200	24.4	-	- 4.0	-	-	-	-
17	-	Resales Subd., Cotabato City	200	30.5	28.0	-11.3	-	38.2	-	1973
18	-	Meter Pool-Circuit Road	200	22.9	17.7	- 4.9	-	9.5	-	1974
19*	-	Santos St., Cotabato City	200	24.4	-	- 7.6	-16.8	-	-	1974
20	-	Gen. Luna (Bu. of Telecom)	200	38.7	32.5	-15.2	-22.9	15.8	2.0	1964
21*	-	Ilang-ilang, Cotabato City	200	24.4	-	- 6.0	-11.0	-	-	
22*	-	Ortouste- Ilang-Ilang St.	200	18.5	15.2	- 6.1	- 8.9	-	-	1974
23	196022	Rosary Heights, Cotabato	100	34.1	33.1	- 7.9	- 9.8	4.41	2.32	1960
24	-	Gutierrez-Sampaguita St	200	19.2	18.3	- 3.0	-	17.4	-	1973

*Well logs are not available.

TABLE VII-2 (Continued)

CDM Well Number	BPW Well Number	Location	Nominal Diameter (mm)	Depth in Ground Surface in Meters: Total	Cased	Static Water Level	Pumping Water Level	Test Yield (lps)	Specific Capacity (lps/m)	Year Completed
25	-	Ortouste-Rosal St.	200	20.4	18.3	- 2.11	-	12.6	-	1973
26*	-	Bubong, Cotabato City	150	9.1	3.7	- 1.5	- 3.1	0.76	0.48	1957
27	12241	Talitay, Dinaig, Maguindanao	150	14.0	7.3	- 1.8	- 2.1	0.63	2.1	1956
28	16277	Tamontaca, Cotabato City		9.1		- 1.5	- 3.0	0.76	0.51	1954
29	16228	Pagalamatan, Cotabato City	100	10.7	6.5	- 1.8	- 3.1	0.76	0.63	1957
30*	-	CEMCOM, Awang Area (Airport)	150	76.2	-	-	-	3.78	-	-
31	196091	Bito, Cotabato City	100	12.5	12.5	- 0.6	- 0.9	0.95	3.17	1960
32	20881	Tiugon, Cotabato City	100	8.5	6.7	- 1.5	- 3.1	0.63	0.42	1957
33*	-	Magamay, Cotabato	100	19.8	19.8	- 8.5	-	-	-	1969
34*	-	So. Linek, Polomotoc Cotabato City	100	15.2	11.0	-10.7	-13.7	0.32	0.11	1959
35	196063	Banga, Cotabato City	100	20.1	20.1	- 3.0	- 4.6	0.76	0.48	1960
36	5487	Market Site, Midsayap, Cotabato City	150	44.2	42.2	- 2.7	- 3.6	1.89	2.1	1956
37	7268	Bo. Gayonga, Tumbao, Cotabato City	150	29.9	7.6	- 2.1	- 3.7	1.3	0.84	1955
38	12245	Tabon, Pigcawagan, Cotabato	112	13.7	12.2	- 3.0	- 3.7	0.95	1.30	1956
39	16882	Bunawan Settlement, Baluan Cotabato City	100	52.1	52.1	-42.7	-47.0	0.63	0.15	1958
40	196051	Malagapas, Cotabato City	100	25.9	19.5	- 4.6	- 7.6	0.63	0.21	1960

Note: Wells No. 30 to 40 are not shown in Figure VII-1.

Wells No. 19, 20, 21 and 25 are present groundwater sources of water for COT-WD.

*Well logs are not available.

dead sand, hard white rock (limestone?), adobe, hard rock with gravel, and stone with clay are examples of general terminology used. Variations in terminology used by different drillers or geologists in describing a geologic section are a constant problem that makes even general correlations of geologic sections and consequent predictions of aquifer characteristics difficult and uncertain.

Data on the 40 wells drilled by the BPW and given in Table VII-2 show that they generally range from 100 to 200 mm in nominal diameter. Well depths range from 8 to 76 meters, and static water levels range from 0.6 to 47 meters below ground level with the wells of deeper static water level located on higher land. Pump test data are available on 25 of the 40 BPW wells with specific capacities ranging from 0.11 to 3.17 lps/m without any observable relation to well depth or casing diameter. Six of these wells have specific capacity of more than 2 lps/m which is fairly good. The generally poor performance of the BPW wells is believed to be largely related to poor well design and construction rather than to a uniformly poor aquifer. This situation is common - many areas underlain by good aquifers (such as in the Cotabato area) support poor wells unless good design and construction procedures are followed.

At present, COT-WD is using four of these BPW wells for supplemental water supply in addition to surface water from Dimapatoy River. All four wells are located within the boundaries of Cotabato City; drilled in an elevated area in the wide, flat marshland surrounding Cotabato City and are each cased with 200-mm diameter well casing. Depth of these four wells ranges from a minimum of 18.5 meters to a maximum of 38.7 meters, and static water level ranges from 2.1 meters to 15.2 meters below ground surface. The formation from which these wells produce appears to be fine to coarse sand underlain by a thick clay bed, probably 30 meters thick in some areas, which is prominent in the Cotabato alluvium. Conductivity measurements of water from these four COT-WD wells were found to be excessively high, indicating excessive dissolved salts, with a minimum of 950 micromhos/cm and a maximum of 2,250 micromhos/cm. This indicates that, because of the low topographic gradient from the east, the groundwater gradient is very small and consequently the groundwater flow is too slow to have flushed out all the salt water remaining when the area was once submerged under sea water. Other wells within Cotabato are evidently experiencing the same water conditions. A conductivity survey of shallow well waters around and within Cotabato City showed that the best wells were shallow, 18 meters deep or less, and produced water of about 700 micromhos/cm. Deeper wells produced waters with conductivities of as high as 2,800 micromhos/cm. Conductivities of well waters are shown in Table VIII-3 and their relative locations within Cotabato City are plotted in Annex Figure VII-B-34. Several local well drillers report that wells drilled within the city limits become saltier with increasing depth, and are extremely salty at depths of 90 meters or more. It is concluded that good large-

TABLE VII - 3

WELL WATER CONDUCTIVITY DATA
COTABATO CITY WATER DISTRICT

Well Number	CDM Well Number	Conductivity (micromhos/cm)	Date of Measurement	Remarks
1	-	1800	28 Oct. 77	Hotel Well
2	16	2100	28 Oct. 77	Military (CEMCOM) Well
3	-	1500	28 Oct. 77	Hospital Well
4	-	1250	28 Oct. 77	Private Well
5	-	1650	28 Oct. 77	Private Well
6	20	1600	28 Oct. 77	COT-WD Well
		1600	12 Jan. 77	
7	-	420	28 Oct. 77	Abandoned
8	-	1600	28 Oct. 77	Abandoned
9	-	1900	28 Oct. 77	Subdivision Well
10	19	950	28 Oct. 77	COT-WD Well
		1200	25 Nov. 76	
11	23	1200	28 Oct. 77	Abandoned
12	-	1800	28 Oct. 77	Abandoned
13	21	1500	28 Oct. 77	COT-WD Well
		1350	25 Nov. 76	
14	25	2250	28 Oct. 77	COT-WD Well
		1700	29 Nov. 77	
15	-	600	28 Oct. 77	Abandoned
16	-	750	28 Oct. 77	Private Well
17	-	700	28 Oct. 77	NGA Well

Note: Locations of these wells are shown in Annex Figure VII-B-34.

production rate wells suitable for domestic water supply cannot be constructed within the city limits or in the Tamontaca River-Mindanao River Valley area because they will become saline under conditions of continued pumping. No free-flowing well could be found in the Cotabato City area. At depths of 90 meters or less, there is no known artesian aquifer pressurized sufficiently to support flowing wells. The extremely flat, average, westward topographic gradient of 1 meter to every 10 km limits the groundwater gradient in the phreatic (water table) aquifer, which, in turn, limits the groundwater flow from the basin to the west (Moro Gulf) to a very small quantity, insufficient to flush the cognate saline water from the sediments completely. It is believed that the vast, flat valley area east of Cotabato, about 10,000 sqkm or more, was once a large embayment of the sea which accounts for the presence of saline water in the sediments of the valley floor. The Linangan Mountains were probably a great reef complex built around the volcanic central core of Mount Cabalalaan that formed the southern shore of the seaway.

It is very unlikely that a good artesian aquifer containing fresh water could exist at great depths below Cotabato City. On and offshore topographic conditions make it likely that any deep aquifer would be saline or subject to rapid salinization under condition of massive groundwater pumping. The offshore topography near Cotabato City shows an abrupt drop in elevation a short distance from the shore. The steep slope truncates the aquifer a short distance from shore and sea water will flow inland into the deep aquifer zones if the piezometric head in the aquifer is lowered by large-scale pumping.

Wells at higher elevations along the lower slopes of the hills and mountains north and south of the city will produce water of good quality but the aquifers will not support large-capacity wells except possibly for the limestone aquifer of the Linangan Mountain area where it would be difficult to find permeable zones in the subsurface. Probably, productive wells could be drilled in this limestone located about 10 to 15 km south of the poblacion. Another potential source of groundwater is the sand and gravel banks of the Simuay River about 5 to 10 km from the poblacion. The river has a relatively large flow, sufficient for the COT-WD beyond the year 2000, and the water quality is good upstream of the reach of sea water intrusion from Moro Gulf. The Simuay River currently carries a sand and gravel load and the flood plain indicates that the river valley alluvium is deep enough and contains enough sand and gravel that good, large capacity wells can be constructed along the river banks if properly located. These wells will induce additional infiltration from the river and so provide a sufficient source of recharge water of good quality. It is estimated that induced infiltration wells along the Simuay River banks in an area not affected by sea water intrusion, if carefully designed and constructed, provided with good well screen and drilled to about 45 meters, would have specific capacities between 1 and

5 lps/m and produce 30 lps or more. A specific capacity of 3 lps/m is suggested for cost estimation purposes. The proposed well site, however, is located outside of Cotabato City. Annex Figure VII-B-32 is a suggested general design for induced infiltration production wells in the Cotabato area. If wells are constructed by COT-WD, this design could be a guide for the first well (which should be a test cum production well). The design should be modified for succeeding wells to reflect data derived from construction and test of the first wells. The specified screen and upper casing are suitable for 30 lps production although a much larger capacity pump could be installed. The screen should be of the corrosion-resistant, continuous wire-wound type to reduce well losses and make development and maintenance procedures more effective. Gravel shrouding is recommended because it is anticipated that water will be produced from numerous horizons of varying grain size.

Recharge to the aquifers in the Cotabato area is believed to be plentiful because of the adequate rainfall and the porous nature of the limestone formations and alluvial deposits. Recharge is particularly high in the mountainous areas as evidenced by large springs with relatively small source areas. A tremendous quantity of potential recharge is available to the alluvial aquifer in the huge valley east of Cotabato. However, the extremely flat topographic gradient causes a very flat groundwater gradient in this water table aquifer and consequently groundwater flow toward the sea is very slow. This situation is confirmed by the very marshy and water-logged condition of the Tamontaca River - Mindanao River Valley (resulting from groundwater forced to the surface and surface water that cannot infiltrate because of the totally saturated aquifer) and by the fact that groundwater flow under Cotabato has been so slow that the cognate salt water has not been flushed from the aquifer. Thus, despite the potential recharge, actual recharge to this area is very low, groundwater flow and flushing under Cotabato are very slow, and the groundwater underlying the poblacion remains saline and undesirable for city water supply.

Monitoring

A monitoring program to gather and interpret water source data is necessary for proper operation and planning in any water district. In Cotabato, production and overflow of proposed spring water sources of the district must be monitored to evaluate long-term, reliable flow rates.

For the purposes of this study, the overflows from the springs identified as probable water sources of COT-WD were measured by the use of a portable current meter in discharge channels. Permanent weirs with calibrated staff gauges should be installed in the discharge channels at strategic locations to measure flows more conveniently. Total flow should be measured twice a month, water samples for bacterial

analysis should be collected once a month, and water samples for chemical and physical analysis should be collected once a year. The collected data will give early warning of flow reduction or contamination so that remedial action can be taken early.

Each COT-WD production well and any succeeding wells should have facilities for measuring the total amount of production or rate of production, times of operation and water levels. Routine monthly observations of static and pumping water levels should be recorded and daily records of pumping kept. Water samples for bacterial analysis should be collected monthly and for chemical analysis, semi-annually. The data from the well monitoring program will provide better aquifer parameters, indicate the magnitude of recharge, give early warning to the COT-WD of deteriorating water quality (most especially saline water intrusion) or pump performance so that remedial action can be taken, and indicate any unforeseen decline in regional water level so that individual well yields (which affect local pumping levels) and design and location of future wells can be adjusted as necessary. For these purposes, copies of all COT-WD well monitoring data should be routinely analyzed by COT-WD personnel (if it has competent staff for such analyses) or by some associated agency competent to perform much analyses.

Summary of Groundwater Resources

Groundwater within the alluvial aquifer of the Tamontaca River - Mindanao River Valley is undesirable for water supply because of a salinity problem. This condition results from very poor flushing of salt minerals (left from when the valley was once fully submerged under sea water) by recharging water in the unindurated sediments in the valley. Wells within this low area produce saline water undesirable for human consumption. Groundwater in the relatively higher areas bounding the Cotabato outwash plain to the north and south of the city is of good quality on account of a higher flow rate of recharging water effectively flushing out cognate salt minerals in the aquifer. Good wells probably can be constructed in the limestones 10 to 15 km south of the poblacion. Also, wells can be constructed in the flood plain of the Simuay River 5 to 10 km north of the poblacion. These wells will derive recharge from the river and so are capable of providing all of Cotabato's water requirements past the year 2000. They would have the advantage of producing water of good quality requiring only chlorination for treatment, but would have the disadvantage (common to all well supplies) of requiring multiple pumping stations with consequent operating costs and mechanical and operational complexities. Also, a transmission pipeline with a river crossing structure probably will be necessary because the north side of the Simuay River appears more suitable from preliminary studies.

A large number of springs have been located along the slopes of the mountain range south of Cotabato City. All these springs produce from fractured and solution-affected limestone formations. Most of these springs produce fairly large volumes of water and could supply significant parts of the water requirement of COT-WD up to the year 2000. The large-capacity springs, however, are located at the lower slopes of the mountain and will require pumping to deliver water to the load centers. The spring water is of excellent quality and will require chlorination for treatment. Facilities to effectively capture the spring production must also be constructed and will serve not only as an impounding structure but also prevent the contamination of water from external sources.

C. SURFACE WATER RESOURCES

The COT-WD water requirements up to and beyond the year 2000 could be supplied by a number of surface water sources in the area. The Dimapatoy River, which is already supplying part of the COT-WD water demand, and the Simuay River, are potential sources. The Mindanao and Tamontaca Rivers would have been excellent surface water sources for COT-WD in terms of proximity to the demand center and volume of water produced but salt contamination of river water from the Moro Gulf which extends to more than 20 km upstream eastward of the river mouth does not make the rivers a favorable source of water supply. Several tributaries of the Mindanao/Tamontaca River network having extensive records of flow were used as the basis of approximating minimum low flow in the nearby rivers with no existing flow records. Necessary data on these tributaries are presented in Table VII-4. Of the five rivers considered, a maximum unit minimum low flow of 992 cumd/sqkm was recorded for a river draining a watershed area of 12,999 sqkm while a minimum of 102 cumd/sqkm unit minimum low flow was recorded for a river having a drainage area of 145 sqkm. It was deemed that by using the mean unit minimum low flow of 540 cumd/sqkm derived from these five rivers, a closer approximation of probable minimum low flows for rivers having no existing flow records could be derived.

Generally, a surface water source is not economically competitive with springs or wells reasonably close to the demand center because surface water usually requires more extensive and more costly treatment than groundwater.

Dimapatoy River

At present, the COT-WD is partly supplied by water from the Dimapatoy River. Water from an intake system at the bank of Dimapatoy River is pumped directly into a nearby settling basin before it flows by gravity to the distribution system. The intake system and settling

TABLE VII - 4

MINIMUM LOW RIVER FLOW RECORDS
OF RIVERS* IN COTABATO

Name of River	Location of Gaging Station	Period of Record (yr)	Drainage Area (sqkm)	Minimum Low Flow (cumd)	Minimum Low Flow/Unit Area (cumd/sqkm)
Rio Grande de Mindanao (Pulangi)	Lat. 7° 03'09" Long. 124°42'27"	22	12,999	12.9×10^6	992
Kabacan River	Lat. 7°06'34" Long. 124°52'39"	16	698	43.6×10^4	625
Allah River	Lat. 6°31'30" Long. 124°36'05"	22	936	30.2×10^4	323
Allah River	Lat. 6°40'45" Long. 124°32'50"	8	1496	95.0×10^4	635
Malasila River	Lat. 6°50'45" Long. 124°36'05"	20	145	14.7×10^3	102

Note: All of the abovementioned rivers are tributaries of the Mindanao/Tamontaca River network which drains the Cotabato watershed basin.

basin are located approximately 9 km southwest of Cotabato City at elevation of 40 and 93 meters, respectively, and serve the service area by gravity flow with water of fairly good quality. The water requirement of COT-WD for the year 2000 represents roughly 17 percent of the projected low flow in the Dimapatoy River.

By rehabilitating the present intake facilities at Dimapatoy River, the COT-WD water requirements could be supplied by this water source even beyond the year 2000. However, for city water supply, this source must have a complete surface water treatment plant (not just the existing basin) and a fully equipped pumping station to lift water from Dimapatoy River into the treatment plant. A permanent dam impoundment will also be made an integral part of the proposed Dimapatoy River intake facilities to collect and divert water from the Dimapatoy River into the intake boxes.

Simuay River

The Simuay River passes 4 km north of Cotabato City at its nearest point. The major length of the river course has the advantage of running along generally elevated areas before discharging into the Moro Gulf which is not true of either the Tamontaca and Mindanao Rivers. Thus, river water within approximately 5 to 8 km of Cotabato City would generally be not affected by salt water intrusion from the Moro Gulf and be suitable for human consumption after conventional water treatment. The Simuay River has a drainage area of about 550 sqkm. By the use of the mean minimum low flow of the flow records presented in Table VII-4, the projected minimum river flow in the Simuay River, with a drainage area of about 550 sqkm, is about 300,000 cumd, more than 10 times the projected water demand of COT-WD in the year 2000. Thus, the Simuay River is a technically feasible water source for COT-WD, but it would require extensive and costly treatment for use as source of domestic water supply. An excellent groundwater supply which will require only minimum and inexpensive treatment can be derived from induced infiltration wells along the Simuay River.

The Simuay River is located in the municipality of Sultan Kudarat, north of Cotabato City. If ever Simuay River is selected as one of the water sources of the COT-WD, it should coordinate with Sultan Kudarat officials to get their full cooperation on the proposed project.

A major disadvantage of the use of Simuay River as a water supply source of the COT-WD is the current unrest prevailing in the Sultan Kudarat area. Sultan Kudarat area is one of areas in Mindanao with an active rebel movement and the situation is expected to continue for an extended period of time. The implementation of the water supply project is expected to be drastically hampered by this situation.

D. WATER QUALITY OF POTENTIAL SOURCES

Water samples were taken from four COT-WD wells, three springs (Tanuel, Taviran and Marques Springs) and two surface water sources (the Dimapatoy and Simway Rivers). Physical and chemical analyses were made on the samples collected to determine the water quality of each potential source with respect to potability and treatment requirements. The results of these analyses are shown in Tables IV-1 and VII-5 are briefly discussed below.

Well Water

Water samples were taken from the four wells presently used by the COT-WD. The results of the physical and chemical analyses show that all four samples exceeded the permissible limits set by the Philippine National Standards for Drinking Water in total dissolved solids and calcium content while three samples also exceeded the permissible limits in total hardness and manganese content. The permissible limits for color, turbidity, magnesium, iron and sulfate have also been exceeded in some of the samples.

The results indicate that the groundwater beneath Cotabato City is heavily contaminated with mineral salts, probably remaining in the alluvium from an earlier period when it was saturated with seawater. This is further shown by high conductivity readings in all well water samples indicating that the dissolved salts content is higher than the permissible limits. Total hardness, which is high in all samples, is another indication of excessive calcium and magnesium salts which most likely result from sea water contamination and possibly also due to the abundant limestones in the area. It is, therefore, undersirable to use the groundwater below the COT-WD area as a primary water source because of its excessive salinity. Continued withdrawal of large volumes of groundwater from wells near the poblacion will likely deteriorate the quality of the groundwater since salt water from the nearby Moro Gulf will intrude further inland due to a lowered water table. Treating the saline groundwater beneath Cotabato City for water supply purposes could be done with the use of various desalinization processes. However, these methods are too costly for practical considerations and are expected to become even more expensive with the rising price of energy. Except for desalinization, no other means of conventional water treatment currently in use is sufficient to eliminate the salinity in the Cotabato groundwater. Mixing the Cotabato groundwater with the fresh water from other sources could possibly reduce the salinity of the groundwater to be acceptable for water supply.

TABLE VII-5

WATER QUALITY TEST RESULTS OF POTENTIAL SOURCES
COTABATO CITY WATER DISTRICT

Test	Unit	Permissible Limits	Dimapatay Dam Bn. Dimapatay, Dinaig 27 Nov 76	Dimapatay River Collection Gallery Bn. Dimapatay, Dinaig 27 Nov 76	Simuay River Bn. Payong Sultan Kudaret 27 Sep 77	Ortenate Well Bn. Rosary Heights Cotabato City 29 Nov 76	Ilang-Ilang Well Bn. Rosary Heights Cotabato City 25 Nov 76	Santos Well Bn. Rosary Heights Cotabato City 25 Nov 76	Gen. Luna Well Cotabato City 12 Jan 77	Tamual Spring Bn. Tamual Cotabato City 27 Sep 77	Marquez Spring Bn. Marquez 27 Sep 77	Taviran Spring Bn. Taviran 27 Sep 77
Physical												
Color	APHA	15	5	5	nil	200**	5	5	5	nil	nil	nil
Turbidity	FTU	5	3	3	7**	750**	2	5	2	nil	nil	nil
Total Dissolved Solids*	mg/l	500	195	218	104	1,105**	878**	780**	1,040**	384	358	377
Conductivity	micromhos/cm		300	335	160	1,700	1,350	1,200	1,600	590	550	580
Chemical												
pH		7-8.5	7.95	7.8	7.35	5.45**	7.65	7.45	7.2	6.95	7.15	7.35
Total Alkalinity	mg/l $CaCO_3$		180	195	84	40	430	420	365	341	317	317
Phenolphthalein Alkalinity	mg/l $CaCO_3$		0	0	0	0	0	0	0	0	0	0
Total Hardness	mg/l $CaCO_3$	400***	177	181	63	864**	351	465**	520**	343	329	314
Calcium	mg/l Ca	75	60.40	64.4	16	276.4**	76.8**	132**	114**	103**	101**	65
Magnesium	mg/l Mg	50	6.24	4.8	6	47.1	38.2	32	56**	20	18	36
Total Iron	mg/l Fe	0.3	0.12	0.1	0.015	4.25**	nil	nil	0.09	0.01	0.01	0.01
Fluoride	mg/l F	1.5	0.44	0.44	0.05	0.87	0.62	0.49	0.7	0.45	0.10	0.50
Chloride	mg/l Cl	200	0	2.44	3	81.74	146.4	82	173	15	12	24
Sulfate	mg/l SO_4	136	nil	nil	5	375**	48.3	25	78	8	7	23
Nitrate	mg/l NO_3	50	10.2	10.2	8.3	10.1	8.1	12	4.16	6.6	9.2	7
Manganese	mg/l Mn	0.1	0.1	0.2**	nil	2.6**	0.3**	0.2**	0.05	nil	0.25**	nil

*Computed as 65 percent of conductivity.
**Exceeds the permissible limits set by the Philippine National Standards for Drinking Water.
***Limits inferred from limits of individual metals causing hardness.

