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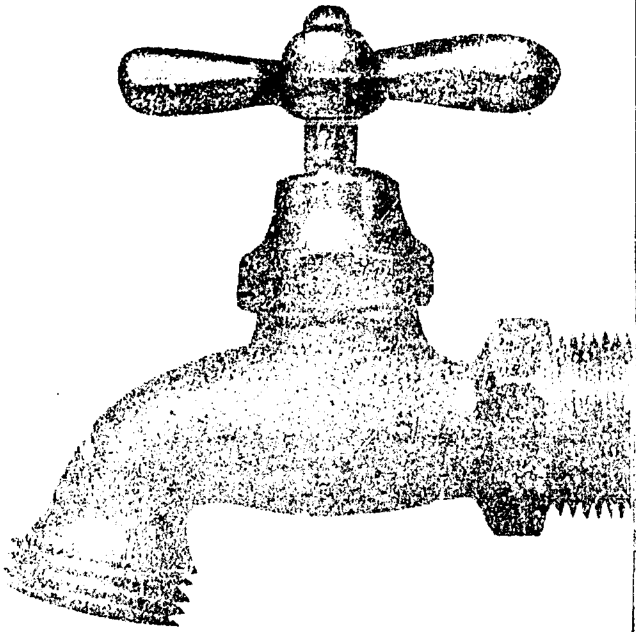

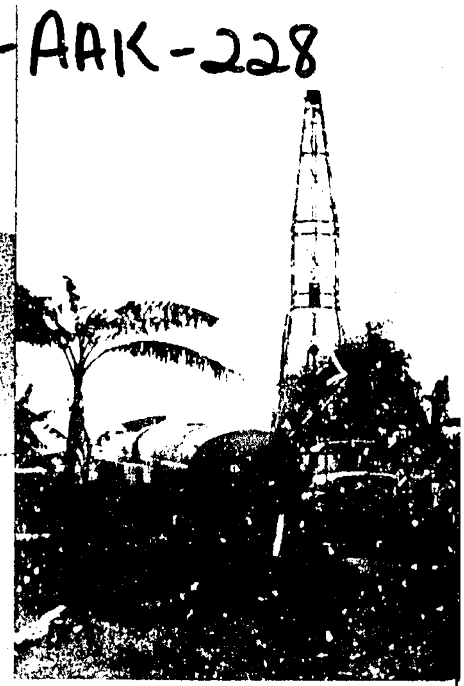

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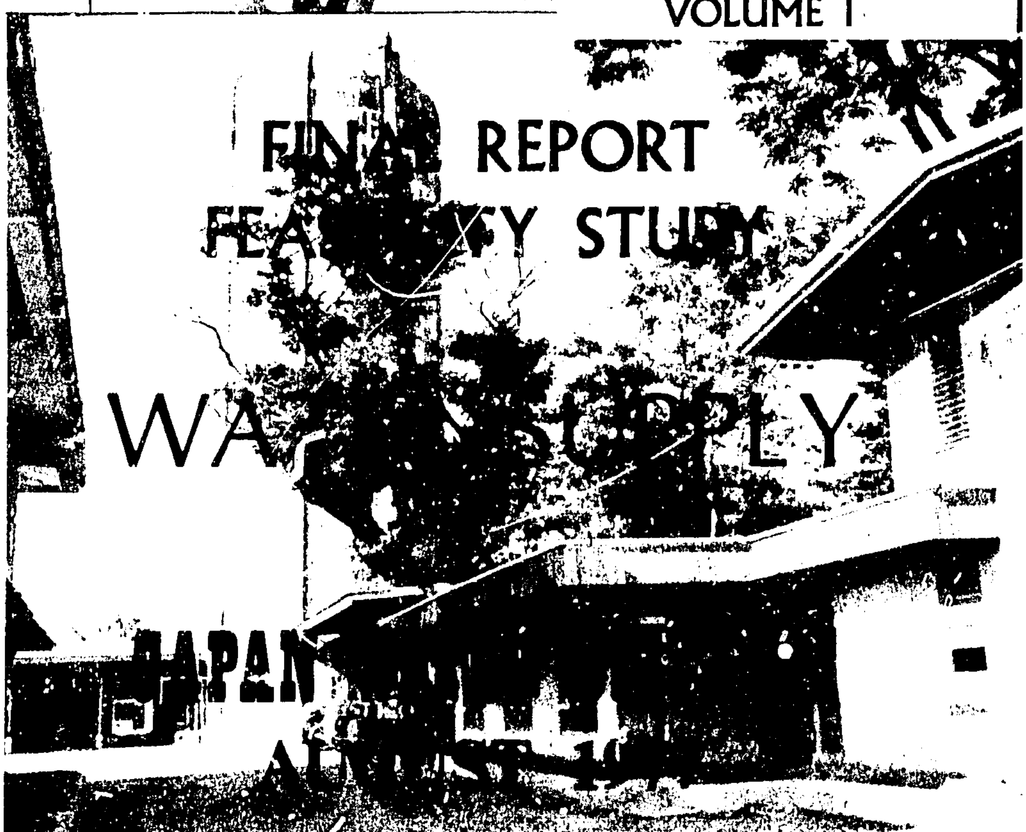

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FEASIBILITY STUDY

WATER SUPPLY

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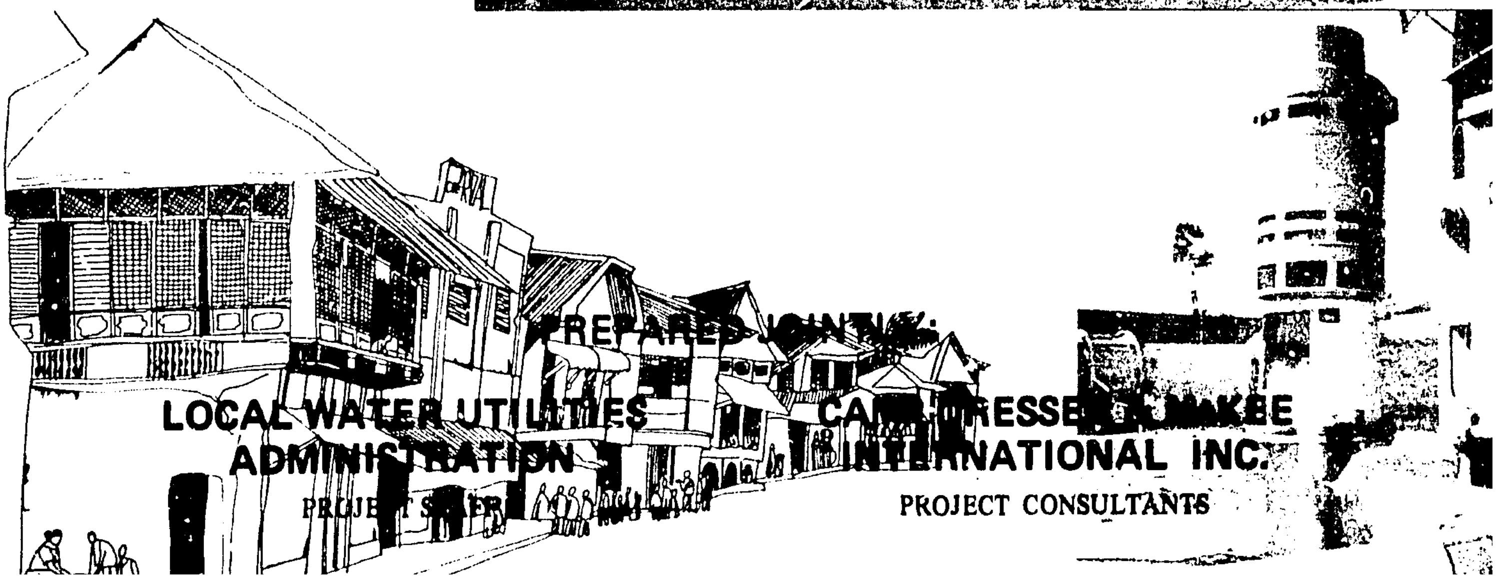

PREPARED JOINTLY BY:

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15 September 1977

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 – Gapan Water District (GAP-WD)

Dear Mr. Leaño:

In accordance with the contract between Local Water Utilities Administration (LWUA) and Camp Dresser & McKee International Inc., 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 alternative studies and cost optimisation 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 utilising mostly the services of LWUA counterparts to fulfill the on-the-job training requirements of the LWUA/CDM contract. For the next phase, the LWUA counterparts will take the dominant role in the project studies.

Mr. Carlos C. Leaño, Jr.
General Manager
Local Water Utilities Administration
Re: Final Report - Feasibility Study
for Water Supply - Gapan Water
District (GAP-WD)
Page # 2

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

Very truly yours,

CAMP DRESSER & MCKEE INTERNATIONAL INC.

LEONARDO V. GUTIERREZ, JR.
Project Manager

LOCAL WATER UTILITIES ADMINISTRATION

ANTONIO DE VERA
Counterpart Project Manager

FOREWORD

This feasibility study presents the recommended plan for the upgrading and expansion of the water supply system of the Gapan Water District (GAP-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 the municipality of Gapan in Nueva Ecija 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 GAP-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 developmental planning capability for water supply projects. The Filipino 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 Second Ten-Area Feasibility Studies:

James Arbuthnot, Chief Engineer
Eugene Rumph, Hydrogeologist

James DeYoung, Water Supply Engineer
Bruce Conklin, Systems Engineer
Peter West, Distribution Engineer
Antonio de Vera, Counterpart Project Manager
Wilfredo Sevilleja, Counterpart Chief Engineer
Reginald Abustan, Group Leader
Delia Castañeda, Economist
Jean Casten, Economist
Lourdes Gutierrez, Technical Writer
Isagani Manuel, Former GAP-WD General Manager
Arsenio Ancheta, GAP-WD General Manager

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

Reynaldo Tabao, Staff Engineer
Miguel Buenavides, Junior Staff Engineer
Pedrito Camilet, Jr., Field Technician
Rommel Liamco, Cadet Engineer
Salvador Ner, Cadet Engineer
Cesar Matig-a, Chief Draftsman
Angel Angeles, Draftsman
Meredith Maraño, Secretary/Typist
Cesar Florendo, Printing Assistant
Diosdado Piroa, Printing Assistant

LIST OF ABBREVIATIONS

Organizations

ADB	Asian Development Bank
BAN-WD	Bangued Water District
LB-WD	Los Baños 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
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 Gapan Water District (GAP-WD) was formed on 14 October 1975 by virtue of Resolution No. 46 of the Sangguniang Bayan (municipal council) of Gapan. The GAP-WD includes the entire municipality of Gapan in the Nueva Ecija Province. Following its formation, GAP-WD acquired the ownership and management of the entire water system in accordance with Presidential Decree (PD) No. 198 (The Provincial Water Utilities Act of 1973).

Gapan is situated in the southern portion of Nueva Ecija Province on the island of Luzon about 85 kilometers north of Manila. Gapan consists of 18 barrios and its poblacion with a total land area of 15,590 hectares.

Gapan is located in the Central Luzon Plain at an elevation of about 18 meters above mean sea level.

The population of Gapan was 45,426 in 1970 of which 77 percent were considered rural and 23 percent urban. The majority of the population is employed in agriculture or manufacturing.

Existing Water System

The existing water system of GAP-WD was largely constructed in 1932-34 with a new well and some distribution pipeline constructed in 1955. The source of water today is the 184-meter deep well constructed in 1955 and located along Bonifacio Street in Barrio San Lorenzo. The production from the well is estimated to be 470 cumd.

Storage facilities for GAP-WD consist of one 380-cum concrete elevated storage tank located near the public market. The tank presently leaks badly.

The distribution system consists of 13.7 km of 62, 75, 100, 125 and 150-mm pipeline. The majority of the pipeline was constructed in 1932-34 and is cast iron. There are very few known valves in the system and most of the existing fire hydrants do not operate.

Projections

The present service area of GAP-WD only includes the poblacion and portions of the barrios of San Nicolas, Santo Niño, Mangino and Pambuan. The service area is expected to include the barrios of

Bayanihan, Santo Cristo Norte, Santo Cristo Sur, Malimba, San Roque, Santa Cruz and the poblacion of and barrio Malapit in the adjacent municipality of San Isidro by the year 2000.

The population in the GAP-WD was 53,967 in 1975 and is projected to increase to 131,290 by the year 2000. During the same period the population served by the GAP-WD is expected to increase from 2,860 to 91,900.

The per capita consumption of water is expected to be 178 lpcd in 1980 with a total average daily demand of 2,290 cumd. The per capita consumption is expected to decrease to 174 lpcd in 1990 due to improved water accountability and then increase to 181 lpcd in 2000. The estimated total average daily demand is 6,660 cumd in 1990 and 16,630 cumd in 2000.

Water Resources

Three potential groundwater sources and two potential surface water sources were identified for GAP-WD. One surface source and a groundwater source (induced infiltration wells), each utilizing the Peñaranda River as a source, were not further investigated since its minimum flows would not be sufficient for the ultimate demands of GAP-WD. A second groundwater source (induced infiltration wells) and surface water source from the Pampanga River were considered feasible but the surface water alternative would have been much costlier due to the required treatment and transmission facilities.

The remaining groundwater source, wells located in the service area, and the induced infiltration wells at the Pampanga River were the only sources that were technically and financially comparable and were analyzed in more detail.

The cost analysis indicated that wells located within the service area would be the most economical water source in the project planning period.

Gapan is located over an excellent, widespread and relatively uniform aquifer that can supply expected water demands through the year 2000. The quality of water is also expected to be good with no treatment other than disinfection required. Wells located to the southeast of the poblacion will have to be developed with caution since the aquifer becomes thinner in this area.

The regional drawdown effect of wells in GAP-WD cannot be predicted at this time; however, as other uses such as irrigation become more prevalent, the effects of drawdown will become critical. Pumping levels should be carefully monitored to determine the effects of future groundwater pumping in this region.

Alternative Studies

Studies on alternative sources of water supply for GAP-WD indicate that wells withdrawing water from the aquifers beneath GAP-WD would be most economical over the project planning period. Surface water and induced infiltration wells from the Pampanga River were also investigated and found not to be cost effective for GAP-WD.

The requirements for the distribution system were analyzed with the aid of a computer and the recommended system is included in detail in Chapter IX. An analysis of pressure requirements in GAP-WD indicates that the system could be operated satisfactorily from the overflow elevation of the existing elevated storage tank.

B. RECOMMENDATIONS

General

A water supply system utilizing wells located throughout the GAP-WD as the source is recommended for GAP-WD. Construction of new wells and improvement of the distribution system and administrative facilities will be implemented during an immediate improvement program and a long-range construction program divided into four phases. The salient features of the recommended long-term project for GAP-WD are summarized on Table I-1 and shown in Figure IX-1 (appended).

Source

In the year 2000 a total of 8 wells will supply 1½ times the maximum-day water demand to meet most peak-hour demand conditions. Each well will be constructed complete with pumphouse, miscellaneous mechanical equipment and chlorination facilities. Some wells will be equipped with dual drive facilities to meet average-day water demands during power outages.

The GAP-WD should file an application with the National Water Resources Council to secure rights to water sources that they intend to exploit in the future.

Distribution Facilities

The existing distribution system will be largely replaced by the year 1990 and the system will be expanded to serve 7 barrios in addition to the poblacion. Approximately 29 km of pipeline varying from 100 to 350 mm in diameter will be constructed as replacement pipelines or new pipelines by 1990. By 2000 another 18 km of distribution pipelines will be constructed.

TABLE I-1

SUMMARY OF PROPOSED WATER SUPPLY IMPROVEMENTS
GAPAN 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)	5,831	9,053	5,863	13,277	12,717
Foreign Exchange Component* (₱ x 1000)	2,654	4,588	2,984	6,934	5,832
Source Development	Obtain legal water rights, complete 2 new well pump stations.	Construct one additional well pump station; enlarge pumpset in one existing well.	Construct one additional well pump station.	Construct two additional well pump stations; enlarge pumpset in one existing well.	Construct two additional well pump stations; enlarge pumpset in one existing well.
Distribution	Leakage survey and repair (see Table IX-1). 100 mm - 4.4 km 150 mm - 2.5 km 200 mm - 1.4 km 300 mm - .030 km 350 mm - .015 km	See Table IX-3. 100 mm - 1.9 km 150 mm - 2.4 km 200 mm - 9.2 km	See Table IX-5. 100 mm - 3.5 km 150 mm - 1.5 km 200 mm - 2.1 km 250 mm - .015 km	See Table IX-7. 200 mm - 13.3 km	See Table IX-9. 200 mm - 4.3 km
Storage	Repair existing 360 cum tank.	-	-	-	Construct new 120 cum elevated storage tank.
Internal Network	Leakage survey and repair	166 ha	92 ha	216 ha	216 ha
Service Connections	Repair 88 Add 1,400	Repair 350 Add 2,270	Add 2,270	Add 4,470	Add 4,470
Hydrants	Repair existing hydrants.	27 ha	118 ha	157 ha	158 ha
Miscellaneous	Administrative facilities and equipment, plumbing shop and equipment, vehicles.	-	-	-	-

*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 R.P. pesos at a rate of U.S. $1.0 = R.P. ₱7.0. 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.

The GAP-WD will install internal network pipelines to cover about 690 hectares and add 14,900 new service connections to the existing system by 2000. All of the existing and new services will be metered.

Storage

The existing 380-cum elevated storage tank will be adequate through Phase II-A. The tank will have to be repaired in the immediate improvement program to eliminate leakage. During Phase II-B a small amount of additional storage will have to be constructed at the site of the new test well.

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 salaries and benefits, power, chemicals, maintenance and miscellaneous expenses. Estimates of the annual operation and maintenance costs of the water district (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 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 reserved 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 GAP-WD householder.

The recommended water rates by revenue unit are as follows:

	Rate/RU
1978-1980	₱ 0.70
1981-1983	1.20
1984-1989	1.50
1990	1.60

TABLE I-2

CAPITAL COST SUMMARY

Construction Phase	Construction Period	Construction Cost (₱)	Project Cost (₱) Local	FEC*	Total
Immediate Improvement Program	1997-80	4,717,500	3,176,600	2,654,200	5,830,800
I-A	1980-85	7,486,600	4,464,900	4,588,000	9,052,900
I-B	1986-90	4,890,100	2,879,300	2,983,600	5,862,900
II-A	1991-95	11,018,200	6,342,700	6,933,900	13,276,600
II-B	1996-2000	10,570,600	6,884,500	5,832,100	12,716,600
Total		38,683,000	23,748,000	22,991,800	46,739,800

TABLE I-3

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

Item	Local	Foreign*	Total
Immediate Improvement Program			
Source Facilities			
Well and Pumphouse	415,000	275,000	690,000
Pumphouse	100,000	170,000	270,000
Disinfection Facilities	14,400	34,600	49,000
Distribution Facilities			
Leakage Detection and Repair	35,000	107,000	142,000
Distribution System Pipelines	690,100	622,100	1,312,200
Service Connections			
Installation, Conversion and Repair	534,800	788,500	1,323,300
Administrative and Miscellaneous			
Administrative Building and Equipment	381,000	26,000	407,000
Vehicles	60,000	60,000	120,000
Plumbing Shop and Equipment	365,000	26,000	391,000
Miscellaneous	5,000	8,000	13,000

*US $1.00 = ₱7.00

TABLE I-3 (Continued)

Item	Local	Foreign*	Total
Total Construction Cost	2,600,300	2,117,200	4,717,500
Contingencies	322,800	272,200	595,000
Engineering	142,500	264,800	407,300
Land Costs	111,000	-	111,000
TOTAL PROJECT COST	3,176,600	2,654,200	5,830,800
Stage 1 Phase A Construction			
Source Development	422,200	292,300	714,500
Pipelines and Valves	1,437,500	1,482,200	2,919,700
Internal Network	966,800	695,400	1,662,200
Service Connections	907,700	1,200,800	2,108,500
Fire Hydrants	34,300	47,400	81,700
Total Construction Cost	3,768,500	3,718,100	7,486,600
Contingencies	469,900	460,600	930,500
Engineering	220,500	409,300	629,800
Land Costs	6,000	-	6,000
TOTAL PROJECT COST	4,464,900	4,588,000	9,052,900

TABLE I-4

ANNUAL OPERATION AND MAINTENANCE COSTS (₱)

Item	1976	1980	1990	2000
Administration and Personnel	62,700	142,500	376,800	509,600
Power and Fuel	55,100	62,700	147,900	387,900
Chemicals	-	11,400	27,300	63,700
Maintenance	9,300	48,900	98,100	227,800
Miscellaneous	3,300	4,800	12,500	32,600
Total	130,400	270,300	662,600	1,221,600

*US $1.00 = ₱7.00

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	1.70
greater than 24 cum	2.70

Borrowing requirements will include ₱6.914 million from 1978 to 1981 for the immediate improvement program; ₱11.098 million from 1980 to 1985 for Phase I-A improvements; and ₱9.226 million from 1986 to 1990 for Phase I-B improvements.

Economic Feasibility

The recommended improvements to the GAP-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 1.24:1 and an IERR of 20.6 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] (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 also 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, Daet, Ozamiz 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-A 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 of implementation of the remaining five of the first 10 areas, namely: Lipa, Lucena, Tarlac, Cabanatuan and San Fernando (La Union).

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[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 areas are: Urdaneta, Gapan, Calamba, Bislig, Silay City, Bangued, 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 Gapan, Nueva Ecija.

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:[2]

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 GAPAN WATER DISTRICT

The GAP-WD was formed on 14 October 1975 by Resolution No. 46 of the Sangguniang Bayan (municipal council) of Gapan to include the entire municipality of Gapan. The formation of the GAP-WD was prompted primarily by the need for adequate water supply and an

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

[2] Refer to Appendix A, Volume II for complete Terms of Reference.

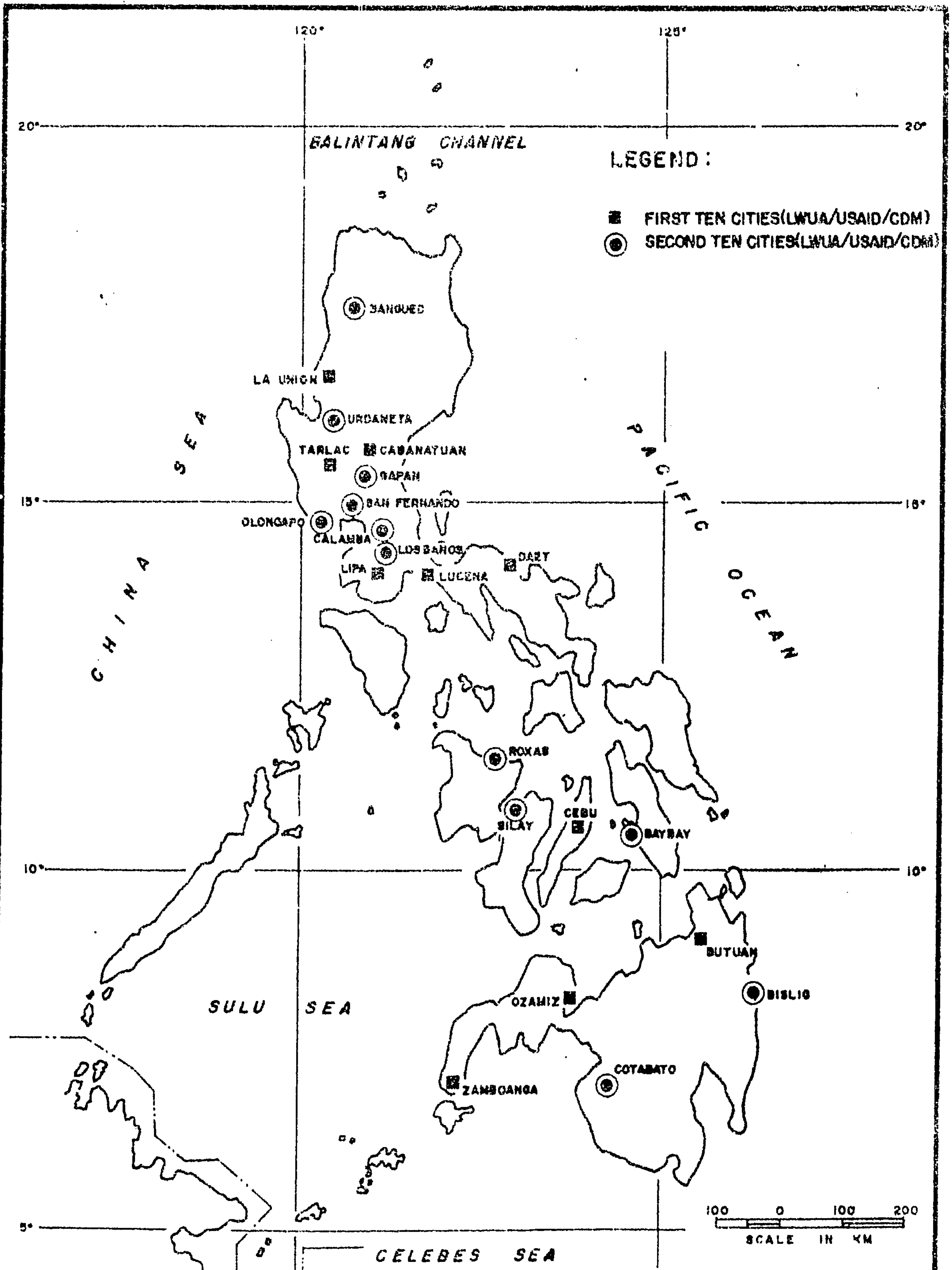

FIGURE II-1
LOCATION MAP
REPUBLIC OF THE PHILIPPINES

upgraded water system. Limited funding prevented substantial improvements to the system. Moreover, the local officials recognized the potential role of the water district in providing sufficient, safe and potable water supply.

The existing water system of Gapan was constructed in 1932-34 by the municipal government. In 1956, the National Waterworks and Sewerage Authority (currently the Metropolitan Waterworks and Sewerage System), took over the water system but in 1964 control of the water system, again reverted to the municipal government. Following its formation, the GAP-WD acquired the ownership and management of the entire system in accordance with Presidential Decree (PD) No. 198 (The Provincial Water Utilities Act of 1973).

The GAP-WD was established 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 GAP-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 GAP-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 GAP-WD can promulgate its own operating laws through its 5-member board of directors who are appointed by the municipal mayor. The district can only be dissolved through the act of this board.

On 30 March 1976, LWUA awarded the Conditional Certificate of Conformance to the GAP-WD after it had complied with the minimum requirements of LWUA's certification program. This certificate entitles the GAP-WD to rights and privileges authorized under PD No. 198.

CHAPTER III DESCRIPTION OF THE WATER DISTRICT[1]

A. PHYSICAL DESCRIPTION

Location

Gapan is located in the southern portion of Nueva Ecija province[2] on the island of Luzon. With an area of 15,590 hectares, Gapan is divided into the poblacion[3] and 18 barrios[4].

The present service area[5] of the GAP-WD includes the poblacion (composed of barrios San Lorenzo and San Vicente) and the barrios of San Nicolas, Sto. Niño, Bayanihan and Mangino. The service area in the year 2000 extends to the barrios of Pambuan, Sto. Cristo Norte, Sto. Cristo Sur, Malimba, San Roque and Sta. Cruz. By that time, the poblacion and barrio Malapit in San Isidro municipality, located west of Gapan, are expected to be served by the water system. (See Figures III-1.)

Physical Features

Gapan is mostly flat, with elevations ranging from 10 to 30 meters above mean sea level. The service area averages 18 meters above mean sea level.

The most important river in Gapan is the Peñaranda River. It flows through the northern boundary of the service area and empties westward into the Pampanga River.

Gapan is classified under the Type IV climate characterized by even rainfall throughout the year (Figure III-2). The average annual rainfall for the period 1960-69 was 2,127 mm. During the same years, temperature ranged from 25.5°C in January to 29.4°C in May, with the average at 27.6°C. The climatological data are listed in Table III-1.

---

[1] The GAP-WD covers all lands within the geographic boundaries of the municipality of Gapan.

[2] Nueva Ecija is located in the center of Central Luzon. Its bordering provinces are Bulacan on the south; Nueva Vizcaya and Pangasinan on the northeast and northwest; Pampanga on the southwest; Tarlac on the west; and Quezon on the east.

[3] Town proper

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

[5] The service area represents sections of the water district which are currently served or intended to be served by the water system.

TABLE III-1

CLIMATOLOGICAL DATA[6]
(1960-69)

	Average Rainfall (mm)	Average Temperature (°C)
January	5.5	25.5
February	7.9	26.1
March	77.7	27.9
April	30.5	28.6
May	190.2	29.4
June	330.2	29.0
July	330.0	28.3
August	405.4	28.1
September	361.6	27.9
October	168.1	27.5
November	113.7	26.4
December	106.3	26.0
Yearly Average	2,127.1	27.6

B. POPULATION

Gapan's population in 1970 was 45,426, an increase of 40 percent over the 1960 total of 32,514. The 1970 population was composed of 7,501 households, or an average of 6.1 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 the municipality are listed in Table III-3. These indicators include types of dwelling units, household facilities and utilities.

Health

Water-borne diseases occur particularly in the more densely populated sections of the municipality. 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 the province of Nueva Ecija[7] from 1964 to 1974. During this period, the national average morbidity of 666.5 per annum was 9 times higher than Nueva Ecija's average of 70.9. Its average mortality of 14.9 was much lower than the national average of 48.1.

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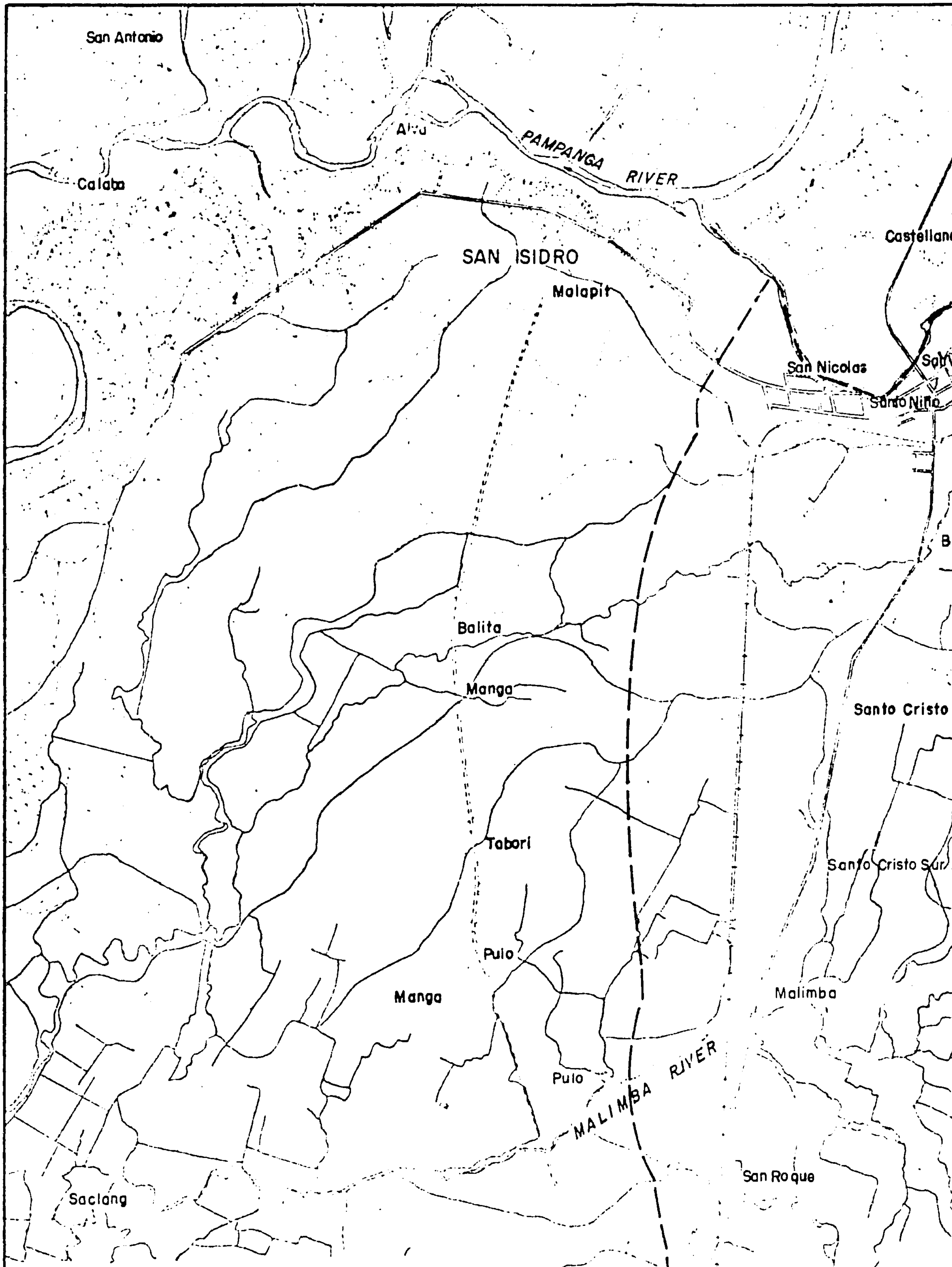
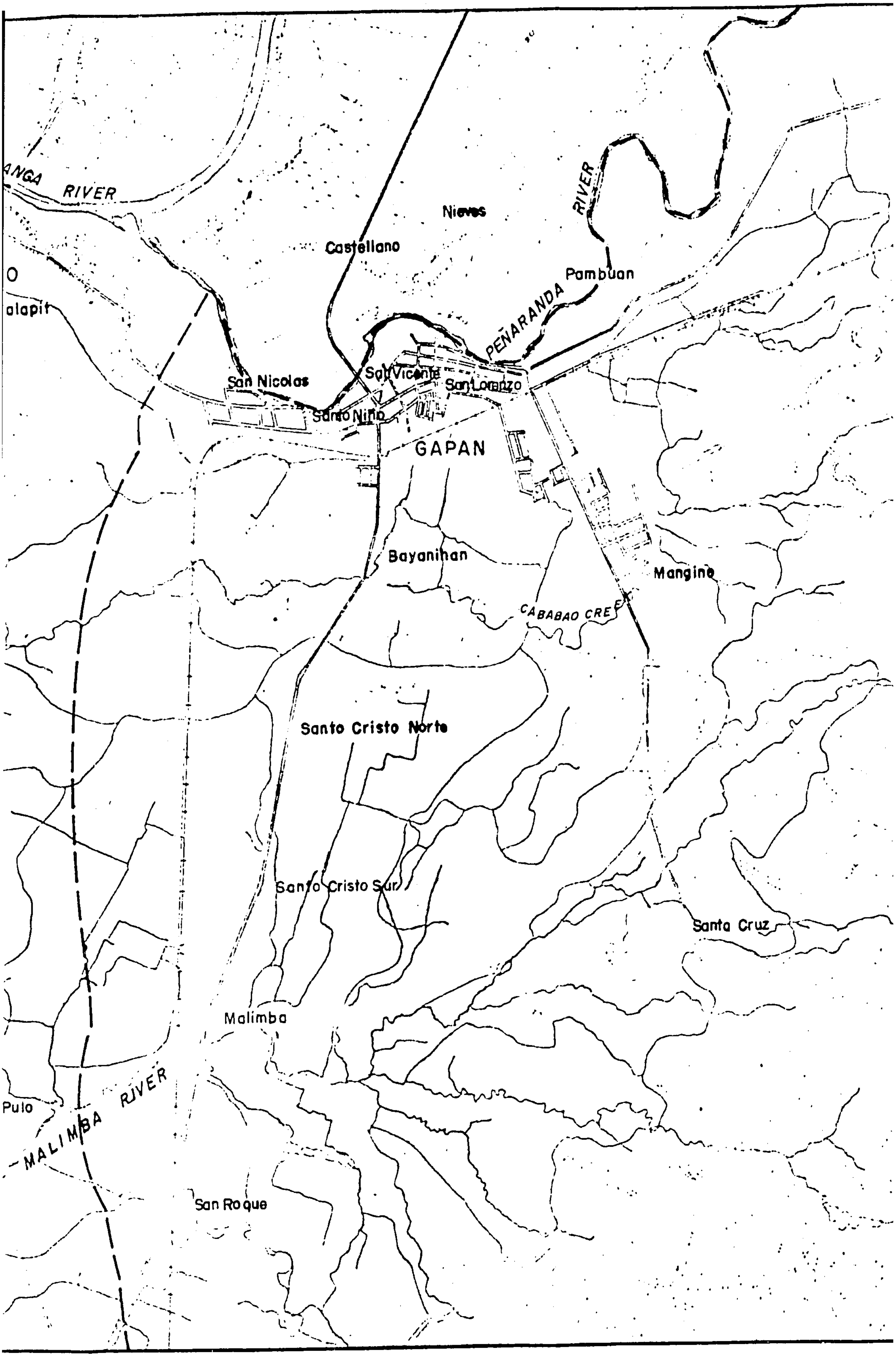
[6] Source: PAGASA Station in Cabanatuan City, Nueva Ecija.

[7] The only records available are for the province. The morbidity and mortality trends in Gapan are assumed from these data.



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



ANGA RIVER
Nieves
RIVER
Castellano
Pambuan
O
alapit
PEÑARANDA
San Nicolas
San Vicente
San Lorenzo
Santo Niño
GAPAN
Bayanihan
Mangino
CABABAO CREEK
Santo Cristo Norte
Santo Cristo Sur
Santa Cruz
Malimba
MALIMBA RIVER
Pulo
San Roque

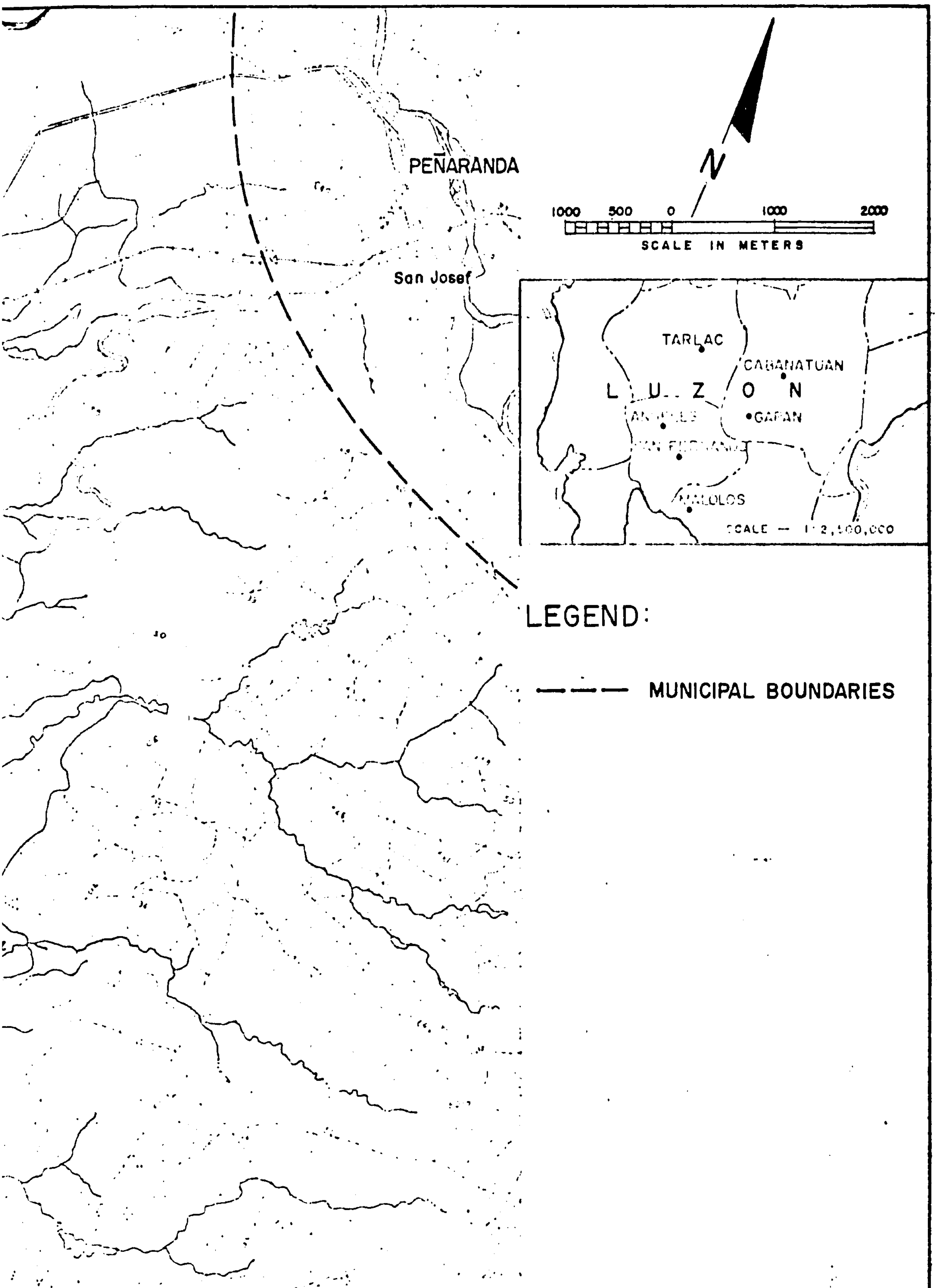


FIGURE III-1
LOCATION MAP
GAPAN WATER DISTRICT

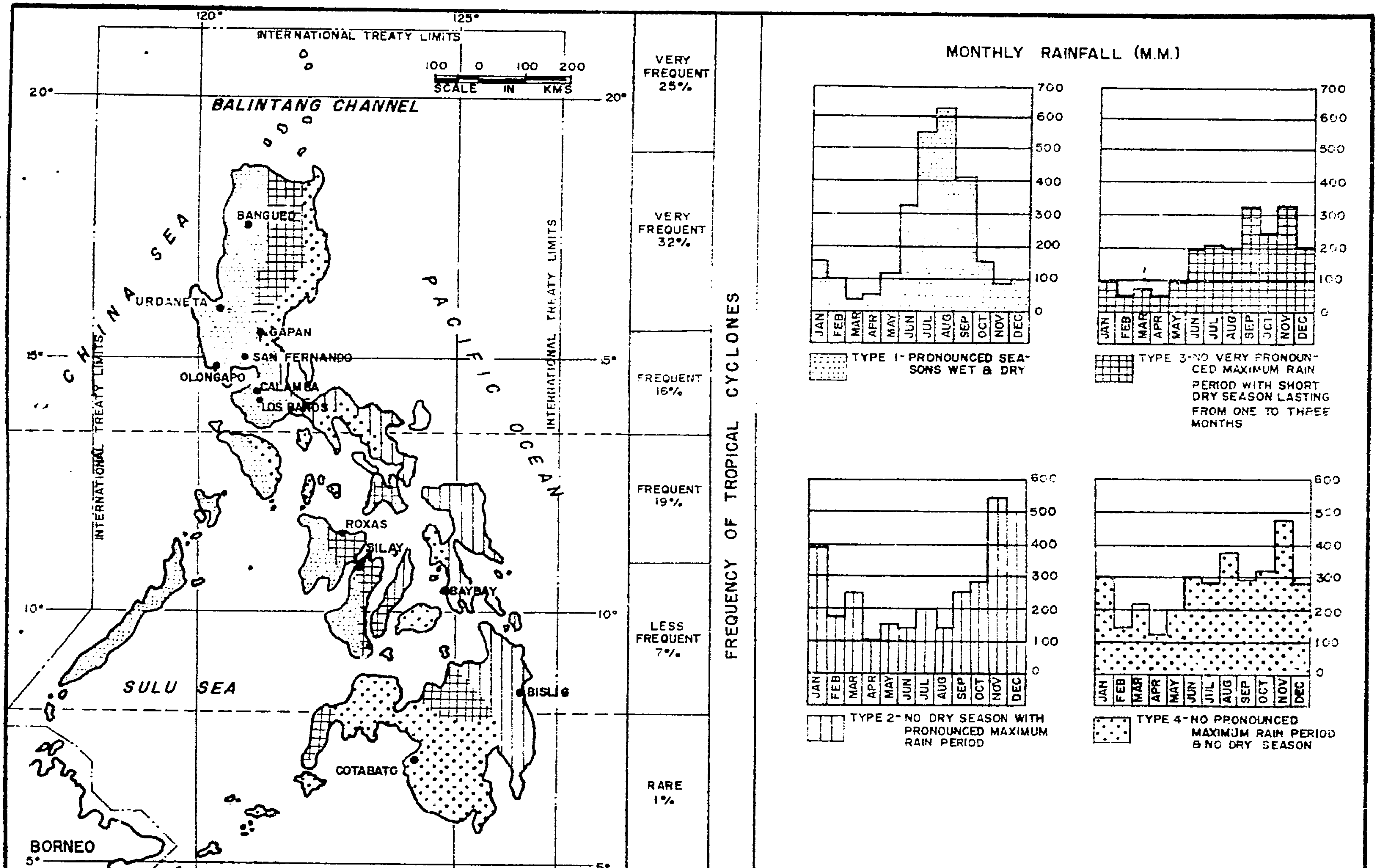


FIGURE III-2
CLIMATE MAP
REPUBLIC OF THE PHILIPPINES

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

TABLE III-2

MUNICIPAL POPULATION CHARACTERISTICS[8/] (1970)

1.	Total Population	45,426
2.	Growth Rate (1960-70)	3.4% per annum
3.	Density	2.9 persons per hectare
4.	Urban/Rural Composition	urban, 23%; rural, 77%
5.	Sex Composition	male, 49%; female, 51%
6.	Age Composition	0-14 years, 46%; 15-64 years, 50%; 65 years and over, 4%
7.	Employment (% of those 10 years and over)	10 years and over, 31,276 employed, 40%; unemployed, 60%
	a) By class of worker (% of labor force)	wage and salary, 45%; own business, 42%; unpaid family workers, 13%
	b) By industry (% of labor force)	agriculture, forestry and fishing, 37%; manufacturing, 21%; commerce, 12%; services, 15%; construction, utilities, and other industries, 15%
8.	Education (% of those 6 years and over)	6 years and over, 36,149 literate, 84%; illiterate, 16%
	a) By attainment (% of those 25 years and over)	25 years and over, 15,662 elementary grades, 67%; high school, 11%; college, 7%; no formal education, 15%
	b) Number of schools	public elementary, 25; private elementary, 1; public high school, 4; private high school, 1; private college, 1; vocational, 5
9.	Dialects	Tagalog, 98%; others, 2%
10.	Religion	Catholic, 97%; Iglesia ni Cristo, 2%; others, 1%

8/ Source: 1970 Census of Population and Housing, National Census and Statistics Office (NCSO)

These data apply to the municipality of Gapan as a whole.

TABLE III-3

CLASSIFICATION OF HOUSEHOLDS BY TYPE OF FACILITIES[9] (1970)

1.	Total Households	7,501
2.	Average Household Size	6.1 members per household
3.	Water Facilities (% of total households)	piped water, 17%; artesian well, 26%; pump, 56%; open well, spring, other sources, 1%
4.	Toilet Facilities (% of total households)	flush/water sealed, 28%; closed pit, 12%; open pit, 15%; public toilet, 1%; no facilities, 39%
5.	Solid Waste Disposal Service	About 20 cumd of solid wastes is collected by the municipal staff. These wastes are disposed in an area adjacent to the Peñaranda River near the Gapan-Cabanatuan Road.
6.	Lighting Facilities (% of total households)	electricity, 22%; kerosene, 77%; oil and others, 1%
7.	Appliances (% of total households)	radio, 74%; TV, 5%; refrigerator, 4%
8.	Cooking Fuel (% of total households)	electricity, 1%; kerosene, 17%; LPG, 6%; wood, 74%; charcoal and other fuel, 2%
9.	Total Dwelling Units	7,501
	a) Type of dwelling unit (% of total units)	single type, 97%; apartment, commercial, etc., 3%
	b) Roofing material (% of total units)	durable materials (aluminum/galvanized iron, asbestos, tile/concrete), 70%; non-durable materials (cogon, nipa, others), 30%

[9] Source: 1970 Census of Population and Housing, NCSO
These data apply to the municipality of Gapan as a whole.

TABLE III-4

REPORTED MORBIDITY AND MORTALITY DUE TO WATER-BORNE DISEASES[10] (1964-74) (PER 100,000 POPULATION)

Year	Nueva Ecija Morbidity	Nueva Ecija Mortality	Philippines Morbidity	Philippines Mortality
1964	49.8	17.3	846.3	60.2
1965	109.2	18.0	715.8	51.6
1966	23.2	22.9	715.1	61.9
1967	18.2	13.5	572.1	47.6
1968	17.2	14.9	564.8	46.5
1969	19.8	11.2	706.9	46.0
1970	23.8	7.4	612.8	39.0
1971	38.1	9.7	422.5	35.8
1972	99.1	19.5	743.4	49.4
1973	195.2	16.3	768.4	50.4
1974	186.8	13.0	663.8	40.4
Total	780.4	163.7	7,331.9	528.8
Average	70.9	14.9	666.5	48.1

D. ECONOMY[11]

Family Income[12]

In 1971, the province of Nueva Ecija had about 143,800 families, with a combined annual income of ₱700.5 million. The average family income of ₱4,871 was higher than the country's average of ₱3,736. Majority of the total number of families, 51 percent, comprised the middle income (₱3,000-₱5,999) group. About 26 percent belonged to the low-income (less than ₱500-₱2,999) bracket; 23 percent had annual earnings of ₱6,000 and over.

10/ Source: Disease Intelligence Center, Department of Health.

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

11/ The Philippine economy from 1946 to 1976 is discussed in Appendix E, **Volume II.**

12/ Only provincial data on family income are available at the NCSO.

Agriculture, Commerce and Industry

Agriculture is the most important sector of Gapan's economy, with rice as the main crop. Secondary crops are corn, fruits (watermelons), onions and other vegetables.

Gapan has about 170 manufacturing establishments engaged in small and medium-scale industries. Slipper-making is the biggest cottage industry. The Sevilla Farms is popular for its fine fruit wines. Other manufactured goods include clay and ceramic products.

There are over 400 commercial establishments, many of which are rice mills and warehouses.

CHAPTER IV EXISTING WATER SUPPLY FACILITIES

A. GENERAL

Gapan is served by a water system constructed in 1932-34. The original source of supply was a deep well which supplied a distribution system covering basically the same service area as today. In 1955, another well was constructed and the original source was subsequently abandoned. Other waterworks facilities include a reinforced concrete elevated tank and a diesel-driven triplex booster pump, some 14 km of distribution piping, and valves and hydrants. Figure IV-1 is a schematic plan of the existing water system.

B. WATERWORKS FACILITIES

Water Source Facilities

The existing GAP-WD supply source is a deep well located along Bonifacio Street, Barrio San Lorenzo in Gapan poblacion. The deep well was drilled in 1955 by the now defunct National Waterworks and Sewerage Authority (NWASA) to a depth of about 184 meters, with casing diameters of 200 mm and 150 mm. The pump, which was installed in 1956, is an 8-stage deep well turbine pump with a 100 mm diameter discharge pipe and is set at a depth of 30 meters below ground level. The pump is driven by a 65 horsepower diesel engine. Production from the well was measured in December 1976 to be 470 cumd. No additional information is available.

Storage Facilities

A reinforced concrete elevated storage tank located at the market site was constructed in 1932-34 as part of the original system. It has a capacity of 380 cum and overflow elevation of about 45 meters above mean sea level.

The storage tank is being used on a "fill-and-draw" basis. Water from the deep well is pumped into this tank for 22 hours by a diesel-driven triplex booster pump located at the base of the tank. Water is then rationed from the tank by operating the valves, which divide the distribution system into the east side and the west side, for one half hour to each side. The tank is ordinarily kept half-full for fire reserve purposes. This is controlled, during rationing, by means of a float gauge installed in the tank.

Treatment

The only treatment of the water supply is done at the storage tank. Powdered chlorine is applied to the water in the storage tank every 15th and 30th of the month. Dosage per application is computed to be 0.17 mg/l.

Distribution System

The distribution system has undergone only a minimal expansion (in length of piping) since it was installed in 1932-34.

A 150-mm cast iron along Tinio Street in the downtown area serves as the backbone of the distribution grid of mostly 125-mm pipes with some 62-mm, 75-mm and 100-mm pipes. There is usually no pressure in most of the distribution system except between the existing pump station and the reservoir. Most concessionaires receive water for only 30 minutes each day. Water from the reservoir is distributed from the tank, in turn, for one-half hour to the east side and another one-half hour to the west side of the distribution system early in the morning. About 23 percent of the concessionaires are connected to the pipe carrying water from the well to the elevated tank, so water is available most of the time. A diagram of the present distribution system is shown in Figure IV-2.

Pipe Sizes and Lengths. At present, the distribution system has about 13.73 km of piping ranging in size from 62 to 150 mm. Details of the distribution pipe are given in Figure IV-1. Sixty-four (64) percent of the piping is 125 mm in diameter and 28 percent, 150 mm in diameter. Ninety-three (93) percent of the piping is cast iron that is about 43 years old.

System Pressure. Pressures over the distribution system are generally zero except between the existing pump station and the reservoir where pressures sometimes rise to a meter or two. Water is available to most concessionaires for one-half hour each morning only.

Valves and Hydrants. According to available information, about 5 valves are regularly operated in the existing system. There are about 27 locally made fire hydrants, most of which have 75-mm GS riser pipes ("wet-barrel") and tee, with gate valve and nipple. Most hydrants are inoperative.

Service Connections and Public Faucets. As of September, 1976, the GAP-WD had 440 registered connections, all unmetered. Figure IV-1 shows the number of service connections by consumer category and basis of billing.

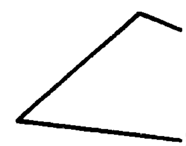
There are no public faucets connected to the GAP-WD system at present.

Operation and Maintenance

The GAP-WD operates and maintains the deep well source and distribution system. Present staffing includes the administrative officer who also acts as production supervisor, 6 pump operators and one plumber.

DISTRIBUTION SYSTEM

DIAMETER (MM)	TYPE	LENGTH (M) OF PIPE BY YEAR INSTALLED		TOTAL
		1932 — 1934	1955 — 1965	
62	GS	—	470	470
75	GS	--	480	480
100	CI	—	200	200
125	CI	8780	—	8780
150	CI	3800	—	3800
TOTAL		12,580	1,150	13730



APPURTENANCES

	SIZE	NUMBER	REMARKS
VALVES	25MM & 150MM	5	*
HYDRANTS	75 MM GS RISER	27	MOST ARE INOPERATIVE
PUBLIC FAUCETS	NONE		

* THESE VALVES ARE ALL LOCATED NEAR THE STORAGE TANK. THERE IS NO AVAILABLE DATA ON THE SIZE, NUMBER OR LOCATION OF OTHER VALVES IN THE SYSTEM.

BOOSTER F

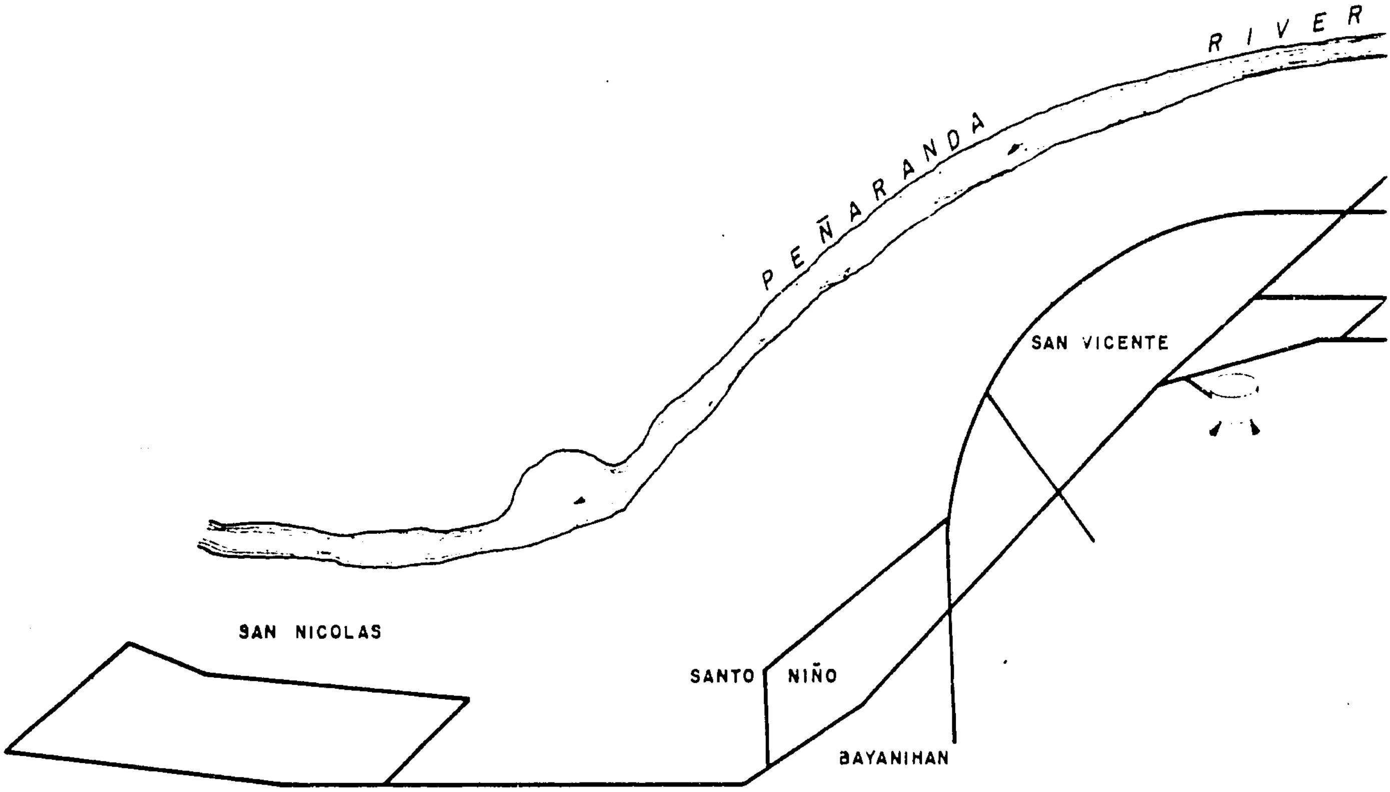
- PISTON PU POWERED DIESEL E
- DISCHARGE

SERVICE CONNECTIONS, SEPTEMBER 1976

TYPE	FLAT-RATE
DOMESTIC	395
COMMERCIAL	42
INSTITUTIONAL	3
TOTAL	440

TREATME

- POWDERED TANK TWI DOSAGE P



BOOSTER PUMP (1932) AT BASE OF STORAGE TANK

- PISTON PUMP, 3-CYLINDER POWERED BY A 15 HP, 2-CYLINDER DIESEL ENGINE
- DISCHARGE = 190 CUMD TO STORAGE TANK

STORAGE TANK (1932)

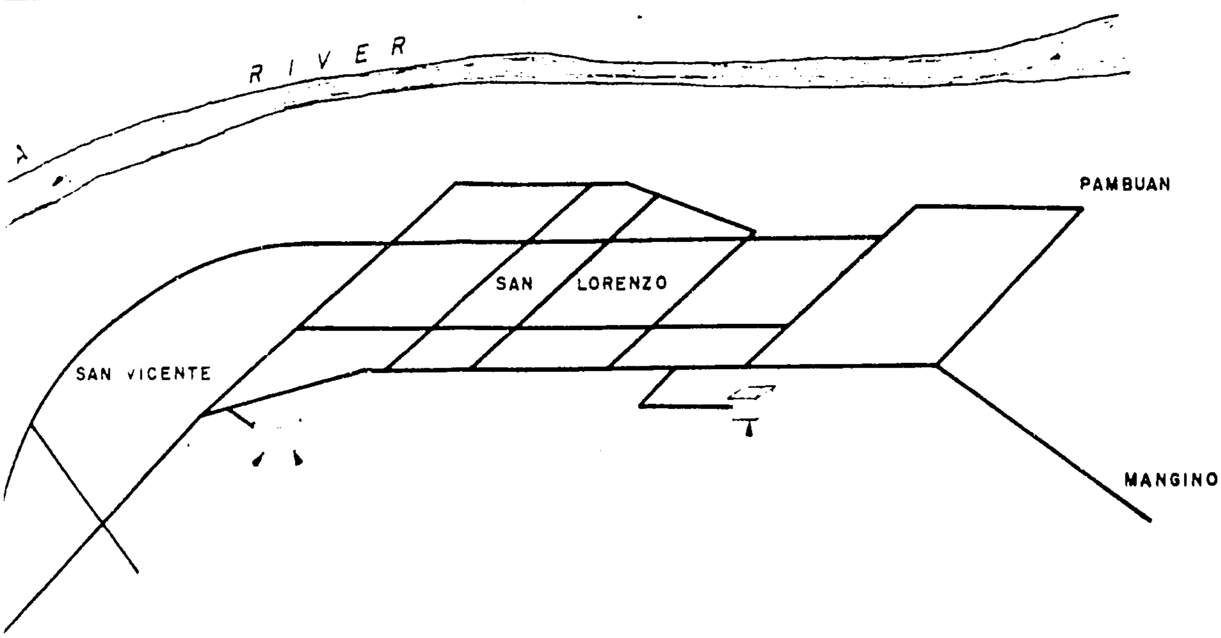
- CAPACITY = 380 CUM
- OVERFLOW ELEVATION = 45 M M
- REINFORCED CONCRETE
- WATER IS PUMPED INTO THIS RES FOR 22 HOURS A DAY BY THE B
- FOR 1/2 HOUR WATER IS RATION EAST SIDE AND TO THE WEST S
- ORDINARILY KEPT HALF FULL FO

TREATMENT

- POWDERED CHLORINE IS APPLIED TO THE STORAGE TANK TWICE EVERY MONTH (15th AND 30th) DOSAGE PER APPLICATION IS 0.17 MG/L

SYSTEM PRESSURE

- NO PRESSURE IN MOST OF THE SYSTEM EXCEPT OCCASIONALLY RESERVOIR



ORAGE TANK (1932)

- APACITY = 380 CUM
- VERFLOW ELEVATION = 45 M MSL
- EINFORCED CONCRETE
- ATER IS PUMPED INTO THIS RESERVOIR
- R 22 HOURS A DAY BY THE BOOSTER PUMP
- R 1/2 HOUR WATER IS RATIONED TO THE
- AST SIDE AND TO THE WEST SIDE ALSO FOR 1/2 HOUR
- RDINARILY KEPT HALF FULL FOR FIRE RESEREVE

DEEP WELL & PUMP STATION (1956)

- TURBINE PUMP WITH A 65 HP DIESEL ENGINE
- CASING DIAMETER = 200 MM AND 150 MM
- WELL DEPTH = 184 M
- DISCHARGE = 470 CUMD
- DISCHARGE PRESSURE = 0.05 KG/SQ CM
- ELEVATION = 19 M ABOVE MSL
- PUMPS TO DISTRIBUTION SYSTEM AND BOOSTER PUMP

'STEM PRESSURE

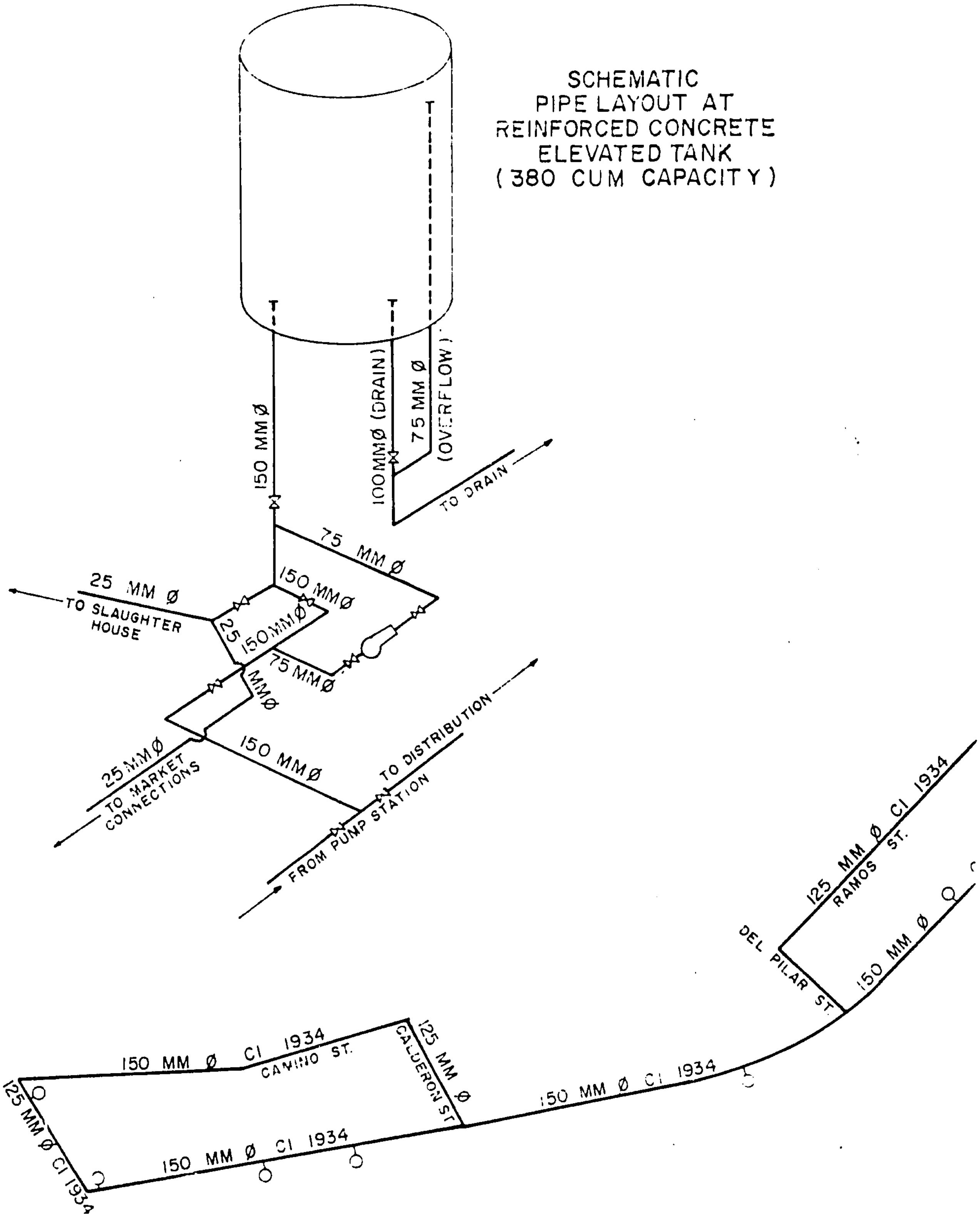
: PRESSURE IN MOST OF THE DISTRIBUTION
'STEM EXCEPT OCCASIONALLY NEAR THE
ESERVOIR

SERVICE AREA OPERATION

- MOST CONSUMERS ARE LOCATED IN THE SAN LORENZO AREA, PREDOMINANTLY A COMMERCIAL AREA
- WA R IS RATIONED TO SAN VICENTE AREA FROM 0530 TO 0600 HOURS WHILE THE SAN LORENZO AREA RECEIVES WATER FROM 0600 TO 0630 HOURS

FIGURE IV-1
EXISTING FACILITIES
GAPAN WATER DISTRICT

SCHEMATIC PIPE LAYOUT AT REINFORCED CONCRETE ELEVATED TANK (380 CUM CAPACITY)