Surface Water

Water samples were collected from the Dimapatoy and Simuay Rivers and the results of the physical and chemical analyses of these water samples are shown in Table VII-[illegible]. Two water samples were collected from the Dimapatoy river, the present source, one from the abandoned dam located 15 km southwest of Cotabato City and the other from the collection gallery located 5.5 km downstream of the dam. Analyses of the samples show that the river water meets the permissible physical and chemical limits set by the Philippine National Standards for Drinking Water, except for manganese content in the sample taken from the collection gallery which is reported to be higher than the permissible limit. However, this is believed to be a laboratory error because high dissolved manganese content in aerated surface waters is very unusual. The analysis shows that samples from the Dimapatoy river are generally favorable as a water source. Even color, turbidity and suspended solids are unusually low considering that the samples were collected during the rainy season. This condition could be a result of the basically limestone bed of the river and the general bank area through which the river course passes. However, during heavy rainfall, the Dimapatoy river water becomes turbid and thus will require complete normal water treatment (coagulation, sedimentation, filtration and disinfection). The physical and chemical analysis of the Simuay River water indicates that, except turbidity, all tested parameters meet the requirements of the Philippine National Standards for Drinking Water. Even so, this water would require complete normal treatment to remove turbidity and suspended matter.

A conductivity survey of the Simuay River starting 8 km from its mouth showed no sea water intrusion. Conductivity measurements averaged 160 micromhos/cm.

The Simuay River is a favorable surface water source, not only as a direct source but also as a water recharge source for induced infiltration wells drilled along the river's sand and gravel banks. If surface water is used as a major source of recharge for nearby induced infiltration wells, disinfection of the water, usually chlorination at the point of discharge, will be sufficient as treatment since the major portion of the impurities will be filtered out of the recharging suface water by the alluvium separating the river from the well.

The Simuay River water is chemically favorable for municipal supply as shown by the results of the analysis in Table VII-5 and various conductivity measurements. The Simuay River is a possible source of recharge for induced infiltration wells drilled on the river banks. These wells would induce infiltration of the river water into the aquifer to replace the pumped water so that eventually the well would be pumping recently infiltrated water and practically produce out of the Simuay River instead of the groundwater. The quality of the resulting water will essentially be similar to that of the river water, except for the physical quality (such as turbidity and color) which will be improved as a result of the sieving action of the alluvium between the river and the well. The water produced from these wells will require only disinfection for treatment.

Spring Water

Physical and chemical analyses show that samples collected from Tanuel, Marquez and Taviran springs are of excellent quality, except for concentrations of calcium in samples from the Tanuel and Marquez springs which are higher than the permissible limits of the Philippine National Standards for Drinking Water. High calcium concentration causes the water to be slightly hard but the relatively low magnesium content reduces the effect, making the spring water acceptable for city supply. Excessive calcium concentration is to be expected from springs producing from limestone formations because the calcium carbonate dissolves readily in water containing carbon dioxide from the atmosphere. If the hardness becomes objectionable, corrective treatment for calcium hardness could be achieved by simple water softening processes.

Except for calcium content, water from the Cotabato springs is of excellent quality and would require only disinfection for treatment. Prime concern must be given to possible contamination of proposed sources since the springs are located at generally low elevations (about 5 meters above MSL) along the shoulders of the Cotabato City southern highway. It is advisable that collection methods be improved and the local areas immediately above the spring openings be protected from possible contamination.

Spring water could also be used in combination with the saline Cotabato groundwater. Combining the spring water with the groundwater could reduce the overall salinity of the mixed water to an acceptable level for municipal supply. The resulting water will only require minimal treatment, usually chlorination, but will require large expenses for transmission pipelines, mixing tanks and similar appurtenances.

ANNEX VII-B

GROUNDWATER RESOURCES

DESCRIPTIVE DATA

WELL NO. (CDM) 1
(OTHER) 10513
LOCATION BARRIO MACABISO NULING
CITY COTABATO
PROVINCE COTABATO
CONST. BY B.P.W.
DRILLER JOSE C. SAMSON
STARTED MAY 28, 1956
COMPLETED JUNE 26, 1956
OWNER B.P.W.
STATUS
CASING DIAMETER 150 MM
CASING LENGTH 38.4 M

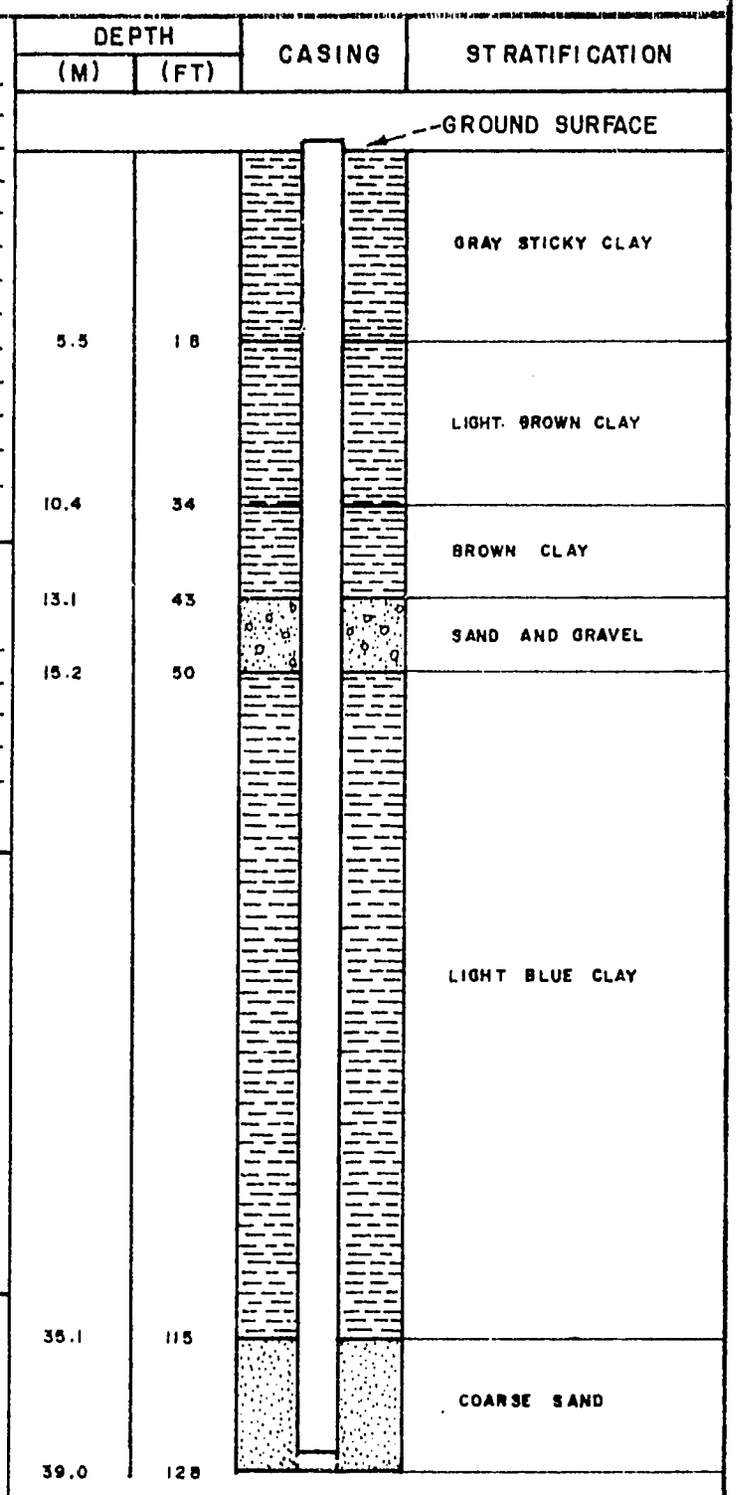
DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL
PUMPING WATER LEVEL 3.4 M
TEST PUMP YIELD 0.63 LPS
SPECIFIC CAPACITY

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG



ANNEX FIGURE VII-B-1
WELL DATA SHEET
WELL CDM-1
COTABATO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

DESCRIPTIVE DATA

WELL NO. (CDM) 2
(OTHER) 6136
LOCATION KILADA CROSSING, KABACAN
CITY COTABATO
PROVINCE COTABATO
CONST. BY B.P.W.
DRILLER MAMERTO LAWAS
STARTED
COMPLETED 1954
OWNER B.P.W.
STATUS
CASING DIAMETER 150 MM
CASING LENGTH 25.6 M

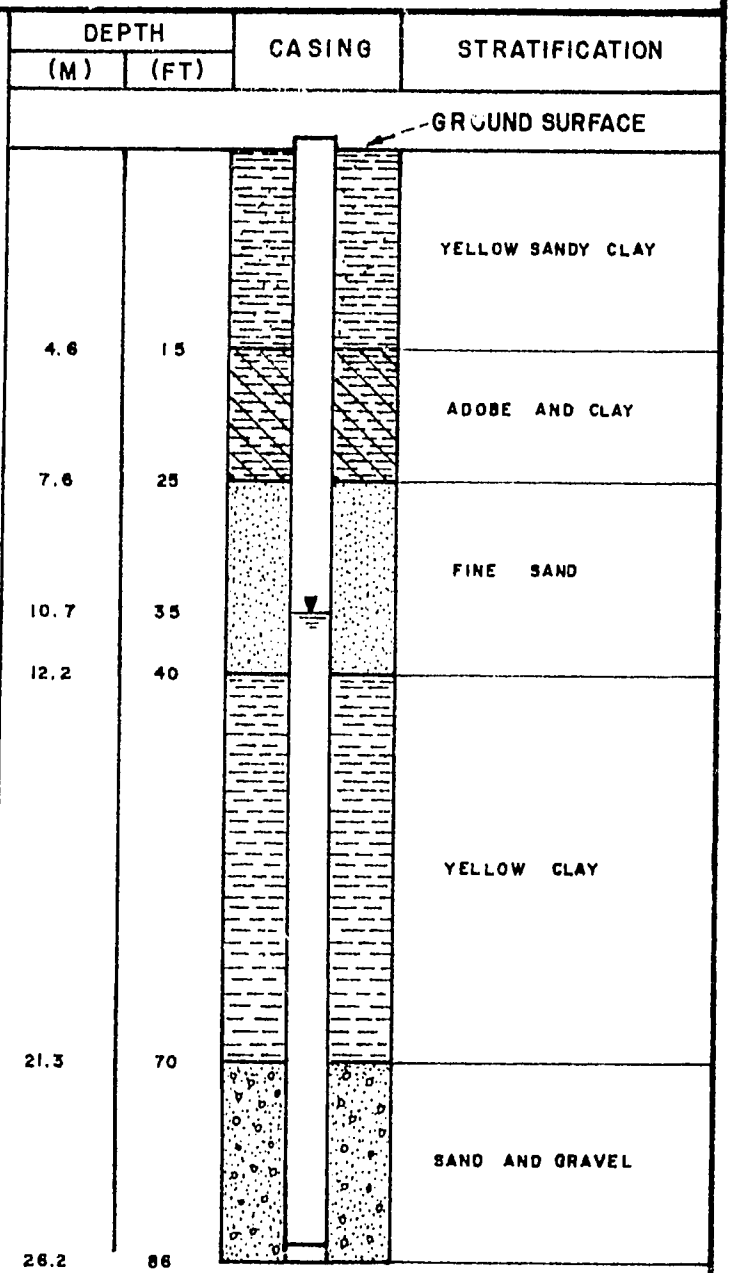
DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL 10.7 M
PUMPING WATER LEVEL 11.3 M
TEST PUMP YIELD 1.58 LPS
SPECIFIC CAPACITY 2.63 LPS/M

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG



ANNEX FIGURE VII-B-2
WELL DATA SHEET
WELL CDM-2
COTABATO WATER DISTRICT

DESCRIPTIVE DATA

WELL NO. (CDM) 3
(OTHER) 16221
LOCATION BARRIO PAGALONGAN, NULING
CITY COTABATO
PROVINCE COTABATO
CONST. BY B.P.W.
DRILLER
STARTED 1957
COMPLETED 1957
OWNER B.P.W.
STATUS
CASING DIAMETER 112 MM
CASING LENGTH 53.5 M

DRILLER'S TEST DATA:

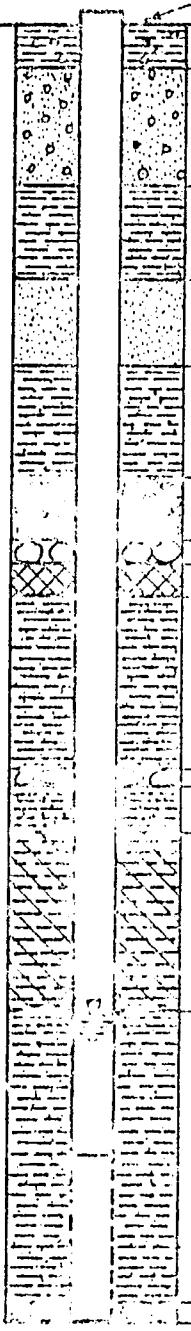
DATE
STATIC WATER LEVEL 47.3 M
PUMPING WATER LEVEL 48.8 M
TEST PUMP YIELD 0.94 LPS
SPECIFIC CAPACITY 0.63 LPS/M

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG

DEPTH (M)	DEPTH (FT)	STRATIFICATION
		GROUND SURFACE
2.1	7	STICKY CLAY WITH STONE
7.6	25	SAND AND GRAVEL
12.2	40	SANDY CLAY
16.2	53	COARSE SAND
21.3	70	YELLOW SANDY CLAY
24.4	80	GRAVEL
25.3	83	BOULDER
26.8	88	VOLCANIC ROCK
35.4	116	SANDY CLAY
36.0	118	BOULDER
38.1	125	SANDY CLAY
46.6	153	ADOBE AND BLUE CLAY
60.4	198	SANDY CLAY
61.0	200	FINE SAND WITH GRAVEL



ANNEX FIGURE VII-B-3
WELL DATA SHEET
WELL CDM-3
COTABATO WATER DISTRICT

DESCRIPTIVE DATA

WELL NO. (CDM) 4
(OTHER) 7475
LOCATION DUNGOAN, PAGALUNGA
CITY COTABATO
PROVINCE COTABATO
CONST. BY B.P.W.
DRILLER
STARTED
COMPLETED
OWNER B.P.W.
STATUS
CASING DIAMETER 150 MM
CASING LENGTH 10.1 M

DRILLER'S TEST DATA:

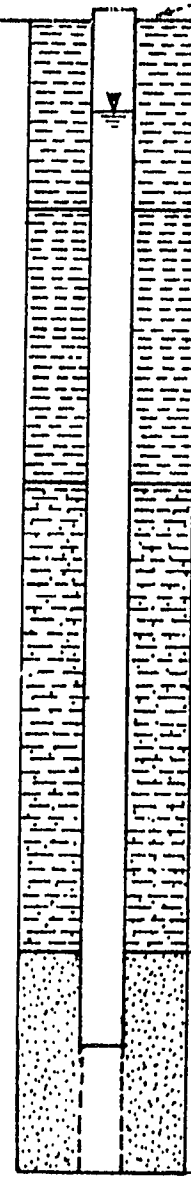
DATE
STATIC WATER LEVEL 0.9 M
PUMPING WATER LEVEL 3.0 M
TEST PUMP YIELD 0.95 LPS
SPECIFIC CAPACITY 0.45 LPS/M

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG

DEPTH (M)	DEPTH (FT)	CASING	STRATIFICATION
			GROUND SURFACE
0.9	3		YELLOW CLAY
1.8	6		BLUE STICKY CLAY
4.6	15		BLUE SANDY CLAY
9.2	30		FINE SAND
10.0	33		
11.3	37		



ANNEX FIGURE VII-B-4
WELL DATA SHEET
WELL CDM-4
COTABATO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

DESCRIPTIVE DATA

WELL NO. (CDM) 5
(OTHER) 15425
LOCATION PIGCALAGAN NULING
CITY COTABATO
PROVINCE COTABATO
CONST. BY B.P.W.
DRILLER
STARTED
COMPLETED
OWNER B.P.W.
STATUS
CASING DIAMETER 100 MM
CASING LENGTH 19.2 M

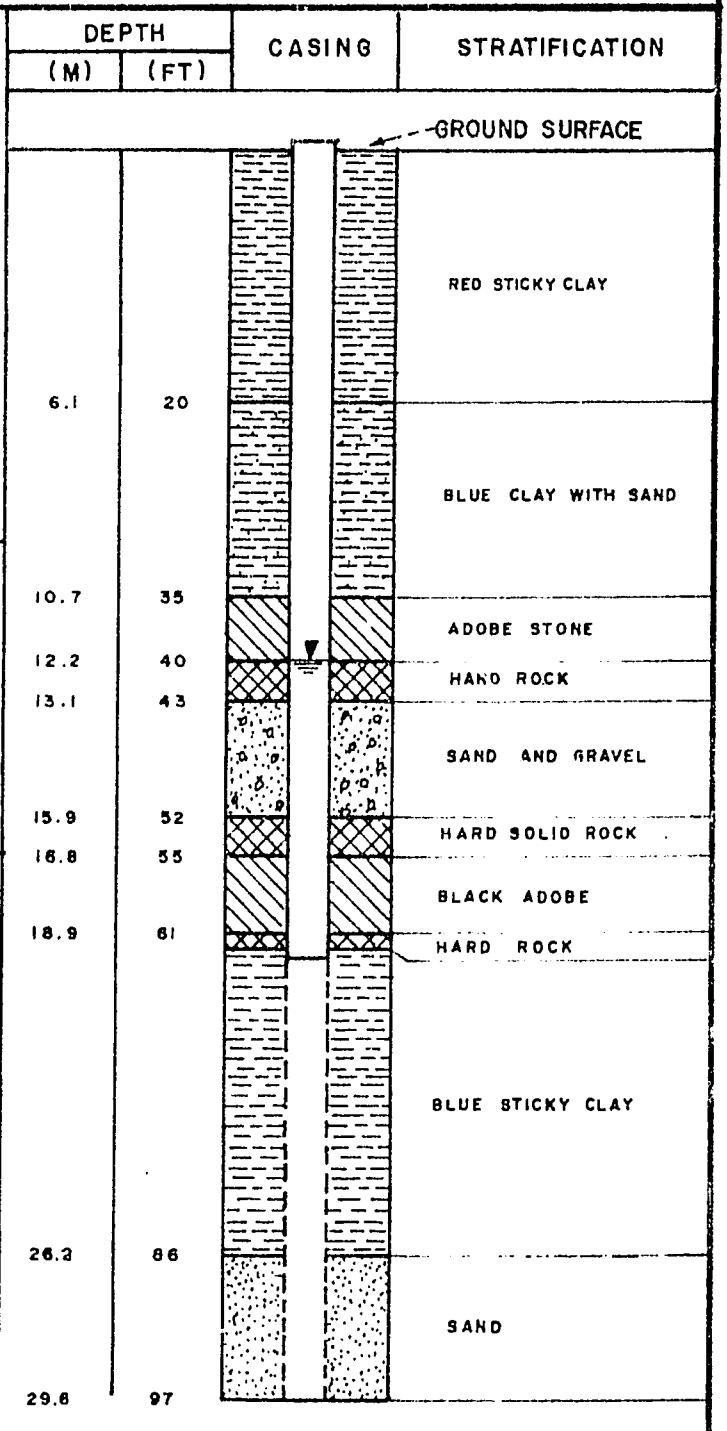
DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL 12.2 M
PUMPING WATER LEVEL 13.7 M
TEST PUMP YIELD 0.63 LPS
SPECIFIC CAPACITY 0.42 LPS/M

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG



ANNEX FIGURE VII-B-5
WELL DATA SHEET
WELL CDM-5
COTABATO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

DESCRIPTIVE DATA

WELL NO. (CDM) 6
(OTHER) 20310
LOCATION BARRIO MAKAGUILING, NULING
CITY COTABATO
PROVINCE COTABATO
CONST. BY B.P.W.
DRILLER JUAN M. ABULENCIA
STARTED
COMPLETED
OWNER B.P.W.
STATUS
CASING DIAMETER 150 MM
CASING LENGTH 3.7 M

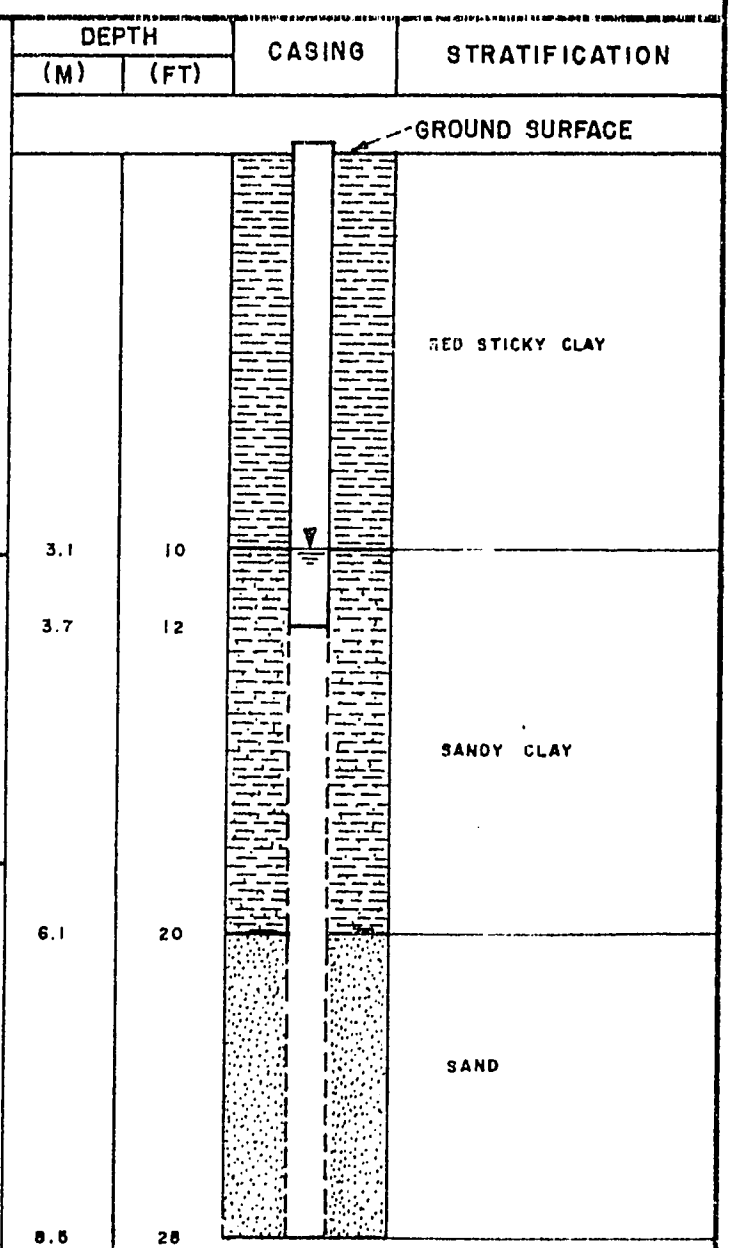
DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL 3.1 M
PUMPING WATER LEVEL
TEST PUMP YIELD 0.63 LPS
SPECIFIC CAPACITY

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG



ANNEX FIGURE VII-B-6
WELL DATA SHEET
WELL CDM-6
COTABATO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

DESCRIPTIVE DATA

WELL NO. (CDM) 7
(OTHER) B.P.W. 20311
LOCATION BARRIO GANG, NULING
CITY COTABATO
PROVINCE COTABATO
CONST. BY
DRILLER
STARTED
COMPLETED
OWNER
STATUS
CASING DIAMETER 100 MM
CASING LENGTH 10 M

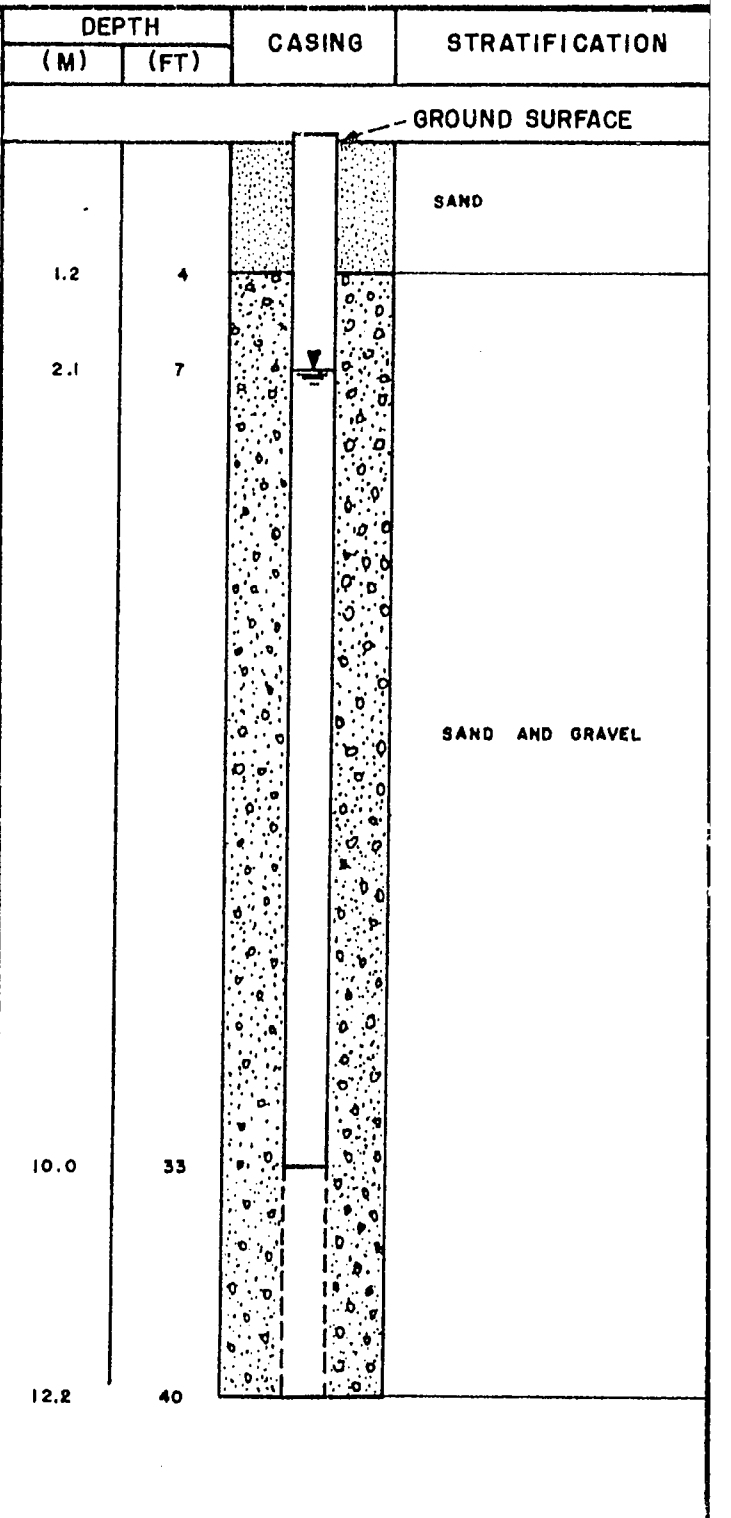
DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL 2.1 M
PUMPING WATER LEVEL
TEST PUMP YIELD 0.63 LPS
SPECIFIC CAPACITY

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG



ANNEX FIGURE VII-B-7
WELL DATA SHEET
WELL CDM 7
COTABATO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS **LWUA-CDM**

DESCRIPTIVE DATA

WELL NO. (CDM) 8
(OTHER) 16230
LOCATION BARRIO KALANGANAN
CITY COTABATO
PROVINCE
CONST. BY B.P.W.
DRILLER EMILIO CASTILLO
STARTED NOVEMBER 13, 1957
COMPLETED NOVEMBER 23, 1957
OWNER B.P.W.
STATUS
CASING DIAMETER 100 MM
CASING LENGTH 7.3 M

DRILLER'S TEST DATA:

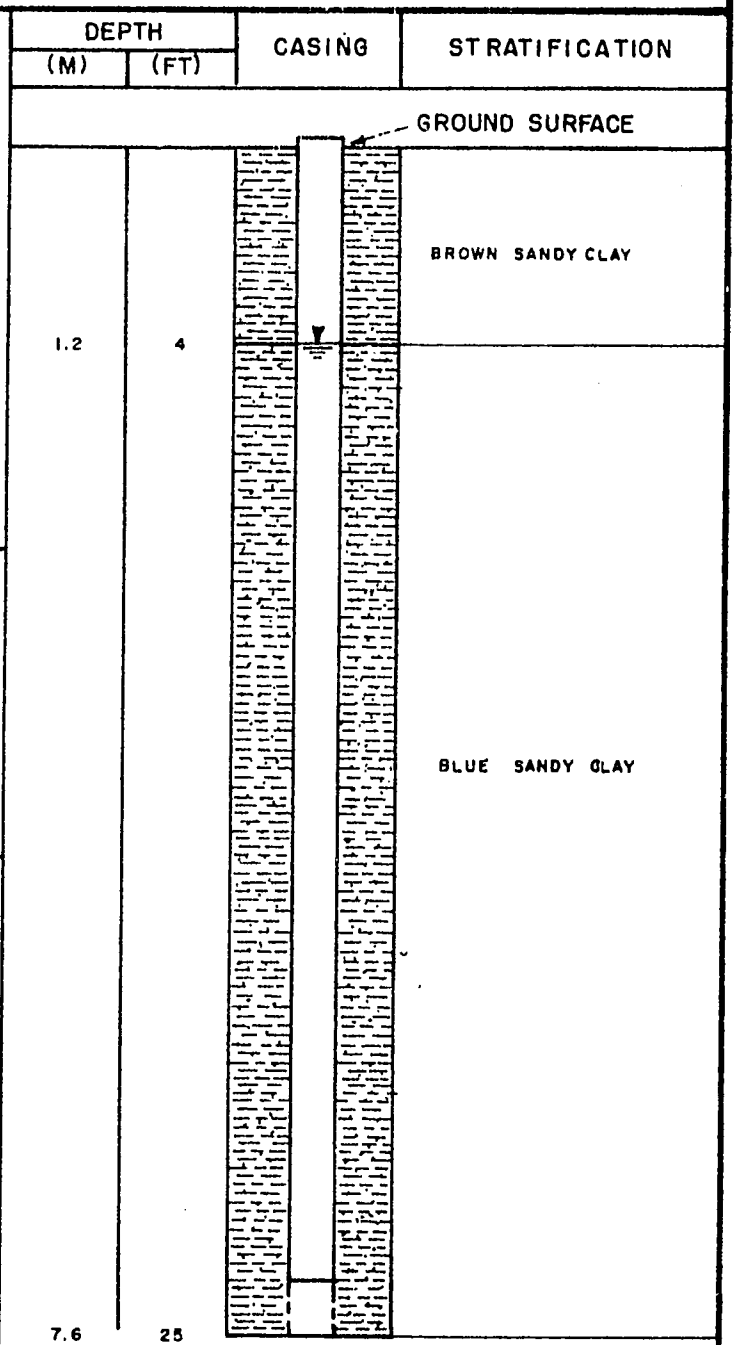
DATE
STATIC WATER LEVEL 1.2 M
PUMPING WATER LEVEL 2.4 M
TEST PUMP YIELD 0.63 LPS
SPECIFIC CAPACITY 0.53 LPS/M

REMARKS:

WATER QUALITY DATA:

CLEAR FOR DRINKING PURPOSES.

GRAPHIC LOG



ANNEX FIGURE VII-B-8
WELL DATA SHEET
WELL CDM-8
COTABATO WATER DISTRICT

DESCRIPTIVE DATA

WELL NO. (CDM) 9
(OTHER) 15427
LOCATION LEPROSARIUM HOSPITAL
NULING
CITY COTABATO
PROVINCE COTABATO
CONST. BY B.P.W
DRILLER JUAN M. ABULENCIA
STARTED SEPTEMBER 10, 1957
COMPLETED SEPTEMBER 27, 1957
OWNER B.P.W.
STATUS
CASING DIAMETER 150 MM
CASING LENGTH 22 M

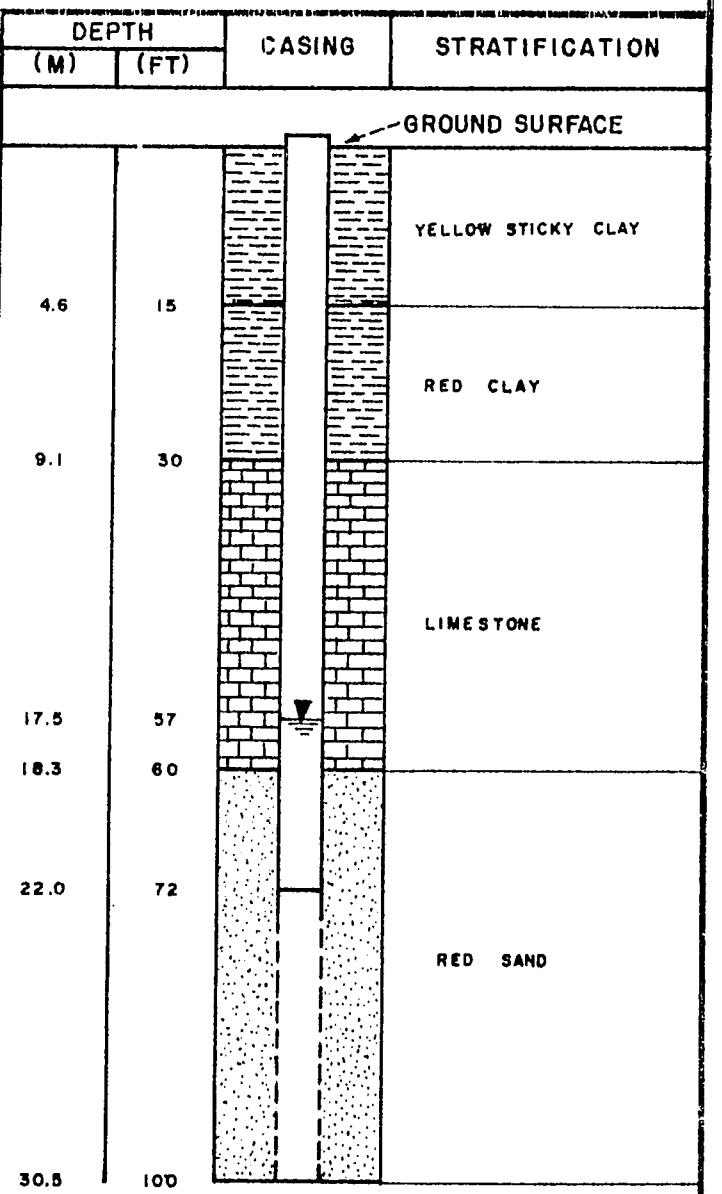
DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL 17.4 M
PUMPING WATER LEVEL 18.9 M
TEST PUMP YIELD 0.94 LPS
SPECIFIC CAPACITY 0.63 LPS/M

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG



ANNEX FIGURE VII-B-9
WELL DATA SHEET
WELL CDM-9
COTABATO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS **LWUA-CDM**

DESCRIPTIVE DATA

WELL NO. (CDM) 10
(OTHER) 15426
LOCATION BARRIO ALMADA NULING
GITY COTABATO
PROVINCE COTABATO
CONST. BY B.P.W
DRILLER JUAN M. ABULENCIA
STARTED AUGUST 14, 1957
COMPLETED SEPTEMBER 6, 1957
OWNER B.P.W.
STATUS
CASING DIAMETER 100 MM
CASING LENGTH 13.1 M

DRILLER'S TEST DATA:

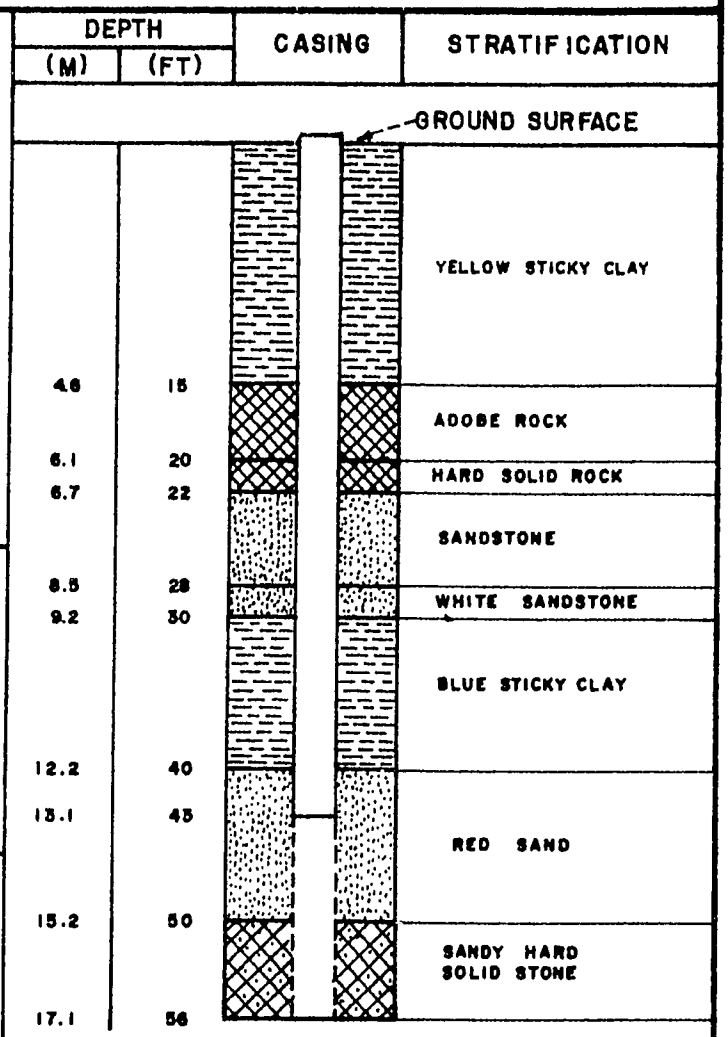
DATE
STATIC WATER LEVEL 10.4 M
PUMPING WATER LEVEL 12.2 M
TEST PUMP YIELD 0.95 LPS
SPECIFIC CAPACITY 0.53 LPS/M

REMARKS:

GOOD FOR DRINKING AND DOMESTIC PURPOSES.

WATER QUALITY DATA:

GRAPHIC LOG



ANNEX FIGURE VII-B-10
WELL DATA SHEET
WELL CDM-10
COTABATO WATER DISTRICT

DESCRIPTIVE DATA

WELL NO. (CDM) 12
(OTHER) 195912
LOCATION BAGUA
CITY COTABATO
PROVINCE
CONST. BY B.P.W
DRILLER BRANDO P. DIAZ
STARTED NOVEMBER 11, 1959
COMPLETED DECEMBER 9, 1959
OWNER B.P.W.
STATUS
CASING DIAMETER 100 MM
CASING LENGTH 16.9 M

DRILLER'S TEST DATA:

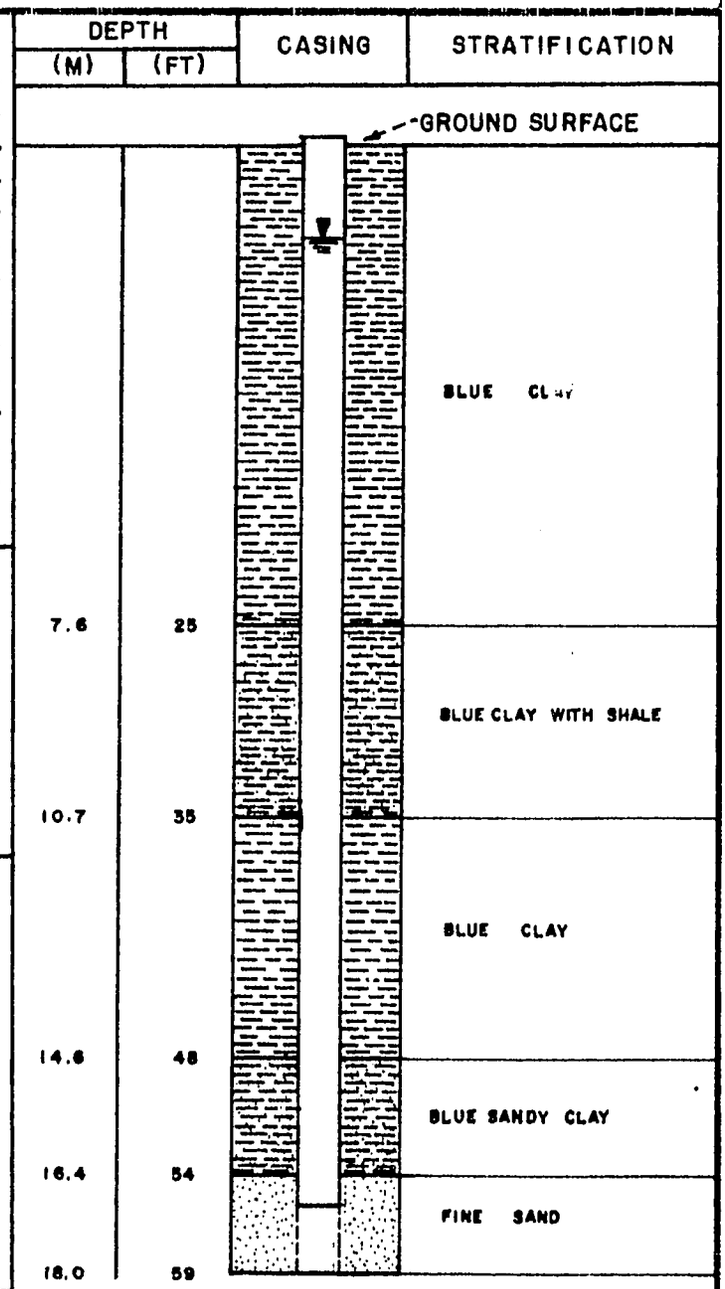
DATE
STATIC WATER LEVEL 1.5 M
PUMPING WATER LEVEL 1.8 M
TEST PUMP YIELD 0.32 LPS
SPECIFIC CAPACITY 1.07 LPS/M

REMARKS:

WATER QUALITY DATA:

WATER IS CLEAR AND FRESH.

GRAPHIC LOG



ANNEX FIGURE VII-B-II
WELL DATA SHEET
WELL CDM -12
COTABATO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

DESCRIPTIVE DATA

WELL NO. (CDM) 13
(OTHER)
LOCATION COTABATO CITY HIGH SCHOOL COMPOUND
CITY COTABATO
PROVINCE MAGUINDANAO
CONST. BY
DRILLER
STARTED MARCH 16, 1973
COMPLETED APRIL 2, 1973
OWNER
STATUS ABANDONED
CASING DIAMETER 200 MM B.I. PIPE
CASING LENGTH 30.5 M

DRILLER'S TEST DATA:

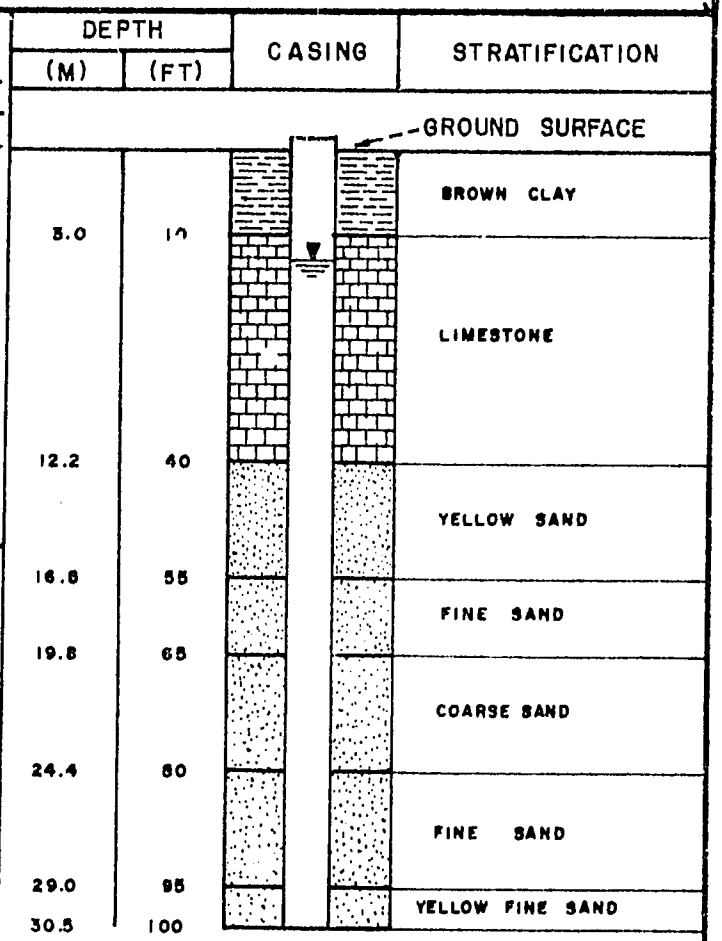
DATE
STATIC WATER LEVEL 13.7 M
PUMPING WATER LEVEL
TEST PUMP YIELD
SPECIFIC CAPACITY

REMARKS:

FORMERLY WITH SUBMERSIBLE PUMP.