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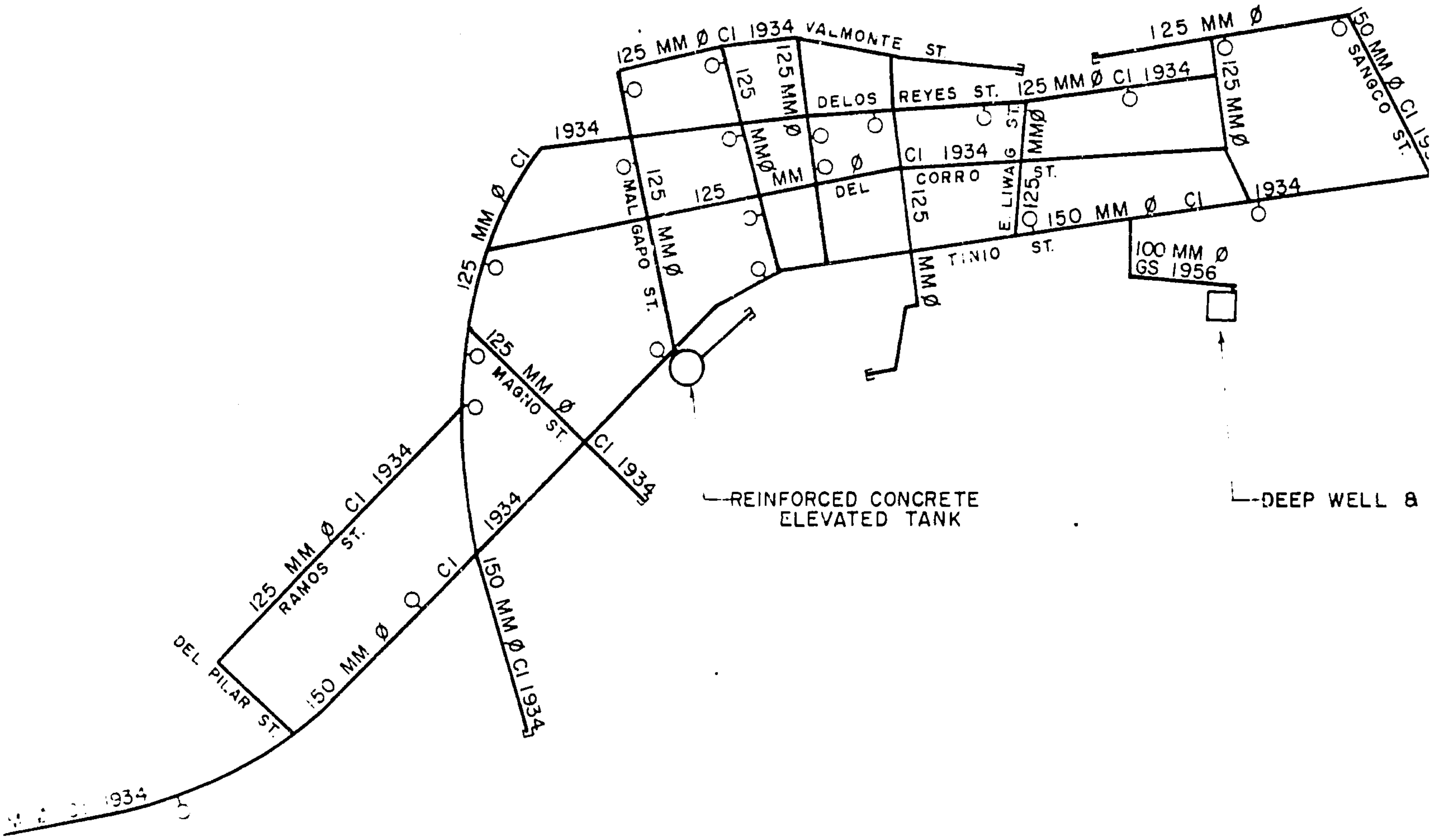


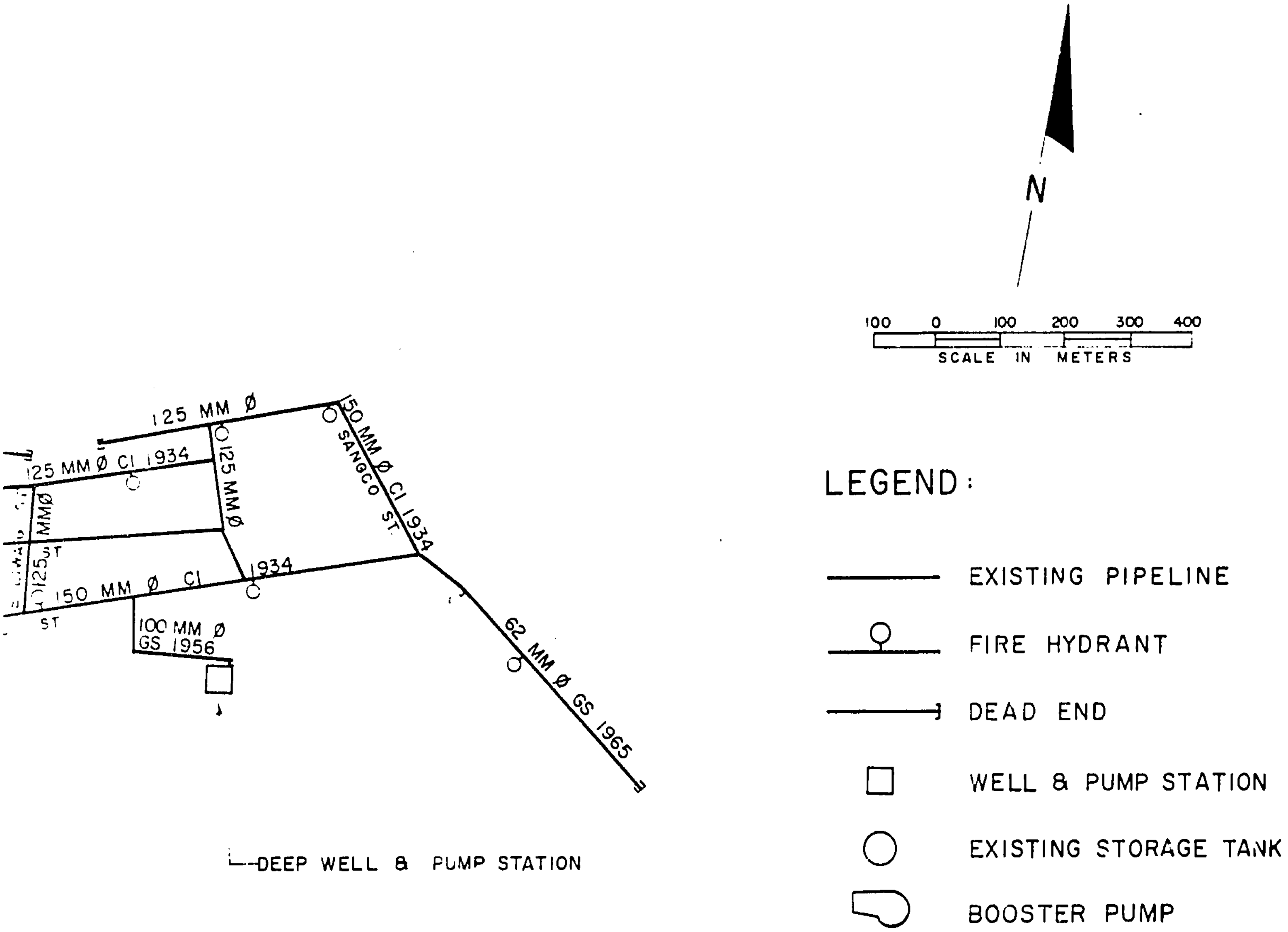


FIGURE IV-2
EXISTING WATER DISTRIBUTION SYSTEM
GAPAN WATER DISTRICT

The operational program consists primarily of operating the deep well pumping station and pumping facilities at the storage tank and emptying and refilling the storage tank. The maintenance program consists primarily of servicing the pumping units and repairing service lines.

C. WATER QUALITY

Water samples were taken from the present deep well source and 4 other deep wells in different barrios near the poblacion. Results of the laboratory analysis of the water samples are listed and compared with the Philippine National Standards for Drinking Water in Table IV-1. Water quality parameters for the present source appear to be within the permissible limits. The water from one deep well has slightly higher value than the permissible limits of 0.1 mg/l for manganese.[1/]

D. WATER USE PROFILE

General

The current water demands of Gapan have been analyzed in order to predict future water requirements. Data on revenue produced from the sale of water were obtained from the water district. Other data were taken from field measurements on water production and from the pilot area study conducted in December 1976.

A pilot area was selected within the present service area where a survey was made to establish the present water use profile. (Methodology Memoranda 1 and 2). Household members in the pilot area were interviewed to determine their source of water supply, number of hours water is available, approximate daily or monthly water consumption, amount paid to the water district per month, number of neighbors asking for water (borrowers), and number of faucets. The number of persons in each household, the family income bracket and the amount each household is willing to pay for improved water service were also determined. The summary of the pilot area study is presented in Annex IV-D.

1/ These limits have been established on the basis of aesthetic and economic considerations rather than physiological hazards. In concentrations not causing unpleasant tastes, manganese is regarded to be of no toxicological significance in drinking water. Observations in the GAP-WD indicate that the people using water from the said sources have raised no complaints on the chemical/physical quality of their water.

TABLE IV-1

WATER QUALITY TEST RESULTS
GAPAN WATER DISTRICT

Test	Unit	Permissible limits	Water District Well Barrio San Lorenzo 1 Sept 76	Well Barrio Sta. Cruz 2 Sept 76	Well Barrio Sto. Cristo 1 Sept 76	Well Barrio Sto. Cristo Sur 1 Sept 76	Well Barrio Malimba 1 Sept 76
Physical							
Color	APHA	15	0	8	0	0	0
Turbidity	FTU	5	0	5	0	0	0
Total Dissolved Solids **	mg/l	500	221	211	250	280	306
Conductivity	micromhos/cm		340	325	385	430	470
Chemical							
pH		7-8.5	8.4	8.5	8.3	8.4	8.3
Total Alkalinity	mg/l CaCO3		190	160	190	210	175
Phenolphthalein	mg/l CaCO3		30	25	15	20	20
Total Hardness***	mg/l CaCO3	400	0	0	0	0	0
Calcium	mg/l	75	0	0	0	0	0
Magnesium	mg/l	50	0	0	0	0	0
Total Iron	mg/l Fe	0.3	nil	0.03	0.02	0.04	0.03
Fluoride	mg/l F	1.5	nil	nil	nil		nil
Chloride	mg/l	200	5	18	18	18	42
Sulfate	mg/l	200	4.05	35	5.4	8.2	10.2
Nitrate****	mg/l	50	3.57	8.24	9.3	7.66	8.33
Manganese	mg/l Mn	0.1	0.1	0.1	0.1	0.1	0.25*

*Exceeds the permissible limits set by the Philippine National Standards for Drinking Water.
**Computed as 65% of conductivity.
***Limit inferred from limits of individual metals causing hardness.
****Fifty to 100mg/l may cause infant desease according to Philippine National Standards for Drinking Water.

Population Served

From the pilot area analysis, it is estimated that approximately 4,200 persons are entirely dependent on the GAP-WD for water supply, from 440 service connections (see Annex IV-D). Based on these numbers, for every connection, an average of 9.5 persons are served. Since the average number of persons per household in the pilot study was found to be 7, the implication is that about 1 1/3 households are served by one connection. There is more than 1 household served per connection; there are primary users or consumers residing in the house of the concessionaire. There are also secondary users or consumers obtaining water by handcarried buckets from the the concessionaires. The secondary users are also termed "borrowers".

Water Consumption

Water consumption in the GAP-WD was calculated on the basis of pilot area survey data and information on the existing water supply system. The present production of the existing deep well was gaged in December 1976 to be 470 cumd. About 190 cumd is pumped into the reservoir and distributed the following morning. The remaining 280 cumd is presumably consumed along the pipelines from the deep well pum station to the reservoir. Of the 440 service connections in the system, 97 connections, representing 737 primary users, are along the line from the pump station to the reservoir. Based on the pilot area survey data, there are about 203 secondary users. Total demand then is 380 lpcd, including wastage and leakage. Assuming wastage to be 40 percent[2/] of the total consumption and leakage to be 25 percent[2/], consumption along the line from pump station to reservoir is summarized as follows:

Flat-rate consumption	112 lpcd	91 cumd
Borrowers	17 lpcd	4 cumd
Wastage	152 lpcd	112 cumd
Leakage	99 lpcd	73 cumd
Total	380 lpcd	280 cumd

[2/] Water accountability for the first 10 urban areas indicates that the weighted composite for the different categories of water use is as follows; accounted-for-water, 31 percent of production; underestimated flat-rate use, 11 percent of production; wastage, 26 percent; leakage, 25 percent; and other uses, 7 percent of production.

Wastage along this portion of the distribution system was assumed to be 60 percent higher than the weighted composite for wastage for the first 10 urban areas, from observations during the pilot area survey.

The remaining service connections in the distribution system get water for only 30 minutes a day. There are about 2,530 persons who are primary users, and about 700 persons, who are secondary users, served by these connections. Total demand is estimated to be only 75 lpcd including leakage and minimum wastage. Assuming leakage to be 25 percent of the total consumption and wastage to be 5 percent[3/], consumption in the rest of the distribution system is summarized below:

Flat-rate consumption	34 lpcd	117 cumd
Borrowers	17 lpcd	12 cumd
Wastage	4 lpcd	10 cumd
Leakage	20 lpcd	51 cumd
Total	75 lpcd	190 cumd

E. HYDRAULIC STUDIES

During the first week of December 1976, field measurements were conducted to determine the hydraulic conditions in the Gapan water system. The purpose of these field measurements is to provide data for a computer model of the existing system and to isolate any areas with major operational problems. The results of the field observations in Gapan are as follows:

Deep Well Pump Station. The packing in the stuffing box of the pump could not withstand more than 7 meters (0.70 kg/sqcm) pressure without significant leakage, so that a pump test could not be conducted. The water level in the well could not be measured due to a thick layer of oil in the well. The operating discharge pressure of the pump was 0.53 meter (0.05 kg/sqcm).

Booster Pump at the Storage Tank. The piston booster pump discharged between 2.2 and 2.3 lps to the storage tank while creating a vacuum of 0.84 meter pressure (0.08 kg/sqcm) within the adjacent distribution pipeline during testing.

Pipeline from Pump Station to Tinio Street. The 100 mm cast iron pipeline from the pump station was tapped near Tinio Street and the pressure was 1.06 meters (0.10 kg/sqcm). A flow measurement indicated that about 5.44 lps was entering the distribution system from the pump station. Pressures within the distribution system were at or near zero during the test period.

[3/] Wastage along this portion of the distribution system was assumed to be a minimal 5 percent due to extreme rationing as observed during the pilot area survey.

F. COMPUTER STUDIES

The purpose of conducting computer studies on the existing transmission and distribution system is to duplicate, to the greatest extent practicable, the hydraulic conditions observed in the field. By doing this, it is possible to evaluate the impact of improvements on the existing system.

In order to provide data for computer studies there must be a significant positive pressure over the entire distribution system during field tests. There were very little significant field data gathered in Gapan for the existing system as discussed in Section E, therefore, computer studies on the existing system were not conducted.

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

G. DEFICIENCIES OF THE EXISTING SYSTEM

The present level of service in the GAP-WD has many deficiencies. There is not sufficient water for all consumers due to leakage, wastage and insufficient pump capacity. Water is normally rationed for 30 minutes each day to each half of the town.

Leakage is primarily due to the age of the existing pipelines. Most were constructed in 1932-34 and, after 45 years of service, are leaking badly. The elevated storage tank also leaks badly.

The existing well pump does not have sufficient capacity to supply the requirements of GAP-WD and is also in a state of disrepair. The packing of the pump is so deteriorated that the pump can not create more than 7 meters (0.70 kg/sqcm) of pressure.

The GAP-WD system also creates potential health hazards to the people of Gapan. There are several pipelines that are laid in polluted drainage ditches that could contaminate the water supply. Chlorine is only applied periodically, which defeats its main purpose of maintaining a chlorine residual in the system to kill pathogenic organisms that may enter the system.

Only a small portion of the population (13 percent) is served by the GAP-WD and none of the usage is metered.

There are insufficient equipment, tools and spare parts for the GAP-WD personnel to effectively maintain the water system. There are no laboratory facilities, plumbing shops or sampling and testing programs.

ANNEX IV-D

SUMMARY OF PILOT AREA
SURVEY OF GAP-WD

ANNEX IV-D

Memorandum

T o : L. V. Gutierrez, Jr.

F r o m: R. P. Abustan

D a t e: 20 December 1976

Subject: Summary of Pilot Area Survey of GAP-WD

I. GENERAL INFORMATION

A. The pilot area covers about one half block where water from the WD is available to consumers from 8 to 24 hours. The pilot area is along Bonifacio and Tinio Streets, and includes about 1.78 hectares.

B. A total of 45 households were surveyed within the pilot area, with a total household population of 315. The average number of persons per household is 7 and the density, 177 persons/hectare.

C. The survey was made in December 7 and 8, 1976 with Pablo Yuzon, Isagani Pineda and Domingo Sison (WD) as enumerators. The results were checked and verified by Avelino Gamboa (WD) Mel Liamco and R. Abustan (CDM-LWUA).

II. SURVEY RESULTS

A. Primary and Secondary Users:

No. of connected households	26	(all flat-rate, domestic)
No. of household borrowers from connected households	10	36
No. of households relying solely on own private wells	8	
No. of household borrowers solely using public/private wells	1	9
Total households		45

B. Consumption Figures

Flat-rate concessionaire	No data
Private well owners	No data
Borrowers	9 lpcd (for drinking purposes only)
	17 lpcd (maximum borrowed consumption)

C. Willingness to pay for improved service/month

Average Income	₱20.76	(33 households)
Upper Middle	24.17	(12 households)

III. Pilot Area Data

A. Total Monthly Production = 90 gpm for 24 hours @ 30 days
= 470 cumd
= 14,115 cum/mo

B. No. of connections
Flat-rate = 440   Consumption = no data

C. Total households 45

Total no. of connected households = 26   Persons/household = 7

Household borrowers from connected households = 10

36

Households relying solely on own private wells = 8

No. of household borrowers solely from public/private wells = 1

9

$$\frac{\text{Total Connections}}{\text{Total Dependent on System}} = \frac{26}{36} = 0.72$$

D. Total households dependent on system = $\frac{440}{0.72}$ = 610 households or 4,200 persons

Total borrowers from connected households = 610 – 440 = 170 households

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), evaluation 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, groundwater derived from wells, when available, is expected generally to be more economical than conventionally treated surface water.

3. 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	Construction Started 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 to 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.

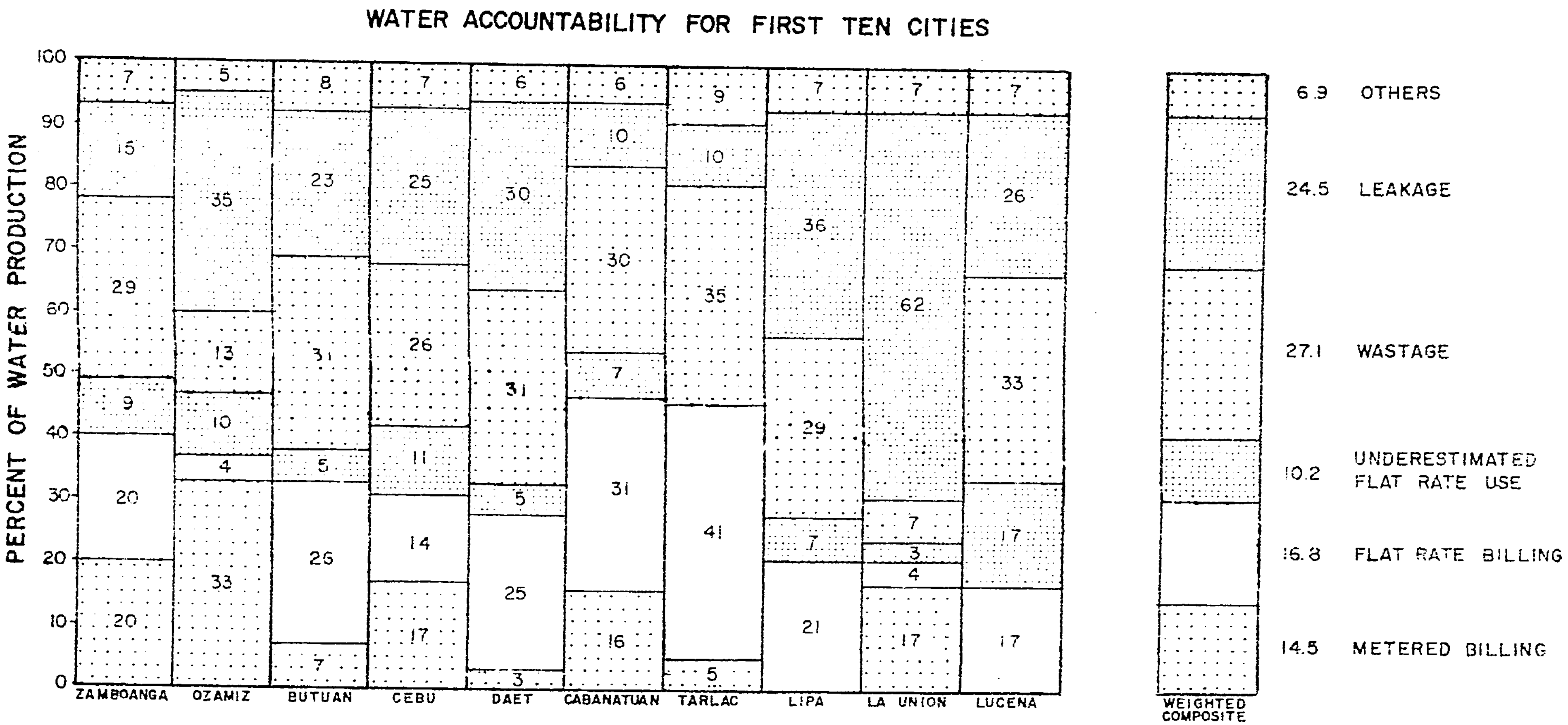
9. Social Soundness: The successful completion of any project must take into account the social acceptability of its recommended programs (Appendix S, Volume II).

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 included in Volume I of this report.

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 of 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, a financial feasibility analysis (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 IWUA Interim Demonstration Program by 1979.

Estimated Phase I-A Schedule

Final Report Submission	September	1977
Select Final Design Engineer	September	1978
Start Final Design	October	1978
Complete Final Design	September	1979
Start Construction	January	1980
Complete Construction:		
a) Source	Early	1981
b) Distribution	Early	1982
c) Internal Network	Late	1985

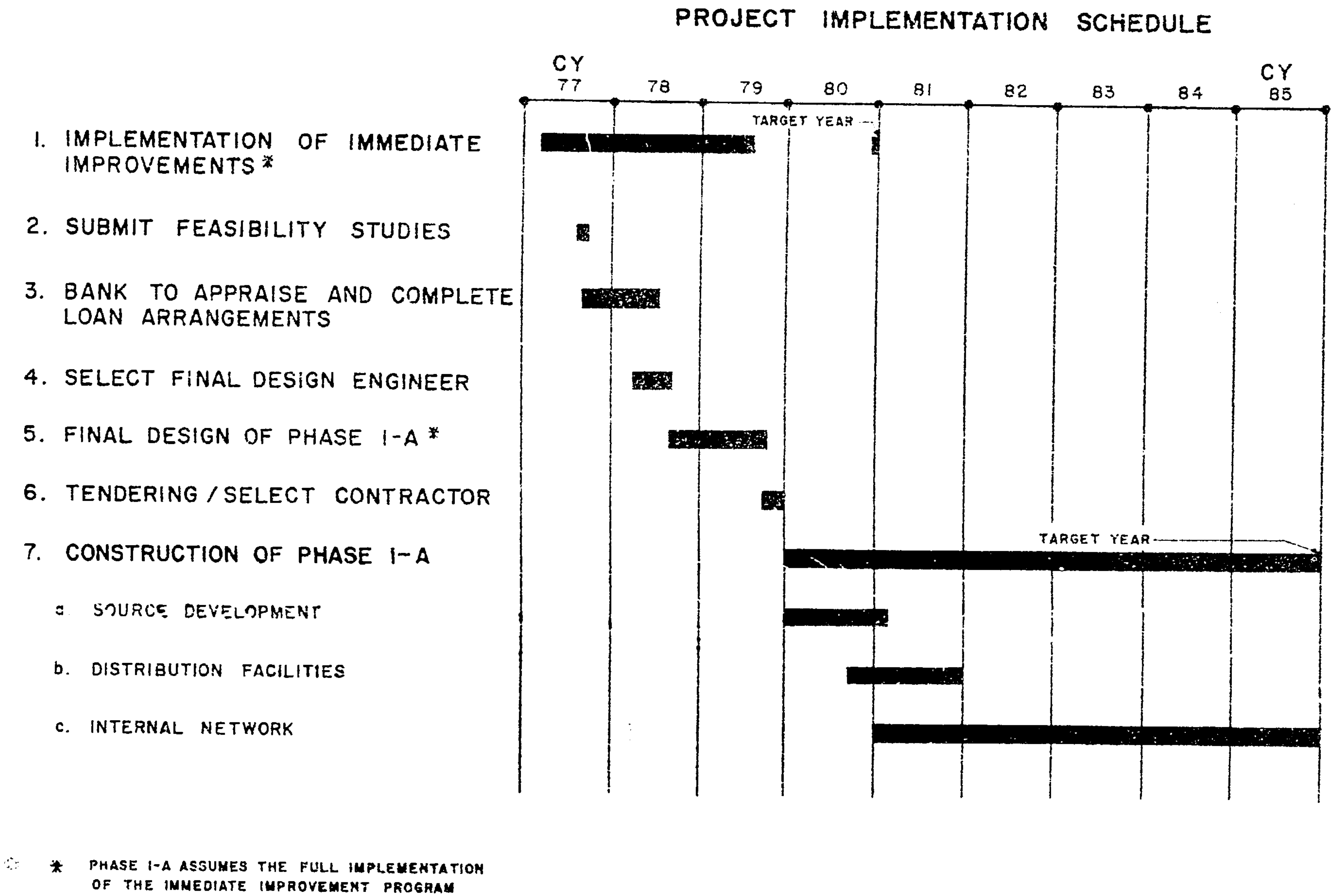


FIGURE V-2
PROJECT IMPLEMENTATION SCHEDULE
GAPAN WATER DISTRICT

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 materially affect facility layouts and sizes, construction staging and the cost of the project. Projections for the GAP-WD are developed in this chapter.

B. POPULATION PROJECTIONS

The population of Gapan as measured in the past has indicated fluctuating growth rates through the censal years covered, as shown below:

Year	Population	Gapan Annual Growth (%)	National Annual Growth Rate (%)
1948	25,719		
1960	32,514	2.10 (1948-1960)	3.10
1970	45.426	3.33 (1960-1970)	3.00
1975	50,488	2.14 (1970-1975)	2.66

The average annual growth rate from 1948 to 1975 of Gapan was 2.57 percent. The increase in population from 1960 to 1970 with an annual growth rate of 3.33 percent, compared to 2.10 percent in 1948-1960, can be attributed to considerable migration from the rural to the urban areas. This growth rate was higher than the national growth rate of 3.00 percent for the period 1960-1970. The decrease in growth rate (2.14 percent) in 1970-1975 can be correlated to the decrease in the national growth rate also for the same period.

Population projections for the years 1970-2000 for Gapan were done by the National Economic Development Authority (NEDA) and the Commission on Population, (POPCOM) using high, medium and low assumptions. The methodology of these projections is discussed in Appendix H, Volume II. Field observations and data gathered indicate a population trend which could surpass the NEDA-POPCOM projections although NCSO population tally for 1975 is lower than the NEDA-POPCOM projections for the same year.

The present, immediate, and the projected 1990 and year 2000 service areas of GAP-WD have been developed based on field inspection, discussions with water district and local officials, land use or development plans and current and proposed public facilities (see Figure VI-1). By the year 2000, the principal portions of Gapan Poblacion, barrios San Nicolas, Sto. Niño, Mangino, Pambuan, Bayanihan, Sto. Cristo Norte, Sto. Cristo Sur, Malimba, San Roque, Sta. Cruz, the poblacion and Barrio Malapit in San Isidro municipality will be served by the GAP-WD.

The method of projecting population used in this report is based on development of annual growth rates for the poblacion and barrios in the service area derived from historical rates, field observation and discussions with water district and local officials and citizens. The population growth rates were determined after considering the service area population densities and development plans. The growth rates used in Table VI-1 are higher than the basic growth rates of the NEDA-POPCOM high assumption projections for the municipality of Gapan as a whole.

Relatively fast population growth anticipated in the service area is based on the following factors:

(1) Migration from the rural areas to the urban areas of Gapan is occurring. Therefore, the growth rate in the service areas is expected to be higher than the town as a whole.

(2) Industry and commerce are expanding in the area. New industries include bentonite, marble, fruit- and wine-making and a proposed paper factory. Present commercial enterprises that are increasing operations in the area include hollow-block making, shirt-, slipper- and shoe-making and construction contractors.

(3) According to the land use and development plan prepared by the Municipal Development Office, a strip of land along the National Highway from Gapan to Manila and another along the Gapan-Olongapo Highway have been designated as industrial zones. These areas cover parts of the barrios Bayanihan, Sto. Cristo Norte, Sto. Cristo Sur, Malimba, San Roque, Sto. Niño, San Nicolas, the poblacion and Barrio Malapit in San Isidro.

(4) There are about 15 active housing subdivisions (about 900 houses) in barrios Bayanihan, Sto. Cristo Norte, Mangino, Pambuan, Sto. Niño and San Roque.