WATER QUALITY DATA:

GRAPHIC LOG



ANNEX FIGURE VII-B-12
WELL DATA SHEET
WELL CDM-13
COTABATO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

DESCRIPTIVE DATA

WELL NO. (CDM) 14
(OTHER) 20351
LOCATION LAMBAYONG INSTITUTE
CITY COTABATO
PROVINCE
CONST. BY B.P.W.
DRILLER EVANGELISTA MACONOCIDO
STARTED NOVEMBER 15, 1957
COMPLETED DECEMBER 11, 1957
OWNER B.P.W.
STATUS
CASING DIAMETER 150 MM
CASING LENGTH 25.9 M

DRILLER'S TEST DATA:

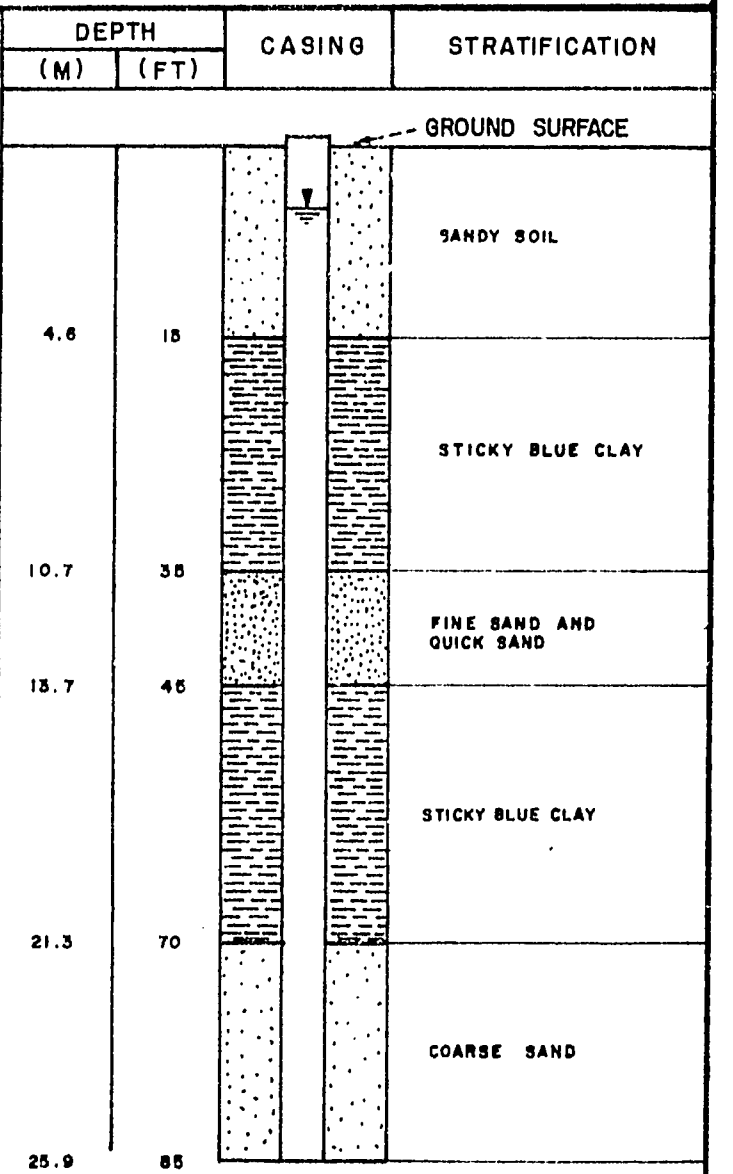
DATE
STATIC WATER LEVEL 1.5M
PUMPING WATER LEVEL 2.4M
TEST PUMP YIELD 0.94 LPS
SPECIFIC CAPACITY 1.05 LPS/M

REMARKS:

WATER QUALITY DATA

FRESH CLEAR & POTABLE WATER.

GRAPHIC LOG



ANNEX FIGURE VII-B-13
WELL DATA SHEET
WELL CDM - 14
COTABATO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

DESCRIPTIVE DATA

WELL NO. (CDM) 15
(OTHER) 196021
LOCATION COTABATO HIGH SCHOOL
CITY COTABATO
PROVINCE COTABATO
CONST. BY B.P.W.
DRILLER AMADO I. CRUZ
STARTED APRIL 25, 1960
COMPLETED JUNE 7, 1960
OWNER B.P.W.
STATUS
CASING DIAMETER 200 MM
CASING LENGTH 26.5 M

DRILLER'S TEST DATA:

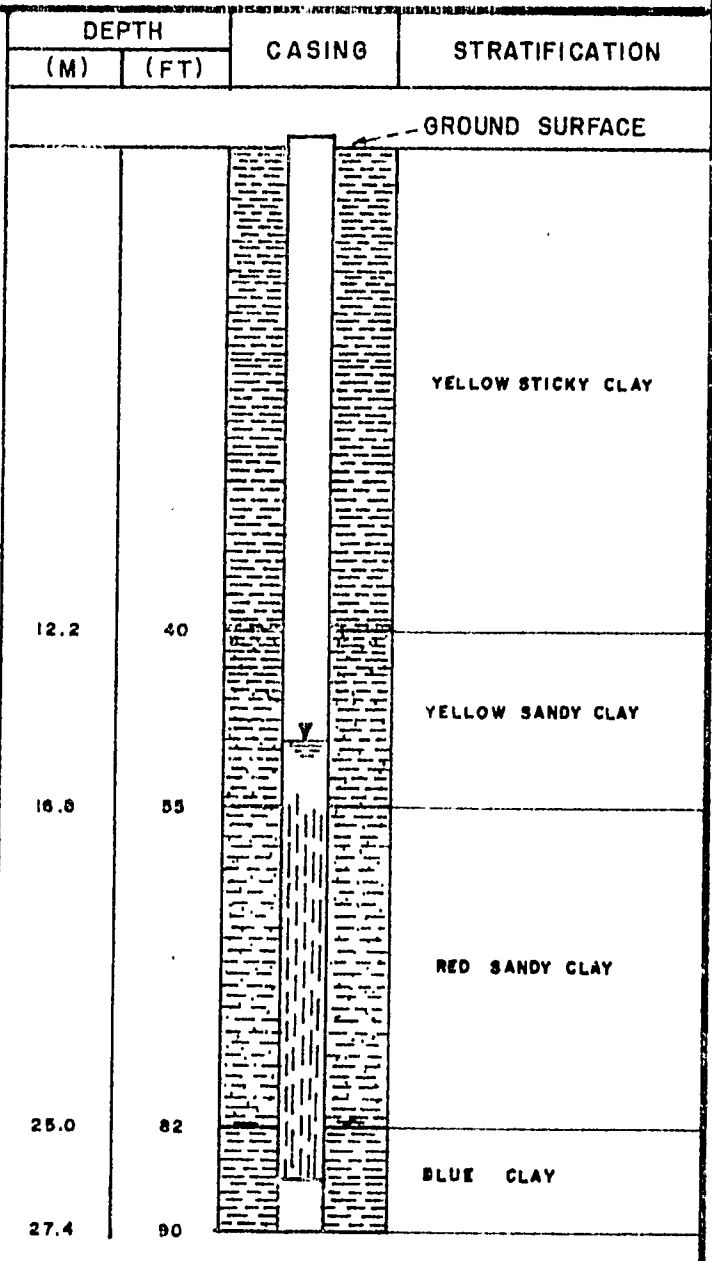
DATE
STATIC WATER LEVEL 15.2 M
PUMPING WATER LEVEL 19.5 M
TEST PUMP YIELD 3.40 LPS
SPECIFIC CAPACITY 0.79 LPS/M

REMARKS:

CASING PERFORATED FROM DEPTH 17.7 M. (58 FT.) TO DEPTH 26.5 M (87 FT.).
WATER BEARING STRATA FROM DEPTH 19.5 M. (64 FT.) TO DEPTH 25 M. (82 FT.)

WATER QUALITY DATA:

GRAPHIC LOG



ANNEX FIGURE VII-B-14
WELL DATA SHEET
WELL CDM-15
COTABATO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

DESCRIPTIVE DATA

WELL NO. (CDM) 17
(OTHER)
LOCATION ROSALES SUBDIVISION
CITY COTABATO
PROVINCE MAGUINDANAO
CONST. BY
DRILLER
STARTED JANUARY 31, 1973
COMPLETED FEBRUARY 6, 1973
OWNER
STATUS
CASING DIAMETER 200 MM
CASING LENGTH 28.0 M

DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL 11.3 M
PUMPING WATER LEVEL
TEST PUMP YIELD 38.2 LPS
SPECIFIC CAPACITY

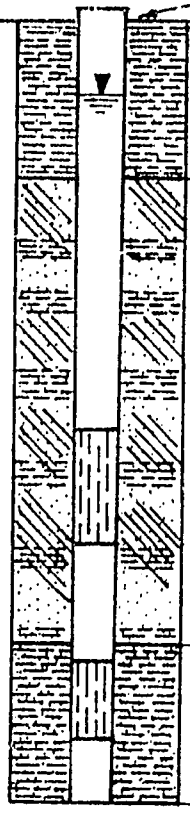
REMARKS:

FORMERLY WITH SUBMERSIBLE PUMP.

WATER QUALITY DATA:

GRAPHIC LOG

DEPTH (M)	DEPTH (FT)	CASING	STRATIFICATION
			GROUND SURFACE
6.1	20		YELLOW SANDY CLAY
15.9	52		YELLOW ADOBE SANDY CLAY
20.4	67		
24.4	80		
25.0	82		
28.0	92		BLUE SANDY CLAY
30.5	100		



ANNEX FIGURE VII-B-15
WELL DATA SHEET
WELL CDM - 17
COTABATO WATER DISTRICT

DESCRIPTIVE DATA

WELL NO. (CDM) 18
(OTHER)
LOCATION MOTOR POOL- CIRCUIT ROAD
CITY COTABATO
PROVINCE MAGUINDANAO
CONST. BY
DRILLER
STARTED JANUARY 25, 1974
COMPLETED FEBRUARY 4, 1974
OWNER
STATUS
CASING DIAMETER 200 MM
CASING LENGTH 17.7 M

DRILLER'S TEST DATA:

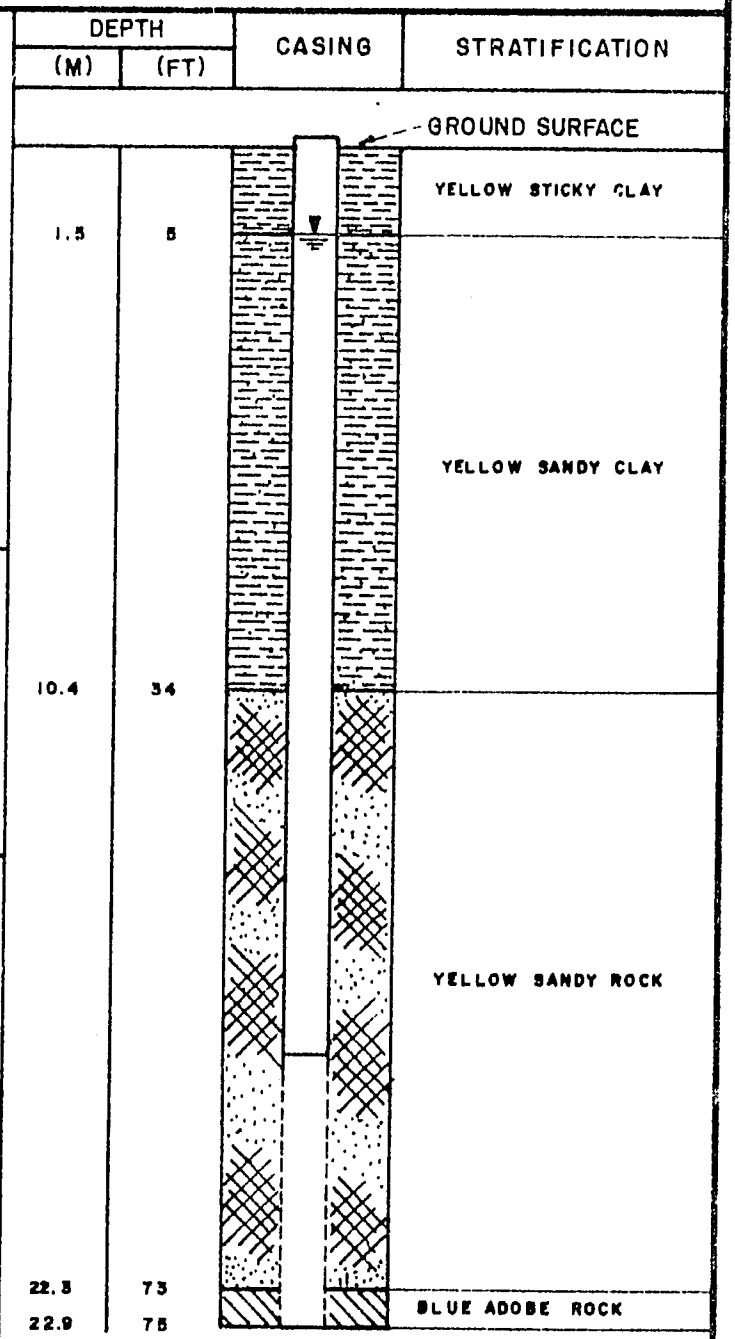
DATE
STATIC WATER LEVEL 4.9 M
PUMPING WATER LEVEL
TEST PUMP YIELD 9.45 LPS
SPECIFIC CAPACITY

REMARKS:

FORMERLY WITH SUBMERSIBLE PUMP

WATER QUALITY DATA:

GRAPHIC LOG



ANNEX FIGURE VII-B-16
WELL DATA SHEET
WELL CDM-18
COTABATO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

DESCRIPTIVE DATA

WELL NO. (CDM) 20
(OTHER)
LOCATION GEN. LUNA (BU. OF TELECOM)
CITY COTABATO
PROVINCE MAGUINDANAO
CONST. BY
DRILLER
STARTED SEPTEMBER 25, 1964
COMPLETED NOVEMBER 14, 1964
OWNER
STATUS
CASING DIAMETER 200MM
CASING LENGTH 33.5 M

DRILLER'S TEST DATA:

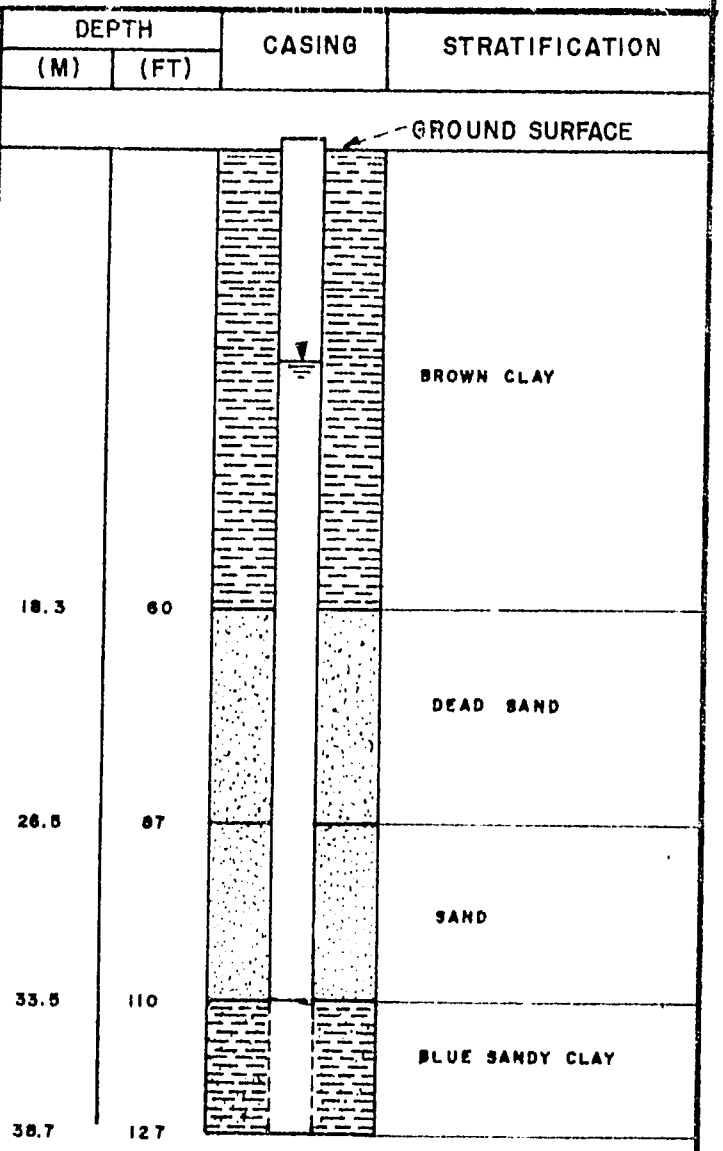
DATE
STATIC WATER LEVEL 15.2 M
PUMPING WATER LEVEL 22.9 M
TEST PUMP YIELD 15.8 LPS
SPECIFIC CAPACITY 2 LPS/M

REMARKS:

FORMERLY WITH SUBMERSIBLE PUMP

WATER QUALITY DATA:

GRAPHIC LOG



ANNEX FIGURE VII-B-17
WELL DATA SHEET
WELL CDM - 20
COTABATO WATER DISTRICT

DESCRIPTIVE DATA

WELL NO. (CDM) 23
(OTHER) 196022
LOCATION ROSARY HEIGHTS
CITY COTABATO
PROVINCE
CONST. BY B.P.W.
DRILLER AMADO CRUZ
STARTED JUNE 8, 1960
COMPLETED JULY 11, 1960
OWNER B.P.W.
STATUS
CASING DIAMETER 100 MM
CASING LENGTH 34.1 M

DRILLER'S TEST DATA:

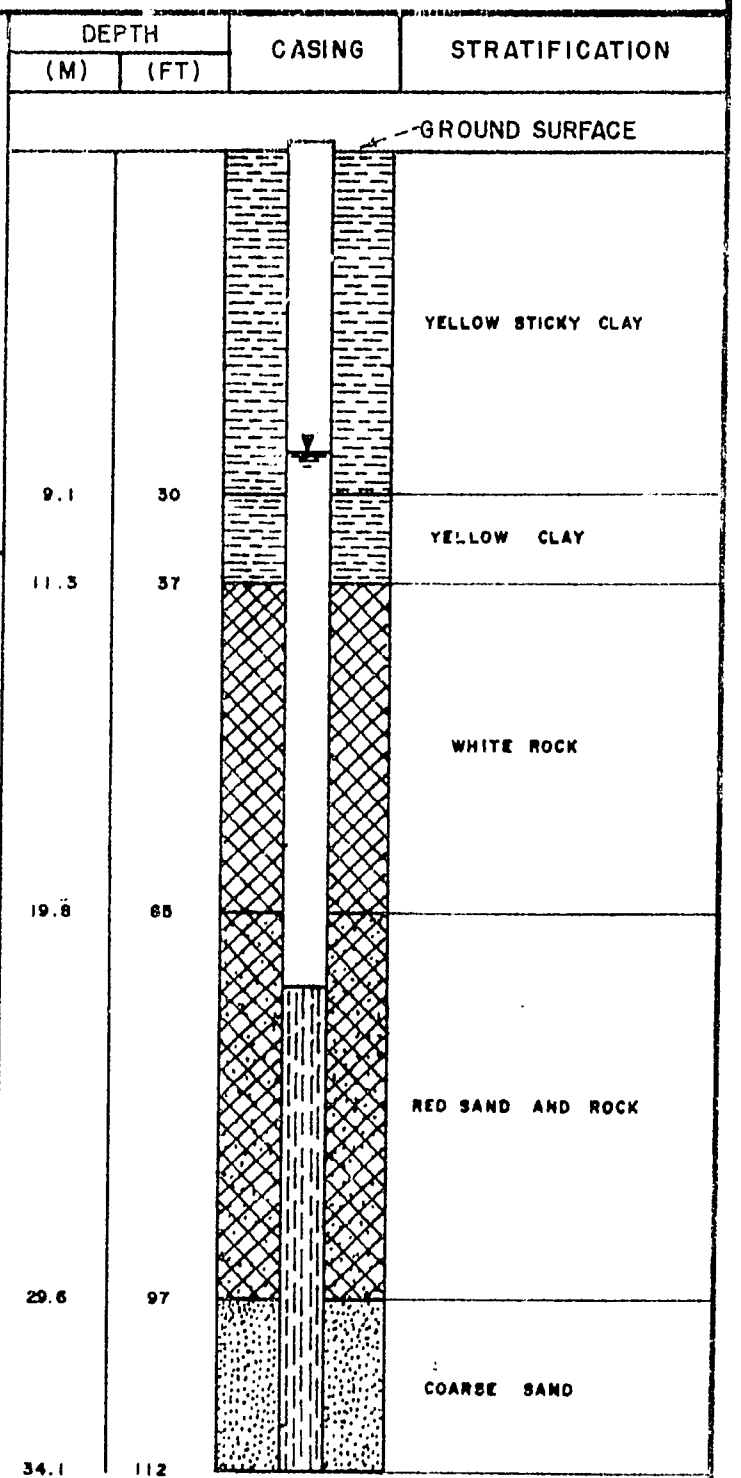
DATE
STATIC WATER LEVEL 7.9 M
PUMPING WATER LEVEL 9.8 M
TEST PUMP YIELD 4.41 LPS
SPECIFIC CAPACITY 2.32 LPS/M

REMARKS:

CASING PERFORATED FROM DEPTH 22 M. (72 FT.) TO DEPTH 34.1M (112 FT.).
WATER BEARING STRATA FROM DEPTH 27.4 M. (90 FT.) TO DEPTH 34.1 M. (112 FT.).

WATER QUALITY DATA:

GRAPHIC LOG



ANNEX FIGURE VII-B-18
WELL DATA SHEET
WELL CDM - 23
COTABATO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

DESCRIPTIVE DATA

WELL NO. (CDM) 24
(OTHER)
LOCATION GUTIERREZ - SAMPAGUITA ST.
CITY COTABATO
PROVINCE MAGUINDANAO
CONST. BY
DRILLER
STARTED NOVEMBER 23, 1973
COMPLETED DECEMBER 5, 1973
OWNER
STATUS
CASING DIAMETER 200 MM
CASING LENGTH 18.3 M

DRILLER'S TEST DATA:

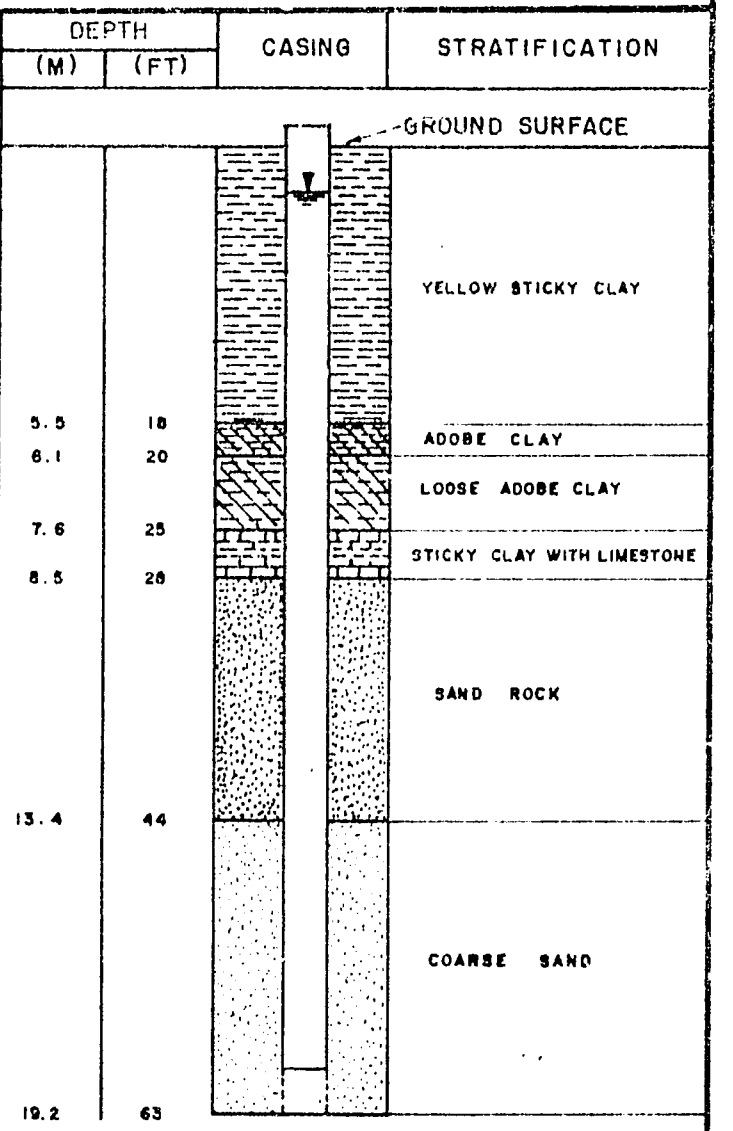
DATE
STATIC WATER LEVEL 3.0 M
PUMPING WATER LEVEL
TEST PUMP YIELD 27.4 LPS
SPECIFIC CAPACITY

REMARKS:

FORMERLY WITH
SUBMERSIBLE PUMP

WATER QUALITY DATA:

GRAPHIC LOG



ANNEX FIGURE VII-B-19
WELL DATA SHEET
WELL CDM - 24
COTABATO WATER DISTRICT

DESCRIPTIVE DATA

WELL NO. (CDM) 25
(OTHER)
LOCATION ORTOUSTE - ROSAL ST.
CITY COTABATO CITY
PROVINCE MAGUINDANAO
CONST. BY
DRILLER
STARTED DECEMBER 18, 1973
COMPLETED DECEMBER 29, 1973
OWNER
STATUS INACTIVE
CASING DIAMETER 200 MM
CASING LENGTH 18.3 M

DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL 2.1 M
PUMPING WATER LEVEL
TEST PUMP YIELD 12.6 LPS
SPECIFIC CAPACITY

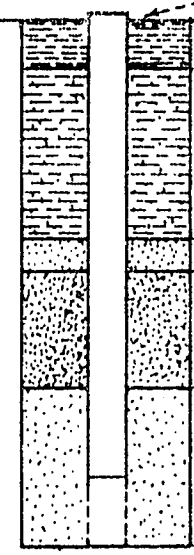
REMARKS:

FORMERLY WITH TURBINE PUMP.

WATER QUALITY DATA:

GRAPHIC LOG

DEPTH (M)	DEPTH (FT)	CASING	STRATIFICATION
			GROUND SURFACE
1.8	6		YELLOW STICKY CLAY
8.5	28		SANDY CLAY
9.8	32		SAND
14.3	47		SAND ROCKS
20.4	67		COARSE SAND



ANNEX FIGURE VII-B-20
WELL DATA SHEET
WELL CDM-25
COTABATO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

DESCRIPTIVE DATA

WELL NO. (CDM) 27
(OTHER) B.P.W. NO. 12241
LOCATION TALITAY, DINAIG
CITY
PROVINCE COTABATO
CONST. BY B.P.W.
DRILLER JUAN ABULENCIA
STARTED 1956
COMPLETED 1956
OWNER
STATUS
CASING DIAMETER 150 MM
CASING LENGTH 7.3 M

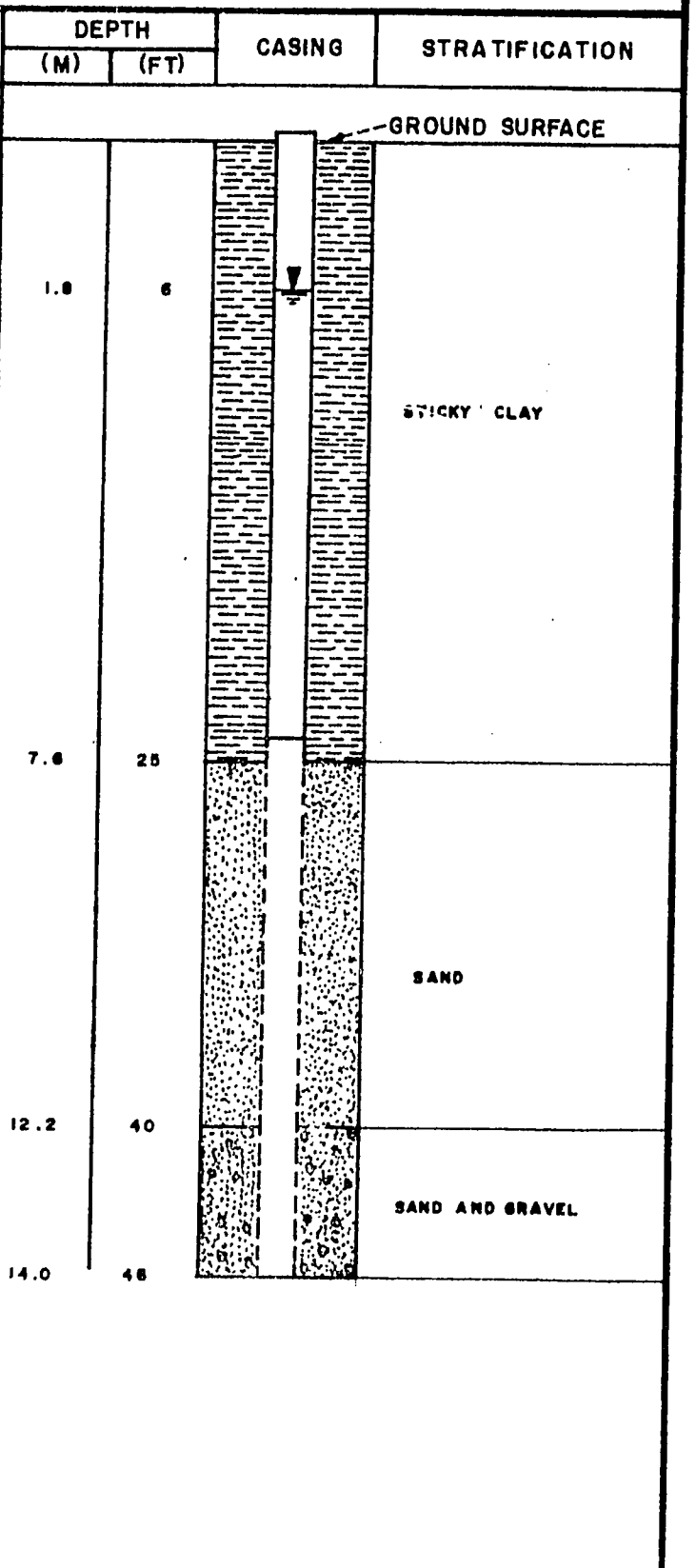
DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL 1.8 M
PUMPING WATER LEVEL 2.1 M
TEST PUMP YIELD 0.63 LPS
SPECIFIC CAPACITY 2.1 LPS/M

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG



ANNEX FIGURE VII-B-21
WELL DATA SHEET
WELL CDM - 27
COTABATO WATER DISTRICT

DESCRIPTIVE DATA

WELL NO. (CDM) 28
(OTHER) 16227
LOCATION TAMONTACA
CITY COTABATO
PROVINCE COTABATO
CONST. BY B.P.W.
DRILLER EMILIO CASTILLO
STARTED JULY 10, 1954
COMPLETED JULY 24, 1954
OWNER B.P.W.
STATUS
CASING DIAMETER
CASING LENGTH

DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL 1.5 M
PUMPING WATER LEVEL 3.0 M
TEST PUMP YIELD 0.76 LPS
SPECIFIC CAPACITY 0.51 LPS / M

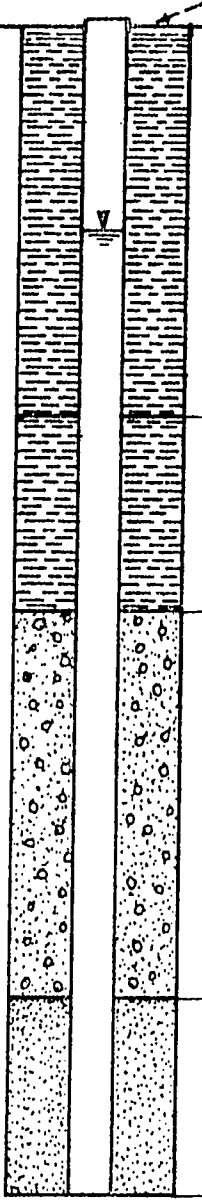
REMARKS:

GOOD FOR WATER SUPPLY.

WATER QUALITY DATA:

GRAPHIC LOG

DEPTH (M)	DEPTH (FT)	CASING	STRATIFICATION
			GROUND SURFACE
1.5	5		BROWN STICKY CLAY
3.0	10		BLUE STICKY CLAY
4.5	15		SAND AND GRAVEL
7.6	25		FINE SAND
9.2	30		



ANNEX FIGURE VII-B-22
WELL DATA SHEET
WELL CDM - 28
COTABATO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

DESCRIPTIVE DATA

WELL NO. (CDM) 29
(OTHER) 16228
LOCATION BARRIO PAGALAMATAN
CITY COTABATO
PROVINCE COTABATO
CONST. BY B.P.W.
DRILLER
STARTED
COMPLETED
OWNER B.P.W.
STATUS
CASING DIAMETER 100 MM
CASING LENGTH 6.5 M

DRILLER'S TEST DATA:

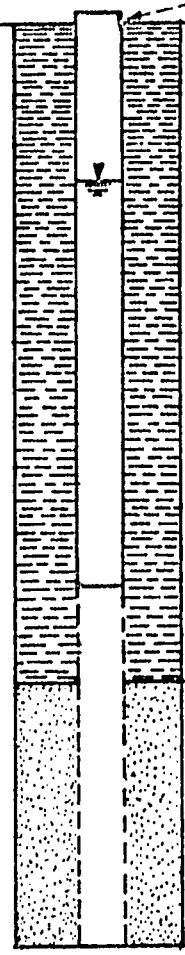
DATE
STATIC WATER LEVEL 1.8 M
PUMPING WATER LEVEL 3.1 M
TEST PUMP YIELD 0.76 LPS
SPECIFIC CAPACITY 0.63 LPS/M

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG

DEPTH (M)	DEPTH (FT)	CASING	STRATIFICATION
			GROUND SURFACE
1.8	6		BROWN STICKY CLAY
6.5	21.25		
7.6	25		FINE SAND
10.7	35		



ANNEX FIGURE VII-B-23
WELL DATA SHEET
WELL CDM - 29
COTABATO WATER DISTRICT

DESCRIPTIVE DATA

WELL NO. (ODM) 31
(OTHER) 196091
LOCATION BARRIO BITO DINANG
CITY COTABATO
PROVINCE COTABATO
CONST. BY B.P.W.
DRILLER RUBEN BERMUDEZ
STARTED APRIL 8, 1960
COMPLETED APRIL 30, 1960
OWNER B.P.W.
STATUS
CASING DIAMETER 100 MM
CASING LENGTH 12.5 M

DRILLER'S TEST DATA:

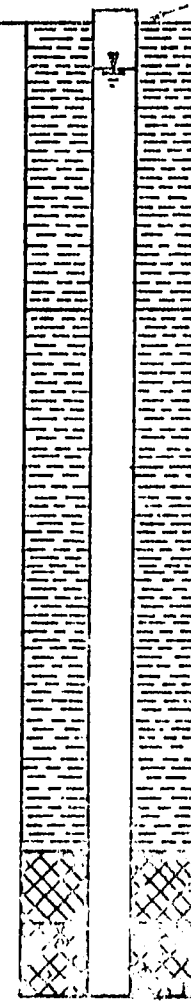
DATE
STATIC WATER LEVEL 0.6 M
PUMPING WATER LEVEL 0.9 M
TEST PUMP YIELD 0.95LPS
SPECIFIC CAPACITY 3.17LPS / M

REMARKS:

WATER QUALITY DATA

GRAPHIC LOG

DEPTH (M)	DEPTH (FT)	CASING	STRATIFICATION
			GROUND SURFACE
			BLACK CLAY
3.7	12		YELLOW CLAY
10.7	35		HARD ROCK
11.6	29		HARD ROCK WITH GRAVEL
12.5	41		



ANNEX FIGURE VII-B-24
WELL DATA SHEET
WELL CDM-31
COTABATO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

DESCRIPTIVE DATA

WELL NO. (CDM) 32
(OTHER) 20881
LOCATION BARRIO TIUGON
CITY COTABATO
PROVINCE COTABATO
CONST. BY B.P.W.
DRILLER EMILIO CASTILLO
STARTED NOVEMBER 29, 1957
COMPLETED DECEMBER 11, 1957
OWNER B.P.W.
STATUS
CASING DIAMETER 100 MM
CASING LENGTH 6.7 M

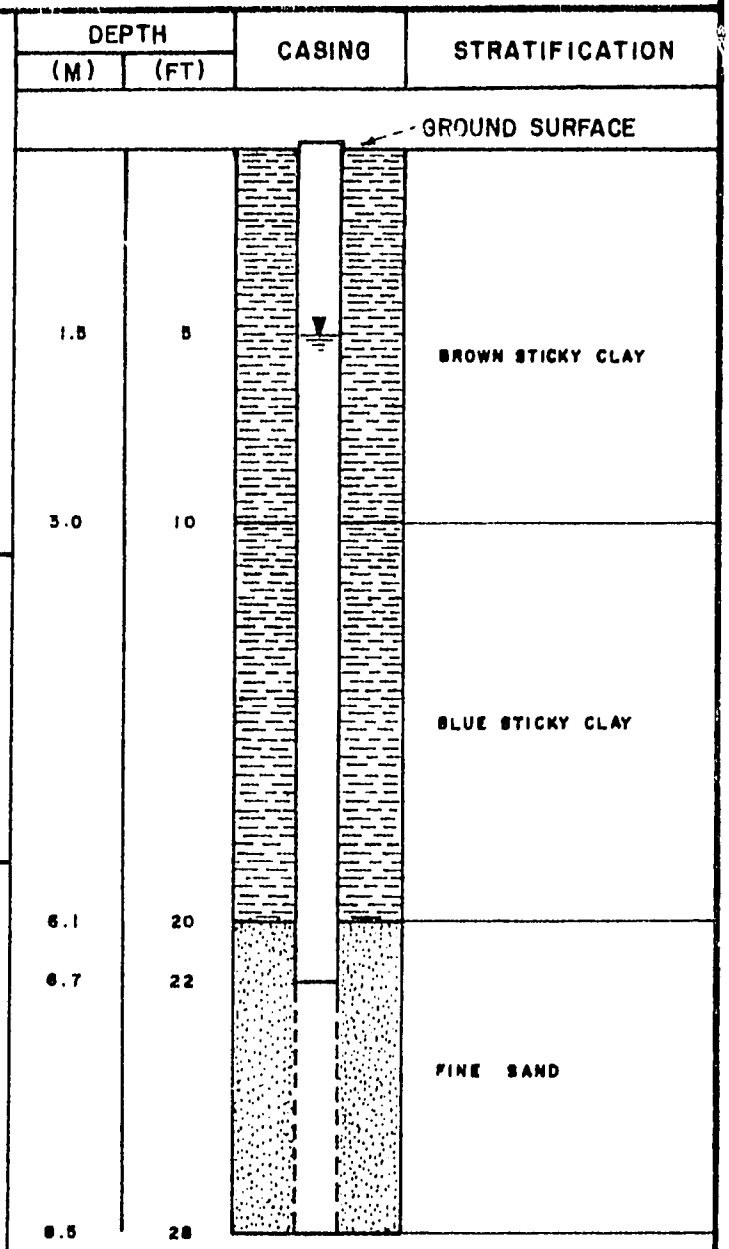
DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL 1.5 M
PUMPING WATER LEVEL 3.1 M
TEST PUMP YIELD 0.63 LPS
SPECIFIC CAPACITY 0.42 LPS/M

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG



ANNEX FIGURE VII-B-25
WELL DATA SHEET
WELL CDM - 32
COTABATO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

DESCRIPTIVE DATA

WELL NO. (CDM) 35
(OTHER) BPW NO. 196063
LOCATION BANGA

CITY COTABATO
PROVINCE COTABATO
CONST. BY B.P.W.
DRILLER EMILIO CASTILLO
STARTED JUNE 1, 1960
COMPLETED SEPTEMBER 7, 1960
OWNER
STATUS
CASING DIAMETER 100 MM
CASING LENGTH 20.1 M

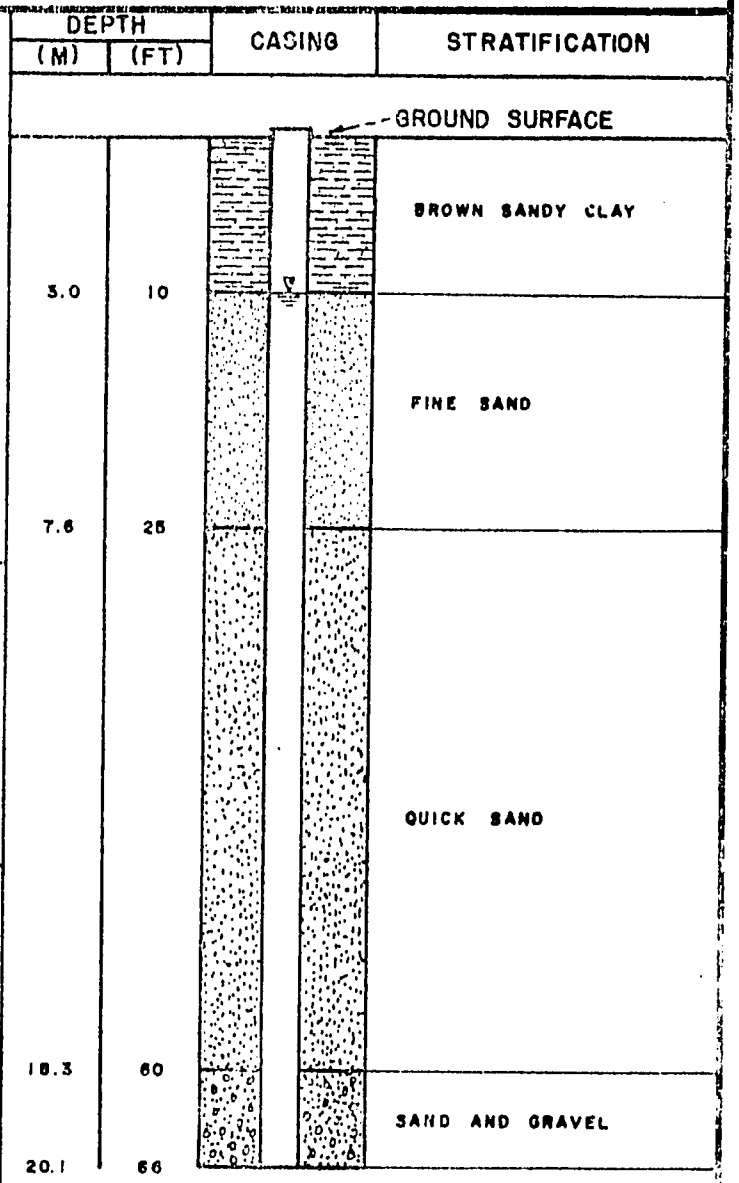
DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL 3.0 M
PUMPING WATER LEVEL 4.6 M
TEST PUMP YIELD 0.76 LPS
SPECIFIC CAPACITY 0.48 LPS/M

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG



ANNEX FIGURE VII-B-26
WELL DATA SHEET
WELL CDM - 35
COTABATO WATER DISTRICT

DESCRIPTIVE DATA

WELL NO. (CDM) 36
(OTHER) B.P.W 5487
LOCATION MARKET SITE
CITY MIDSAYAP
PROVINCE COTABATO
CONST. BY B.P.W
DRILLER
STARTED JUNE 12, 1952
COMPLETED JULY 23, 1952
OWNER
STATUS
CASING DIAMETER 150 MM
CASING LENGTH 42.4 M

DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL 2.7 M
PUMPING WATER LEVEL 3.6 M
TEST PUMP YIELD 1.9 LPS
SPECIFIC CAPACITY 2.1 LPS/M

REMARKS:

WATER QUALITY DATA:

DRILLING LOG

DEPTH (M)	DEPTH (FT)	CASING	STRATIFICATION
			GROUND SURFACE
			BROWN CLAY
4.0	13		
			BLACK CLAY
6.7	22		
			BLUE STICKY CLAY
12.2	40		
			YELLOW STICKY CLAY
15.5	51		
			BLACK STICKY CLAY
18.3	60		
			YELLOW STICKY CLAY
23.5	77		
			BLACK CLAY
25.3	83		
			YELLOW STICKY CLAY
30.5	100		
			BLUE STICKY CLAY
34.4	113		
			BLACK CLAY
36.6	120		
			BLUE CLAY
38.7	127		
			YELLOW CLAY
42.7	140		
			FINE SAND
44.2	145		

ANNEX FIGURE VII-B-27
WELL DATA SHEET
WELL CDM - 36
COTABATO WATER DISTRICT

DESCRIPTIVE DATA

WELL NO. (CDM) 37
(OTHER) B.P.W. 7268
LOCATION BARRIO GAYONGA
CITY TUMBAO
PROVINCE COTABATO
CONST. BY BPW
DRILLER AMADO CRUZ
STARTED AUGUST 25, 1955
COMPLETED SEPTEMBER 21, 1955
OWNER
STATUS
CASING DIAMETER 150 MM
CASING LENGTH 7.6 M

DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL 2.1 M
PUMPING WATER LEVEL 3.7 M
TEST PUMP YIELD 1.3 LPS
SPECIFIC CAPACITY 0.84 LPS/M

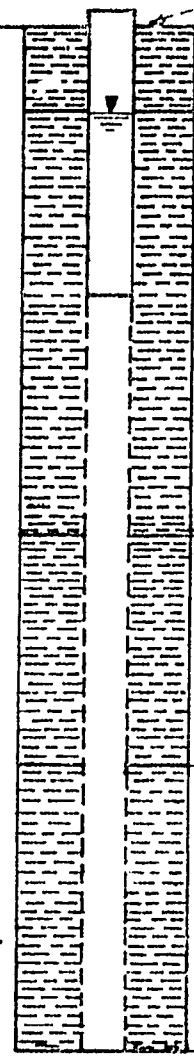
REMARKS:

WATER QUALITY DATA:

WATER IS FRESH AND CLEAR

GRAPHIC LOG

DEPTH (M)	DEPTH (FT)	CASING	STRATIFICATION
			GROUND SURFACE
2.1	7		YELLOW CLAY
14.6	48		BLUE STICKY CLAY
21.3	70		BLACK CLAY
29.9	98		BLUE STICKY CLAY



ANNEX FIGURE VII-B-28
WELL DATA SHEET
WELL CDM-37
COTABATO WATER DISTRICT

DESCRIPTIVE DATA

WELL NO. (CDM) 38
(OTHER) BPW 12245
LOCATION BARRIO TOBON
CITY PIGCAWAYAN
PROVINCE COTABATO
CONST. BY B.P.W.
DRILLER JUAN ABULENCIA
STARTED AUGUST 28, 1956
COMPLETED
OWNER
STATUS
CASING DIAMETER 112 MM
CASING LENGTH 12.2 M