Projected populations are shown in Table VI-1 and Figure VI-2 and summarized as follows:

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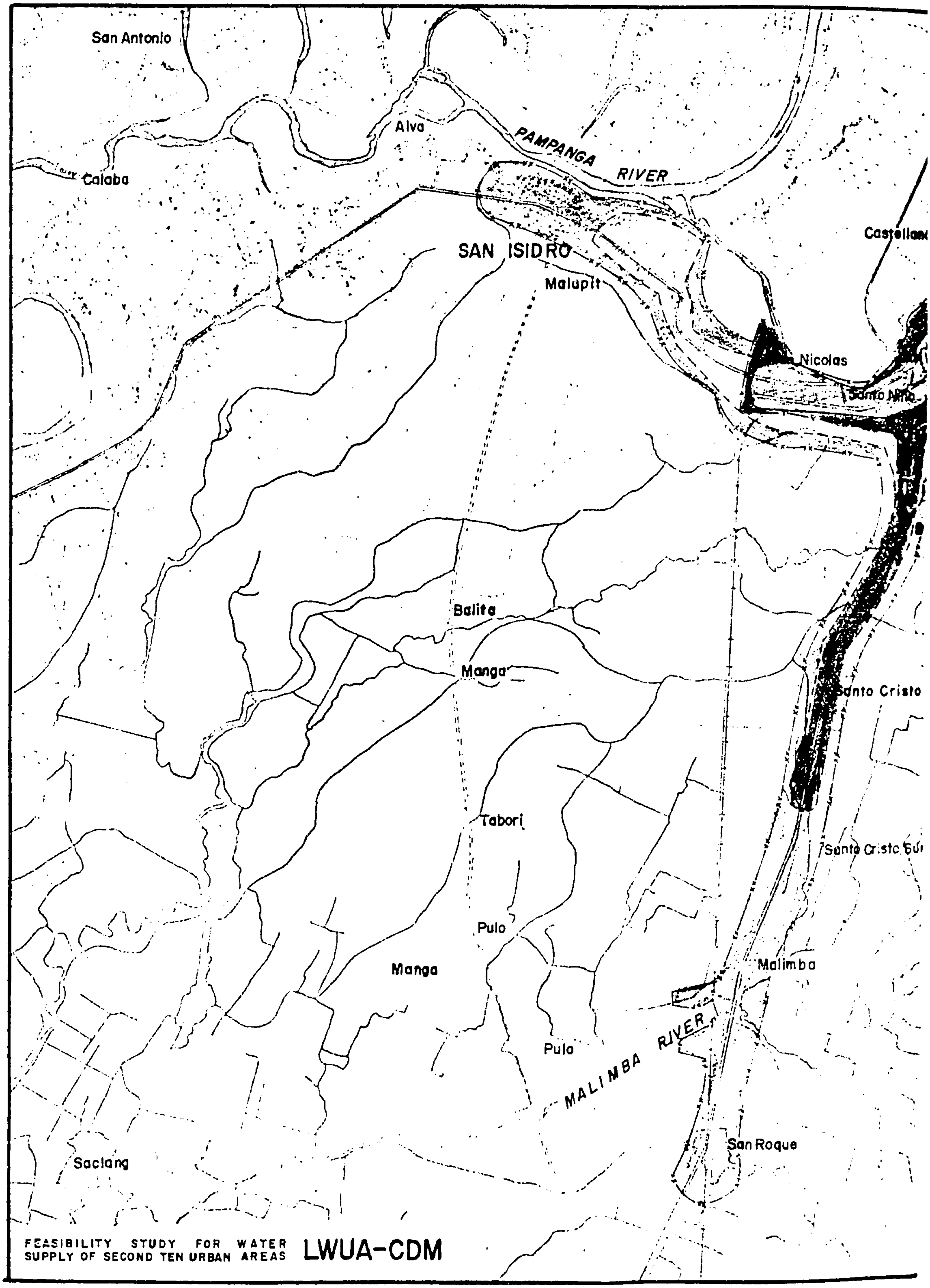
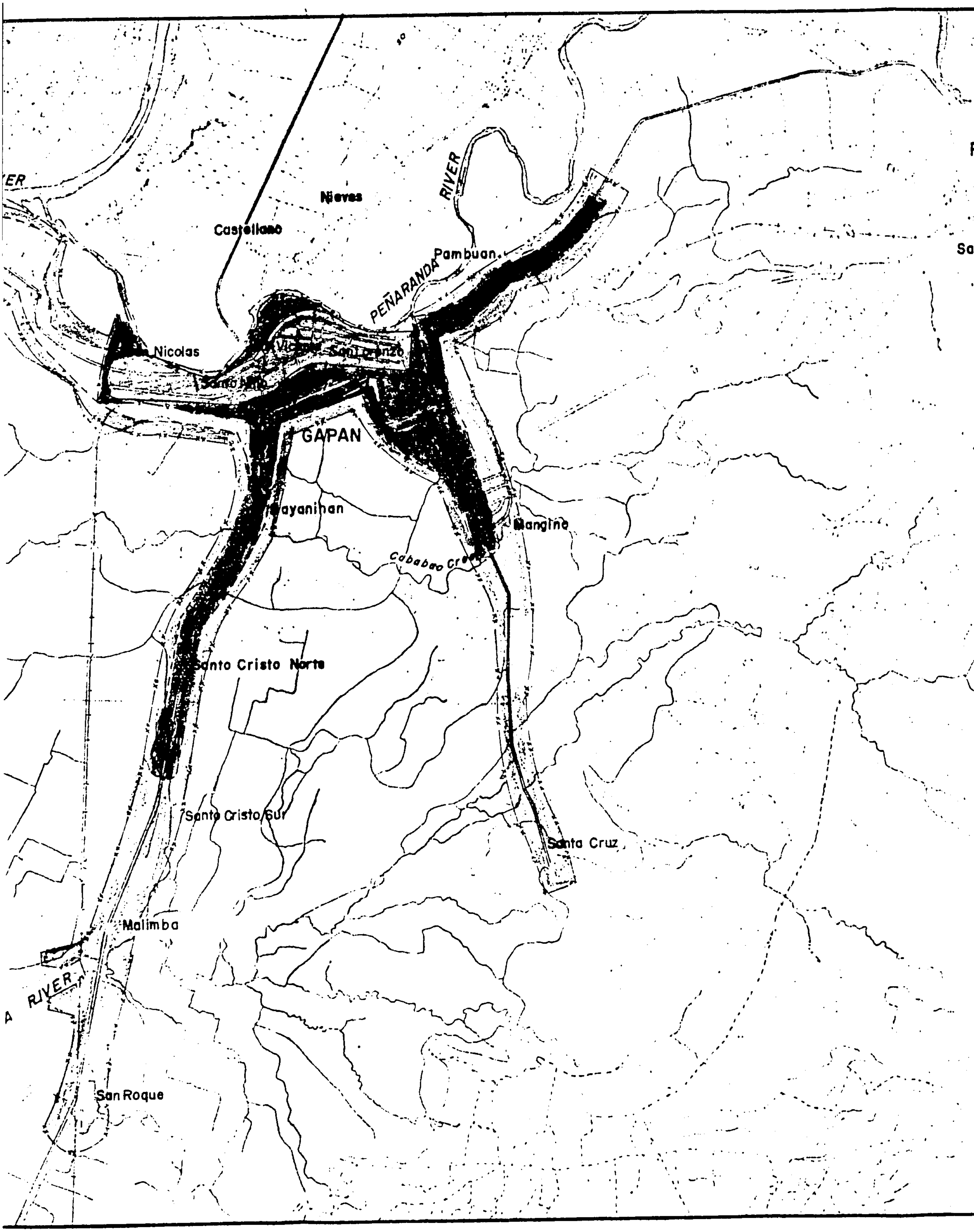

San Antonio
Alva
Calaba
PAMPANGA RIVER
SAN ISIDRO
Malupit
Castellano
Nicolas
Santo Niño
Balita
Manga
Santo Cristo
Tabori
Santo Cristo Sur
Pulo
Manga
Malimba
MALIMBA RIVER
Pulo
San Roque
Saclang
FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS
LWUA-CDM



RIVER
Nieves
Castellano
RIVER
Pambuan
PEÑARANDA
Nicolas
Santo Niño
GAPAN
Bayanihan
Mangino
Cababao Cr
Santo Cristo Norte
Santo Cristo Sur
Santa Cruz
Malimba
RIVER
San Roque

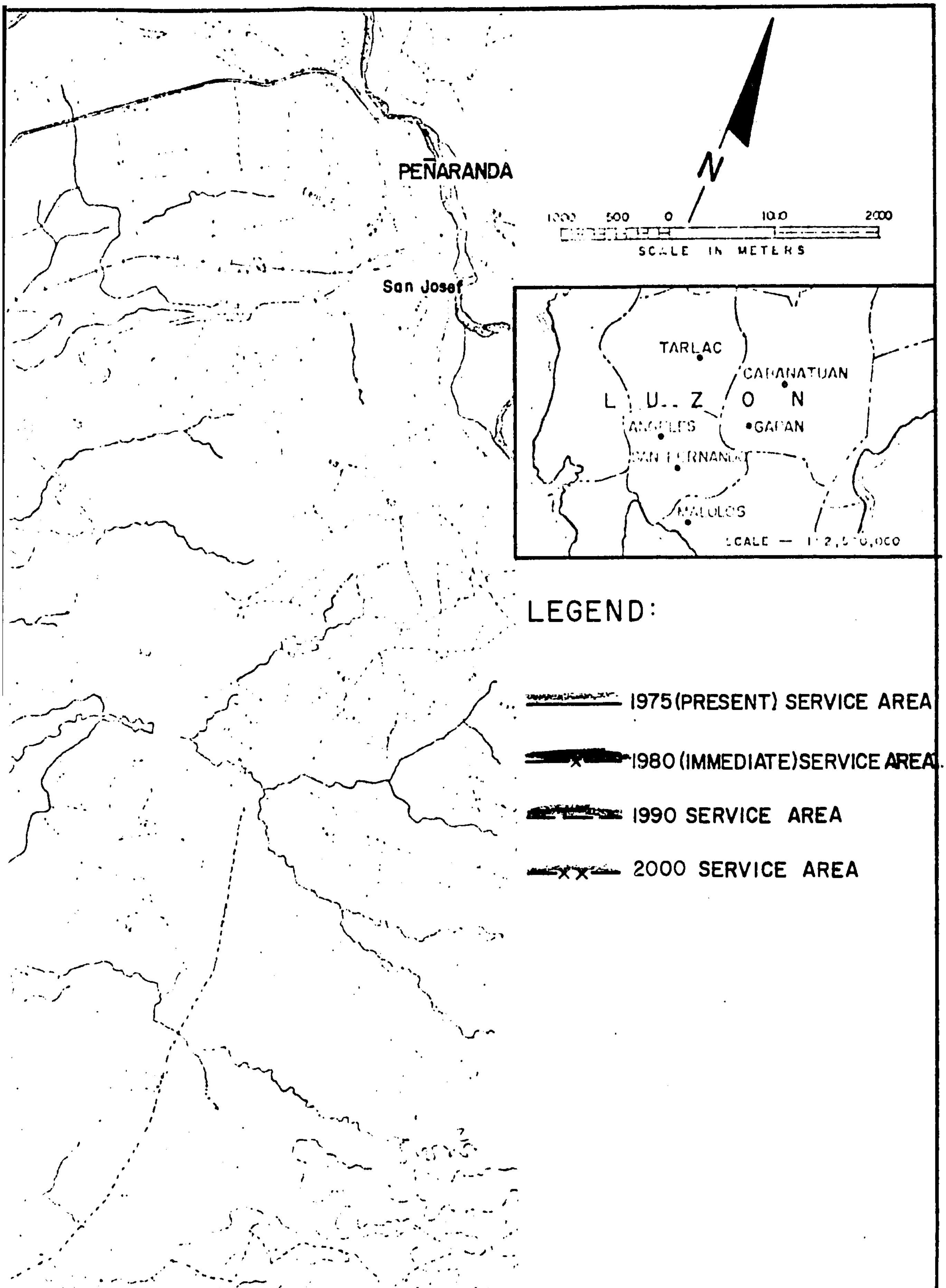


FIGURE VI-1
PRESENT AND FUTURE SERVICE AREA
GAPAN WATER DISTRICT

TABLE VI-1

SERVICE AREA POPULATION PROJECTIONS
GAPAN WATER DISTRICT

	Population 1975	Present Service Area			Immediate Service Area			1990 Service Area			2000 Service Area		
		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 persons/ha	Population in Service Area	Service Area (ha)	Density persons/ha
GAPAN:													
Poblacion	10,526	10,526	75	140	13,300	114	117	17,900	114	157	22,800	114	200
San Nicolas	7,109	7,109	57	125	9,000	84	108	13,450	112	120	19,550	132	148
Sto. Niño	3,836	3,836	28	137	4,800	40	120	6,450	40	161	8,100	40	202
Mangino	3,526	353	5	71	2,640	35	75	6,500	88	74	11,200	110	101
Pambuan	4,280	214	4	54	1,050	16	65	6,600	50	132	12,570	101	124
Bayanihan	871	-	-	-	540	12	46	1,600	68	24	2,760	128	22
Sto. Cristo Norte	2,266	-	-	-	-	-	-	3,780	55	69	6,160	100	62
Sto. Cristo Sur	2,160	-	-	-	-	-	-	-	-	-	5,400	108	50
Malimba	1,766	-	-	-	-	-	-	-	-	-	3,800	43	88
San Roque	3,327	-	-	-	-	-	-	-	-	-	7,600	55	138
Sta. Cruz	4,400	-	-	-	-	-	-	-	-	-	8,100	115	70
SAN ISIDRO:													
Poblacion	5,100	-	-	-	-	-	-	-	-	-	11,350	75	151
Malapit	4,800	-	-	-	-	-	-	7,550	84	90	11,900	118	101
Total	53,967	22,038	169	130	31,330	301	104	63,830	611	104	131,290	1,239	106

Year		Total Population*	Overall Annual Growth Rate (%)	Population In Service Area	Service Area (ha)	Average Density in Service Area (persons/ha)
1975	(Present)	53,967		22,038	169	130
1980	(Immediate)	66,200	4.17 (1975-1980)	31,330	301	104
1990		95,530	3.74 (1980-1990)	63,830	611	104
2000		133,940	3.44 (1990-2000)	131,290	1,239	105

*Includes Poblacion of San Isidro and Barrio Malapit.

The analysis shows that the population in the service area will increase from 22,038 in 1975 to 131,290 in the year 2000. The total population of the poblaciones of Gapan and San Isidro and other barrios will increase from 53,967 in 1975 to 133,940 in the year 2000 or about 2½ times more than the 1975 population within a span of 25 years. Densities in the service area will average between 104-130 persons per hectare. Overall annual growth rates in this area will decline from 4.17 percent in 1975-1980 to 3.44 percent in 1990-2000.

C. PROJECTIONS FOR SERVED POPULATION

Served populations in the GAP-WD have been projected to increase significantly in the next 2 decades. The increase will be a result of:

(1) The intense campaign of the GAP-WD to connect and reconnect as many customers as possible;
(2) The desire of residents in the GAP-WD to partake of the benefits of modern piped water system;
(3) The increase in population and in the geographical coverage of the GAP-WD.

Tables VI-2 and VI-3 show the detailed breakdown of the served population projections for the poblaciones of Gapan and San Isidro and the associated barrios. Figure VI-2 shows that served population in the year 2000 will increase 7 times more than the 1980 served population. The present service area will have faster growth in served population than the future service area extensions. Generally, the increase in the total served population would be greater in 1990-2000 than in 1980-1990. The served population projections are summarized as follows:

Year		Projected Served Population	Population in the Service Area	Percent Served
1975	(Present)	2,860	22,038	13
1980	(Immediate)	12,880	31,330	41
1990		38,300	63,830	60
2000		91,900	131,290	70

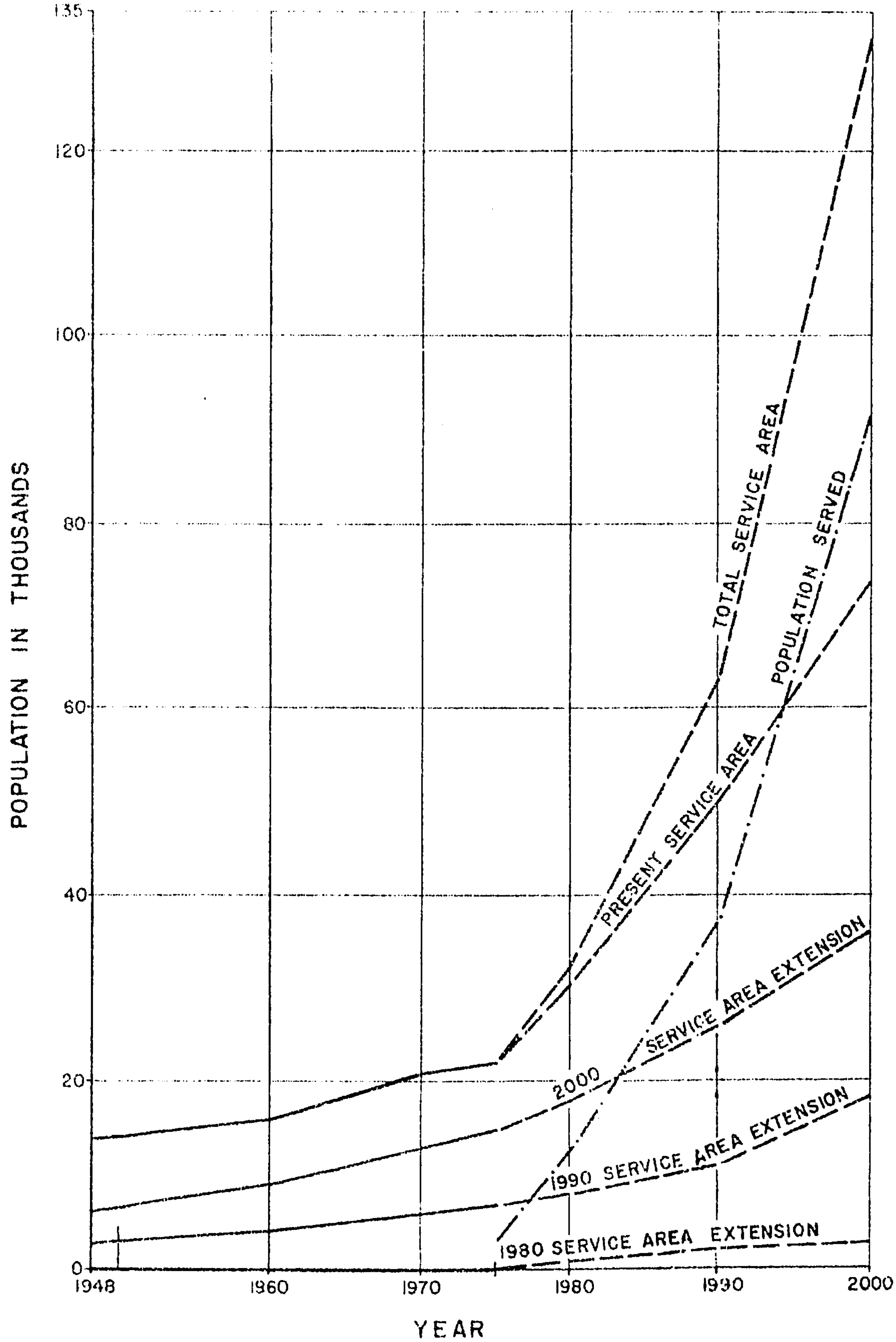


FIGURE VI-2
POPULATION PROJECTION
GAPAN WATER DISTRICT

TABLE VI-2

SERVED POPULATION PROJECTIONS
GAPAN WATER DISTRICT

	Present Service Area	1980 Immediate Service Area	1990 Service Area	2000 Service Ar
Poblacion-Gapan				
a. Population in Service Area	10,526	13,300	17,900	22,800
b. Number of Service Connections	399	950	1,900	3,220
c. Connected Population	2,595	6,650	11,400	19,300
d. % Connected	25%	50%	64%	85%
San Nicolas				
a. Population in Service Area	7,109	9,000	13,450	19,550
b. Number of Service Connections	8	420	1,400	2,300
c. Connected Population	51	2,940	8,400	13,800
d. % Connected	0.7%	33%	62%	71%
Sto. Niño				
a. Population in Service Area	3,836	4,800	6,450	8,100
b. Number of Service Connections	30	215	680	970
c. Connected Population	195	1,505	4,080	5,820
d. % Connected	5%	31%	63%	72%
Mangino				
a. Population in Service Area	353	2,640	6,500	11,200
b. Number of Service Connections	2	140	600	1,250
c. Connected Population	13	980	3,600	7,500
d. % Connected	4%	37%	55%	67%
Pambuan				
a. Population in Service Area	214	1,050	6,600	12,570
b. Number of Service Connections	1	45	630	1,430
c. Connected Population	6	315	3,800	8,580
d. % Connected	3%	30%	58%	68%
Bayanihan				
a. Population in Service Area	-	540	1,600	2,760
b. Number of Service Connections	-	70	250	450
c. Connected Population	-	490	1,500	2,700
d. % Connected	-	91%	94%	98%
Sto. Cristo Norte				
a. Population in Service Area	-	-	3,780	6,610
b. Number of Service Connections	-	-	220	670
c. Connected Population	-	-	1,320	4,020
d. % Connected	-	-	35%	65%

TABLE VI-2 (Continued)

	Present Service Area	1980 Immediate Service Area	1990 Service Area	2000 Service Area
VII. Sto. Cristo Sur				
a. Population in Service Area	-	-	-	5,400
b. Number of Service Connections	-	-	-	550
c. Connected Population	-	-	-	3,300
d. % Connected	-	-	-	61%
IX. Malimba				
a. Population in Service Area	-	-	-	3,800
b. Number of Service Connections	-	-	-	370
c. Connected Population	-	-	-	2,220
d. % Connected	-	-	-	58%
X. San Roque				
a. Population in Service Area	-	-	-	7,600
b. Number of Service Connections	-	-	-	800
c. Connected Population	-	-	-	4,800
d. % Connected	-	-	-	63%
XI. Sta. Cruz				
a. Population in Service Area	-	-	-	8,100
b. Number of Service Connections	-	-	-	750
c. Connected Population	-	-	-	4,500
d. % Connected	-	-	-	56%
XII. San Isidro Poblacion				
a. Population in Service Area	-	-	-	11,350
b. Number of Service Connections	-	-	-	1,160
c. Connected Population	-	-	-	6,960
d. % Connected	-	-	-	61%
XIII. Malapit				
a. Population in Service Area	-	-	7,550	11,900
b. Number of Service Connections	-	-	700	1,400
c. Connected Population	-	-	4,200	8,400
d. % Connected	-	-	56%	71%
Total Number of Connections	440	1,840	6,380	15,320
Total Population	22,038	31,330	63,830	131,290
Total Population Served	2,860*	12,880	38,300	91,900
Served Population (%)	13%	41%	60%	70%

---

*The figure of 6.5 persons per household was used for the present service area based on the 1975 census data. However, for 1980, the figure of 7 persons per household was used to conform with the pilot area figures.

D. WATER DEMAND PROJECTIONS

The water demand of the GAP-WD has been projected to increase significantly as a result of continuous growth in served population.

Per capita domestic water 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 (see Methodology Memorandum No. 3), GAP-WD has been classified under Group IV which has the following water use parameters:

	1980	1990	2000
Domestic use, lpcd	95	110	125
Commercial/Industrial/Institutional, lpcd	12	15	20
Accounted-for-water, lpcd	107	125	145
% Unaccounted-for-water	(40)	(28)	(20)
Unaccounted-for-water, lpcd	71	49	36
Total Water Demand, lpcd	178	174	181

Using the above water demand parameters and the projected served populations, 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	178	174	181
Served population	12,880	38,300	91,900
Average daily water demand, cumd	2,290	6,660	16,630
Maximum-day water demand[1/], cumd	2,750	7,990	19,960
Peak-hour water demand[2/], cumd	4,010	11,660	29,110

The unaccounted-for-water will diminish from 56 percent of present total water demand to 40 percent of the total water demand in 1980 with the implementation of the immediate improvement program. The factors that will contribute to the decrease in unaccounted-for-water are: (1) the extensive leak detection program; (2) system repair campaign; and (3) metering of all service connections.

[1/] Based on 1.2 times average daily water demand.

[2/] Based on 1.75 times average daily water demand.

TABLE VI-3

YEAR-BY-YEAR PROJECTIONS OF SERVED POPULATION AND WATER DEMAND
GAPAN WATER DISTRICT

Year	Served Population	Average-Day Demand, cumd	Maximum-Day Demand, cumd	Peak-Hour Demand, cumd
1978	7,950	1,385	1,660	2,425
1979	10,415	1,835	2,200	3,210
1980	12,880	2,290	2,750	4,010
1981	14,360	2,550	3,060	4,460
1982	16,020	2,840	3,410	4,970
1983	17,860	3,160	3,790	5,530
1984	19,920	3,510	4,220	6,150
1985	22,210	3,910	4,690	6,840
1986	24,770	4,350	5,220	7,610
1987	27,620	4,840	5,810	8,470
1988	30,800	5,380	6,460	9,420
1989	34,350	5,990	7,190	10,480
1990	38,300	6,660	7,990	11,660
1991	41,800	7,300	8,760	12,780
1992	45,630	8,000	9,600	14,010
1993	49,800	8,770	10,520	15,350
1994	54,360	9,610	11,530	16,820
1995	59,330	10,530	12,640	18,430
1996	64,750	11,540	13,850	20,190
1997	70,680	12,640	15,170	22,130
1998	77,140	13,860	16,630	24,250
1999	84,200	15,180	18,220	26,570
2000	91,900	16,630	19,960	29,110

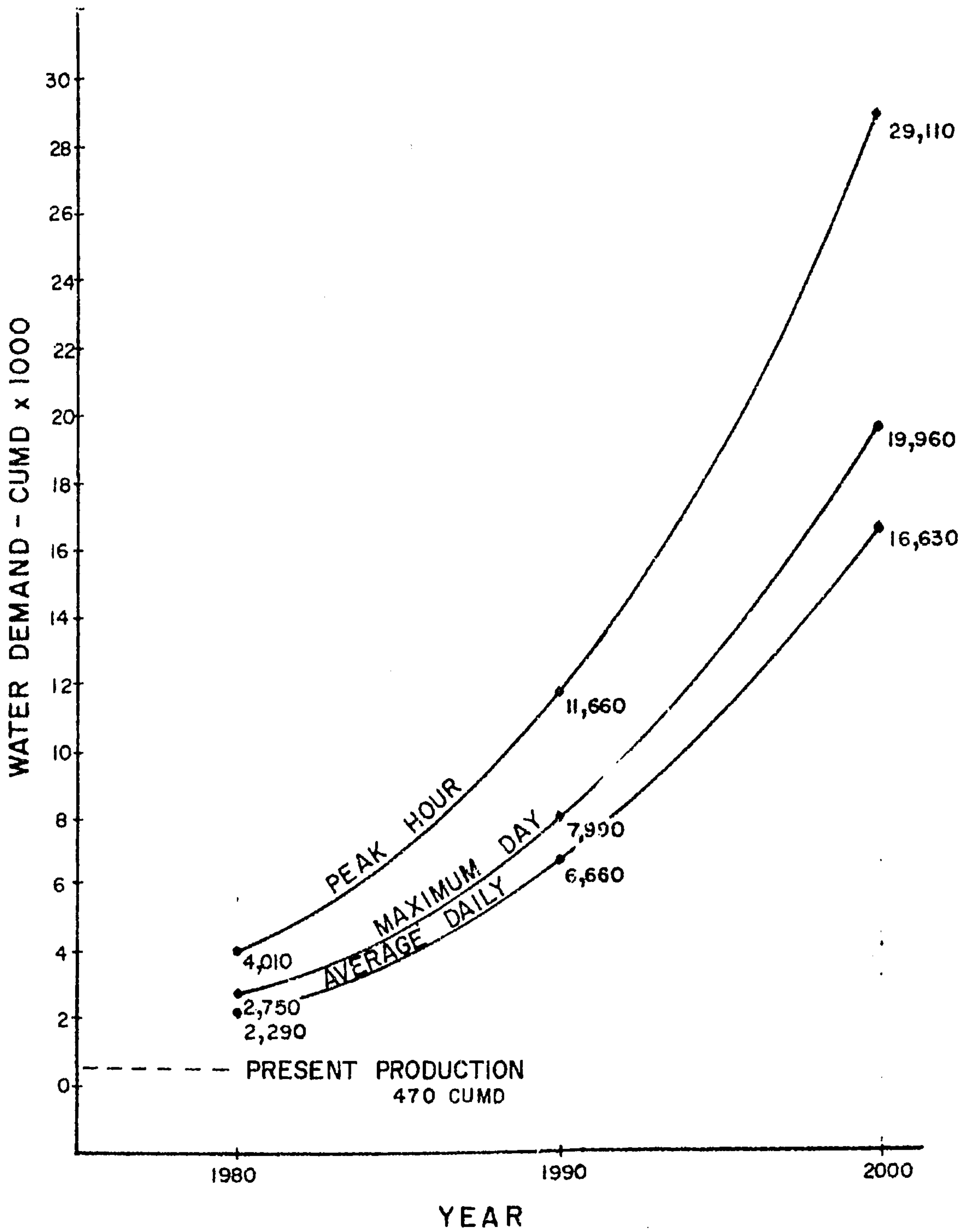


FIGURE VI-3
PROJECTED WATER DEMAND
GAPAN WATER DISTRICT

CHAPTER VII WATER RESOURCES

A. GENERAL

The Gapan Water District currently obtains all of its water supply from one old well of small capacity. The possible sources of water for municipal supply are groundwater and surface water from the Pampanga and Peñaranda Rivers. Water rights to the chosen source must be obtained from the National Water Resources Council (NWRC) in order to protect the GAP-WD from encroachment by other private or government water consumers in the region.

B. GROUNDWATER RESOURCES

GAP-WD is located in the eastern part of the Central Plain of Luzon and the entire present service area lies within the Central Plain, a very productive groundwater region. The service area projected for the year 2000 approaches and may overlap the less productive older rocks that border the Central Plain. Wells near Gapan are in almost all cases used for city, private and industrial water supply but are not currently in use for large-scale irrigation. Most of the wells in the immediate vicinity of the GAP-WD considered for this study are shown in Figure VII-1. Numerous additional distant wells are studied for regional analysis. Relevant information on wells is shown in Annex Table VII-B-1. The critical factor in groundwater exploitation is control to avoid overproduction, rather than the technical problems of production.

Geology

The Central Plain of Luzon is the physiographic expression of a large structural trough separating the Zambales Mountains to the west from Sierra Madres to the east and the Caraballo Mountains to the north. This trough was depressed below sea level repeatedly during Tertiary and Early Quaternary times. The trough was last filled to its present extent with material washed down from the mountain slopes and deposited in the form of fan and deltaic deposits and, later, flood plain deposits. The deepest well in the Gapan area is over 400 meters deep and may penetrate through a thin wedge of the Recent alluvium into the older sediments. However, the underlying rocks best can be inferred from exposures of older rocks in the hills and mountains that lie to the east.

The basement complex exposed in the Sierra Madres consists of basic igneous and metamorphic rocks probably of Cretaceous to Early Tertiary Age. Overlying the basement are tuffaceous clastic sedimentary rocks (shales, siltstones, sandstones, conglomerates) of

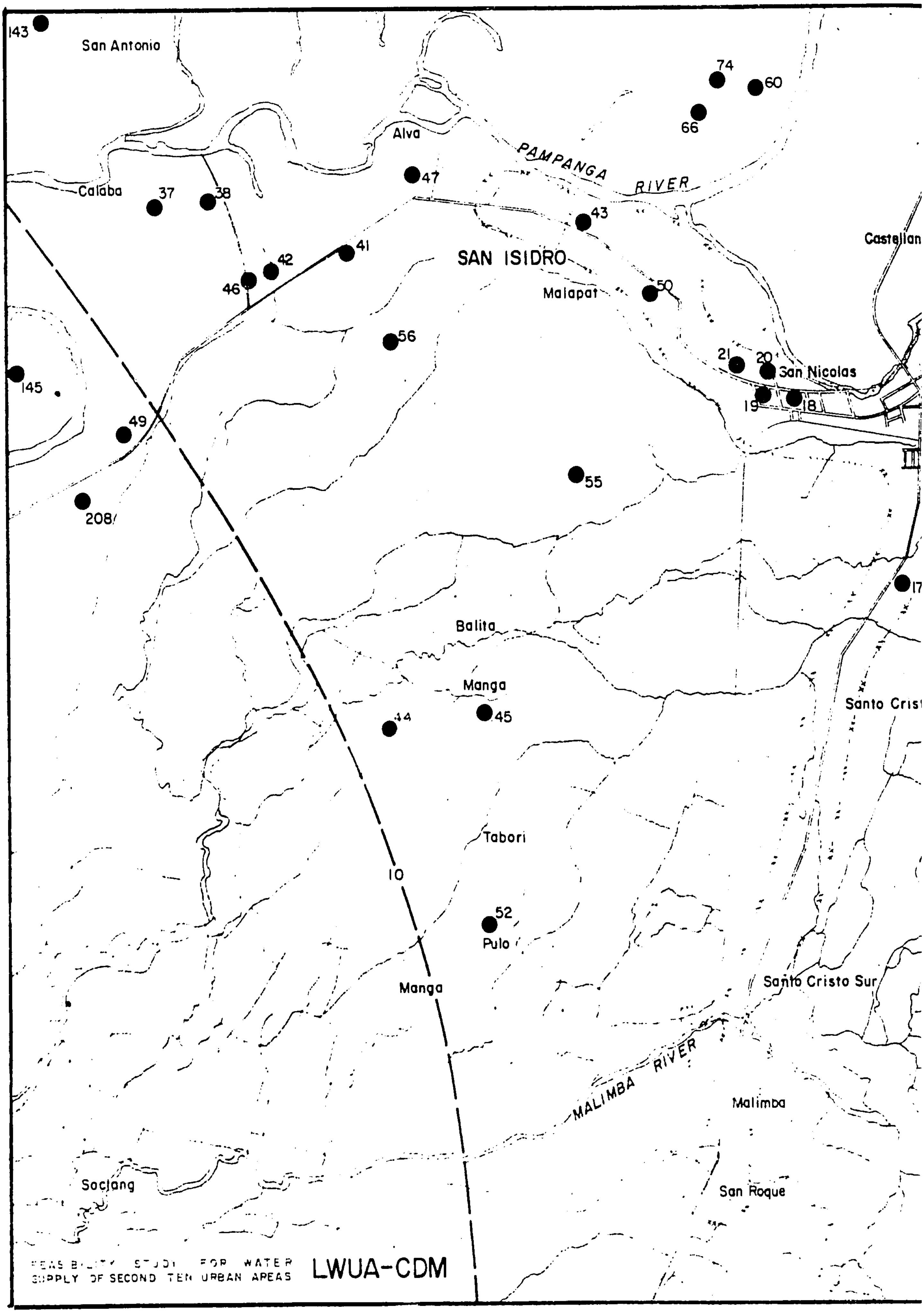
Middle to Late Tertiary Age. Limestones are observed locally. The Tertiary sediments in part are overlain by the Quaternary Guadalupe tuff, composed of waterlain, angular volcanic debris, as well as other marine and terrestial sediments. These sediments in turn, are overlain by the alluvium that fills the depressed plain.

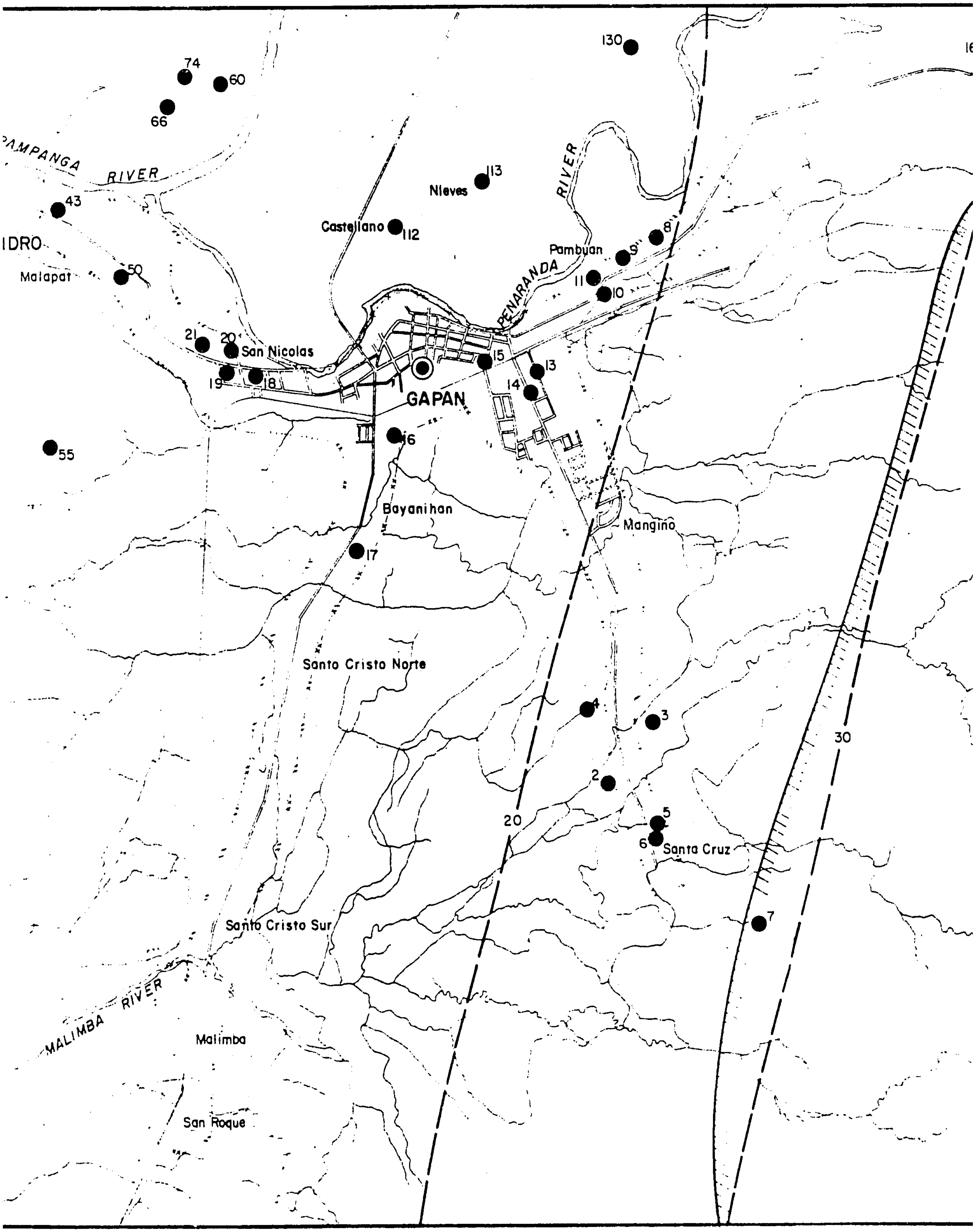
The Recent alluvium is an intricately interbedded sequence of clays, sands and gravels with a small amount of local cementation, probably a mixture of fan, stream, delta and beach deposits. Most of the beds are relatively thin and each bed is of limited extent. The original complex pattern of deposition and reworking has resulted in a maze of fingers and lenses of sands and gravels that are difficult to trace and predict. Annex Figures VII-B-1 through VII-B-9 are stratigraphic logs of wells in the area that illustrate the situation. Many of the major units logged are groups of thin beds lumped under the name of the major constituent, such as "clay with some gravel" or even just "clay" and do not reflect the true complexity of the stratigraphy. The Recent alluvium is more than 200 meters thick in the deep wells in the Gapan area and thins to zero thickness on the gentle hill flanks a short distance to the east. Occasional beds of adobe (tuff) and limestone are encountered in some wells as would be expected in a depositional environment at the edge of volcanic islands. In the Gapan area, most of the alluvial sediments are derived, recently or remotely, from volcanics although this is not specified in the available logs.