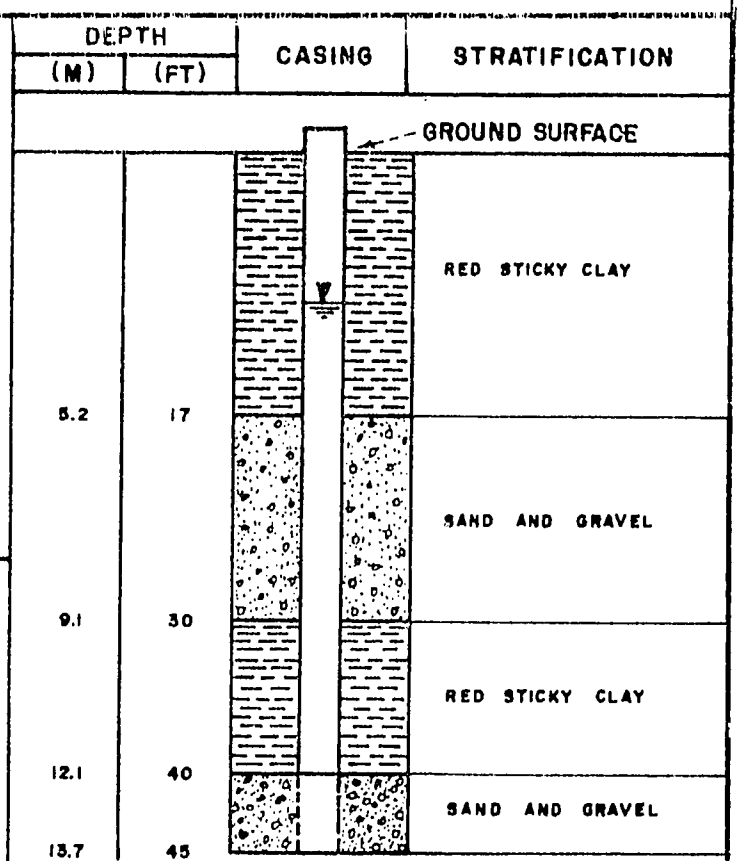
DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL 3.0 M
PUMPING WATER LEVEL 3.7 M
TEST PUMP YIELD 0.95 LPS
SPECIFIC CAPACITY 1.3 LPS/M

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG



ANNEX FIGURE VII-B-29
WELL DATA SHEET
WELL CDM-38
COTABATO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

DESCRIPTIVE DATA

WELL NO. (CDM) 39
(OTHER) 16882
LOCATION SUNAWAN SETTLEMENT
BULUAN
CITY COTABATO
PROVINCE COTABATO
OWNER B.P.W
DRILLER JOSE SAMSON
STARTED MAY 1, 1958
COMPLETED DECEMBER 31, 1958
OWNER B.P.W
STATUS
CASING DIAMETER 100 MM
CASING LENGTH 52.1 M

DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL 40.7 M
PUMPING WATER LEVEL 47.0 M
TEST PUMP YIELD 0.63 LPS
SPECIFIC CAPACITY 0.15 LPS/M

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG

DEPTH (M)	DEPTH (FT)	CASING	STRATIFICATION
			GROUND SURFACE
			YELLOW CLAY
5.7	12		
			HARD ROCK
52.7	160		
55.0	180		SAND ROCKS
52.1	171		

ANNEX FIGURE VII-6-30
WELL DATA SHEET
WELL CDM-39
COTABATO WATER DISTRICT

DESCRIPTIVE DATA

WELL NO. (CDM) 40
(OTHER) 196051
LOCATION MALAGAPAS
CITY COTABATO
PROVINCE COTABATO
CONST. BY B.P.W
DRILLER ALFONSO SERENCIO
STARTED JANUARY 11, 1960
COMPLETED JANUARY 29, 1960
OWNER B.P.W
STATUS
CASING DIAMETER 100 MM
CASING LENGTH 19.5 M

DRILLER'S TEST DATA:

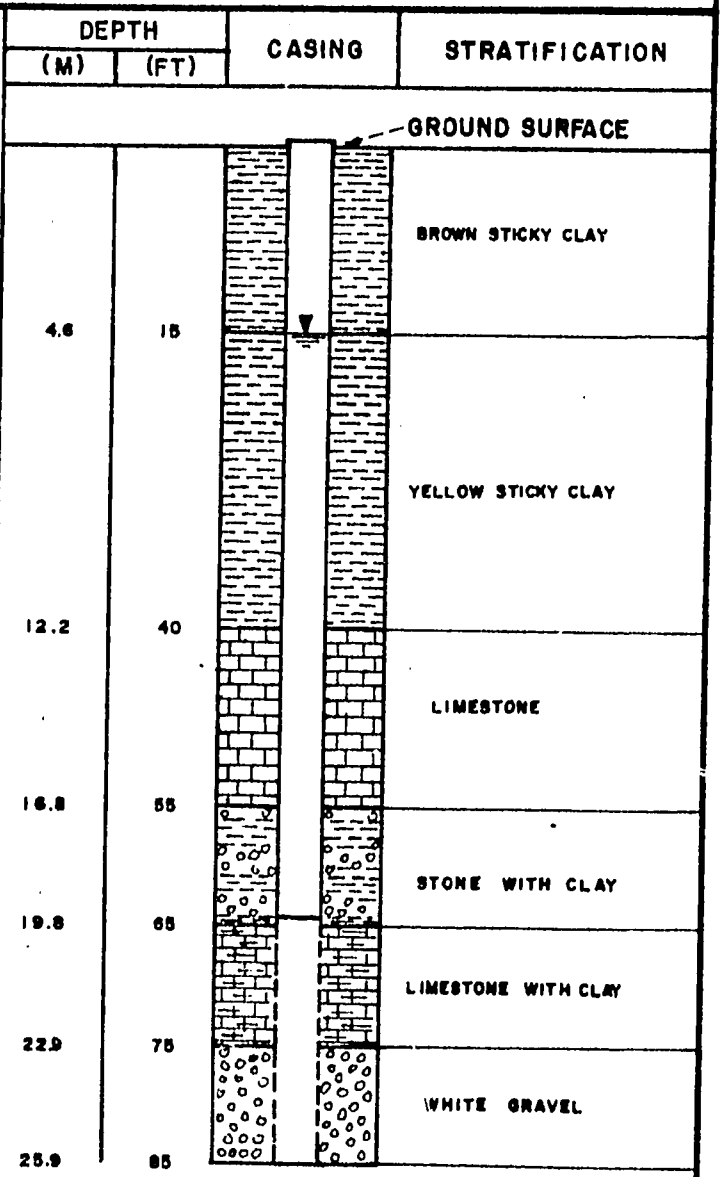
DATE
STATIC WATER LEVEL 4.6 M
PUMPING WATER LEVEL 7.6 M
TEST PUMP YIELD 0.63 LPS
SPECIFIC CAPACITY 0.21 LPS/M

REMARKS:

WATER QUALITY DATA:

WATER IS CLEAR AND FRESH AFTER PUMPING TEST.

GRAPHIC LOG

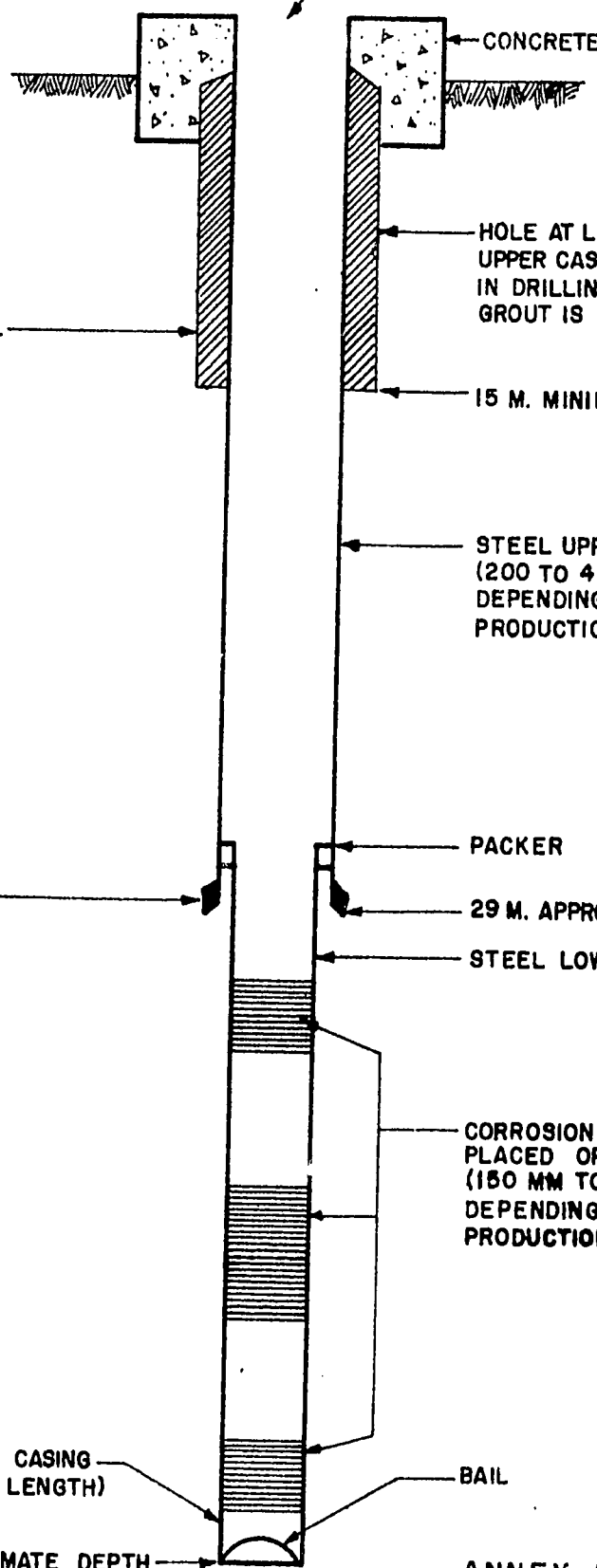


ANNEX FIGURE VII-B-31
WELL DATA SHEET
WELL CDM - 40
COTABATO WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

NOTE:

PROVIDE OPENING FOR WELL SOUNDING IN PUMP DISCHARGE HEAD OR SURFACE PLATE



ANNEX FIGURE VII-B-32
GENERAL DESIGN
INDUCED-INFILTRATION WELL
PERCUSSION DRILLED
COTABATO CITY WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

SUPPLEMENT TO ANNEX FIGURE VII-B-32
GENERAL CONSTRUCTION SUGGESTIONS
COTABATO CITY WATER DISTRICT

General Design - Induced Infiltration Wells - Percussion Drilled

1. Drive and drill 450-mm casing to 15 m or more.
2. Drive and drill 300-mm casing to 45 meters. Collect samples carefully and use no clay in drilling.
3. Examine samples to locate suitable permeable zone at 20 to 45-m depth. Abandon site and pull casing if no suitable zone is found.
4. Install 6 to 12 m of 250-mm screen of slot suited to formation grain size within 300-mm casing.
5. Pull back 300-mm casing to expose screen.
6. Grout annulus between 450-mm casing and 300-mm casing and withdraw 450-mm casing as grout is placed.
7. Develop and test well.
8. Design pump.
9. Construct well head facilities.
10. Set pump just above top of 250-mm screen.

General Design - Induced Infiltration Wells - Rotary Drilled

1. Drill 150-mm pilot hole to 45 meters.
2. Run electric log.
3. Examine samples and electric log to locate suitable permeable zone at 20 m to 45-m depth. Abandon site if no suitable zone is found.
4. Drill 450-mm hole to 15 m or deeper.
5. Drill 300-mm hole to total depth.
6. Install 6 to 12 m of 250-mm screen of slot suited to formation grain size within 300-mm casing.
7. Pull back 300-mm casing to expose screen.
8. Grout annulus between 450-mm hole and 300-mm casing.
9. Develop and test well.
10. Design pump.
11. Construct well head facilities.
12. Install pump.

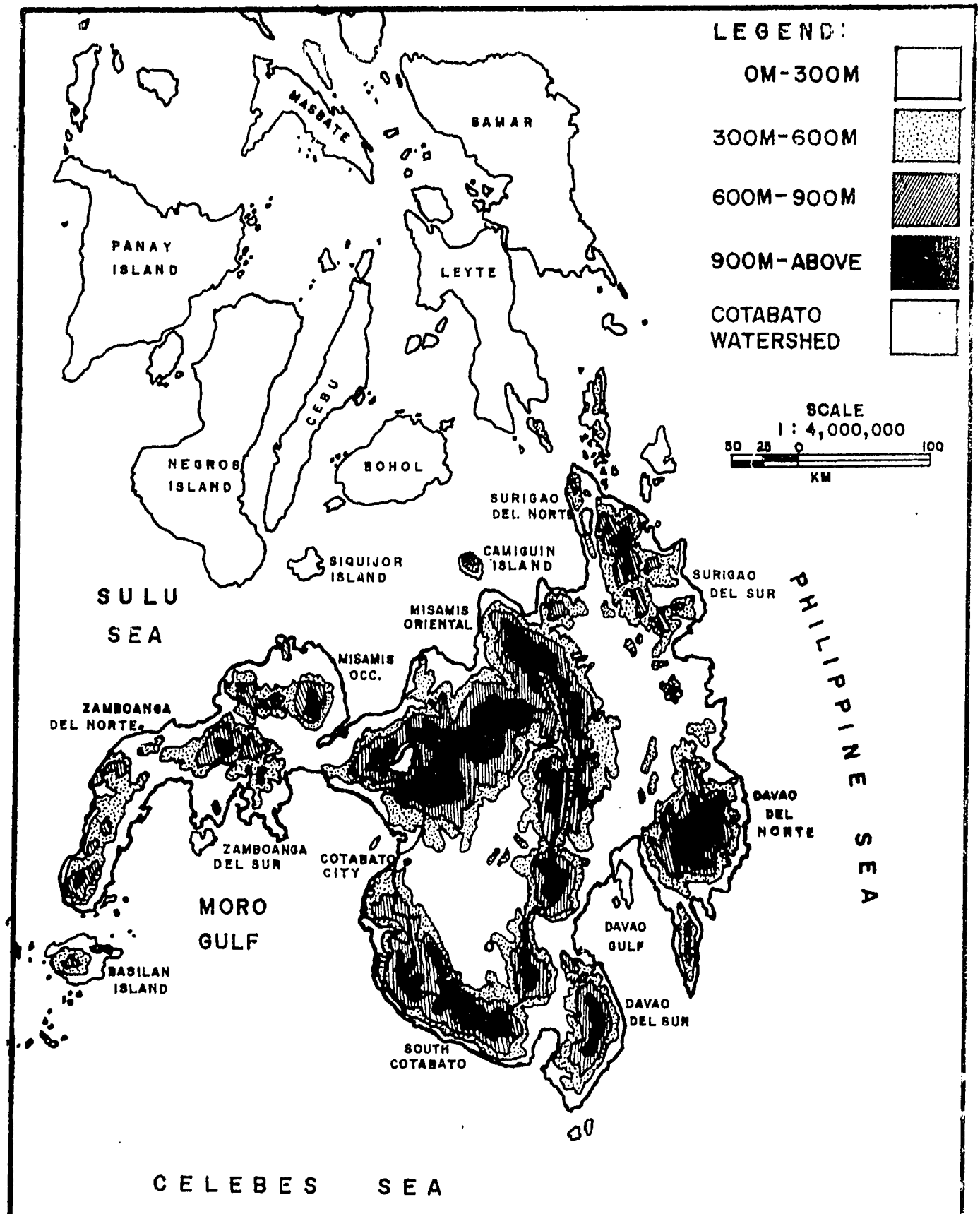
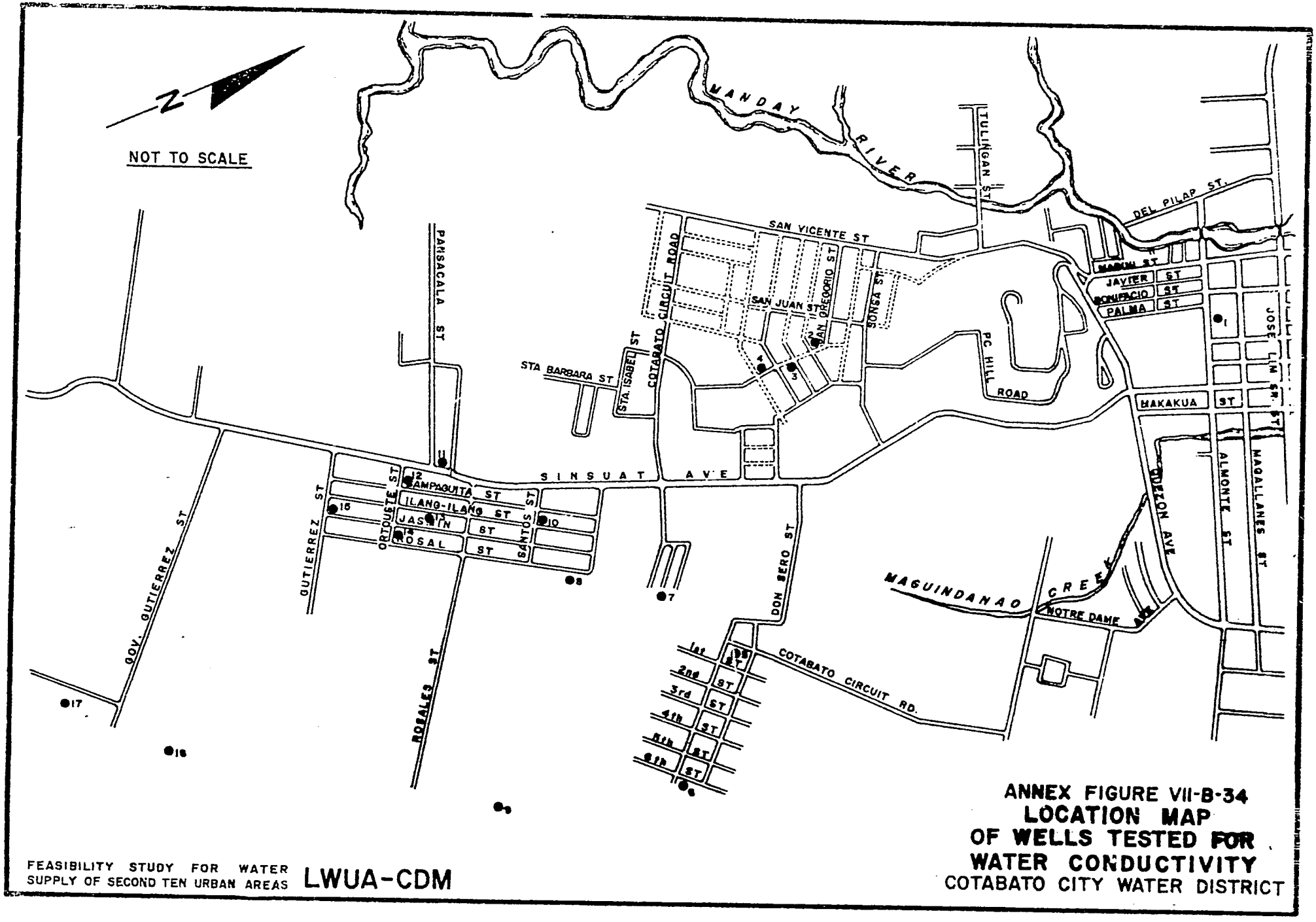


FIGURE VII-B-33
RELIEF MAP OF MINDANAO
COTABATO CITY WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS **LWUA-CDM**



ANNEX FIGURE VII-B-34
LOCATION MAP OF WELLS TESTED FOR WATER CONDUCTIVITY
COTABATO CITY WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS **LWUA-CDM**

CHAPTER VIII ANALYSIS AND EVALUATION OF ALTERNATIVES

A. GENERAL

This chapter identifies and evaluates the alternatives available for source development, transmission and treatment facilities and distribution systems. The analysis and evaluation presented herein are based largely on economic present worth cost studies. However, selection of recommended plan maybe influenced by non-economic parameters especially if the "best" or second best alternatives fall within the degree of cost estimating accuracy. Other water conservation and augmentation alternatives are also included.

B. WATER SUPPLY SOURCE ALTERNATIVES

Surface Water Sources

Since 1939, Cotabato City has been supplied with piped water from Dimapatoy River, 10 km southwest of the poblacion. The chemical quality of the Dimapatoy River water is satisfactory, as shown in Table VII-5. The minimum flow of this river (as discussed in Chapter VII) is more than sufficient to supply the year 2000 maximum-day demand of the COT-WD. Hence, the use of Dimapatoy River as a source of water for Cotabato City is technically feasible.

The use of Dimapatoy River would entail construction of a raw water intake, surface water pump stations, water treatment plant and treated water transmission line.

Groundwater Wells

An inspection of the banks of Simuay River, 8 km north of the poblacion, indicates that field conditions are reasonably favorable for the use of induced infiltration wells. A test well program would be necessary to determine the precise depth and capacity of such wells. Pending the results of the test wells, induced infiltration wells are considered technically feasible as an alternative source of water for Cotabato City. The parameters suggested for cost analysis of infiltration wells are tabulated in Chapter VII.

Wells in the coastal area do not seem to be a suitable source for the future supply that Cotabato City requires. In cases where the aquifer is good (frequently corraline limestone), intrusion of saline water is a problem. Good water can be obtained from an upper zone in the aquifer but production must be strictly limited to avoid intrusion of underlying saline water. The sand aquifer generally seems limited in transmissivity and large drawdowns associated with high production

rates would encourage saline intrusion. Some existing wells within the city have salinity problems. These wells are drilled on the upper zone of the aquifer and are of limited capacity. Thus, the coastal areas do not appear favorable for providing a large-scale ground water source.