Gapan poblacion is situated about 5 km west of the contact between the Recent alluvium and the slightly older (earlier Quaternary?) sediments that form low hills between the Central Luzon Plain and the mountains. These older sediments are similar in general appearance to the Recent alluvium and are difficult to delineate in well logs. On the ground, the heavily mantled contact shows only as a very slight break in topographic slope. These older sediments are less permeable than the Recent alluvium and may produce saline water from wells in places where cognate salt water has not been flushed out of the less permeable rocks or where interstitial water in the older rocks has dissolved considerable mineral salts.

Existing Wells

Wells in the Gapan area range from shallow, hand-dug wells to bored holes over 400 meters deep. Tables VII-1, VII-2 and Annex Table VII-B-1 are summaries of pertinent records of 210 BPW wells and three NIA test wells for which logs, static water levels and pumping data are available. These wells were studied to evaluate the aquifer and to derive production well parameters.


143
San Antonio
74
60
66
Alva
PAMPANGA RIVER
47
Calaba
37
38
43
Castellan
41
SAN ISIDRO
42
46
Malapat
50
56
21
20
San Nicolas
145
19
18
49
55
208
17
Balita
Manga
44
45
Santo Cris
Tabori
10
52
Pulo
Santo Cristo Sur
Manga
MALIMBA RIVER
Malimba
Socjang
San Roque
FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS
LWUA-CDM



130
16
74
60
66
PAMPANGA RIVER
113
Nieves
RIVER
43
Castellano
112
IDRO
8
Pambuan
9
PENARANDA
50
Malapat
11
10
21
20
San Nicolas
15
13
19
18
14
GAPAN
55
16
Bayanihan
Mangino
17
Santo Cristo Norte
4
3
30
2
20
5
6
Santa Cruz
7
Santo Cristo Sur
MALIMBA RIVER
Malimba
San Roque

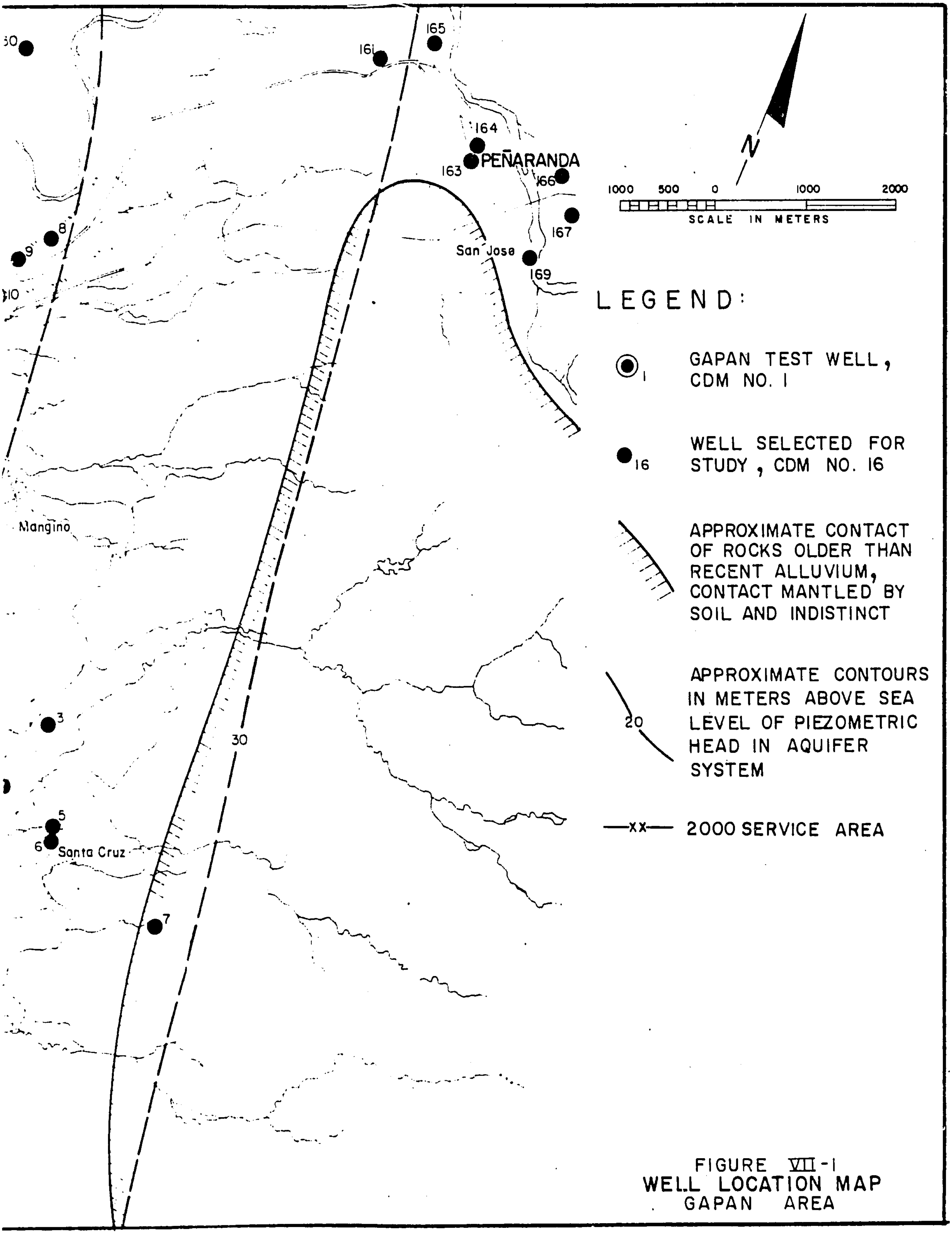


FIGURE VII-1
WELL LOCATION MAP
GAPAN AREA

TABLE VII-1

SPECIFIC CAPACITY VERSUS DEPTH

Depth Range (m)	Number of Wells in Sample	Average Specific Capacity (lps/m)	Maximum Specific Capacity (lps/m)	Minimum Specific Capacity (lps/m)
10-20	15	1.0	2.1	0.1
20-30	56	1.3	9.5	0.1
30-40	49	0.8	4.2	0.02
40-50	14	0.8	5.3	0.03
50-60	7	0.4	1.2	0.2
60-70	9	0.5	1.6	0.1
70-80	4	0.4	0.8	0.1
80-90	4	0.7	1.6	0.2
90-100	7	0.8	1.4	0.1
100-150	7	0.3	0.8	0.1
150-200	4	0.4	1.4	0.01
200-250	1	0.5	0.5	0.5
	176			

TABLE VII-2

SPECIFIC CAPACITY VERSUS CASING DIAMETER

Smallest Casing Diameter (mm)	Number of Wells in Sample	Average Specific Capacity (lps/m)	Maximum Specific Capacity (lps/m)	Minimum Specific Capacity (lps/m)
100	106	0.8	9.5	0.03
112	18	0.6	2.1	0.03
150	49	0.9	5.3	0.01
200	3	0.3	0.7	0.1
	176			

The BPW wells ranged from 12 to 240 meters deep, were cased with 100 to 200 mm casing, were constructed by percussion drilling methods, and produce from either open-holes or slotted pipe at the bottom of the hole. The section tapped is generally not the only, or even the best, water-producing formation. These wells are of poor construction and design and of low yield and low specific capacity.

Data from a large number of BPW wells are tabulated in Tables VII-1 and VII-2 to show the relationships between specific capacity (rate of water production per meter of drawdown) and construction parameters of depth and casing size. It is noted that there is little statistically significant variation in specific capacity with well depth or casing diameter. Wells of 200 mm diameter are unusually poor but here the sample is small. Wells between 10-m and 30-m depth are generally better than deeper wells but the difference is minor and all of the average specific capacities are poor.

The implication of these data is that the specific capacity, loosely the productivity at a reasonable pumping level, is independent of the depth and diameter of the well (except as noted above); and furthermore that the productivity of almost all these wells is very low. This is a result of the poor design where only the bottom of the hole is productive, regardless of depth. It is assumed that wells between 10-m and 20-m depth are located in areas of known good aquifer and consequently have slightly better specific capacities.

Without other data, this almost uniformly poor performance could be taken to indicate a poor aquifer in the area. However, poor performance of most existing water supply wells in the Central Luzon Plain is expected because of poor well design and construction practices.

A few isolated wells have much better specific capacities than average as can be seen from the above tables, although it is believed that even those wells with specific capacities of over 4 lps/m (implying transmissivities of over 480 cumd/m) do not represent the full potential of the aquifer because of partial penetration effects. Thus the well data, taken in conjunction with the experiences in other areas of NIA and others using superior well construction methods, indicate the possiblity of a good aquifer capable of supporting wells with minimum specific capacities of about 4 lps/m throughout most of the GAP-WD area (except the eastern portion).

In many places where other wells are no better than those shown here, the NIA and few qualified commercial drillers have been constructing excellent, large-capacity wells. This is not true in the Gapan area because the only NIA wells were located poorly, either beyond or in the fringe area of the good aquifer.

Three wells were drilled by NIA in 1971 about 5 km southeast of the poblacion. They were located in an area where surface water irrigation is inconvenient and groundwater irrigation would be desirable. The history of these wells follows:

1) NIA P1 was drilled to 155.2-m depth and abandoned without test because no productive aquifer was encountered.

2) NIA P2 was drilled to 401-m depth and screen was set from 300 meters to 327 meters in clayey gravel. The well was free flowing (static water level 1.8 m above ground surface) at 0.4 lps. An 8-hour pump test was run at 4.0 lps giving a poor specific capacity of 0.2 lps/m. The water was very saline; an analysis is given in Table VII-4. The well is still flowing freely and the water damages the local rice crop if it is allowed to inundate it.

3) NIA P3 was drilled to 242-m depth, then backfilled to 28 meters because no production aquifer was discovered in the lower hole. Screen was set from 11.8 meters to 15.8 meters and from 21.25 meters to 24.65 meters in gravel. A five-hour pump test was run at 7.4 lps giving a poor specific capacity of 0.4 lps/m and a low transmissivity of 43.5 cumd/m. The water quality is excellent at the shallow production depth for either agricultural or domestic use; an analysis is given in Table VII-4.

The three NIA test wells are drilled close to the geologic contact between the surface exposures of the Recent alluvium of the Central Luzon Plain and the similar but less permeable rocks of the older formations of the hills to the east. This contact is very indefinite and not readily recognized, showing as only a very slight change in topographic slope. The very poor performance of the NIA wells is believed to result either from drilling into these older sediments or from drilling into a clayey zone at the base (or edge) of the Recent alluvial aquifer where it rests on the older sediments. The very poor quality water from well NIA P2 is believed to result from cognate saline water which has never been flushed from the relatively impermeable section because groundwater flow is so slow, or from a long period of slow solution of minerals from the older sediments by relatively immobile groundwater. Thus, the aquifer tested by NIA wells is not typical of Recent alluvial aquifer of the Central Luzon Plain farther west of the contact with the older sediments. These wells show that less productive wells can be expected east of Gapan poblacion.

Test Well

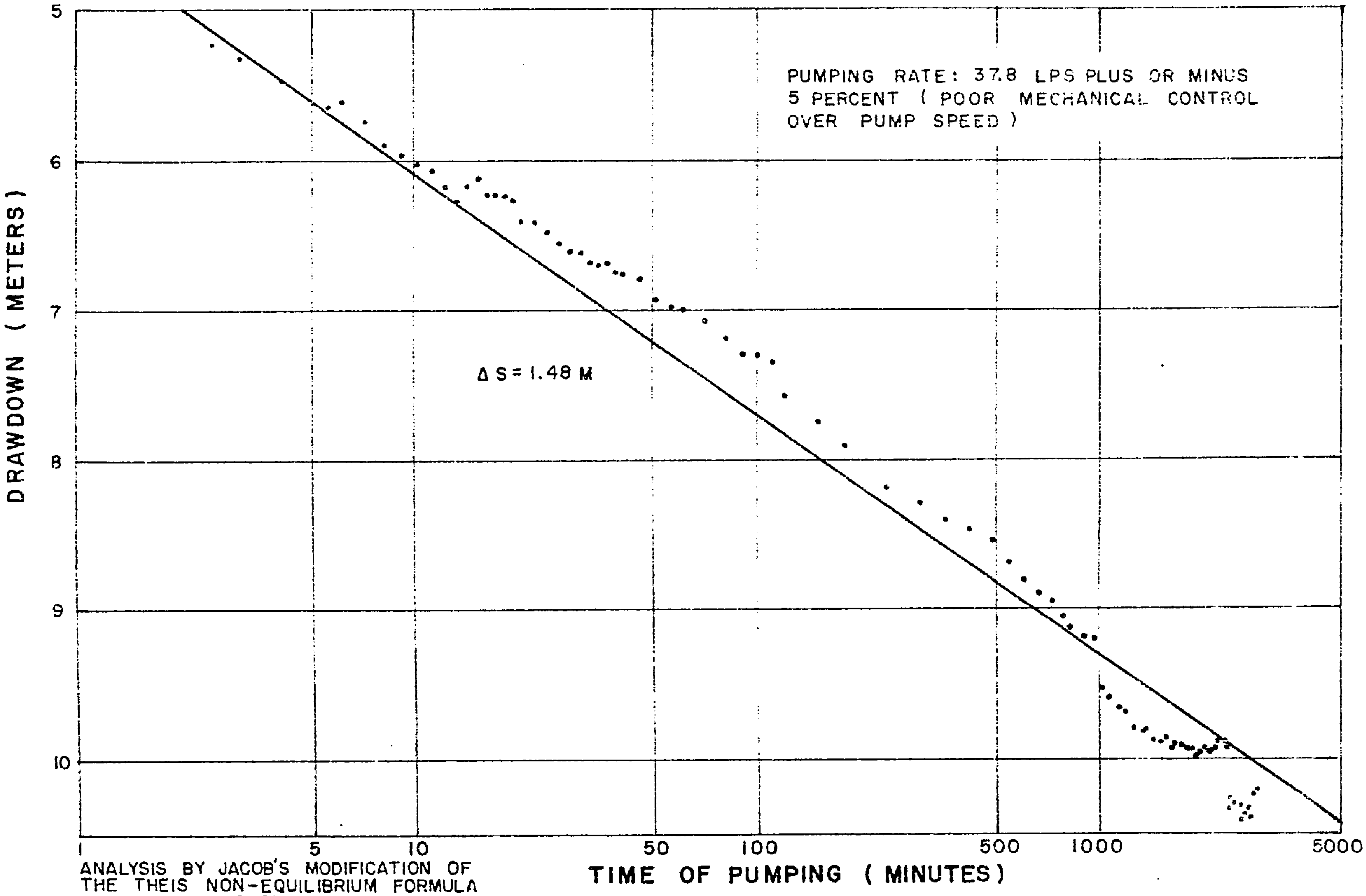
In order to properly evaluate the use of wells for GAP-WD supply, it was necessary to construct a test well. The BPW well records did not provide sufficient definitive data on aquifer characteristics in the Gapan area and the NIA test wells defined an unproductive aquifer containing very saline water at 300-m depth only 5 km from the poblacion. The test well in Gapan was required to determine if production wells could be drilled, to define aquifer parameters, and to sample water underlying the poblacion at depth.

A site was provided by the municipality of Gapan in Freedom Park and the test well was drilled by the rotary method by Katwell, Inc., starting 22 November 1976 and completing test and final cleanup 26 March 1977. Specifications were similar to those in Appendix I, Volume II.

A pilot hole was drilled to 200-m depth. A stratigraphic log was prepared from samples collected during drilling and self-potential and resistivity electric logs were run in the pilot hole. The most permeable zones were delineated using the electric logs supplemented by the sample data. The pilot hole was enlarged to 500-mm diameter to a depth of 190 meters and 250-mm casing was installed with 66.5 meters of slotted casing opposite the selected permeable zones. The well was cleaned and developed by bailing, surging (with a detergent added) and pumping, and a 48-hour pumping test was run. Annex Figures VIII-B-9 and VII-B-10 show the stratigraphic log and the electric logs. Annex Figures VII-B-11 and VII-B-12 are photographs of drilling operation.

A gamma ray log was run for correlation purposes after the hole was cased because the equipment did not arrive in time to use it earlier. However, that log, also shown in Annex Figure VII-B-10, is anomalous and does not clearly separate clayey zones from other rocks undoubtedly because the parent volcanic rocks from which some of the sediments are derived are slightly radioactive. This problem has been noted elsewhere in the volcanic provinces of the Philippines and indicates that gamma ray logs must be interpreted with great caution.

The pumping test was run for 48 hours at an average discharge rate of 37.8 lpm. Annex Table VII-B-2 lists the test data. The pump discharge was difficult to control with the available equipment making the drawdown data somewhat erratic. Figure VII-2 shows an analysis of the drawdown data according to the Jacob's modification of their non-equilibrium formula. The scattering of data indicates that the pumping rate fluctuated about 5 percent above and below the average rate. The indicated transmissivity is about 404 cumd/m. Figure VII-3 is a similar plot and analysis of the recovery data immediately following the pumping period. The recovery analysis shows a



ANALYSIS BY JACOB'S MODIFICATION OF THE THEIS NON-EQUILIBRIUM FORMULA

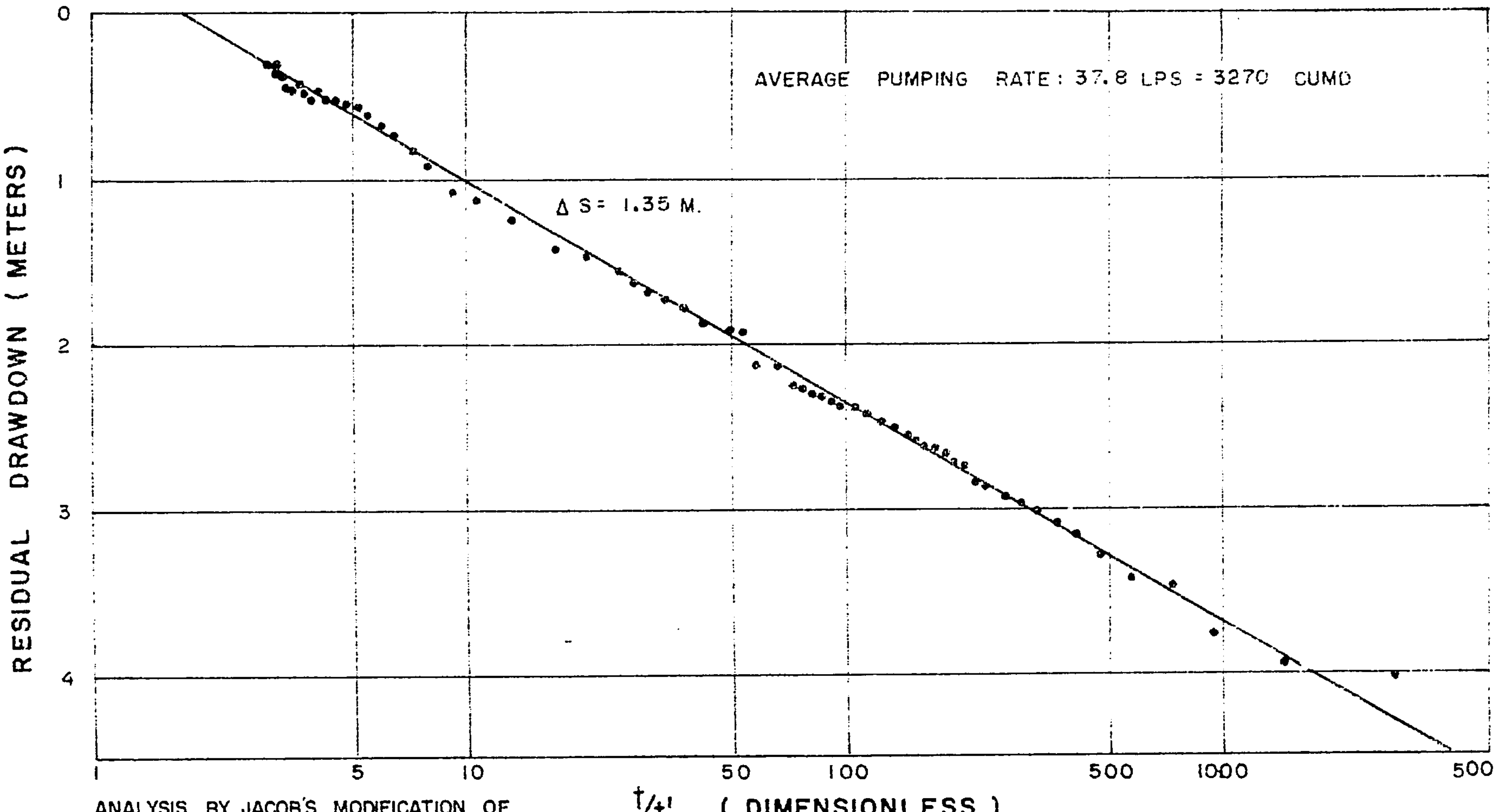
$T = \frac{0.183\ Q}{\Delta S}$

Q = 3270 CUMD/M (37.8 LPS)

Δ S = 1.48 M

T = 404 CUMD/M

FIGURE VII-2
DRAWDOWN DATA ANALYSIS
GAPAN TEST WELL



ANALYSIS BY JACOB'S MODIFICATION OF THE THEIS NON-EQUILIBRIUM FORMULA

$$T = \frac{0.183\,Q}{\Delta S}$$

Q = 3270 CUMD
Δ S = 1.35 M
T = 443 CUMD/M

NOTE :
t = TIME SINCE PUMPING STARTED
t' = TIME SINCE PUMPING STOPPED

FIGURE VII-3
RECOVERY DATA ANALYSIS
GAPAN TEST WELL

transmissivity of about 443 cumd/m which is believed to be more reliable than the drawdown analysis. The specific capacity of the well after 48 hours of pumping was 3.7 lps/m, which is closely compatible with the transmissivity figure of 443 cumd/m indicating an efficient well with low losses. A step-drawdown test to separately determine well efficiency was attempted but the pumping equipment was operating too erratically to provide meaningful data.

The stratigraphic log, Annex Figure VII-B-9, indicates a section largely of sand and gravel with some clay; however, clay is often missed in rotary-drilling samples and the electric logs, Annex Figure VII-B-10, indicates that many of the sands shown to be clay-free in the stratigraphic log are actually clayey. A section with somewhat more clay than shown in the stratigraphic log also is compatible with the transmissivity and specific capacity shown by the pumping test. The clayey section at the bottom of the well may be a zone within the aquifer or may represent the base of the permeable Recent alluvial aquifer. If the permeable aquifer continued to greater depth, overall aquifer transmissivity will be greater than 443 cumd/m, thus 500 cumd/m is used herein as a conservative estimate to compute overall aquifer response.

Aquifer

The Central Luzon Plain is filled with Recent alluvium that forms a very productive aquifer almost everywhere it exists. The maximum thickness of this aquifer is unknown but it appears to encompass most of the alluvium which is at least several hundred meters thick locally and is assumed to be much thicker. This artesian aquifer system may inclnde some older underlying beds at depth and may be contiguous with the aquifer system in the surrounding hills. The aquifer consists of lenses of water-bearing material ranging from fine sands to gravels deposited in complex and random patterns and confined by equally complex clay lenses.

Within the projected service area of the GAP-WD, the aquifer is very thin to the east where it feathers out against the older sediments, and thickens to several hundred meters or more to the west. Consequently, aquifer transmissivity will increase toward the west. The well logs indicate clay at the surface in essentially all cases, which inhibits direct recharge in the Gapan vicinity. Recharge to this aquifer is through infiltration from direct precipitation and from streams into the exposed permeable beds along the edge of the foothills east of Gapan. Initially the recharge water is underwater-table conditions but becomes confined upon moving below the clay beds as shown by free-flowing wells in the Gapan area.

Additional recharge may reach the Recent alluvium from infiltration of precipitation in the mountains and foothills to the east through transfer from older permeable beds where the alluvium abuts these beds along the buried edge of the hills. Although the sands and gravels of the Pampanga and Peñaranda River channels probably extend through the surface clays, the shape of the contours of the piezometric surface, Figure VII-1, and the relative elevations of this surface and river levels indicate that little or no recharge currently comes from the rivers near Gapan, except (perhaps) at high flood stage. In fact, groundwater discharge into the rivers may occur at low stages.

The aquifer is anisotropic and will act as a semi-confined aquifer in that early response to pumping will be in the artesian aquifer range, but if the piezometric head falls below the surface clay zone response will be in the unconfined (water table) aquifer range. The spreading of the piezometric surface contours (Figure VII-4) near Gapan indicates a general area of increased aquifer transmissivity to the west, as would be expected where the aquifer thickens in this direction. Overall transmissivity at the poblacion is estimated to be about 500 cumd becoming much less to the east as the aquifer thins and much more to the west as the aquifer thickens into the center of the basin. The long-term storage coefficient will be variable depending on depth of aquifer dewatered and the contained clays in the dewatered zone.

Groundwater Flow, Recharge and Discharge Relationships

Before large-scale artificial withdrawal of water (pumping from large-capacity wells), the local and regional groundwater balance is in a state of dynamic equilibrium. In the Gapan area, there is little local recharge because of the widespread surface clays and the near-surface piezometric levels. There is also little natural discharge, perhaps with some groundwater discharging into the Pampanga and Peñaranda River systems where groundwater piezometric levels are above river levels. Thus the existing system is essentially one of groundwater underflow entering the Gapan area from recharge sources in the northeast and east and leaving the area to the southwest. The contour map of the groundwater piezometric surface of the Gapan area (Figure VII-4) illustrates this condition, showing the regional situation with the source of the groundwater underflow to the northeast and east of Gapan and the ultimate discharge of the groundwater underflow to Manila Bay southwest of Gapan. However, the goundwater gradient becomes so flat in the middle of the Central Luzon Plain that all of the groundwater flowing from the east, north and west cannot be flowing into Manila Bay.

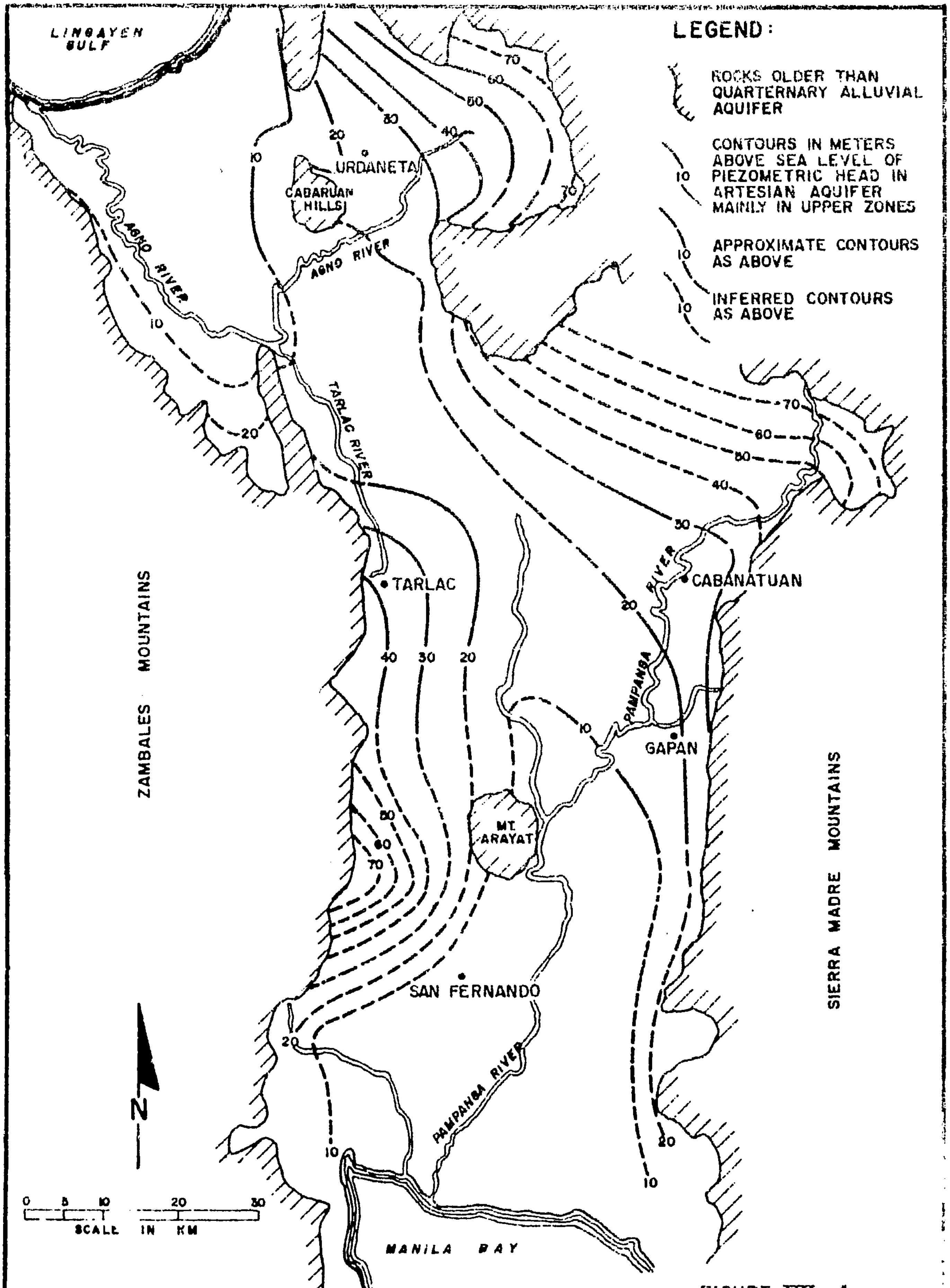


FIGURE VII - 4
GROUNDWATER CONTOURS
CENTRAL LUZON PLAIN

FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS

LWUA-CDM

Much, if not most, of the groundwater underflow into the Pampanga River basin must rise to the surface in seeps into the swamps and streams of the southern Central Plain where the artesian head is above the ground surface. All of this water is lost by non-beneficial evapotranspiration and surface runoff into the Bay. The piezometric levels shown are generally characteristic of the upper part of the aquifer and higher levels may exist in the lower part of the aquifer in some areas.

All well water produced must come from one or more of a limited number of sources; groundwater storage, increased recharge, or diverted groundwater discharge. The natural state is normally one of equilibrium with total recharge equal to total discharge and stable groundwater storage. When a well first begins to operate, all the pumped water comes from local groundwater storage (immediately surrounding the well) as a result of the decreased pressure in the well caused by pumping. This zone of decreased pressure (or lowered piezometric head) spreads radially from the well as stored groundwater flows from the aquifer to the well, and it continues to spread until the area of depressed piezometric levels causes either an increase in recharge (local or distant) or a decrease in pre-established groundwater discharge (local or distant) equal to the pumping rate of the well. When this occurs, a new equilibrium will be established with no further depletion of groundwater storage. If the increased recharge or diverted discharge (or combination thereof) is local, equilibrium will be quickly established with minimal lowering of the areal piezometric surface. However, if the recharge or diverted discharge is distant, equilibrium will be delayed resulting in a widespread and large depression in groundwater levels. If no sources of increased recharge or diverted discharge large enough to equal the pumped withdrawal rate can be tapped, then the groundwater levels will continue to drop until the well becomes inoperative or the aquifer is depleted.

In the case of Gapan, there are a number of prospective sources of additional recharge. The Pampanga River (and other local streams to a lesser extent) probably will contribute considerable recharge once the piezometric levels in the aquifer are depressed below stream level. At the same time, an appreciable amount of the generally clayey surface beds. These local effects will begin fairly soon after large scale pumping begins and will increase with time as the area of depressed groundwater levels (cone of depression) spreads. Also, the major existing source of recharge to the Gapan area is in the hills to the east and additional recharge from this source probably will begin when the depressed groundwater reaches this source and reduces the existing groundwater flow into surface runoff channels. Another, and more significant contribution to the water to be pumped at Gapan will be the reduction of existing natural groundwater discharge which is now flowing to surface seeps in the Central Plain and to underground flow into Manila Bay. This will occur as a result as the expanding and deepening cone of depression (resulting from pumping) diverts groundwater underflow (now escaping to the west) to the wells to be installed in Gapan.

Current recharge to the aquifer is largely restricted to the edges of the aquifer where infiltration and transfer from surrounding areas can occur,as has been previously noted. Neither current recharge nor future additional recharge induced by pumping can be quantified with existing data, but groundwater underflow can be estimated. Groundwater flow is to the southwest at a gradient of about 0.002 in the poblacion area. The average overall transmissivity of the aquifer in this area is estimated at 500 cumd/m. According to Darcy's Law of flow:

Q/km (of aquifer width) = T x G x 1000 m/km

where:

Q = Groundwater underflow (cumd)

T = Aquifer transmissivity (cumd/m)

G = Gradient of the piezometric surface

or:

Q/km = 500 cumd/m x 0.002 x 1000 m/km = 1000 cumd/km.

The underflow of groundwater can be used to roughly determine the groundwater available for exploitation. The GAP-WD average daily demand is projected to be 6,660 cumd in 1990 and 16,630 cumd in 2000. To obtain all this water from underflow would require diverting and capturing all the underflow in a band about 6.7 km wide by the year 1990 and 17 km wide by the year 2000. Much less than this computed amount of underflow would have to be captured because induced additional recharge, as noted previously, would supply much of the water to be pumped. Although projecting accurate pumping levels would require producing a model based on more data than available, it is apparent that diverted groundwater underflow and induced additional local recharge would provide for Gapan's requirements beyond the year 2000 without a prohibitive decline in pumping and groundwater levels. However, this is true only if Gapan is the major large-scale user of groundwater in the locality that surrounds it.

Unfortunately, there are several other fairly large towns within 10 km of Gapan and if they grow at the same rate and ultimately consume the same per capita water quantities as Gapan, the total domestic water requirements will be several times that projected for Gapan. Groundwater will undoubtedly be used to meet these requirements.

In addition, the area is short of irrigation water and, considering the fairly good underlying aquifer, large-scale groundwater irrigation will undoubtedly be introduced. Assuming that one meter net of irrigation water will be required to supplement rainfall, an annual average of about 2,700 cumd of irrigation water would be required per 100 hectares (one square kilometer) of irrigated land. Thus, 615 hectares of groundwater-irrigated land would consume the equivalent of GAP-WD total requirement in the year 2000. Considering that there are tens of thousands of hectares of irrigable land plus numerous water-demanding towns in the Gapan area, total water demand by the year 2000 could greatly exceed the sum of groundwater underflow and probable potential induced recharge. With available data, it is not possible to predict groundwater levels at various future dates with any certainty; but, as more data on aquifer characteristics and response becomes available, predictions should be made based on model studies. One favorable factor is that as groundwater piezometric levels drop below the clayey surface beds, the storage coefficient of the aquifer will increase greatly and more groundwater will be available from storage thus slowing the drop in groundwater levels.

The implications are that the GAP-WD must obtain firm water rights to its long-range requirements from the NWRC and introduce a groundwater monitoring and study program for planning purposes. It is fortunately true that agriculturists cannot afford to pay as much for water as municipalities and if groundwater is depleted to an extreme degree, groundwater irrigation will be curtailed by economic factors leaving the municipal water systems still viable (but with increased production costs).

<u>Well Design and Drilling Programs</u>

A general design for an efficient production well for Gapan can be developed from available data. Such design is illustrated in Annex Figure VII-B-13. For greatest efficiency, to avoid excessive drawdown, and to minimize operating costs, these wells should be drilled to the same standards as the recent NIA wells, that is: rotary-drilled with careful mud control, carefully sampled, electric logged, screened with continuous wire-wound screen, gravel packed, thorougly developed, and tested to determine efficient pump parameters. For the same reasons, all stratigraphic zones down to a depth of 200 to 300 meters that are indicated as productive by the electric and stratigraphic logs should be screened, because in an anisotropic aquifer such as this, the specific capacity will increase greatly as the screened percentage of total permeable section increases. However, caution as to depth drilled must be observed. At the test well site in the poblacion, a clay section at the bottom (190 to 200 meters) may represent the base of the coarse alluvial aquifer, and wells there should be restricted to 200-meter depth unless a deeper test is first conducted. To the east at Barrio Santa Cruz, the NIA wells encountered very clayey sediments and saline groundwater at that depth; so further drilling to the east of the poblacion should be done with caution and with the expectation of completing the wells at shallow depth. To the west the aquifer undoubtedly thickens and deeper wells (to 300 meters or more) can be successfully constructed to yield higher specific capacities.

It is anticipated that such wells in the poblacion area should produce 63 lps at an average of about 20 meters of initial drawdown, with the poorest wells at about 30 meters of initial drawdown. This is believed to be conservative and is used for preliminary design and estimation purposes because reliable data are very limited. The wells should be located so as to minimize the cost and operational complexity of the distribution system, taking into account that the spacing between wells should be as great as practical (preferably an average of 1 km or more) to minimize drawdown interference. It should be recognized that few, if any, existing private well drilling firms have the necessary experience, equipment and ability to design and construct rotary-drilled wells of good quality without external professional supervision.

A drilling program consisting of wells of 63 lps capacity, spaced 1 to 2 km, in the existing GAP-WD service area, is recommended. These wells should be carefully tested and the results from them used to modify the design of succeeding wells. They should be pumped intensively for several [illegible] and the aquifer response monitored. The data can then be used as guidance for further development of the well system which probably will consist of 31 and 63 lps wells spaced about 1 to 2 km apart. Wells designed to produce 63 lps may be pumped at a lesser rate for the period that the local consumption does not require full production. However, this preliminary estimate must be revised and phased into the overall groundwater development plan for the Gapan area. Any future development of groundwater for irrigation must be taken into consideration in the design of GAP-WD wells.

Induced Infiltration Wells

In anticipation of a possible significant over-exploitation of the deep aquifer, making total reliance on deep wells undesirable, the design and use of relatively shallow, induced infiltration wells drilled in the sands and gravels of the Pampanga or Peñaranda River channel was considered. Such wells would have to produce as much water at about the same pumping levels as the deep wells discussed previously to warrant serious consideration. Since production would quickly be replaced by induced recharge from the associated river, total well field production would be limited only by the low flow in the river and conflicting rights to this water. However, such wells are usually shallow with limited available drawdown and screen length because they do not penetrate below the buried river valley floor. Consequently, they must produce from sands and gravels of high porosity to match the productive capacity of deeper wells producing from a thick section of permeable material such as widespread alluvium of the Central Luzon Plain.

The Peñaranda River floodplain is considered unsuitable for such wells because the recorded minimum flow at Gapan is too low (40 lps in 1957) as a result of the NIA taking out the full dry season flow at the dam at Peñaranda, about 10 km upstream of Gapan. Also, although the Peñaranda River at Gapan has moderately broad floodplains, the visible river sediments (mostly sand with a little gravel and much admixed silt and clay) appear dirty and poorly permeable.

The Pampanga River at San Isidro shows wide floodplains with no visible gravel but much sand and some silt and clay in the visible section. The sand appears clean and fairly permeable. Infiltration wells of moderate capacity could probably be constructed there but test wells would be necessary to confirm this assumption. The cost of a test program is not justified as long as good deep wells can be constructed. However, the Pampanga River carries much more water than the GAP-WD requirements in the year 2000 at all seasons.

Induced infiltration wells would be of much the same design and construction as deep wells, but being shallower would be less costly. However, the wells would be 4 or 5 km from the point of use and transmission costs (pipeline plus pumping costs) would be high. Also the wells would preferably be located in the river floodplain or on the river banks and flood protection works might increase the overall costs of each well. Further, the transmission pipeline would act as a point source requiring a somewhat more expensive distribution system than that based on scattered deep wells located near the centers of demand. These considerations will probably make induced infiltration wells economically inferior to deep wells unless future aquifer over-exploitation makes deep well water very costly. A further analysis is included in Chapter VIII.

Monitoring

Basic planning for overall exploitation of groundwater resources in the Gapan area will be based on the limited data currently available and those derived from tests of the first production wells. However, records of water production from all large-capacity wells and of aquifer response to pumping are necessary to refine the preliminary aquifer parameters and to revise the planning as necessary to avoid the dangers of over-exploitation or the waste of under-exploitation. The GAP-WD should monitor the performance of each of their production wells and observation wells both to provide data and information for water district use and for distribution to other agencies for overall planning and control. In turn, other water districts and other groundwater users should monitor their operation and provide appropriate data to GAP-WD.

Each production well 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 should be kept. Water samples for bacterial analysis should be collected monthly and for chemical analysis, annually. It would also be desirable to monitor static water levels in several observation wells located within the area spanned by GAP-WD wells but far enough from any well to minimize local drawdown effects. Similar routine static water level measurements should be taken in numerous observation wells surrounding the well field at a distance.

The data from this monitoring program will provide better aquifer parameters, indicate the magnitude of recharge, give early warning to GAP-WD of deterioration in water quality 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 spacing of future wells can be adjusted as necessary. For these purposes, copies of all GAP-WD well monitoring data should be analyzed routinely by GAP-WD (if they have competent staff for such analysis) or by some associated agency competent to perform such analysis.

Summary of Groundwater Resources

Gapan is located over an excellent, widespread, relatively uniform aquifer that can readily supply all its projected water demands past the year 2000 from deep wells each producing up to 63 lps. Caution must be observed in locating wells toward the east and southeast of the poblacion.

However, the regional drawdown of groundwater levels resulting from such pumping cannot be accurately quantified because available data on aquifer parameters and recharge are insufficient. Other data will become available from pumping tests of the new production wells and from the monitoring program of production and observation wells. Future well design and well field planning must be modified on the basis of the new data to maintain groundwater production for long-term use.

Induced infiltration wells at the Pampanga River are technologically feasible but may be economically undesirable.

If the intensive use of groundwater irrigation eventually occurs in the Gapan area, over-exploitation of the aquifer with its consequent dangers of failing wells and higher water costs will result unless careful and intelligent control of this multiple use is enforced. Consequently, it is very important that GAP-WD acquire firm rights to all the groundwater for which the GAP-WD can anticipate a future need from NWRC. These water rights will confirm access to the water that is vital to the development of Gapan.

C. SURFACE WATER RESOURCES

The only large potential surface water sources within reasonable distance of Gapan are the Pampanga and Peñaranda Rivers. The Pampanga River originates in the mountains northeast of Gapan, flows south from where it leaves the mountains to pass about 4 km west of the poblacion, and then turns southwest and south to discharge ultimately into Manila Bay. The Peñaranda River originates in the mountains east of Gapan and flows in a generally westerly direction to pass adjacent to the poblacion and to join the Pampanga River at San Isidro, 4 km west of Gapan. There is an NIA dam at Peñaranda on the Peñaranda River about 10 km upstream of Gapan which diverts all the dry season flow for irrigation usage, leaving only seepage water in the downstream stretch of the river.

Surface water data from rivers within the vicinity of Gapan have been compiled and analyzed to establish statistical recurrence of average and minimum flows. BPW records of 4 gaging stations with monthly records spanning from 9 to 22 years were tabulated and analyzed using the Gumbel probability method (see Methodology Memorandum No. 4) of establishing 10-year, 5-year, and 1-year recurring flows. The results are shown in Table VII-3. The recorded minimum flow of the Peñaranda River at Gapan poblacion is 3,500 cumd (40 lps) in 1957, and the recorded minimum flow of the Pampanga River at San Antonio, about 8 km downstream of Gapan poblaoion, is 640,000 cumd (7,400 lps) in 1963.

TABLE VII-3

RECURRENCE OF MINIMUM FLOWS
GAPAN WATER DISTRICT

Station	Longitude/ Latitude	Years of Records	Drainage Area (sqkm)	Minimum Flow (cumd/sqkm) at Return Period of 10 Years	5 Years	1 Year
Peñaranda River* Gapan Poblacion	120°56'50" 15°19'11"	22	573	6	6	17
Peñaranda River* San Vicente, Gapan	120°56'30" 15°18'46"	9	575	4	6	31
Peñaranda River* San Jose	121°18'46" 15°21'10"	12	512	3	3	10
Pampanga River San Antonio	120°54'30" 15°20'45"	9	2,851	237	243	313

The preceding table shows that the Peñaranda River has very minimal flow (about 3,400 cumd, minimum at 10-year frequency), insufficient for the future requirements of GAP-WD. On the other hand, the Pampanga River (at San Antonio) has a probable 10-year minimum flow of at least 675,000 cumd. This is obviously sufficient to provide the maximum-day requirements of the GAP-WD for the year 2000.

Many of the general considerations that apply to infiltration wells apply to surface sources. The Peñaranda River is unsuitable because NIA diverts practically all the dry season flow for irrigation. Thus, at least, a reservoir would be required with the Peñaranda River as a source; however, no practical reservoir site can be found downstream of the NIA dam in the vicinity of Gapan.

The low flow of the Pampanga River would suffice for the GAP-WD, but costs of intake structure, water treatment and transmission would make the water much more expensive than well water.

D. WATER QUALITY OF POTENTIAL SOURCES

Water samples were taken from many of the sources, both groundwater and surface water, discussed previously. Chemical analyses of these samples were performed to determine the water quality with

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*Significantly affected by irrigation diversion by the Peñaranda River irrigation system.

respect to potability and treatment requirements. The results of these analyses are shown in Tables IV-1 and VII-4, and are briefly discussed below.

Groundwater

Since groundwater essentially passes through a filtration process while flowing through a granular aquifer (such as in the GAP-WD area), and is not exposed to surface pollution, color and turbidity or suspended solids are usually not present. For this reason, unless other deleterious substances (such as excessive hardness, dissolved gases or dissolved iron) are present, treatment, other than disinfection, is generally not required.

Water analyses of samples taken from the existing GAP-WD well and 4 other Gapan wells are shown in Table IV-1. All of the well water analyzed fall below the "excessive" limits of the Philippine National Standards for drinking water, and below the "permissible" limits in all respects except for manganese content in the Barrio Malimba well. However, the "permissible" limits are not prohibitive but only guidelines, and in this case where the manganese content is not extremely high and where no known complaints about the water have been received, the water is acceptable for domestic use without extensive treatment.

Water analyses of samples taken from two NIA wells are shown in Table VII-4. The water from NIA P2 (CDM No. 3) is extremely saline. The sample comes from over 300-meter depth and probably is contaminated with cognate salt water remaining in marine sediments that are too impermeable to have been completely flushed out by non-saline groundwater movement. This production zone should be avoided in future wells. The water from the nearby well NIA P3 (CDM No. 4) is of good quality for domestic use, but the sample comes from shallow depth, between 10 and 25 meters.

A water analysis of a sample taken from the Gapan test well (CDM No. 1) is also shown in Table VII-4. The water is of good quality for domestic use except for high iron content, turbidity and color. It is possible that the sample was taken before the well was completely flushed of residual drilling mud, which would account for these effects, or it is possible that the water in the tapped aquifer actually contains excessive iron which would produce the reported turbidity and color by precipitation. No other well waters tested from Gapan showed excessive iron, so the first explanation is considered most likely. Further samples will have to be analyzed (after a pump is installed) to determine the true situation, but if the well continues to produce high-iron water, treatment for removal of iron may be necessary. It is

TABLE VII-4

WATER QUALITY TEST RESULTS
GAPAN WATER DISTRICT

Test	Unit	Permissible Limits	CDM No. 1 Test Well Gapan 29 Mar 77	Pampanga River Cabanatuan 4 Mar 75	Sumacbao River Minalungao 2 Sept 76	Peñaranda River Gapan Poblacion 3 Sept 76	CDM No. 3 NIA P2 Maburac 1971	CDM No. 4 NIA P3 Sta. Cruz 1971
Physical								
Color	APHA	15	65*	20*	0	0		
Turbidity	FTU	5	50*	5	0	0		
Total Dissolved Solids**	mg/l	500	229	154	140	182	3,149*	326
Conductivity	micromhos/cm		352		215	280	4,499	469
Chemical								
pH		7-8.5	7.8	8.6*	7.8	7.3	7.4	7.8
Total Alkalinity	mg/l CaCO3		184	148	105	104	185	290
Phenolphthalein	mg/l CaCO3		0	4	0	0	0	0
Total Hardness***	mg/l CaCO3	400	0	70	98	127		
Calcium	mg/l	75	0	30	34	43	123*	28
Magnesium	mg/l	50	0	10	3	5	90*	15
Total Iron	mg/l Fe	0.3	5.6*	0.38	0.07	0.04		
Fluoride	mg/l F	1.5	0.3	0.3	nil	nil		
Chloride	mg/l	200	13	12	2	10	1,628*	8
Sulfate	mg/l	200	11.6	11.1	3.8	6.7	55	65
Nitrate****	mg/l	50	8.2		8.2	3.6		
Manganese	mg/l Mn	0.1	0	0.03	0.45*	0.2*		

*Exceeds the permissible limits set by the Philippine National Standards for Drinking Water.
**Computed as 65% of conductivity, except for CDM No. 3 and 4.
***Limit inferred from limits of individual metals causing hardness.
****Fifty to 100 mg/l may cause infant disease according to Philippine National Standards for Drinking Water.

also possible, if water of high-iron content is determined to be coming from a limited zone in the aquifer, to seal off the contaminating zone. The water that would be produced from new GAP-WD wells generally can be expected to be similar to the tested well waters, that is of good quality and requiring no treatment except chlorination.

Surface Water

Water from surface sources is generally high in color, turbidity and suspended solids during periods of rainfall. Even during non-rainy periods surface water usually requires complete treatment including chemical addition, mixing, coagulation, flocculation, sedimentation, filtration and disinfection.

The results of chemical analyses performed on 3 samples of water from the Pampanga River and several tributaries are shown in Table VII-4. The results indicate that concentration of color and turbidity is relatively low for surface waters in general, but complete treatment would nevertheless be required particularly during the rainy season when turbidity would be much higher. Two of the samples showed manganese content exceeding the permissible limits set by the Philippine National Standards for Drinking Water, but high dissolved manganese content is unusual in aerated surface waters of normal chemistry and it is considered that the manganese is not in solution but is in particulate matter contained in the water.

ANNEX VII-B

GROUNDWATER RESOURCES

ANNEX TABLE VII-B-1

WATER WELL DATA SUMMARY
GAPAN WATER DISTRICT

CDM Well Number	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		Test Well, Gapan	250	200.0	188.0	-3.7	-14.0	37.8	3.7	1977
2	NIA P1	Kapalangan, Gapan	200	155.2						1971
3	NIA P2	Maburac, Gapan	165	401	327	1.8	-15.8	3.97	0.2	1971
4	NIA P3	Sta. Cruz, Gapan	305	242	25	-0.3	-20.9	7.43	0.4	1971
5	15073	Maburac, Gapan	112	21.3	21.3	3.0		1.13		1956
6	5053	Maburac, Gapan	112	22.8		-9.1	-12.2	0.50	0.2	1968
7	40668	Kapalangan, Gapan	112	64	51.5	-4.3	-6.1	0.95	0.5	1966
8	50573	Pambuan North, Gapan	100	19.8	19.2	-4.6	-5.5	0.63	0.7	1959
9	50572	Pambuan Center, Gapan	100	25.6	17.8	-4.9	-5.2	0.95	3.2	1959
10	6406	Pambuan, Gapan	150	70.4	56.6	-1.2	-2.7	1.26	0.8	1955
11	9324	Pambuan, Gapan	150	62.5	59.4	-3.1	-5.8	1.26	0.5	1955
12	6905	Capulangan, Gapan	150	44.2	38.7	5.8	-9.4	1.26	0.3	1955
13	50570	Mangino, Gapan	100	25.6	18.3	-1.2	-4.9	0.50	0.1	1959
14	9325	Mangino, Gapan		54.9	53.0	-1.2	-6.7	1.26	0.2	1955
15	7808	San Lorenzo, Gapan WD Well	200	183.5	125.6	1.2	-2.4	5.04	1.4	1955
			150		183.5					
16	7811	High School Comp.,Gapan	150	65.5	63	-3.0	-6.1	1.26	0.4	1955
17	15082	Kababao, Gapan		15.9		1.8		1.26		1957
18	406621	San Nicolas, Gapan	115	97.6	88.4	-2.4	-6.1	1.57	0.4	1967
19	9427	San Nicolas, Gapan	150	137.2	136.6	0.9		1.26		1956
20	50578	San Nicolas, Gapan	100	36.6	34.1	-3.6	-4.3	0.63	0.9	1958

ANNEX TABLE VII-B-1 (Continued)

CDM Well Number	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
21	15079	San Nicolas, Gapan	112	32.3	32.3	-4.6	-7.6	1.26	0.4	1957
22	15080	Malupan, Gapan	112	37.8	37.8	-4.6	-6.1	1.26	0.8	1957
23	15074	Sta. Cruz, Gapan	112	18.3	18.3	-2.4				1956
24	15076	Malimba, Gapan	112	16.2	14.6	-1.5				1956
25	406617	Bungo, Gapan	112	70.4	40.5	-12.2	-19.8	0.95	0.1	1966
26	406616	Buluarte, Gapan	112	25.9	19.8	-1.8	-2.4			1966
27	406620	Malupan, Gapan	112	39.6	28.7	-4.6	-9.2	1.89	0.4	1966
28	50574	Puting Tubig, Gapan	100	34.1	33.5	-6.1	-21.3	0.32	0.02	1959
29	50576	Pylong Surot, Gapan	100	23.8	20.4	-4.6	-5.2	0.50	0.8	1959
30	50577	Sta. Cruz, Gapan	100	57.0	52.1	-1.1	-12.2	0.38	0.03	1959
31	50571	Puting Tubig, Gapan	100	34.1	32.0	-12.2	-12.8	0.32	0.5	1959
32	17355	Malimba, Gapan	100	38.7	36.9	-0.8	-1.7	0.63	0.7	1951
33	17338	Sapang Cauayan, Gapan	100	25	18.3	-3.7	-5.2	0.76	0.5	1958
34	50579	Guinandosan, Gapan	100	83.5	83.5	-3.6	-5.5	0.38	0.2	1959
35	50580	Malimba, Gapan	100	23.8	21.9	-2.4	-4.9	0.5	0.2	1959
36	17394	San Isidro, San Isidro	100	38.7	34.1	-1.8	-3.7	0.50		1959
37	13169	Bo. Calaba, San Isidro	150	12.2	11.6	-3.7	-4.6	0.95	1.1	1956
38	50633	Bo. Calaba, San Isidro	100	34.1	32.6	-3.4	-5.5	0.50	0.2	1958
39	50632	Bo. Calaba, San Isidro	100	25.0	23.2	-2.1	-3.7	0.50	0.3	1959
40	13171	Bo. Sto. Cristo, San Isidro	112	12.2	11.0	-3.7				1956

ANNEX TABLE VII-B-1 (Continued)

CDM Well Number	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
41	406616	Sto. Cristo, San Isidro	112	27.4	19.8	-3.0	-4.0	0.63	0.6	1966
42	15077	Sto. Cristo, San Isidro	112	15.2	15.2	-1.2		1.26		1956
43	5491	Poblacion, San Isidro	150	61.0	43.6	-4.6	-5.2	0.95	1.6	1952
44	396054	Manga, San Isidro	100	15.2	14.6	-6.1				1960
45	396053	Tabon, San Isidro	100	16.5	16.2	-6.1				1960
46	7809	Calaba, San Isidro	150	53.4	51.5	-2.4	-3.7	1.58	1.2	1955
47	13170	Alva, San Isidro	150	25.9	25.2	-6.1	-7.6	1.26	0.8	1956
48	13169	Calaba, San Isidro	150	12.2	11.6	-3.7	-4.6	0.95	1.0	1956
49	7810	San Roque, San Isidro	150	42.7	41.5	-4.3	-4.6	1.58	5.3	1955
50	396051	Malapit, San Isidro	112	32.9	31.7					1960
51	39594	Malapit, San Isidro	100	38.7	29.6	-6.1	-9.8	0.95	0.3	1959
52	14419	Pulo, San Isidro	100	39.3	38.4	-1.8	-3.0	0.95	0.8	1957
53	50631	Alua East, San Isidro	100	34.1	30.8	-4.6	-5.2	0.63	1.0	1959
54	17393	Calaba, San Isidro	100	25.0	22.9	-4.6	-4.9	0.44	1.5	1959
55	14418	Malapit, San Isidro	100	36.3	33.5	-6.1	-8.2	0.95	0.4	1957
56	50637	Sto. Cristo, San Isidro	100	34.1	27.7	-3.0	-3.4	0.69	1.7	1959
57	50635	Sto. Cristo, San Isidro	100	34.1	32.0	-3.0	-3.7	0.44	0.6	1959
58	50634	San Isidro, San Isidro	100	38.7	34.8	-4.9	-7.6	0.63	0.2	1959
59	8332	San Isidro, San Isidro	150	122.0	117.1	0	-3.7	3.15	0.8	1959
60	396014	Langla, Jaen	100	22.3	21.3	-5.5	-5.8	0.63	2.1	1960

ANNEX TABLE VII-B-1 (Continued)

CDM Well Number	Well Number	Location	Nominal Diameter (mm)	Depth From Ground Surface In Meters				Test Yield (lps)	Specific Capacity (lps/m)	Year Complete
				Total	Cased	Static Water Level	Pumping Water Level			
61	396013	Helera, Jaen	100	14.0	13.7	-3.0	-3.4	0.63	1.6	1960
62	396012	Supang Mahaba, Jaen	100	19.5	17.9	-3.7	-3.7	0.63		1960
63	40675	Manaul, Jaen	112	40.5	39.6	-2.1	-6.1	0.63	0.2	1967
64	395922	Niyugan, Jaen	100	32.9	28.4	-4.6				1959
65	40674	Pitak-Ulanin, Jaen	112	19.8	18.3	-2.1	-3.0	1.26	1.4	1967
66	396015	Sapang, Jaen	100	18.0	16.5	-6.1	-6.1	0.63		1960
67	13165	St. Joseph, Jaen	150	12.5	10.7	-3.7	-4.6	1.26	1.4	1956
68	13166	Lambakin, Jaen	112	22.9	21.3	-4.6	-5.2	1.26	2.1	1956
69	13168	Dampulan, Jaen	150	13.7	11.0	-2.4	-4.0	0.95	0.6	1956
70	13167	Putlod, Jaen	112	22.3	20.7	-6.1	-7.6	0.95	0.63	1956
71	13476	Labunia, Jaen	100	18.3	16.8	-3.0				1959
72	21755	Labunia, Jaen	100	18.3	16.8	-3.0	-4.0	0.76	0.8	1959
73	396112	Lambakin, Jaen	100	15.5	13.4	-3.0	-3.4	0.57	1.4	1961
74	6408	Poblacion, Jaen	150	188.4	185.4	+1.2	0	0.25	0.2	1955
75	6407	San Vicente, Jaen	150	64.0	59.8	-6.1	-13.7	0.63	0.1	1955
76	50596	Langla North, Jaen	100	46.9	43.9	-4.7	-10.2	1.26	0.2	1959
77	50597	Pinangaan, Jaen	100	35.7	32.4	-3.0	-4.0	0.44	0.4	1959
78	50598	Burgos St., Poblacion Jaen	100	25.0	22.6	-4.9	-5.5	0.44	0.7	1959
79	50599	Yuson St., Poblacion, Jaen	100	38.7	36.3	-6.1	-6.4	0.32	1.1	1958
80	50600	Nueva St., Poblacion, Jaen	100	34.1	32.0	-4.6	-5.5	0.76	0.8	1959

ANNEX TABLE VII-B-1 (Continued)

CDM Well Number	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
81	50601	Scout Rivera, Ocampo St., Poblacion, Jaen	100	43.3	39.5	-5.8	-6.8	0.95	0.9	1959
82	50603	Campugo, Sto. Tomas, Jaen	100	29.6	24.1	-4.6	-4.9	1.26	4.2	1959
83	395923	Dampulan, Jaen	100	18.3	18.3	-4.3	-5.2	0.63	0.7	1959
84	8122	Sto. Tomas North, Jaen	150	45.7	39.3	-5.8	-9.1	1.89	0.6	1955
85	9034	Sto. Tomas, Jaen	150	39.6	38.4	-5.2	-8.2	1.26	0.4	1955
86	9035	Sapang Niyugan, Jaen	150	38.1	36.0	-3.4	-3.7	1.26	4.2	1955
87	17365	Langla South, Jaen	100	34.1	27.4	-3.7	-4.6	0.38	0.4	1958
88	17364	Bantug, Jaen	100	29.6	20.4	-2.1	-3.0	0.63	0.7	1959
89	21756	Pamacpacan, Jaen	100	36.6	30.0	-1.5	-4.6	0.63	0.2	1959
90	39592	Pamacpacan, Jaen	100	36.6	30.0	-1.5				1959
91	396018	Pinangaan, Jaen	100	17.7	17.1	-2.4	-3.0	0.63	1.0	1960
92	395913	Sapang Niyugan, Jaen	100	32.9	28.4	-4.6	-6.1	0.76	0.5	1959
93	17366	Marawa, Jaen	100	25.0	21.0	-2.0	-2.9	3.15	3.5	1959
94	17367	Yuson St., Poblacion, Jaen	100	38.7	36.0	-5.2	-5.8	0.44	0.7	1959
95	17368	San Pablo, Jaen	100	34.1	30.0	-4.0	-5.8	0.95	0.5	1959
96	17369	San Vicente N, Jaen	100	34.1	30.8	-2.1	-3.4	1.89	1.4	1959
97	50602	Caingin, Sto. Tomas, Jaen	100	32.3	28.4	-4.0	-4.6	1.26	2.1	1959
98	396016	Putlod, Jaen	100	20.7	19.8	-5.5	-5.5	0.63		1960
99	396017	Putlod Sur, Jaen	100	23.8	22.9	-2.4	-3.4	0.50	0.5	1960
100	9036	Putlod, Jaen	150	36.6	34.1	-3.7	-4.0	1.13	3.8	1956

ANNEX TABLE VII-B-1 (Continued)

CDM Well Number	Well Number	Location	Nominal Diameter (mm)	Depth From Surface In Meters: Total	Depth From Surface In Meters: Cased	Meters: Static Water Level	Meters: Pumping Water Level	Test Yield (lps)	Specific Capacity (lps/m)	Year Completed
101	40672	Castillo, San Leonardo	112	118.0	118.0	-3.0	-6.7	1.26	0.3	1967
102	50645	Mallorca, San Leonardo	100	20.4	17.7	-4.9	-5.2	0.63	2.1	1959
103	8391	Kanbangan, San Leonardo	150	99.7	87.8	-4.6	-16.8	1.26	0.1	1955
104	17411	Abuating, San Leonardo	100	25.0	21.0	-4.9	-6.1	0.63	0.5	1959
105	50651	Tambo Tumana, San Leonardo	100	20.4	17.1	-4.6		1.20		1959
106	7806	Mallorca, San Leonardo	150	80.8	78.7	-4.6	-6.4	1.26	0.7	1955
107	5581	Mambangnan, San Leonardo	112	97.6	96.3	-3.0	-3.7	0.95	1.4	1952
108	50650	Magpapalayok Tambo, San Leonardo	100	25.0	22.3	-6.1	-7.6	0.63	0.4	1959
109	50649	Adorable Tambo, San Leonardo	100	25.0	18.6	-6.1	-7.0	0.44	0.5	1959
110	17410	Magpapalayok Tambo, San Leonardo	100	29.6	25.3	-6.4	-7.6	0.95	0.8	1959
111	17407	Adorable S.S., San Leonardo	100	25.0	22.6	-5.8	-6.1	0.44	1.5	1959
112	17408	Castellano, San Leonardo	100	38.7	18.3	-4.6	-5.5	0.95	1.1	1959
113	8392	Nieves, San Leonardo	150	48.8	37.8	-4.6	-8.2	0.63	0.2	1955
114	50648	San Anton North, San Leonardo		29.6	26.2					1959
115	50646	San Anton, San Leonardo	100	26.5	21.6	-4.0	-5.2	0.38	0.3	1959
116	17409	San Anton, San Leonardo	100	29.6	26.2	-5.2	-5.3	0.95	9.5	1959
117	50647	San Anton, San Leonardo	100	34.1	29.9	-5.2	-5.5	0.63	2.1	1959
118	50644	Corner Reyes St. and Rizal St. Mallorca, San Leonardo	100	25.0	17.4	-5.2	-6.4	0.95	0.8	1959
119	8389	Poblacion Mabini St., San Leonardo	150	25.9	24.1	-4.6	-5.2	1.26	2.1	1955
120	8392	Nieves, San Leonardo	150	48.8	48.2	-4.6	-8.2	0.63	0.2	1955

ANNEX TABLE VII-B-1 (Continued)

CDM Well Number	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
121	17392	Sta. Cruz, San Leonardo	100	25.0	23.5	-3.4	-4.9	1.58	1.0	1958
122	6879	Magpapalayok, San Leonardo	150	26.5	25.3	-5.5	-7.3	1.26	0.7	1954
123	8393	Tabuating, San Leonardo	150	94.5	89.5	-2.1	-3.4	1.26	1.0	
124	8390	Karsadang Putol, San Leonardo	150	99.1	97.6	-3.0	-4.6	1.26	0.8	1955
125	55045	Castellano, San Leonardo	100	25.0	21.3	-4.6	-4.9	0.38	1.3	1959
126	16232	Tanebo Sunction, San Leonardo	112	15.9	15.2	-5.2				1957
127	16231	Tambo Magpapalayok, San Leonardo	112	22.3	21.3	-7.6				1957
128	4527	Poblacion, San Leonardo	100	145.4	145.4	+0.3				1948
129	396261	Mambangnan, San Leonardo	100	119.8	113.7	-7.6	-10.7	0.32	0.1	1962
130	13173	Nieves, San Leonardo	112	29.0	27.9	-6.1	-7.6	1.26	0.8	1957
131	16233	Mallorca, San Leonardo	100	47.9	47.3	-5.2				1958
132	16234	Balanga Lambo, San Leonardo	100	24.4	23.5	-6.1				1957
133	7807	Burgos St., San Leonardo	150	59.5	53.0	-4.6	-8.2	1.26	0.3	1955
134	4570	Mallorca, San Leonardo	100	158.8	158.5	+0.6	-7.6	0.76	0.1	1948
135	4636	Mambangnan, San Leonardo	100	67.1	62.5	-5.5	-5.5	0.88		1948
136	13172	Poblacion, San Leonardo	112	15.2	13.7	-4.6				1956
137	13174	Poblacion, San Leonardo	112	16.8	15.5					1957
138	396231	Papaya, San Antonio	100	27.4	25.7	-2.4	-3.0	1.58	2.6	1962
139	40631	South Malayo, San Antonio	100	35.1	21.3	-6.1	-7.6	0.95	0.6	1963
140	7645	Luyas, San Antonio	150	22.6	22.0	-4.9	-7.0	0.63	0.3	1955