Springs

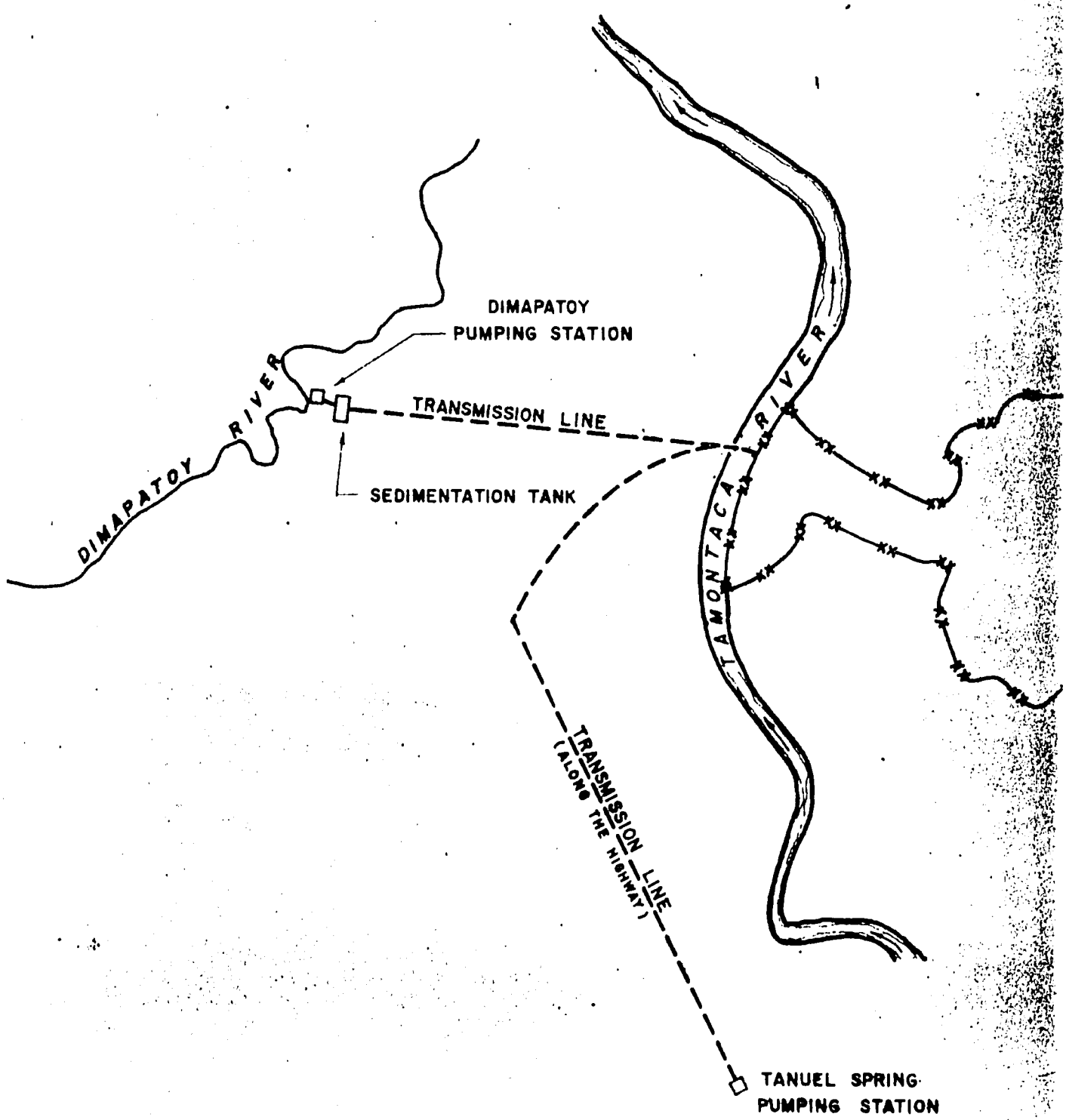
There are several springs that exist within a 20 km radius from Cotabato City proper. Two of the springs (Budacan and Tambanon) are found along Dimapatoy River in the southwestern portion of Cotabato City. Budacan Spring with an estimated discharge of 30 lps is located some 2.7 km upstream of the existing Dimapatoy pumping station. Nine km upstream of the same pumping station is Tambanon Spring with an estimated discharge of 70 lps.

In the southeastern portion of Cotabato City, 12.3 km by road from the city proper, is Tanuel Spring. Several flow measurements were conducted on this spring, the lowest measured being 210 lps. Farther east of Tanuel Spring are two other springs known as Marquez and Taviran, 4.5 and 8 road km from Tanuel Spring, respectively. Estimated discharge of Marquez Spring was 51 lps while that of Taviran Spring was 50 lps.

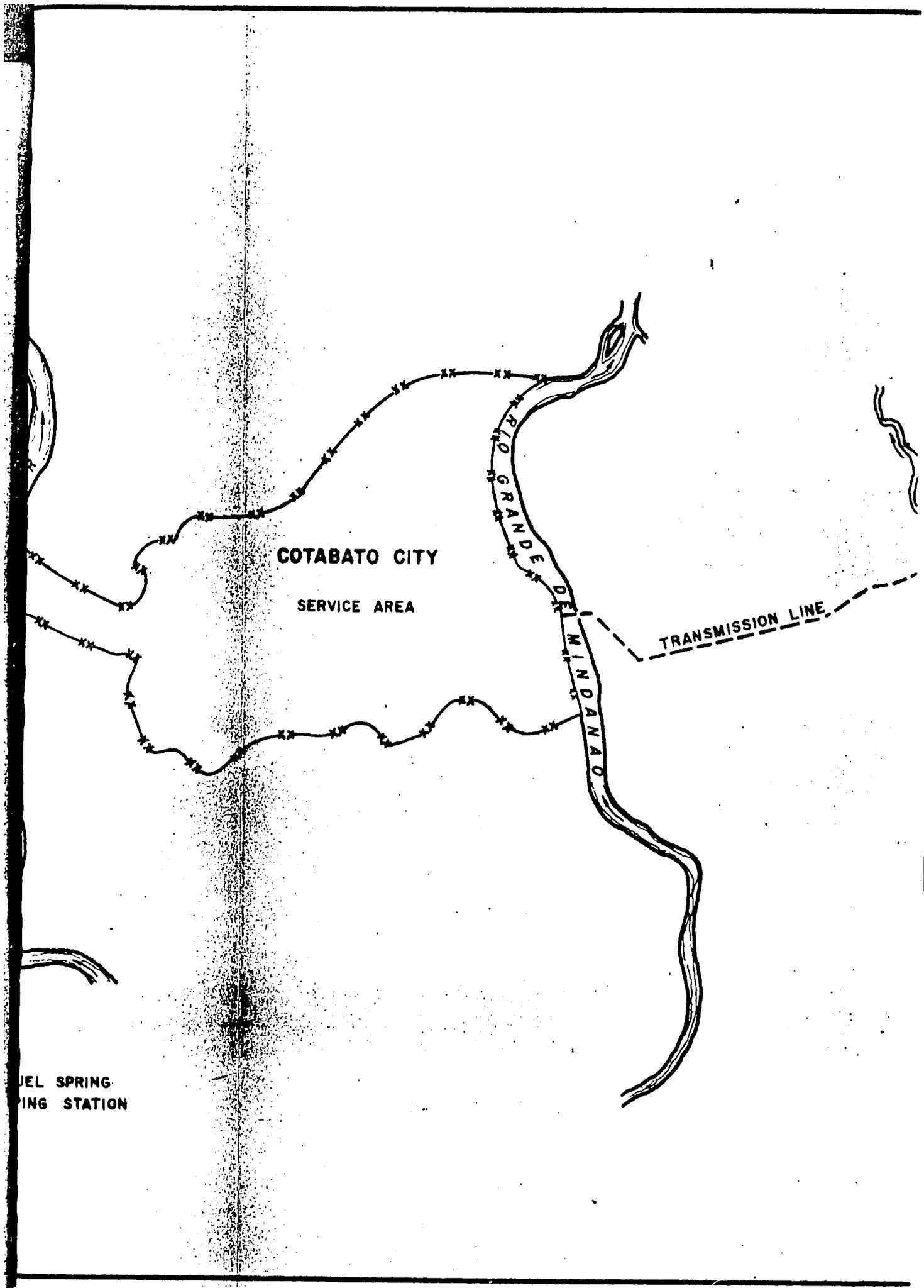
Assuming that the flow of Tanuel Spring does not drop below 70 percent of the lowest flow measured, this spring will meet water requirements of Cotabato City up to year 1988. Development of this spring would require pumping. The measured flows of the four springs other than Tanuel are small compared to the water requirements of Cotabato City. Development of these springs would require construction of a long transmission line. Water from Tambanon and Budacan Springs can flow by gravity but the terrain is very rugged, indicating high construction costs. Water supply from Marquez and Taviran springs can be obtained by pumping. Development of the five springs is considered technically feasible but not all springs are probably economically feasible.

Comparison of Alternatives

Four major alternatives for the COT-WD were analyzed (see Figure VIII-1). These alternatives include the following sources: (1) induced infiltration wells on the Simuay River; (2) Tanuel Spring supplemented by induced infiltration wells along the Simuay River; (3) Dimapatoy River; and (4) Tanuel Spring supplemented by Dimapatoy River. Comparative present worth costs of these alternative are summarized in Table VIII-1; costs common to all alternatives are omitted from the comparison. Annex Tables VIII-B-1 to VIII-B-4 show the detailed present worth costs of each alternative.



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM


COTABATO CITY
SERVICE AREA
RIO GRANDE DE MINDANAO
TRANSMISSION LINE
UEL SPRING
ING STATION

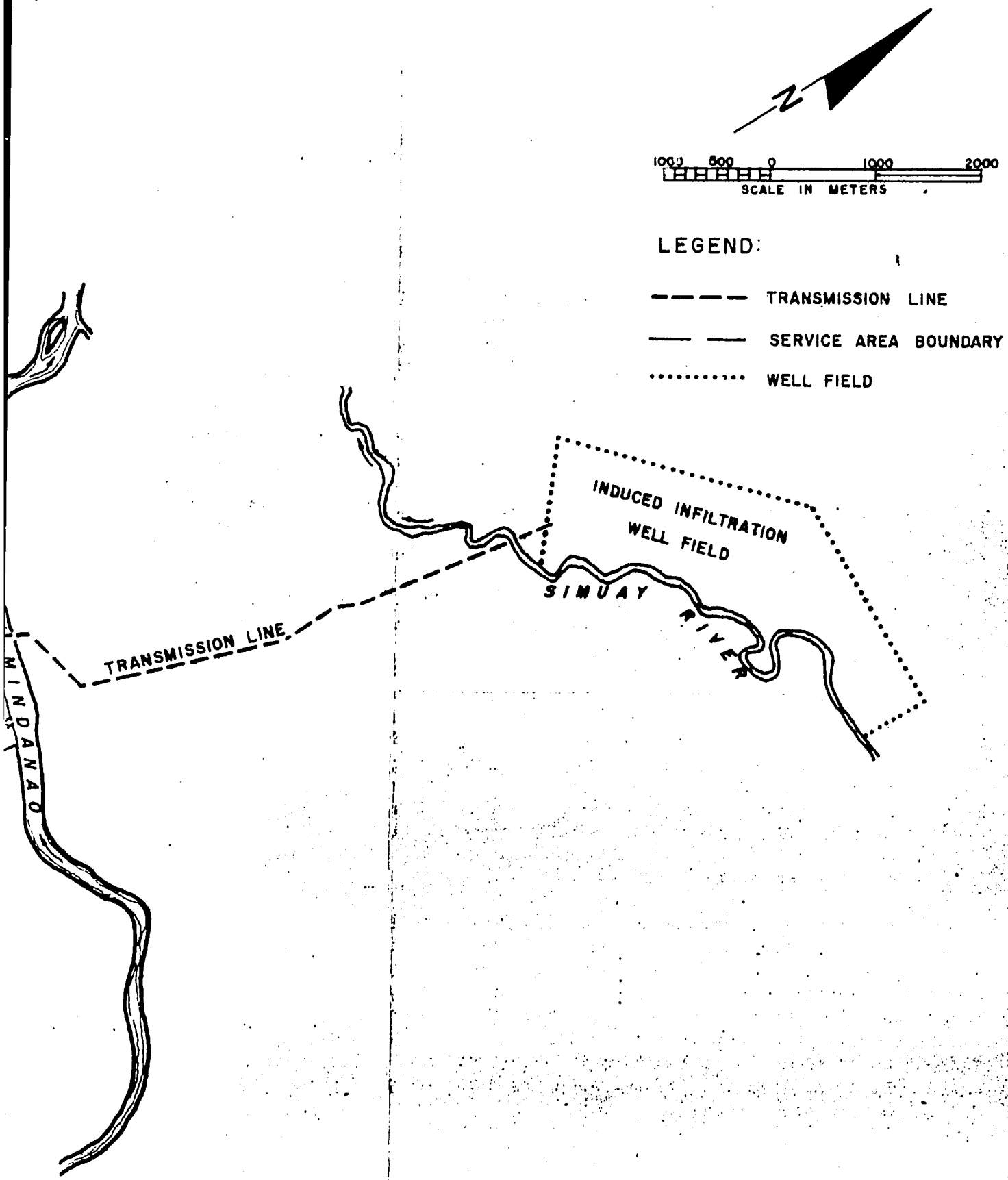


FIGURE VIII-1

ALTERNATIVE SOURCES

COTABATO CITY WATER DISTRICT

TABLE VIII-1

COMPARATIVE PRESENT WORTH COSTS
OF FOUR MAJOR ALTERNATIVES[1]

Item	Construction Cost (₱ x 1000)	Present Worth Cost[2] (₱ x 1000)
1. Induced Infiltration Wells along the Simuay River		
a) Source Development	₱ 7,647	₱ 3,162
b) Transmission Mains	12,850	4,140
c) Distribution Mains	9,335	3,814
d) Operation and Maintenance	-	2,015
Total Cost	₱ 29,832	₱ 13,131
2. Tanuel Spring Supplemented by Induced Infiltration Wells along the Simuay River		
a) Source Development	₱ 5,732	₱ 1,532
b) Transmission Mains	12,474	4,192
c) Distribution Mains	10,336	5,068
d) Operation and Maintenance	-	1,873
Total Cost	₱ 28,542	₱ 12,665
3. Dimapatoy River		
a) Source Development	₱ 38,700	₱ 14,687
b) Transmission Mains	8,369	3,133
c) Distribution Mains	14,632	5,872
d) Operation and Maintenance	-	4,647
Total Cost	₱ 61,701	₱ 28,339
4. Tanuel Spring Supplemented by Dimapatoy River		
a) Source Development	₱ 22,073	₱ 4,348
b) Transmission Mains	6,719	3,602
c) Distribution Mains	12,340	5,478
d) Operation and Maintenance	-	2,026
Total Cost	₱ 41,132	₱ 15,453

1/ These alternatives are based on an estimated staging program. See Annex Tables VIII-B-1 to VIII-B-4 for details.

2/ Less year 2000 salvage values.

The alternative using the Tanuel Spring and the induced infiltration wells along Simuay River is the least cost alternative. Tanuel Spring has capacity up to 1988, after which additional source supply would be required. Simuay induced infiltration wells would be used as additional source. The use of induced infiltration wells alone is about 4 percent or ₱466,000 more than the selected alternative. The peace and order situation in Cotabato City is also a factor that favors the selection of Tanuel Spring over that of induced infiltration wells near Simuay River. If such situation in Simuay River persists in the future, surface water from Dimapatoy River should be considered as a supplementary source to Tanuel Spring (fourth alternative). This alternative is ₱2.788 million and ₱2.322 million costlier than the selected alternative and the alternative using only induced infiltration wells along the Simuay River, respectively.

The use of Dimapatoy River requires the construction of a raw water pumping station and complete water treatment plant. Also, the existing sedimentation basin is assumed to be used up to 2000.

The utilization of existing city wells (which has total capacity of only 32.5 lps) was not considered in the source alternative studies. If existing wells would be used, the development of induced infiltration wells along the Simuay River would be postponed from 1988 to 1991. The postponement would decrease the present worth cost of the least cost alternative by ₱383,000. However, additional transmission lines would be necessary if these wells would be used. Because of poor ground water quality, water from these wells has to be diluted by spring water or treated before it flows into the distribution system. Present worth cost of the additional pipeline to be constructed in 1980 is ₱350,000. Therefore the net difference in present worth cost is only ₱33,000 and is considered insignificant, thus, the use of existing city wells was not considered further. These wells would only be used as stand-by units for emergency purposes until they have to be abandoned.

Development of the four springs other than Tanuel was considered. However, because of their low flows and relative distances from the service area, substantial capital investments needed are all much higher than those for alternatives considered economically feasible.

C. TREATMENT ALTERNATIVES

Analysis of water from the Tanuel Spring and Simuay River (Table VII-2) shows that, except for total hardness, all chemical constituents are within the acceptable limits of the Philippine National Standards for Drinking Water. Hardness in domestic water supply is an economic problem since it results in waste of soap and encrustation of utensils. It is also undesirable for certain industrial processes such as carbonated

beverages, metal finishing, food processing, textile industries and pulp and paper process. However, hardness has no demonstrable harmful effects on public health.

The analysis of water from wells (Table VII-2) shows the water quality parameter to be within the acceptable limits of the Philippine National Standards for Drinking Water.

Therefore, water from Tanuel Spring and induced infiltrations wells along Simuay River (the least cost alternative) would not require any treatment. However, in order to preserve the good quality of water throughout the distribution system, disinfection would be necessary at these sources. Disinfection may be accomplished by various methods which are discussed in Appendix J, Volume II. For economic and practical reason (availability of the equipment, supply and application, and lasting effectiveness), chlorination is the recommended process of disinfection.

D. DISTRIBUTION ALTERNATIVES

General

This section presents the distribution alternatives considered for the COT-WD. The recommended improvement program for the water system is discussed in Chapter IX.

The components of a water distribution system and some of the alternatives in planning a system are discussed in Appendix K. The design criteria for the distribution system are given in Appendix F. Appendices F and K were largely developed for the First Ten Provincial Urban Areas and are applicable to moderate-size communities. The Second Ten Provincial Urban Areas are generally smaller and the parameters presented in Appendices F and K must be applied with discretion.

Particular attention has been given to the requirements of fire flow in the COT-WD. In general, fire flow is applied at various locations in a system coincidentally with maximum-day demands, and the pipelines are sized to convey the required flow at specified head losses. In large communities, the total peak-hour flow is greater than the maximum-day flow plus fire flow and therefore relatively minor adjustments are required in the pipe system to provide fire flow. In the smaller communities, especially small barrios some distance from the poblacion, the fire flow alone can be 3 or 4 times the total peak-hour demand.

Providing adequate fire flow to areas where the fire flow may be far greater than the ultimate peak demand is rarely justified economically; but, as a general rule, some fire protection should be pro-

vided. Included in this study is information on the available fire flow at various locations where the system has been designed for conditions other than fire flow.

The flows used for the design of the various components of the distribution system are as follows (see Water Demand Projections, Chapter VI):

	1980	1990	2000
Water demand (lpcd)	198	193	199
Served population	22,080	61,490	108,520
Average daily water demand (cumd)	4,370	11,870	21,600
Maximum-day water demand (cumd)	5,240	14,240	25,920
Peak-hour water demand (cumd)	7,650	20,770	37,800

Pressure Zones

The ground elevations within the year 2000 service area for Cotabato City range from a low of 2 meters in Barrio Tamontaca to a high of 20 meters in Barrio Rosary Heights. The core city and Barrio Rosary Heights, comprising the high-density service area, lie at an average elevation of 3 meters and 10 meters, respectively. The rest of the service area has an elevation of 3 meters. The system can be operated adequately at an HGL of 53 meters from the overflow of the existing storage tank, therefore, only a single pressure zone was considered for COT-WD.

Storage Facilities

Storage facilities are provided in a distribution system to meet hourly fluctuations in water demand over the day, as discussed in Appendix F.

In Cotabato area, several locations for future storage facilities are available. However, only Colina Hill, the site of the existing storage tank, was considered economical for two main reasons. The hill, with top elevation of 60 meters, is centrally located in the service area and the construction cost of ground storage tank is more economical than that of elevated storage tank which has to be designed for high seismic loading.

The existing storage tank at Colina Hill which has an overflow elevation of 53 meters would be incorporated into the long-range water system plan since the entire service area of COT-WD can be adequately served at a HGL of 53 meters.

If the source of supply is capable of supplying water at a rate equal to the maximum-day demands, then a volume equal to 15 - 20 percent of the maximum-day demand is usually sufficient to meet the hourly fluctuations in demand.

An alternative to supplying this volume of storage would be to increase the capacity of the supply facilities in order to meet hourly demand fluctuations. The rationale for providing adequate supply to respond to the hourly fluctuations is discussed in Methodology Memorandum No. 5.

An alternative study between providing storage capacity or additional supply capacity would mean that the transmission mains from the sources would be sized based on the required supply rate which ranges from 1.2 to 1.5 times the maximum-day demand.

The present worth analysis comparing the alternative costs of providing additional supply versus additional storage volume for Cotabato City is presented in Table VIII-2. The analysis shows that it is more economical to provide additional storage capacity at a volume equal to 13.3 percent of maximum-day demand.

The recommended storage tank sizes and source development program are described in detail in Chapter IX.

TABLE VIII-2

PRESENT WORTH COSTS
OF ALTERNATIVE STORAGE AND
ADDITIONAL SUPPLY[3]

	Alternative 1 (Maximum Storage)	Alternative 2 (Intermediate Storage)	Alternative 3 (Minimum Storage)
Storage Required (Percent)[4]	13.3	7.6	2.3
(Volume, cum)	3,450	1,970	590
Present Worth Cost (₱ x 1000)			
Storage[5]	₱ 661	₱ 237	₱ -
Supply	5,672	6,384	7,639
Total	6,333	6,621	7,639

[3] Analysis includes facilities up to year 2000.
[4] Percentage of maximum-day demand
[5] Cost includes only storage in addition to existing 750-cum storage tank. It is assumed that the existing tank would be adequate in Alternative 3.

Distribution System

The analysis of the distribution system for Cotabato City generally conforms to the criteria set in Appendices F and K. In the First-Ten Area Feasibility Studies, the computer analyses were conducted only on pipelines larger than 200 mm, which were classified as distribution mains as differentiated from the internal network pipelines.

An alternative study was conducted on two possible pipeline configurations for the distribution system.

Two possible route locations for the main distribution pipelines were considered. The main pipelines could be located and installed along the national highway at the required size and capacity or additional pipelines could be constructed parallel to the main highway route but would be located in the subdivision roads to provide the equivalent capacity. Both analyses meet the hydraulic requirements of the system. The pipeline layout is shown schematically in Figures VII-2a and VIII-2b.

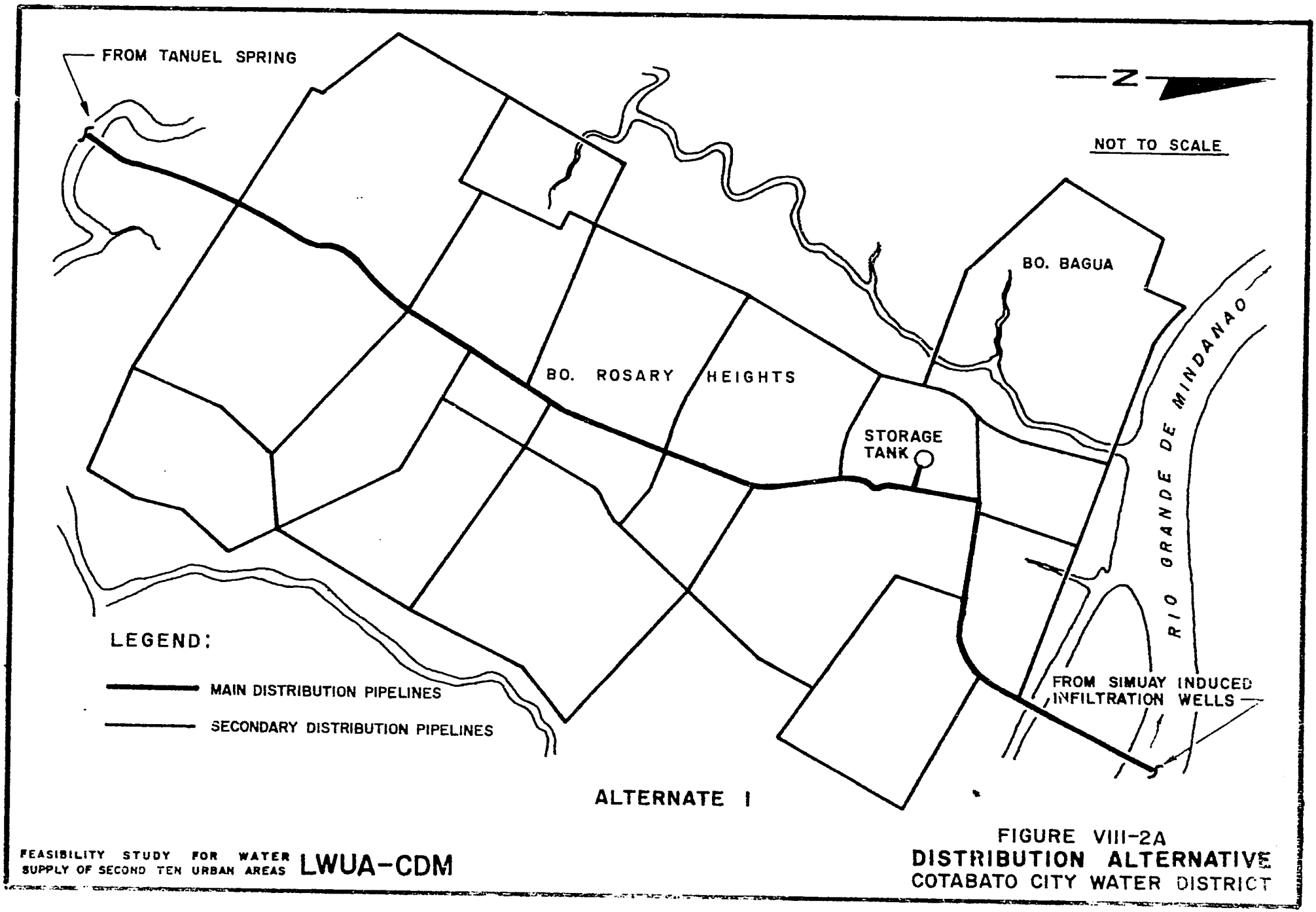
Present worth analysis of both alternatives is presented in Table VIII-3. The costs include other distribution pipelines in the system.