ANNEX TABLE VII-B-1 (Continued)

CDM Well Number	Well Number	Location	Nominal Diameter (mm)	Depth From Ground Surface In Meters: Total	Cased	Static Water Level	Pumping Water Level	Test Yield (lps)	Capacity (lps/m)	Year Completed
141	7646	Sta. Barbara, San Antonio	150	18.6	16.9	-1.8	-3.4	0.95	0.6	1955
142	9778	San Francisco, San Antonio	150	96.0	92.7	-1.8	-3.0	1.26	1.0	
143	11102	Poblacion, San Antonio	150	97.6	94.5	-3.0	-4.9	1.26	0.7	1956
144	9780	San Mariano, San Antonio	150	64.0	59.4	-3.0				1956
145	11101	Buliran, San Antonio	150	61.0	50.0	-6.1	-7.6	1.26	0.8	1956
146	9777	Papaya, San Antonio	150	108.2	107.6	-0.9	-3.0	0.95	0.4	1956
147	9779	Kupang Lauang, San Antonio	150	19.5	19.5	-3.0	-4.6	1.13	0.7	1956
148	50629	San Mariano West, San Antonio	100	22.3	22.3	-1.2	-5.2	1.26	0.3	1959
149	50628	San Mariano, San Antonio	100	38.7	37.5	-2.7	-5.2	0.38	0.1	1959
150	11103	Fanabingan, San Antonio	150	30.5	30.5	-4.6	-6.1	1.26	0.8	1956
151	50630	Sta. Barbara, San Antonio	100	34.1	31.1	-.18	-3.7	0.63	0.2	1959
152	50627	Camias, San Francisco, San Antonio	100	29.6	25.3	-1.5	-4.7	2.20	0.7	1959
153	50625	Sta. Barbara, San Antonio	100	29.6	25.9	-1.8	-2.4	0.63	1.0	1959
154	50626	San Francisco, San Antonio	100	25.0	22.6	-1.8	-2.1	1.89	6.3	1959
155	17391	Maugat, San Antonio	100	38.7	35.1	-3.0	-4.6	0.50	0.3	1959
156	50624	Julo, San Antonio	100	25.0	22.3	-4.0	-4.3	0.44	1.4	1959
157	17390	Julo School Site, San Antonio	100	29.6	25.6	-4.3	-4.4	0.63	6.3	1959
158	11104	Coma Juan, San Antonio	150	31.4	31.4	-3.0	-4.0	1.26	1.3	1956
159	396251	Maungat, San Antonio	100	40.1	38.3	-8.5	-17.4	0.63	0.07	1962
160	18283	Poblacion, Peñaranda	100	26.2	25.9	-5.5	-12.2	1.26	0.2	1957

ANNEX TABLE VII-B-1 (Continued)

CDM Well Number	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
161	6404	Sto. Tomas, Peñaranda	150	22.9	17.4	-6.1	-7.3	1.26	1.0	1954
162	6402	Callas, Peñaranda	150	240.9	229.3	-3.0	-6.1	1.58	0.5	1954
163	5527	Poblacion, Peñaranda	150	131.1	114.9	+0.6		0.32		1952
164	4957	Real St., Peñaranda	112	122.0	118.0	+1.2	-6.1			1949
165	5021	Sto. Tomas, Peñaranda	100	132.6	129.9	+3.0	-1.8	1.26	0.3	1949
166	17385	Sinisahan, Peñaranda	100	41.8	37.2	-4.0	-7.3	0.95	0.3	1959
167	50619	Sinisahan, Peñaranda	100	34.1	32.9	-4.6	-7.9	0.32	0.1	1954
168	6403	San Josef, Peñaranda	150	51.8	32.0	-5.8	-12.2	1.26	0.2	1954
169	50620	San Josef, Peñaranda	100	25.0	22.6	-5.2	-6.7	0.50	0.3	1959
170	396055	San Josef, Peñaranda	100	35.4	34.8	-9.1	-13.7	0.39	0.1	1960
171	18282	Sto. Tomas, Peñaranda	112	64.3	64.3	-9.1		1.89		1957
172	4933	Poblacion, General Tinio	100	70.1	64.6	-9.1	-12.2	1.26	0.4	1949
173	4831	Rizal St., General Tinio	100	70.1	66.5	-6.1	-12.2	1.26	0.2	1949
174	4804	Poblacion, General Tinio	100	89.3	86.9	-5.2	-5.8	0.95	1.6	1949
175	7812	Pulong Sampaloc, General Tinio	150	83.8	80.5	-9.1	-12.2	0.63	0.2	1955
176	21753	Tabuating, General Tinio	100	13.7	13.4	-4.6	-10.4	0.95	0.2	1959
177	396026	Bonifacio St., Poblacion General Tinio	100	24.4	22.4	-6.1	7.9	0.44	0.2	1960
178	39623	San Pedro, General Tinio	100	35.7	26.2	-7.0	-8.5	0.76	0.5	1962
179	396025	Poblacion, General Tinio	100	36.3	34.4	-8.4	-10.7	0.63	0.3	1960
180	396027	Lico, General Tinio	100	21.3	18.8	-6.7	-9.1	0.14	0.2	1961

ANNEX TABLE VII-B-1 (Continued)

CDM Well Number	Well Number	Location	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
181	9456	Rio Chico, General Tinio	150	163.1	161.6	-9.8	-48.8	0.32	0.01	1956
182	5127	Poblacion, General Tinio	100	65.5	45.7	-8.5	-13.7	1.26	0.2	1949
183	5140	Rio Chico, General Tinio	100	100.6	80.8	-6.1	-11.0	1.26	0.3	1949
184	4860	Calle H. S., General Tinio	100	108.2	104.9	-4.6	-12.2	1.26	0.2	1949
185	17418	San Gregorio, Sta. Rosa	100	35.7	29.9	-5.8	-7.9	0.95	0.4	1958
186	17416	Mapalad, Sta. Rosa	100	33.5	32.6	-12.2	-13.1	0.44	0.5	1958
187	50652	San Mariano, Sta. Rosa	100	38.7	37.2	-5.8	-7.6	0.50	0.3	1958
188	17412	La Fuente School Site, Sta. Rosa	100	25.0	23.0	-5.5	-6.1	0.44	0.7	1958
189	17419	San Gregorio, Sta. Rosa	100	26.5	23.8	-8.2	-10.1	0.63	0.3	1958
190	17417	Bajal School Site, Sta. Rosa	100	24.4	16.0	-2.1	-3.0	1.58	1.8	1958
191	17415	Malillo South, Sta. Rosa	100	28.4	28.0	-4.6	-6.1	1.26	0.3	1958
192	17414	Malidlid, Sta. Rosa	100	29.6	27.4	-4.9	-5.5	0.44	0.7	1958
193	17413	La Fuente Old, Sta. Rosa	100	25.0	22.6	-6.1	-6.7	0.32	0.5	1958
194	39621	Sinaguing Rajal, Sta. Rosa	100	21.3	21.2	-4.0	-6.1	0.63	0.3	1962
195	39611	Valencia St., Poblacion, Sta. Rosa	100	39.3	39.3	-12.2	-12.8	0.76	1.3	1961
196	6401	Poblacion, Sta. Rosa	150	216.5	157.0	0	-6.7			1954
197	396111	Sto. Rosario, Sta. Rosa	100	13.7	13.4	-3.7	-4.0	0.63	2.1	1961
198	396061	Soledad, Sta. Rosa	100	34.8	32.0	-9.1	-9.8	0.63	0.9	1961
199	20242	Div. Housing Proj., Sta. Rosa	200	61.0	42.7	-15.2	-29.3	2.21	0.2	1958

ANNEX TABLE VII-B-1 (Continued)

CDM Well Number	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
200	20243	Div. Housing Proj., Sta. Rosa	200	59.5	52.6	-13.7	-16.8	2.21	0.7	1958
201	40671	Sapsap	112	18.6	17.7	-5.8	-9.1	0.32	0.1	1967
202	20244	Sta. Rosa Div. Site, Sta. Rosa	200	61.0	47.0	-6.1	-36.6	2.65	0.1	1958
203	406612	Sinipit, Cabiao	112	44.2	44.2	-0.3	-2.4	1.26	0.6	1966
204	6285	Entablado, Cabiao	150	47.9	39.0	-3.4	-6.1	0.95	0.3	1954
205	7638	Bagong Buhay, Cabiao	150	39.0	23.5	-1.8	-2.3	1.26	2.5	1955
206	406619	Bagong Silang, Cabiao	112	46.6	45.7	-4.9	-16.8	0.32	0.03	1966
207	11405	San Vicente South, Cabiao	150	42.7	42.4	-3.7	-4.3	0.95	1.6	1956
208	11706	San Fernando, Cabiao	150	20.4	20.4	-3.4	-5.2	0.95	0.5	1956
209	11404	Cabiao H.S., Cabiao	150	24.4	21.6	-4.0	-4.6	0.95	1.6	1956
210	17345	Sta. Rita, Cabiao	100	56.4	55.2	-2.1	-3.4	0.38	0.3	1959
211	17344	San Roque, Cabiao	100	31.7	29.8	-2.7	-4.3	0.63	0.4	1959
212	17343	Poblacion, Cabiao	100	38.7	37.5	-2.1	-2.4	0.50	1.7	1959
213	17342	Pantalan, Cabiao	100	29.6	28.1	-4.6	-5.2	0.44	0.7	1959
214		Sinipit, Cabiao	150	30.2	28.4	-1.8	-4.3	0.95	0.4	1955

DESCRIPTIVE DATA	
WELL NO. (CDM)	2
(OTHER)	NIA-PI
LOCATION	BARRIO KAPALANGAN
CITY	GAPAN
PROVINCE	NUEVA ECIJA
CONST. BY	BPW
DRILLER	
STARTED	
COMPLETED	1971
OWNER	NIA
STATUS	ABANDONED
CASING DIAMETER	UNCASED

DRILLER'S TEST DATA:

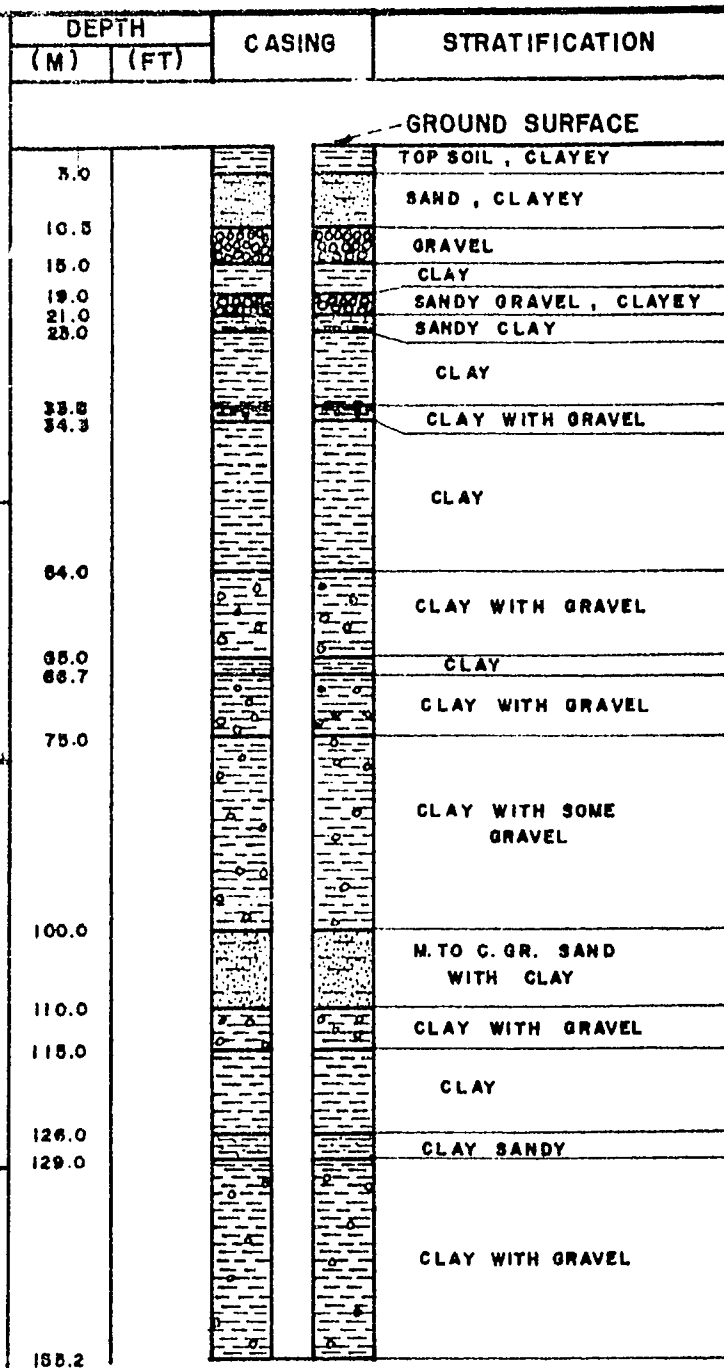
DATE	
STATIC WATER LEVEL	
PUMPING WATER LEVEL	
TEST PUMP YIELD	

REMARKS:

DRILLED BY ROTARY METHOD
HOLE DIAMETER: 200 MM.(7 7/8 IN.)
DEPTH: 155.2 M.
SURFACE PIPE MAY EXIST
HOLE FILLED WITH DRILLING MUD AND ABANDONED

WATER QUALITY DATA:

GRAPHIC LOG



FEASIBILITY STUDY FOR WATER SUPPLY OF SECOND TEN URBAN AREAS

LWUA-CDM

ANNEX FIGURE VII-B-1
WELL DATA SHEET
WELL CDM-2

DESCRIPTIVE DATA

WELL NO. (CDM) 3
(OTHER) NIA – P 2
LOCATION SITIO MABURAC
BARRIO SANTA CRUZ
CITY GAPAN
PROVINCE NUEVA ECIJA
CONST. BY NIA
DRILLER
STARTED 1971
COMPLETED 1971
OWNER NIA
STATUS FREE FLOWING (24 SEPT. 1978)
CASING DIAMETER 165 MM (6 5/8 IN.) 0-300 M
CASING LENGTH 300 M
SLOTTED PIPE 300 TO 327 M.

DRILLER'S TEST DATA:

DATE SEPTEMBER 1971
STATIC WATER LEVEL 1.83 M ABOVE G.L.
FREE FLOWING 7 GPM (0.44 LPS)
PUMPING WATER LEVEL 15.77 M BELOW G.L.
TEST PUMP YIELD 63 GPM (3.97 LPS)
SPECIFIC CAPACITY 0.23 LPS/M (1.1 GPM/FT.)

REMARKS:

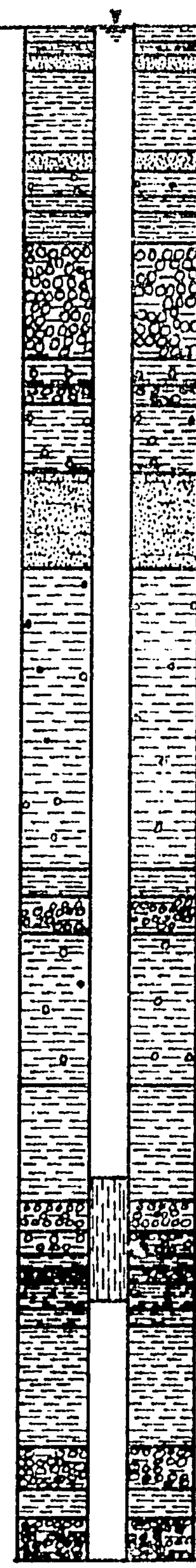
ROTARY DRILLED 58 M. TO 15 3/4 IN.
58-401 M. TO 13 IN.
ELECTRIC LOGGED SP 2 R 0-240 M.
ELEVATION: 25.45 M.
LOCATION:
COORDINATES
LAT. 120° 59' N
LONG 15° 18' E
WATER TEMPERATURE
29.5° C FREE FLOW
32 ° C PUMPING

WATER QUALITY DATA:
FREE FLOWING SAMPLE
LABORATORY ANALYSIS 1971
COND. 4499 MICROMHOS/CM
TDS. 3149 PPM
SAR. 16.5

pH	7.4	
Ca	6.42	Meq/l
Mg	7.40	Meq/l
Na	43.48	Meq/l
K	2.56	Meq/l
Cl	45.90	Meq/l
SO_4	0.43	Meq/l
CO	0.00	Meq/l
HCO_3	1.85	Meq/l

ADDITIONAL SAMPLES
10/9/71 TDS 2460 PPM FREE FLOW
15/9/71 TDS 3700 PPM PUMPED
7/10/71 TDS 3600 PPM FREE FLOW
24/9/71 COND. 46.00 MMHO/CM FREE FLOW

GRAPHIC LOG



DEPTH (M)	DEPTH (FT)	STRATIFICATION
		CLAY, BROWN
3		SANDY CLAY, BROWN
5		SAND, BROWN
7		CLAY, BROWN AND GREY
37		SAND
42		CLAY, GREY, GRAVELLY
50		CLAY, BROWN
52		CLAY, SANDY, GREY
58		CLAYEY GRAVEL, GREY
90		CLAY, BROWN, SOME GRAVEL
98		CLAYEY GRAVEL, GREY
104		CLAY, BROWN, SOME GRAVEL
119		CLAYEY SAND, M TO GR.
145		CLAY, GREY-BROWN WITH SOME GRAVEL
221		CLAY, BLUE
227		CLAYEY GRAVEL, GREY
237		CLAY, BROWN, GRAVELLY IN PART
276		CLAY, BLUE AND BROWN
304		CLAYEY GRAVEL
315		GRAVEL, CLAYEY IN PART
321		CLAY, BLUE
322		GRAVEL, COARSE CLAYEY
324		CLAY, GRAVELLY BLUE
334		CLAY, BLUE
337		CLAY, BROWN
370		GRAVEL, CLAYEY GREY
381		CLAY, BLUE
389		GRAVEL, CLAYEY, BROWN
401		

ANNEX FIGURE VII-B-2
WELL DATA SHEET
WELL CDM-3

DESCRIPTIVE DATA	GRAPHIC LOG

WELL NO (CDM) 4
(OTHER) NIA - P3
LOCATION SITIO BALANTE
BARRIO SANTA CRUZ
CITY GAPAN
PROVINCE NUEVA ECIJA
CONST. BY NIA
DRILLER
STARTED 1971
COMPLETED
OWNER NIA
STATUS SCREEN AND CASING REMOVED
WELL ABANDONED
CASING 300 MM (12 IN.) 0-24.65 M.
SCREEN 300 MM (12 IN.)
11.80 M-15.80 M, 21.28-24.65 M.

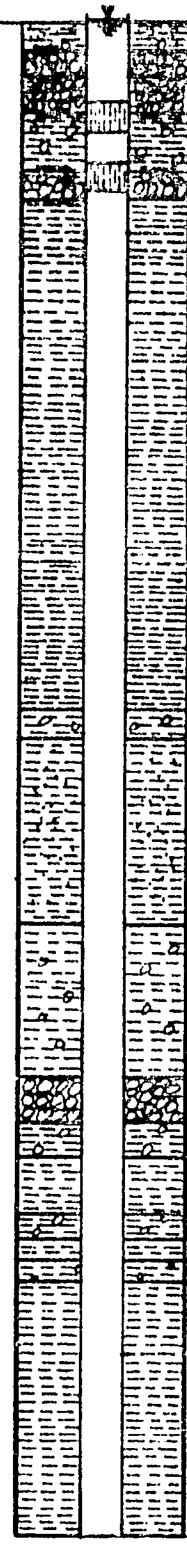
DRILLERS TEST DATA:
DATE OCTOBER 1971
STATIC WATER LEVEL 0.30 M
PUMPING WATER LEVEL 20.9 M.
TEST PUMP YIELD 118 GPM (7.43 LPS)
SPECIFIC CAPACITY 0.36 LPS/M (1.86 GPM/FT.)
TRANSMISSIVITY 44 CUMD/M (3500 GPD/FT.)

REMARKS:

ROTARY DRILLED 10 5/8 INCHES UP TO 243 M, REAMED 15 3/4 INCHES UP TO 28 M.
ELECTRIC LOGGED 0-190 M, SP FAILED TO FUNCTION
SURFACE ELEVATION 14.99 M.

WATER QUALITY DATA:

OCTOBER 1971
TEMP 28.5°C
COND. 469 MICROMHOS/CM.
TDS 326 PPM
SAR 3.03
pH 7.8
Ca 1.40 Meq/l
Mg 0.62 Meq/l
Na 3.04 Meq/l
K 0.13 Meq/l
Cl 0.23 Meq/l
SO_4 0.51 Meq/l
CO_3 0.00 Meq/l
HCO_3 2.90 Meq/l



DEPTH (M)	(FT)	CASING	STRATIFICATION
			GROUND SURFACE
4			CLAY, BROWN, SANDY, SOME GRAVEL
7			GRAVEL, SANDY, BROWN
13			GRAVEL, V COARSE, SOME CLAY
23			CLAY, BROWN, SOME GRAVEL
28			GRAVEL, COARSE, SOME CLAY
108			CLAY, GREY
113			CLAY, SOME GRAVEL, BROWN
142			CLAY, SOME SAND, BROWN
165			CLAY, SOME GRAVEL, BROWN
175			GRAVEL, CLAYEY, GREY
180			CLAY, DARK BLUE, SOME GRAVEL
189			CLAY, DARK BLUE
193			CLAY, GRAVELLY, DARK BLUE
196			CLAY, DARK BLUE
200			CLAY, GRAVELLY, DARK BLUE
242			CLAY, GREY

ANNEX FIGURE VII-B-3
WELL DATA SHEET
WELL CDM-4

DESCRIPTIVE DATA	
WELL NO. (CDM)	10
(OTHER)	BPW NO. 6406
LOCATION	BARRIO PAMBUAN
CITY	GAPAN
PROVINCE	NUEVA ECIJA
CONST. BY	
DRILLER	NICASIO TANDOC
STARTED	JANUARY 4, 1955
COMPLETED	JANUARY 15, 1955
OWNER	
STATUS	
CASING DIAMETER	150 MM. (6 IN.)
CASING LENGTH	56.6 M (155 FT AND 7 IN.)
SPECIFIC CAPACITY	0.8 LPS/M (4 GPM/FT.)

DRILLER'S TEST DATA:

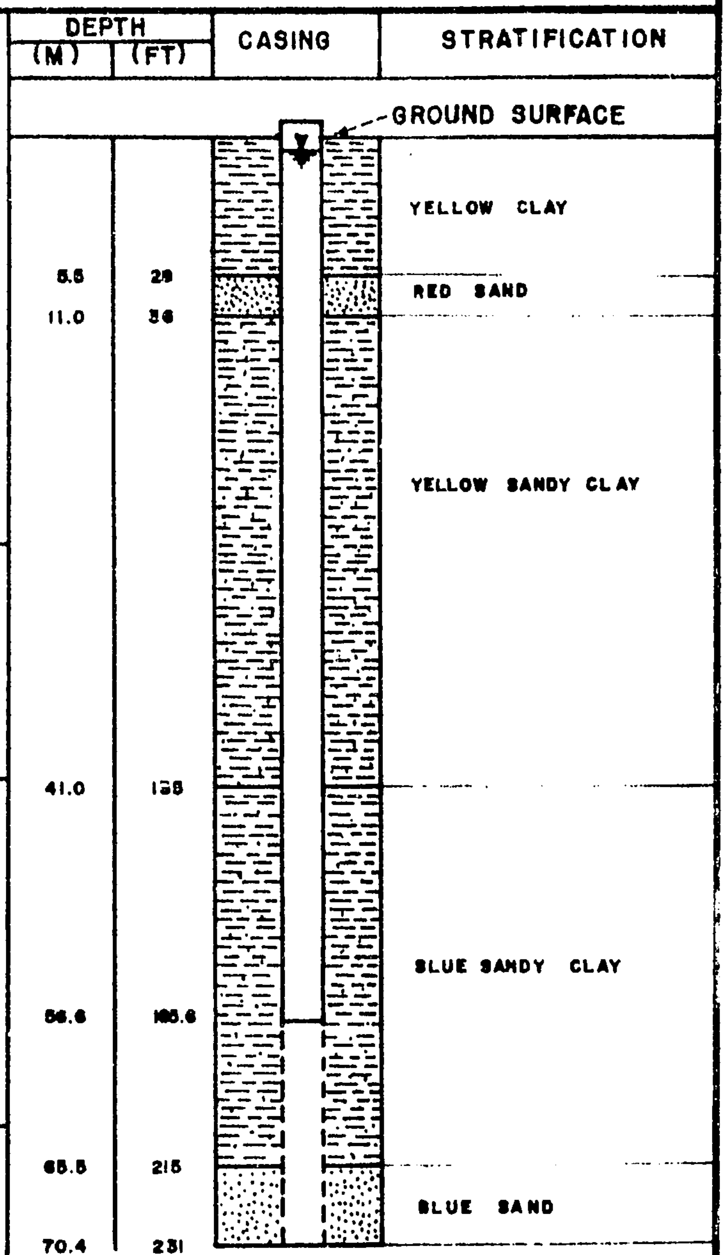
DATE	
STATIC WATER LEVEL	− 1.22 M (4 FT.)
PUMPING WATER LEVEL	− 2.74 M (9 FT.)
TEST PUMP YIELD	20 GPM. (1.26 LPS)

REMARKS:

WHEN PUMPING 20 GPM (1.26 LPS)
DRAWDOWN = 2.74 M (9 FT.)
WHEN PUMPING 25 GPM (1.58 LPS)
DRAWDOWN = 3.2 M. (10 1/2 FT.)
WATER BEARING STRATA AT
65.5 – 70.4 M. (215 - 231 FT.)

WATER QUALITY DATA:

GRAPHIC LOG



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

ANNEX FIGURE VII-B-4
WELL DATA SHEET
WELL CDM-10

DESCRIPTIVE DATA

WELL NO. (CDM) 12
(OTHER) BPW 6405
LOCATION : BARRIO CAPULANGAN
CITY GAPAN
PROVINCE NUEVA ECIJA
CONST. BY
DRILLER NICASIO TANDOC
STARTED DECEMBER 20, 1954
COMPLETED JANUARY 3, 1955
OWNER
STATUS
CASING DIAMETER 155 MM (6 IN.)
CASING LENGTH 38.7 M (127 FT.)

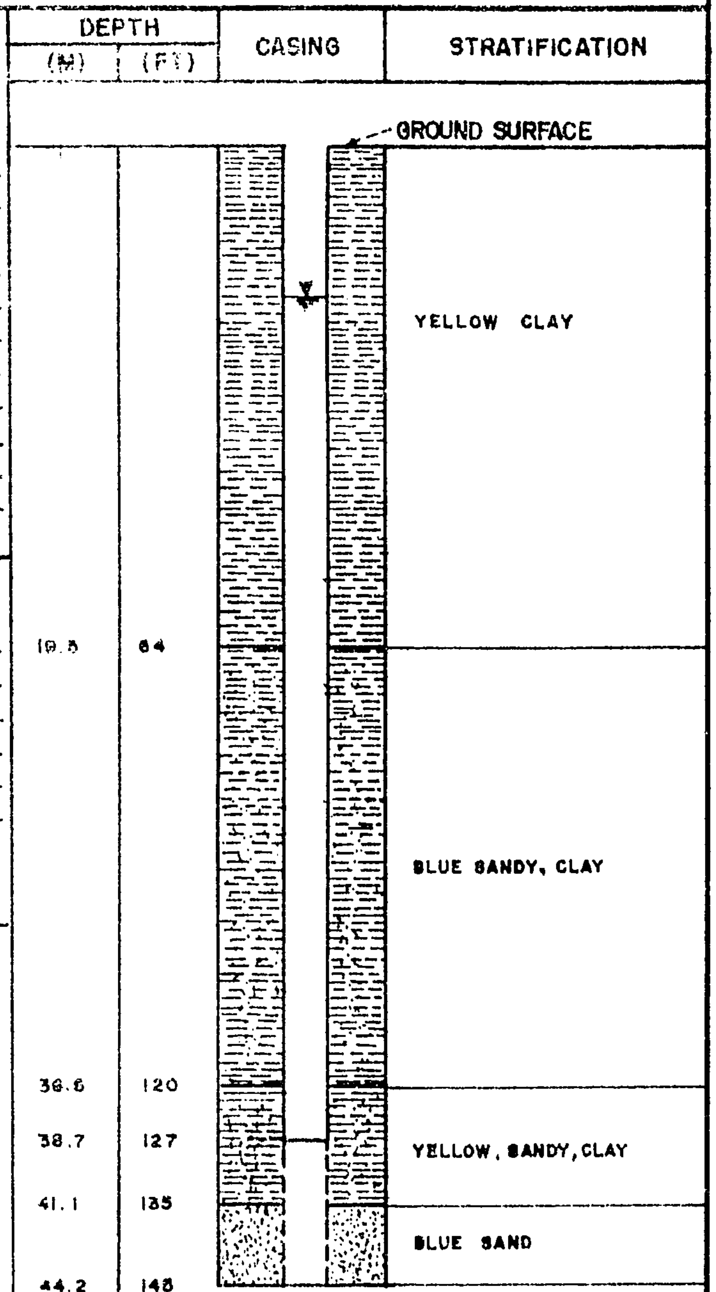
DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL -5.8 M (19 IN.)
PUMPING WATER LEVEL -9.4 M (31 FT.)
TEST PUMP YIELD 20 GPM (1.3 LPS)
SPECIFIC CAPACITY 0.3 LPS/M (1.7 GPM/FT.)

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG



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

ANNEX FIGURE VII-B-5
WELL DATA SHEET
WELL CDM-12

DESCRIPTIVE DATA	GRAPHIC LOG

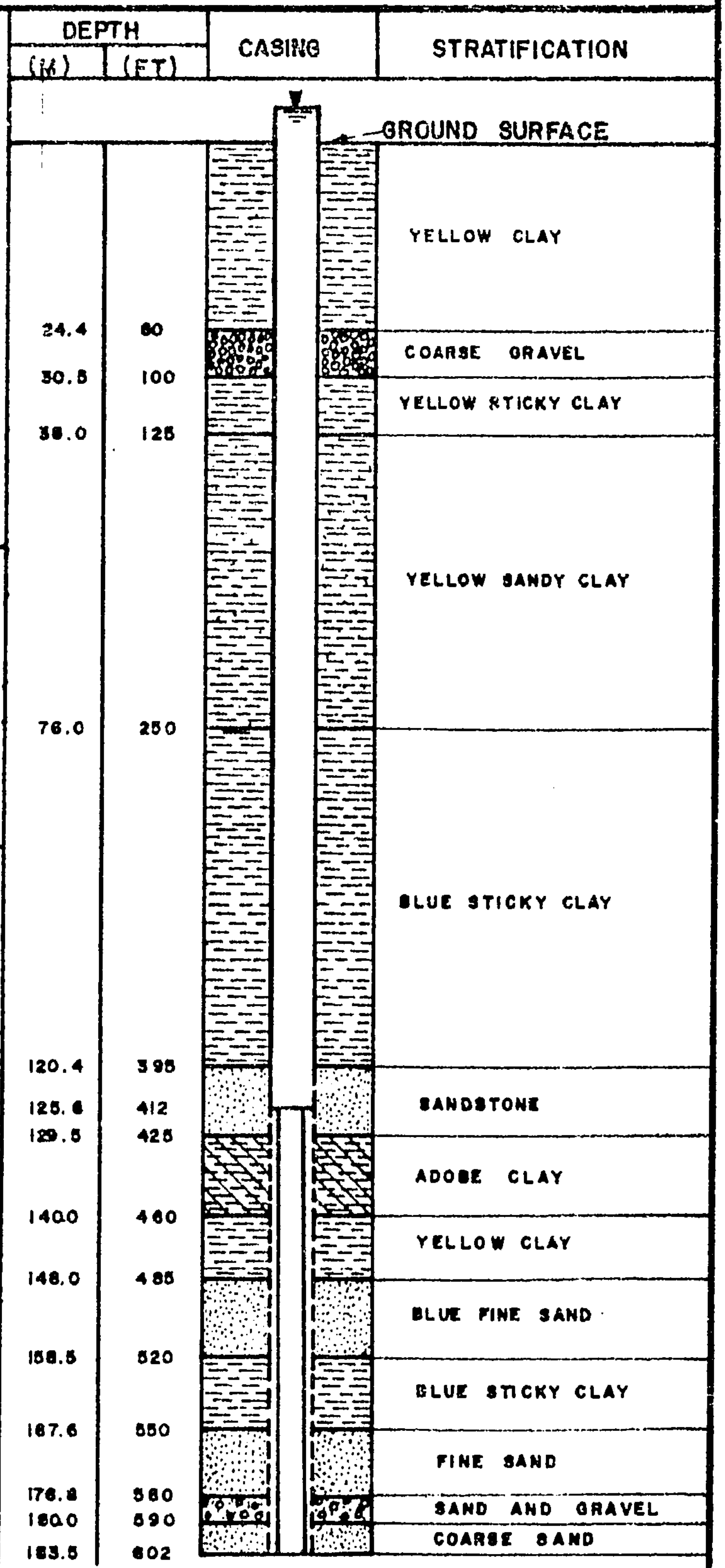
WELL NO. (CDM) 15
(OTHER) BPW NO. 7808
LOCATION BARRIO SAN LORENZO
CITY GAPAN
PROVINCE NUEVA ECIJA
CONST. BY BPW
DRILLER GASTON DE LOS PRIMOS
STARTED MAY 16, 1955
COMPLETED AUGUST 5, 1955
OWNER GAPAN WATER DISTRICT
STATUS SOURCE WELL
CASING 200 MM (8 IN.) - 0 TO 125.6 M
150 MM (6 IN.) - 125.6 TO 183.5 M

DRILLER'S TEST DATA:
DATE
STATIC WATER LEVEL + 1.22 M (4 FT.) ABOVE GROUND LEVEL
PUMPING WATER LEVEL -2.44 M (8 FT.)
TEST PUMP YIELD 80 GPM (5.04 LPS.)
SPECIFIC CAPACITY 1.38 LPS/M

REMARKS:

WELL WAS FREE - FLOWING AT 30 GPM (1.9 LPS)
SOLE SOURCE OF GAPAN WATER DISTRICT.