Table VIII-3 shows that it is more economical to lay the distribution mainline along the national highway. This also has the advantage of conveying the water directly to the high density portion of the service area since most of the present consumers are located along the national highway. It is expected that development in Cotabato City would start along the highway and move towards the extremities of the subdivisions.

A computer analysis on distribution system based on the most economical pipeline configuration was conducted for all the four major alternatives considered in Section B of this chapter. The comparative costs of the distribution system for all four alternatives and the total long-range comparative cost of each alternative are included in Table VIII-1.

Fire Protection

Present fire protection in COT-WD is inadequate. There are four existing fire hydrants but only one is operational. Water pressures in the system are very low. Areas near the pump stations and along the transmission mains have some water pressure while areas in the core city have very low or nearly zero pressure.



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

FIGURE VIII-2A
DISTRIBUTION ALTERNATIVE
COTABATO CITY WATER DISTRICT

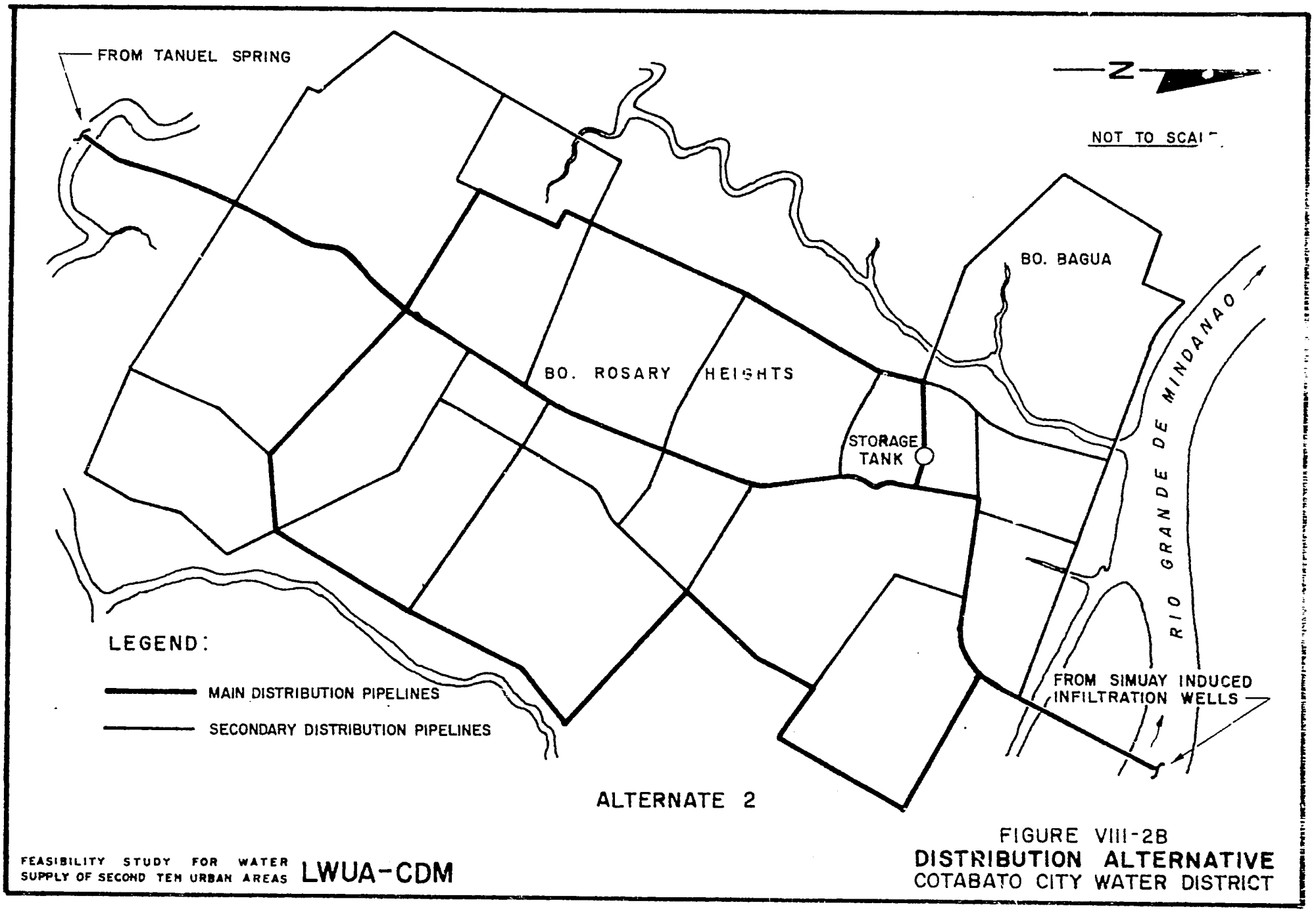


FIGURE VIII-2B
DISTRIBUTION ALTERNATIVE
COTABATO CITY WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS **LWUA-CDM**

As stated in Appendix K, there are two standards of fire protection: one for the high-density residential, commercial areas and another for the low-density, residential areas. In the high-density residential, commercial and industrial areas, an available fire flow of 20 lps at each of two adjacent fire hydrants should be provided; and in the low-density residential areas, 10 lps at each of two adjacent hydrants. Figure VIII-3 shows the outline of the fire service areas in Cotabato City.

TABLE VIII-3

DISTRIBUTION SYSTEM ALTERNATIVE COSTS[6/]

A. Alternative 1: Distribution Main Line along the National Highway

Pipe Size (mm)	Pipe Length (m)	Construction Cost (₱ x 1000)	Present Worth Cost (₱ x 1000)
100	4,550	₱ 441	₱ 329
150	24,930	4,537	1,588
200	3,440	833	409
250	2,690	1,073	150
300	2,390	1,271	951
350	3,340	2,181	1,631
Total	41,340	₱ 10,336	₱ 5,058

B. Alternative 2: Distribution Main Line along the National Highway and Subdivision Roads

Pipe Size (mm)	Pipe Length (m)	Construction Cost (₱ x 1000)	Present Worth Cost (₱ x 1000)
100	4,550	₱ 441	₱ 329
150	19,020	3,463	1,252
200	9,790	2,369	1,101
250	5,560	2,218	1,024
350	3,340	2,181	1,631
Total	42,260	₱ 10,672	₱ 5,337

6/ Present worth costs based on staging the different pipe sizes.

In general, full fire protection to the entire city has not been provided in the immediate improvement program because of the high cost of full fire protection.

The completion of the immediate improvement program by 1980 would provide 20 percent of full fire protection to the outlying parts of the core city and Barrio Rosary Heights, while full fire protection would be provided along Sinsuat Avenue and in most part of the core city. In order to obtain fire protection by 1980, existing hydrants would be repaired or replaced.

By the year 1990, all existing pipelines less than 125 mm would be replaced. These are mostly the old and deteriorated distribution pipelines in the core city. The installation of new 150-200 mm distribution pipelines and source facilities would greatly increase the available fire flow in the source area. By the year 1990, the whole 1990 service area could be provided full fire protection.

In the year 2000, additional 150-200 mm pipelines would be installed to serve the increasing population of Cotabato City. The development of the Simuay River bank induced infiltration wells for the year 2000 would further enhance the pressure distribution of the system since supply would be obtained from the south (Tanuel Spring) and north (Simuay induced infiltration wells) of the service area: By the year 2000, full fire protection could be provided for the entire service area of Cotabato City.

The preceding discussion of fire protection relates only to the capacity provided in the distribution mains. In providing fire protection, an adequate number of fire hydrants in the various service areas have to be considered. The primary criterion for providing fire hydrants would be the degree of development in a specific area. In Chapter IX, a schedule of fire hydrant construction is included, based on the projected development of the COT-WD. This schedule can be modified as development requires, but the necessary distribution mains have to be provided.

System Operation

Several operational aspects of the alternative distribution system are discussed in this section.

The completion of the first stage of the long-range program for COT-WD would provide adequate supply of water and pressure in the system. Some operational aspects have to be considered to maintain a good standard of water service. The main source for 1990 service area would be the Tanuel Spring. The existing city wells would not be used to supply water during normal conditions but would serve

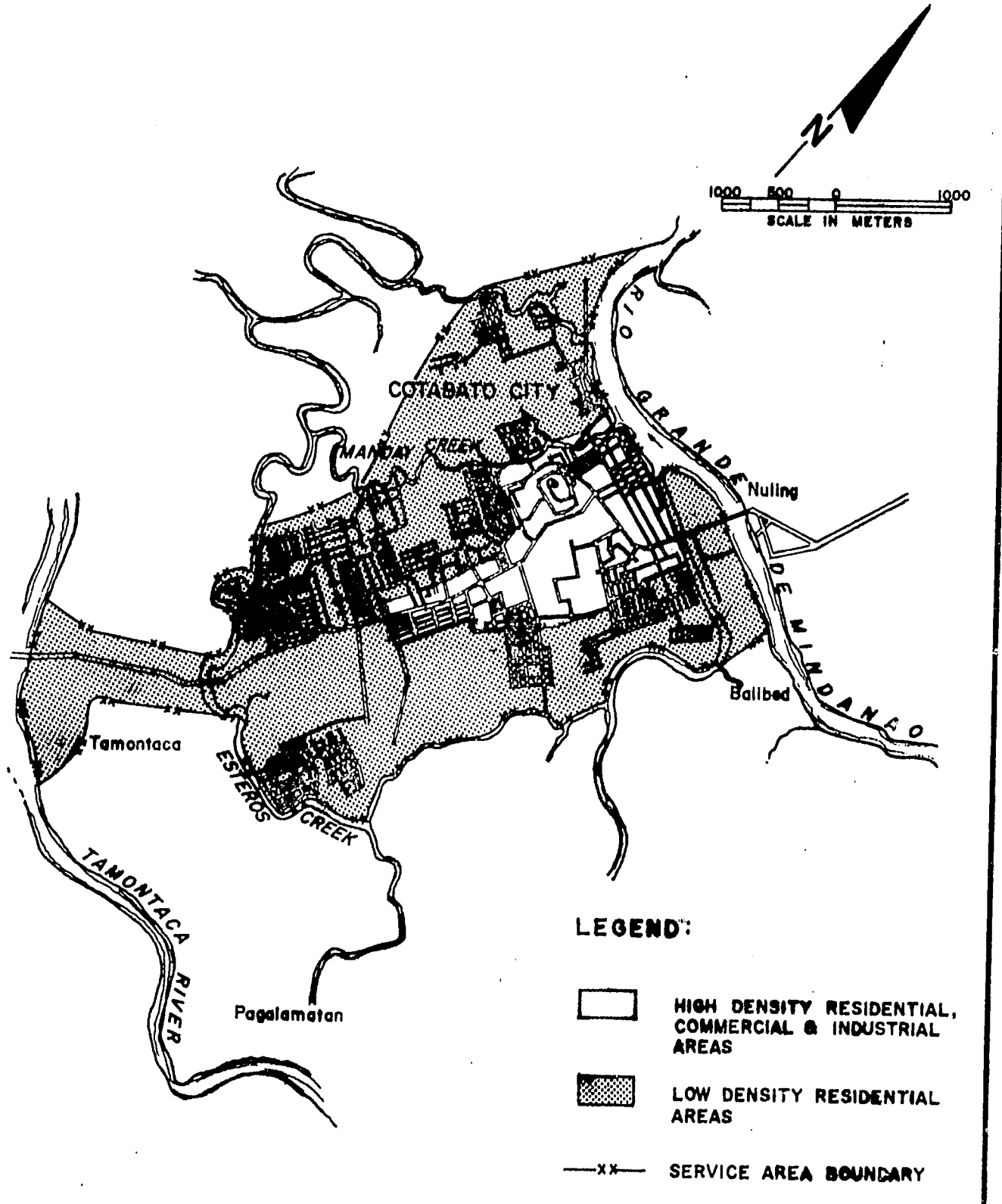


FIGURE VIII-3
FIRE PROTECTION AREAS
COTABATO CITY WATER DISTRICT

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS LWUA-CDM

as stand-by units for emergency purposes. The reasons for such operation are that the existing city wells have poor water quality, and the system pressure could be adequately maintained by using only the Tanuel Spring as a source.

During the second stage of the long-range program, the Simuay induced infiltration wells would be developed as supplementary source to Tanuel Spring while the existing city wells would be used as stand-by units or abandoned depending on conditions (salinization, productivity, etc). The option of obtaining a large portion of demand from one source and a small portion from the remaining source under different consumption conditions during this period was analyzed. The analysis showed that the system can meet the demands at adequate pressures under these conditions. Other operational aspects such as lack of water supply in either Tanuel Spring or Simuay induced infiltration wells due to power failure or mechanical problems were analyzed with the aid of computer. In cases of operational problems such as the breakdown of source facility, the hydraulic conditions in the system at peak-hour could still be maintained since the storage tank is located centrally in the high-demand area, thus, maintaining the system pressure. The tank could supply the required amount of water for three hours assuming the tank is half-full when such condition occurs.

The system has been looped as much as possible to maintain adequate pressures and reduce operational problems in case shutting of valves is required to isolate pipelines during service installation or pipe repair.

Internal Network

A general but complete discussion of the internal network for distribution system is included in Appendix K. The small size of the COT-WD does not affect the application of the recommendations contained in Appendix K since these are the minimum pipeline sizes recommended for any municipality. The cost data contained in Appendix K have to be multiplied by a factor of 1.21 to obtain mid-1978 costs in this report.

E. OTHER ALTERNATIVES FOR WATER CONSERVATION AND AUGMENTATION

In areas where water is a scarce resource, there are several alternative measures of conserving water. These alternatives depend on sophisticated technology in the case of water reuse and desalting, or on governmental policy in the case of land management. Appendix M, Volume II is a discussion of these conservation and augmentation alternatives.

ANNEX VIII-B

SCHEDULE OF FACILITIES FOR ALTERNATIVE ANALYSIS

ANNEX TABLE VIII-B-1

COMPARATIVE PRESENT WORTH COST OF ADDITIONAL SUPPLY
FROM SIMUAY INDUCED INFILTRATION WELLS[1]

Item	Date of Construction	Construction Cost (₱ x 1000)	Present Worth Cost (₱ x 1000)[2]
Two Induced Infiltration Wells[3]	1980	768	598
River Crossing	1980	1,500	1,121
Access Road	1980	400	293
Transmission Main	1980	3,809	2,848
Connection Pipe	1980	327	244
Disinfection Facilities[4]	1980	50	39
Induced Infiltration well	1984	384	185
Connection Pipe	1984	266	120
Disinfection Facilities	1984	25	12
Induced Infiltration Well	1987	384	126
Connection Pipe	1987	121	36
Disinfection Facilities	1987	25	8
Induced Infiltration Well[5]	1989	410	101
Transmission Main	1989	5,116	1,141
Disinfection Facilities	1989	25	7
Induced Infiltration Well	1992	410	63
Connection Pipe	1992	327	44
Disinfection Facilities	1992	25	4
Induced Infiltration Well	1994	410	43
Connection Pipe	1994	266	24
Disinfection Facilities	1994	25	3
Two Pumps (Replacement)	1995	320	29
Two Disinfection Equipment (Replacement)	1995	36	3
Induced Infiltration Well	1996	410	25
Connection Pipe	1996	121	7
Disinfection Facilities	1996	25	1
Induced Infiltration Well	1997	384	17
Transmission Main	1997	3,925	151
Disinfection Facilities	1997	25	1
One Pump (Replacement)	1999	160	2
Disinfection Equipment (Replacement)	1999	18	-
Operation and Maintenance	1981-2000		2,015
Total 1978 Present Worth Cost			9,317
			x 1000

1/ For economic service life for each item, refer to Appendix F, Volume II and Annex Table VIII-B-5.

2/ Less year 2000 salvage value.

3/ Itemized cost (₱ x 1000)

for	70-hp	80-hp
Well	115	115
Structure	109	117
Equipment	160	178

4/ Itemized cost (₱ x 1000)

Equipment	18
Structure	7

5/ For itemized cost, see footnote 3 for 80-HP.

ANNEX TABLE VIII-B-2

COMPARATIVE PRESENT WORTH COST OF ADDITIONAL SUPPLY FROM DIMAPATOY RIVER (SURFACE WATER)[1]

Item	Date of Construction	Construction Cost (₱ x 1000)	Present Worth Cost (₱ x 1000)[2]
Raw Water Pump[3]	1980	3,100	2,392
Water Treatment Plant[4]	1980	9,000	6,927
Transmission Main	1980	2,950	2,206
Water Treatment Plant	1986	9,000	3,315
Transmission Main	1986	160	55
Transmission Main	1988	2,790	723
Raw Water Pump	1990	3,100	649
Transmission Main	1992	196	26
Water Treatment Plant	1994	9,000	906
Raw Water Pump Equipment (Replacement)	1995	1,500	136
Water Treatment Equipment (Replacement)	1995	4,000	362
Transmission Main	1986	2,273	123
Operation and Maintenance	1981-2000		4,647
Total 1978 Present Worth Cost			₱22,467 x 1000

1/ For economic service life for each item, refer to Appendix F, Volume II and Annex Table VIII-B-5.

2/ Less year 2000 salvage value.

3/ Itemized costs (₱ x 1000): Structure - 1,600
Equipment - 1,500

4/ Itemized Costs (₱ x 1000): Structure - 5,000
Equipment - 4,000

ANNEX TABLE VIII-B-3

COMPARATIVE PRESENT WORTH COST OF ADDITIONAL SUPPLY FROM TANUEL SPRING AND SIMUAY INDUCED INFILTRATION WELL[1]

Item	Date of Construction	Construction Cost (₱ x 1000)	Present Worth (₱ x 1000)[2]
Spring Intake Structure	1980	50	37
Booster Pump Station[3]	1980	778	605
Transmission Main	1980	4,293	3,209
Disinfection Facilities[4]	1980	25	19
Induced Infiltration Well[5]	1988	429	122
River Crossing	1988	1,500	389
Transmission Main	1988	2,328	603
Access Road	1988	400	104
Disinfection Facilities	1988	25	7
Induced Infiltration Well	1991	429	77
Connection Pipe	1991	121	20
Disinfection Facilities	1991	25	5
Induced Infiltration Well	1993	429	54
Transmission Main	1993	2,727	304
Disinfection Facilties	1993	25	3
Booster Pump Equipment (Replacement)	1995	467	42
Induced Infiltration Well	1996	429	27
Connection Pipe	1996	121	7
Disinfection Facilities	1996	25	1
Induced Infiltration Well	1998	429	12
Transmission Main	1998	3,126	76
Disinfection Facilities	1998	25	1
Operation and Maintenance	1981-2000		1,873
	Total 1978 Present Worth Cost		₱7,597 x 1000

1/ For economic service life for each item, refer to Appendix F, Volume II and Annex Table VIII-B-5.

2/ Less year 2000 salvage value.

3/ Itemized costs (₱ x 1000): Structure - - 311
Equipment - - 467

4/ Itemized costs (₱ x 1000): Structure - - 7
Equipment - - 18

5/ Itemized costs (₱ x 1000): Well - - - - 115
Structure - - 123
Equipment - - 191

ANNEX TABLE VIII-B-4

COMPARATIVE PRESENT WORTH COST OF ADDITIONAL SUPPLY FROM TANUEL SPRING AND DIMAPATOY RIVER (SURFACE WATER)[1]

Item	Date of Construction	Construction Cost (₱ x 1000)	Present Worth (₱ x 1000)[2]
Spring Intake Structure	1980	50	37
Booster Pump Station[3]	1980	778	605
Transmission Main	1980	4,293	3,209
Disinfection Facilities[4]	1980	25	19
Raw Water Pump[5]	1988	1,900	538
Water Treatment Plant[6]	1988	7,760	2,172
Transmission Main	1988	1,153	299
Raw Water Pump	1993	1,900	239
Transmission Main	1993	120	14
Water Treatment Plant	1995	7,760	620
Transmission Main	1995	1,033	74
Raw Water Pump	1996	1,900	118
Transmission Main	1996	120	6
Operation and Maintenance	1981-2000		2,026
	Total 1978 Present Worth Cost		₱9,976
			x 1000

1/ For economic service life for each item, refer to Appendix F, Volume II and Annex Table VIII-B-5.

2/ Less year 2000 salvage value.

3/ Itemized cost (₱ x 1000) Structure -- 311
Equipment -- 467

4/ Itemized cost (₱ x 1000) Structure -- 18
Equipment -- 7

5/ Itemized cost (₱ x 1000) Structure -- 900
Equipment -- 1,000

6/ Itemized cost (₱ x 1000) Structure -- 4,290
Equipment -- 3,470

ANNEX TABLE VIII-B-5

ECONOMIC SERVICE LIFE OF WATER SUPPLY FACILITIES[1]

Item		Economic Service Life (Years)	
Embankment Dams[2]:	Embankment	50	
	Structure	50	
	Equipment	50	
Water Treatment Plants:	Structure	50	
	Equipment	15	
Groundwater Wells:	Well	25	
	Structure	50	
	Equipment	15	
Transmission Facilities:	Pipes	50	
	Valves	50	
Distribution Facilities:	Pipes	50	
	Valves	50	
Internal Network:	Pipes	50	
	Valves	50	
	Hydrants	50	
Service Connections:	Service Pipes	50	
	Water Meter	15	
Disinfection Facilities:	Structure	50	(may depend on
	Equipment	15	associated facility)
Storage Facilities:	Structure	50	
	Equipment (specialized, other than pipes and valves)	15	
Miscellaneous Structures		50	
Miscellaneous Mechanical Equipment		15	
Vehicles		7	

1/ The economic service lives presented here have been used throughout this report whenever facility replacement or present worth analysis has been required.

2/ Although the physical life expectancy of certain facilities, such as dam embankments, is greater than the economic service life indicated, the latter more realistically reflects the useful life of the facility.