WATER QUALITY DATA:



ANNEX FIGURE VII-B-6
WELL DATA SHEET
WELL CDM-15

DESCRIPTIVE DATA

WELL NO. (CDM) 16
(OTHER) BPW NO. 7611
LOCATION HIGH SCHOOL COMPOUND
POBLACION
CITY GAPAN
PROVINCE NUEVA ECIJA
CONST. BY BPW
DRILLER GASTON DE LOS PRIMOS
STARTED SEPTEMBER 5, 1955
COMPLETED SEPTEMBER 16, 1955
OWNER
STATUS
CASING DIAMETER 150 MM (6 IN.)
CASING LENGTH 62.7 M (207 FT.)

DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL 3.3 M (10 FT.)
PUMPING WATER LEVEL 6.6 M (20 FT.)
BELOW GROUND LEVEL
TEST PUMP YIELD 20 GPM (1.26 LPS)
WATER BEARING STRATA 62.5 - 65.5 M
(205-215 FT.) DEEP.
SPECIFIC CAPACITY 0.42 LPS/M (2.0 GPM/FT.)

REMARKS:

WATER QUALITY DATA:

WATER, FRESH AND CLEAR

GRAPHIC LOG

DEPTH (M)	DEPTH (FT)	STRATIFICATION
		GROUND SURFACE
		YELLOW STICKY CLAY
4.6	15	BLUE STICKY CLAY
7.6	25	STICKY CLAY WITH GRAVEL
12.0	40	YELLOW STICKY CLAY
15.0	50	YELLOW STICKY CLAY WITH GRAVEL
24.0	80	YELLOW STICKY CLAY
62.5	205	SAND
65.5	215	

ANNEX FIGURE VII-B-7
WELL DATA SHEET
WELL CDM-6

DESCRIPTIVE DATA

WELL NO. (CDM) 22
(OTHER) BPW 15080
LOCATION BARRIO MALUPAN
CITY GAPAN
PROVINCE NUEVA ECIJA
CONST BY
DRILLER QUIRINO CRUZ
STARTED FEBRUARY 7, 1957
COMPLETED MARCH 21, 1957
OWNER
STATUS
CASING DIAMETER 112 MM (4 1/2 IN.)
CASING LENGTH 37.8 M (124 FT.)

DRILLER'S TEST DATA:

DATE
STATIC WATER LEVEL – 4.6 M (15 FT.)
PUMPING WATER LEVEL – 6.1 M (20 FT.)
TEST PUMP YIELD 20 GPM.(1.3 LPS)
SPECIFIC CAPACITY 0.8 LPS/M (4 GPM/FT.)

REMARKS:

WATER QUALITY DATA:

GRAPHIC LOG

DEPTH (M)	DEPTH (FT.)	STRATIFICATION
		GROUND SURFACE
		ADOBE CLAY
4.3	14	
		ADOBE
8.8	29	
		GRAVEL
13.1	43	
		HARD GRAVEL
14.9	49	
		HARD CLAY AND GRAVEL
18.0	59	
		HARD ADOBE
26.8	88	
		BLUE CLAY
34.7	114	
		ADOBE STONE
35.7	117	
		SAND AND GRAVEL
37.8	124	

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

ANNEX FIGURE VII-B-8
WELL DATA SHEET
WELL CDM-22

DESCRIPTIVE DATA	
WELL NO. (CDM)	GAPAN TEST WELL-NO.1
(OTHER)	
LOCATION	FREEDOM PARK
CITY	GAPAN
PROVINCE	NUEVA ECIJA
CONST. BY	KATWELL INC.
DRILLER	ELMER PAYNO
STARTED	NOVEMBER 22, 1976
COMPLETED	MARCH 26, 1977
OWNER	LWUA
STATUS	
CASING DIAMETER	250 MM
TOTAL DEPTH CASED	188 M
TOTAL SLOTTED CASING	66.5 M
GRAVEL SHROUDED	12.2 TO 190 M

DRILLER'S TEST DATA:

DATE	MARCH 22, 1977
STATIC WATER LEVEL	-3.68 M
PUMPING WATER LEVEL	-14.0 M
TEST PUMP YIELD	600 GPM (37.8 LPS)
SPECIFIC CAPACITY	3.7 LPS/M (17.7 GPM/FT)
TRANSMISSIVITY	440 CUMD/M

REMARKS:

SLOTTED SECTION LOCATIONS DETERMINED FROM ELECTRIC LOG
20 SETS (3 CENTRALIZERS/SET) OF CENTRALIZERS INSTALLED AT PERFORATED SECTIONS.

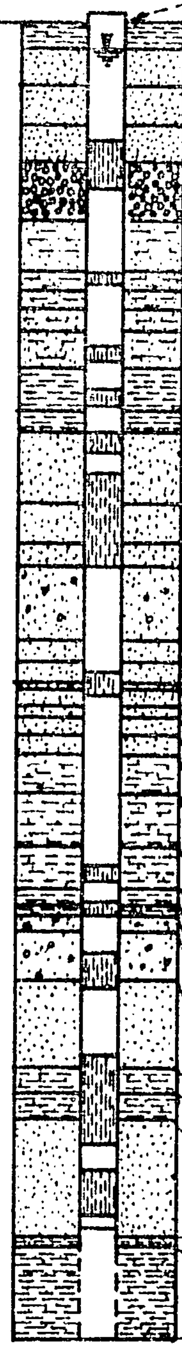
75 MM GRAVEL FILL PIPE PLACED DOWN TO 13.2 M. BELOW GROUND LEVEL

ARTIFICIALLY GRAVEL PACKED
BOTTOM OF CASING WELDED SHUT BEFORE INSTALLATION
12.2 M OF CEMENT SANITARY SEAL

WATER QUALITY DATA:

COND. 352 MICROMHOS/CM
pH 7.75

GRAPHIC LOG



DEPTH (M)	DEPTH (FT)
3.0	10
9.1	30
15.2	50
21.3	70
30.5	100
38.1	125
41.2	135
44.2	145
47.3	155
53.4	175
59.4	195
62.8	206
75.0	246
81.1	266
84.1	276
96.3	316
99.4	326
102.7	337
103.0	338
105.5	346
106.7	350
110.0	360
113.0	370
119.0	390
128.0	420
134.4	441
136.7	449
136.3	447
138.1	453
146.3	480
162.5	533
166.5	546
170.7	560
189.0	620
189.6	622
204.3	670

STRATIFICATION:

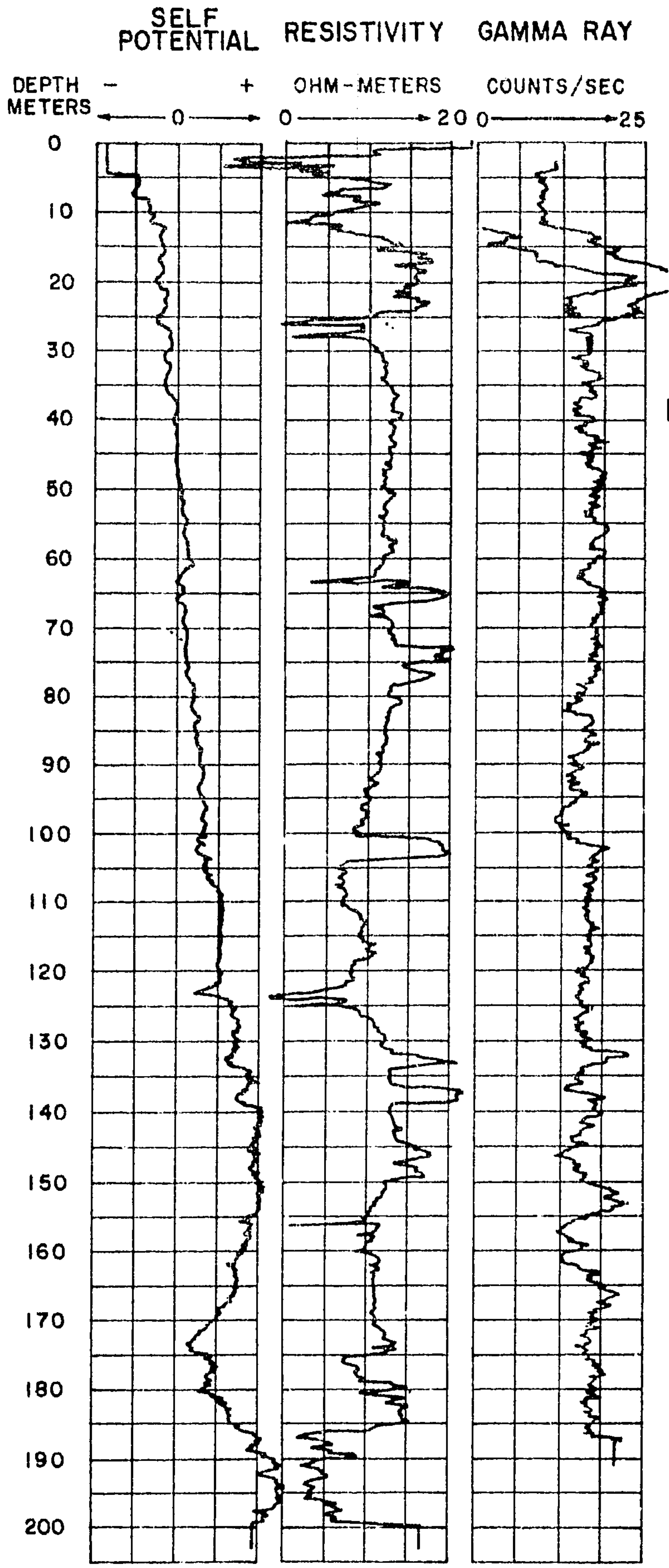
GROUND SURFACE
- BROWN CLAY (TOP SOIL)
- VERY FINE SAND, SUB-ROD
- FINE SAND, ANGULAR
- MEDIUM SAND, ANGULAR
- GRAVEL, ANGULAR
- SUB-ANGULAR, CLAYEY MEDIUM SAND
- SUB-ANGULAR, CLAYEY MEDIUM TO COARSE SAND
- ANGULAR, CLAYEY, FINE TO MEDIUM SAND
- SUB-ROUNDED, CLAYEY, FINE SAND
- SUB-ROUNDED, CLAYEY, FINE TO MEDIUM SAND
- CLAY
- SILT AND CLAY
- ANGULAR, COARSE SAND
- SUB-ANGULAR, COARSE SAND
- ANGULAR, COARSE SAND
- ANGULAR, COARSE SAND WITH SOME GRAVEL
- ANGULAR, COARSE SAND
- ANGULAR, VERY COARSE SAND
- SUB-ANGULAR, COARSE SAND WITH CLAY
- ANGULAR, VERY COARSE SAND
- ANGULAR, COARSE SAND WITH SHELLS
- ANGULAR, COARSE SAND WITH CLAY
- SUB-ANGULAR, COARSE SAND WITH CLAY
- SUB-ROUNDED, COARSE SAND WITH CLAY
- SUB-ANGULAR, COARSE SAND WITH MUCH CLAY
- CLAY WITH SUB-ANGULAR SAND
- CLAY
- SANDY CLAY
- VERY COARSE, ANGULAR SAND WITH GRAVEL
- COARSE, SUB-ANGULAR SAND WITH GRAVEL
- VERY COARSE, ANGULAR SAND
- CLAY WITH SUB-ANGULAR SAND
- ANGULAR, COARSE SAND WITH SOME CLAY
- VERY COARSE, ANGULAR SAND
- VERY COARSE SAND WITH CLAY
- SANDY CLAY

NOTE:
SANDS AND GRAVELS CONTAIN VERY LITTLE QUARTZ

MUCH OF THE SEDIMENTS ARE DERIVED FROM VOLCANICS

ELECTRIC LOG INDICATES ERRORS IN AND DOWNWARD DISPLACEMENT OF DRILLERS LOG

ANNEX FIGURE VII-B-9
WELL DATA SHEET
WELL CDM-1



NOTE:

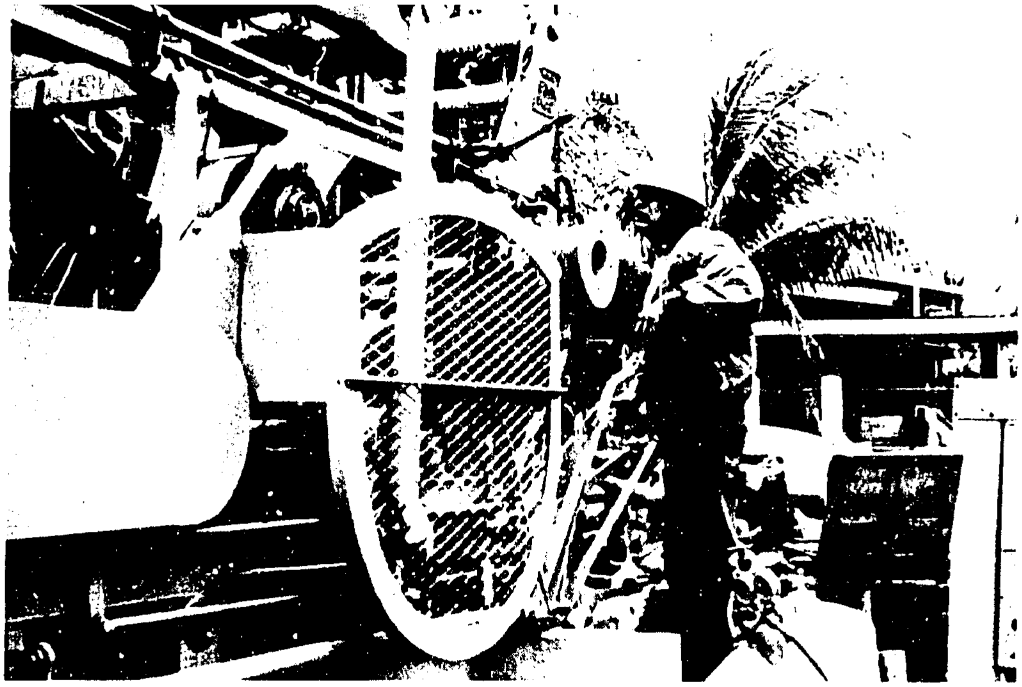
WIDCO 1200 LOGGER

SINGLE POINT RESISTIVITY

GAMMA RAY LOG:
TIME CONSTANT 10
RECOVERY SPEED 4 M/MIN.

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

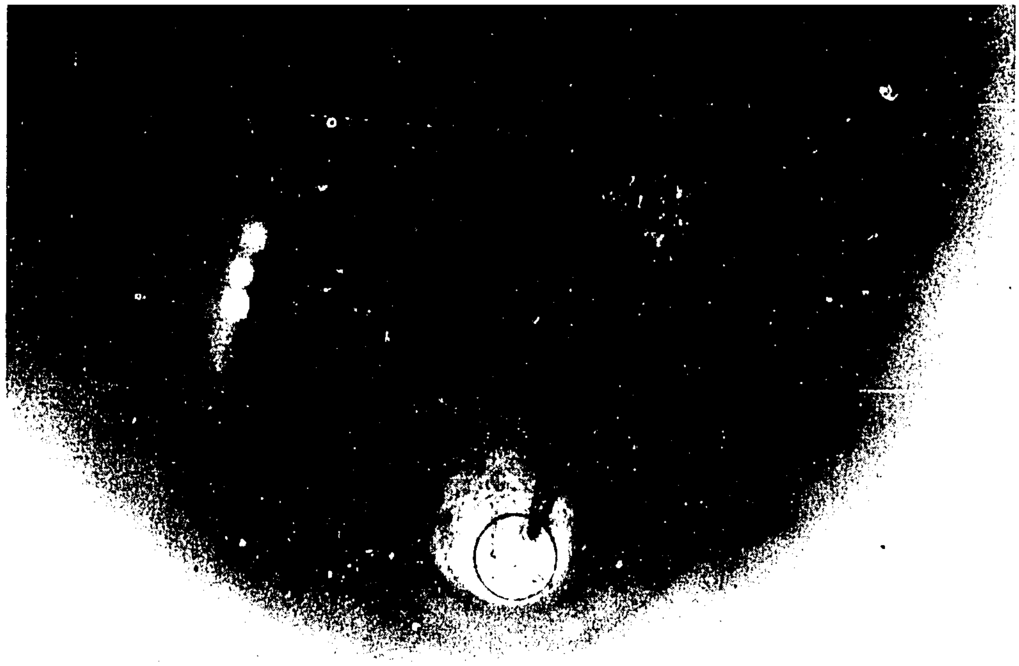
ANNEX FIGURE VII-B-10
ELECTRIC LOGS
GAPAN TEST WELL



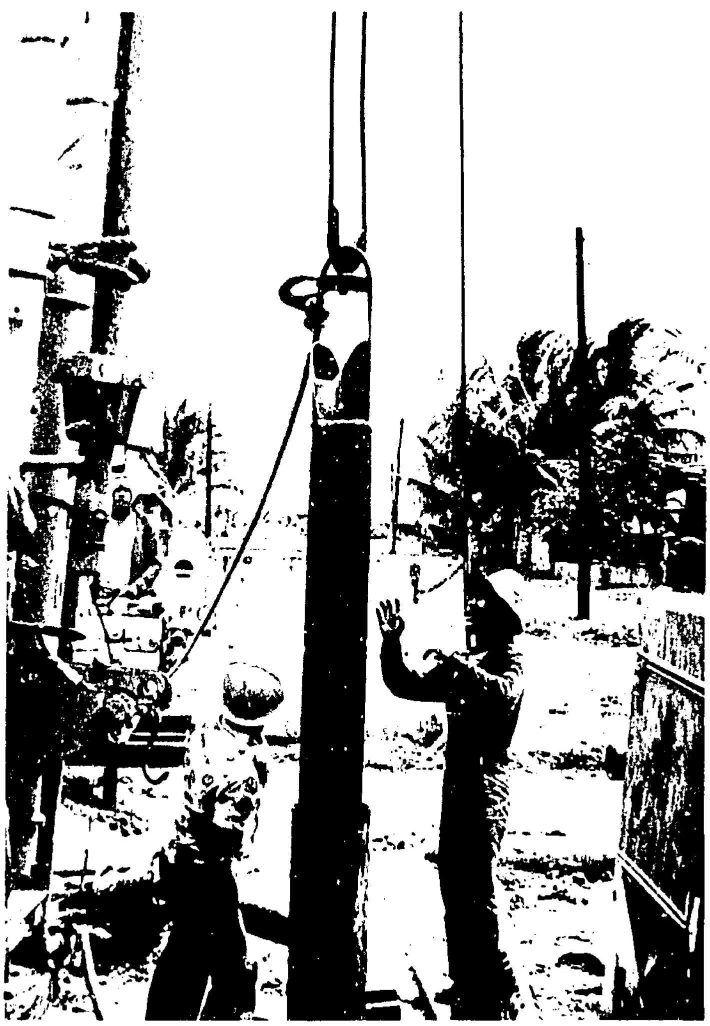
DRILLER AT RIG CONTROLS

WATER RISING OUT OF CASING
DURING SWABBING DEVELOPMENT

ANNEX FIGURE VII-B-11
DRILLING OPERATIONS
GAPAN TEST WELL



VIEW DOWN WELL CASING DURING DEVELOPMENT
NOTE SPIRAL WELDED CASING AND CABLE
(SUPPORTING BAILER) DISAPPEARING UNDER
WATER SURFACE 3 METERS DOWN.



SAND-PUMP-BAILER
COMING OUT OF HOLE.

ANNEX FIGURE VII-B-12
DRILLING OPERATIONS
GAPAN TEST WELL

ANNEX TABLE VII-B-2

PUMPING TEST - GAPAN TEST WELL

Data:
- Start Pumping: 22 Mar 1977, 4:00 p.m.
- Start Recovery: 24 Mar 1977, 4:00 p.m.
- Pumping Rate: 37.8 lps
- Original Static Water Level: 3.66 m

DRAWDOWN TEST

Pumping Time (min)	Water Level (m)	Drawdown (m)
0	3.66	0
1	8.56	4.90
2.5	8.78	5.12
3	9.00	5.34
4	9.14	5.48
5.5	9.31	5.65
6	9.27	5.61
7	9.41	5.75
8	9.56	5.90
9	9.63	5.97
10	9.67	6.01
11	9.72	6.06
12	9.83	6.17
13	9.92	6.26
14	9.82	6.16
15	9.77	6.11
16	9.87	6.21
17	9.89	6.23
18	9.89	6.23
19	9.92	6.26
20	10.06	6.40
22	10.06	6.40
24	10.13	6.47
26	10.21	6.55
28	10.26	6.60
30	10.26	6.60
32	10.34	6.68
34	10.35	6.69
36	10.33	6.67
38	10.40	6.74
40	10.41	6.75
45	10.45	6.79
50	10.58	6.92
55	10.63	6.97
60	10.65	6.99
70	10.73	7.07
80	10.83	7.17

ANNEX TABLE VII-B-2 (Continued)

Pumping Time (min)	Water Level (m)	Drawdown (m)
2640	14.03	10.37
2700	14.00	10.34
2760	14.06	10.40
2820	13.90	10.24
2880	13.88	10.22

RECOVERY TEST

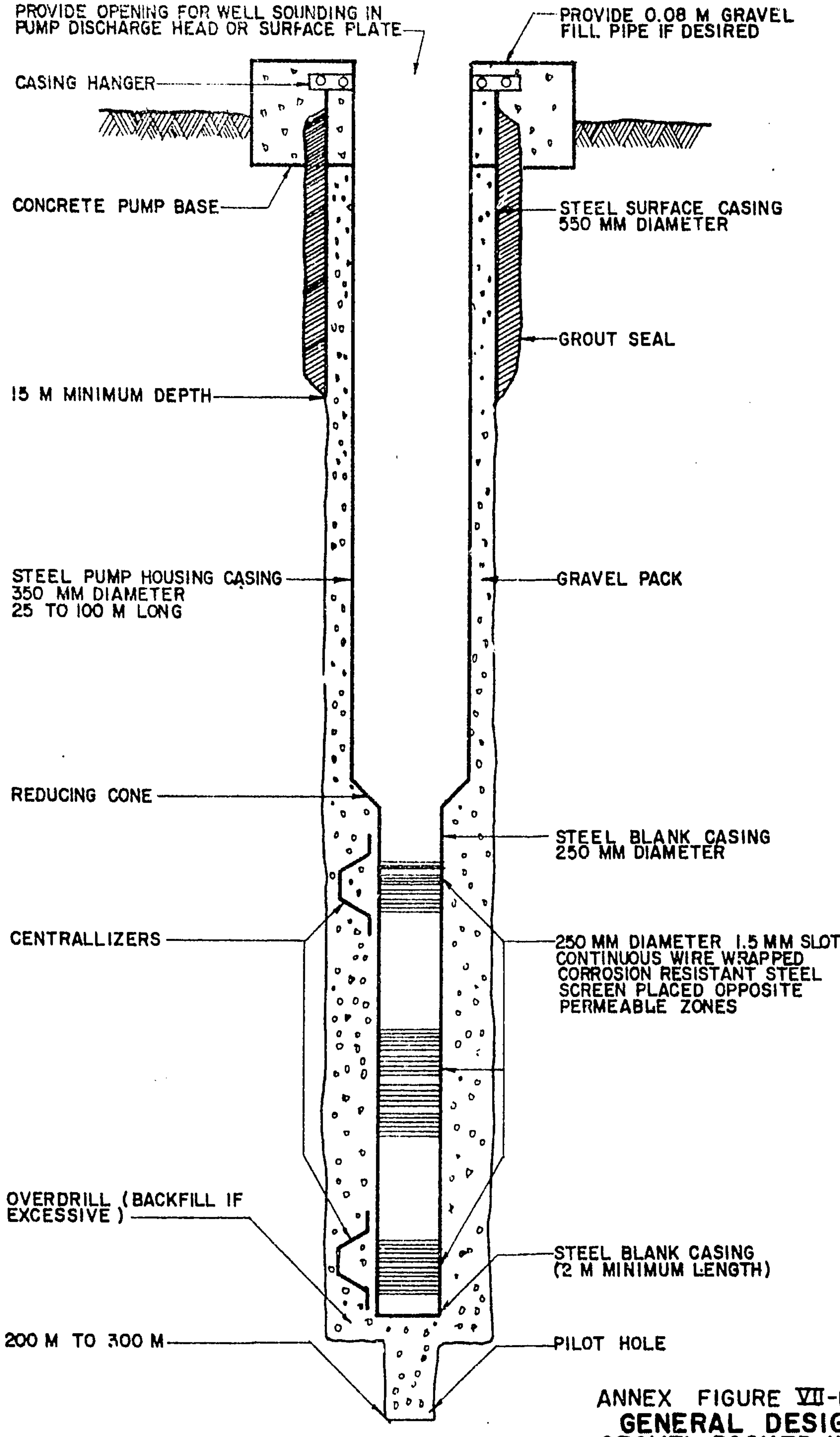
Time Since Pumping Started (t)	Time Since Start of Recovery (t')	Ratio t/t'	Water Level (m)	Residual Drawdown (m)
2880	0	00	13.88	10.22
2881	1	2881	7.72	4.06
2882	2	1441	7.56	3.90
2883.13	3.13	921.13	7.43	3.77
2884	4	721	7.15	3.49
2885	5	577	7.08	3.42
2886	6	481	6.94	3.28
2887	7	412.43	6.82	3.16
2888	8	361	6.76	3.10
2889	9	321	6.68	3.02
2890	10	289	6.63	2.97
2891	11	262.82	6.59	2.93
2892.3	12.3	235.15	6.52	2.86
2893	13	222.54	6.49	2.83
2894	14	206.71	6.41	2.75
2895	15	193	6.37	2.71
2896	16	181	6.34	2.68
2897	17	170.41	6.31	2.65
2898	18	161	6.28	2.62
2899	19	152.58	6.25	2.59
2900	20	145	6.22	2.56
2902	22	131.91	6.17	2.51
2904	24	121	6.12	2.46
2906	26	111.77	6.09	2.43
2908	28	103.86	6.05	2.39
2910	30	97	6.04	2.38
2912	32	91	6.01	2.35
2914	34	85.71	5.98	2.32
2916	36	81	5.96	2.30
2918	38	76.79	5.93	2.27
2920	40	73	5.91	2.25
2925	45	65	5.79	2.13
2930	50	58.6	5.78	2.12
2935	55	53.36	5.60	1.94
2940	60	49	5.58	1.92
2950	70	42.14	5.52	1.86

ANNEX TABLE VII-B-2 (Continued)

Pumping Time (min)	Water Level (m)	Drawdown (m)
90	10.95	7.29
100	10.96	7.30
110	11.00	7.34
120	11.22	7.56
150	11.41	7.75
180	11.56	7.90
240	11.84	8.18
300	11.95	8.29
360	12.06	8.40
420	12.12	8.46
480	12.19	8.53
540	12.33	8.67
600	12.46	8.80
660	12.55	8.89
720	12.60	8.94
780	12.71	9.05
840	12.80	9.14
900	12.84	9.18
960	12.84	9.18
1020	13.20	9.54
1080	13.26	9.60
1140	13.32	9.66
1200	13.36	9.70
1260	13.46	9.80
1320	13.49	9.83
1380	13.47	9.81
1440	13.53	9.87
1500	13.54	9.88
1560	13.52	9.86
1620	13.60	9.94
1680	13.58	9.92
1740	13.58	9.92
1800	13.60	9.94
1860	13.60	9.94
1920	13.65	9.99
1980	13.64	9.98
2040	13.60	9.94
2100	13.61	9.95
2160	13.60	9.94
2220	13.56	9.90
2280	13.56	9.90
2340	13.58	9.92
2400	13.94	10.28
2460	13.96	10.30
2520	13.98	10.32
2580	14.07	10.41

ANNEX TABLE VII-B-2 (Continued)

Time Since Pumping Started (t)	Time Since Start of Recovery (t')	Ratio t/t'	Water Level (m)	Residual Drawdown (m)
2960	80	37	5.44	1.78
2970	90	33	5.39	1.73
2980	100	29.8	5.35	1.69
2990	110	27.18	5.29	1.63
3000	120	25	5.21	1.55
3030	150	20.2	5.13	1.47
3060	180	17	5.07	1.41
3120	240	13	4.90	1.24
3180	300	10.6	4.79	1.13
3240	360	9	4.65	0.99
3300	420	7.86	4.57	0.91
3360	480	7	4.48	0.82
3420	540	6.33	4.41	0.75
3480	600	5.8	4.35	0.69
3540	660	5.36	4.27	0.61
3600	720	5	4.22	0.56
3660	780	4.69	4.21	0.55
3720	840	4.43	4.20	0.54
3780	900	4.2	4.19	0.53
3840	960	4	4.13	0.47
3900	1020	3.82	4.19	0.53
3960	1080	3.67	4.15	0.49
4020	1140	3.53	4.10	0.44
4080	1200	3.4	4.13	0.47
4140	1260	3.29	4.12	0.46
4200	1320	3.18	4.05	0.39
4260	1380	3.09	4.02	0.36
4320	1440	3	3.98	0.32
4380	1500	2.92	3.98	0.32



ANNEX FIGURE VII-B-13

GENERAL DESIGN GRAVEL PACKED WELL ROTARY DRILLED

GAPAN WATER DISTRICT

SUPPLEMENT TO FIGURE VII-B-13

GENERAL CONSTRUCTION SUGGESTIONS

Gravel Packed Well - Rotary Drilled

1. Drill oversized hole to 15-meter minimum depth (more if condition condition require), set and grout 550 mm surface casing.

2. Drill small diameter pilot hole inside surface casing to 200 or 300 meters (or less if in an area where saline groundwater at depth is anticipated).

3. Run electric log.

4. Examine samples and electric log to locate suitable permeable zones. Abandon site if sufficient permeable material is not found.

5. Ream pilot hole diameter to largest diameter that can be drilled inside the surface casing to a depth about five meters below the lowest permeable zone.

6. Install string of casing and screen with screen opposite all permeable zones. Pump housing casing to be 25-meter minimum length, maximum length dependent on depth of upper screened zone and anticipated maximum water levels during life of well.

7. Place gravel.

8. Clean and develop well thoroughly.

9. Test well.

10. Design pump.

11. Construct well head facilities.

12. Install pump.

CHAPTER VIII ANALYSIS AND EVALUATION OF ALTERNATIVES

A. GENERAL

The alternatives available for source development, treatment facilities, transmission, distribution system and storage to meet peak-hour demands are identified and evaluated in this chapter. Other water conservation and augmentation alternatives are also discussed.

B. WATER SUPPLY SOURCE ALTERNATIVES

Surface Water Sources

The Peñaranda River flows along the northern boundary of Gapan poblacion and the present water service area. The river has been dammed at Peñaranda about 10 km upstream from Gapan by the National Irrigation Administration (NIA). During the dry season, the NIA takes practically the entire flow of this river for irrigation purposes. The Peñaranda River therefore could not provide water to Gapan unless a dam and reservoir was constructed to provide storage of wet season flow for dry season use. Construction of such a dam and reservoir on the Peñaranda is impractical as it would flood much valuable land. The Peñaranda River therefore is not a practical source for water supply for Gapan.

The Pampanga River, about 6 km from the Gapan poblacion, is a large river. Near Gapan, at Barrio San Antonio, the Pampanga River is expected to have a minimum flow of about 675,000 cumd once in 10 years and the minimum recorded low flow was 640,000 cumd. A small diversion dam across the Pampanga River would provide adequate water for Gapan, after treatment, even for year 2000 needs.

Ground Water

The GAP-WD has been using ground water from a well in the service area since 1933. It is believed that Gapan is underlain by a good artesian aquifer, and that high-capacity wells (5,450 cumd each) can be constructed in the service area. Wells in the service area are considered a feasible source of water for Gapan and may be the most economic source.

The sands along the Pampanga River appear, in certain places, capable of supplying water to river bank wells. As the Pampanga River has considerable flow throughout the year, such wells should also certainly have good yield throughout the years as they can induce infiltration from the river. An apparently suitable location for induced infiltration wells beside the Pampanga River has been found about 6 km from Gapan.

Two ground water sources may therefore be considered as possible sources of water for Gapan - deep wells in the service area, and river bank induced infiltration wells along the Pampanga River located 6 km from Gapan.

No large capacity springs are known to exist in the vicintiy of Gapan.

Source and Transmission Analysis

The discussion above indicates 3 sources capable of supplying water to the GAP-WD: surface water from the Pampanga River; induced infiltration wells beside the Pampanga River; and wells in the service area.

Supplying water to Gapan from the surface water in the Pampanga River would require construction of a diversion dam and river water pumping station, water treatment works and treated water pumping station, and a transmission main to the city. It would also require continuous operation of treatment works and two pumping stations. Supplying water through this process would certainly cost more than supplying the same quality water from induced infiltration wells on the banks of the same river, as treatment and double pumping would not be needed for the well water. Accordingly the use of surface water has not been considered further in this analysis of alternatives.

Comparative present worth costs have been developed for the 2 alternative sources suitable for Gapan - wells in the service area, and induced infiltration wells beside the Pampanga River 6 km from Gapan. Under the alternative using wells in the service area, it has been assumed: (1) that wells will each be 200 meters deep, will have a 300 mm pump casing and 200 mm screen; (2) that one well will be capable of providing 5,450 cumd with a pumping level of 28 meters below ground, but that most wells will provide 2,700 cumd with pumping level of 15 meters below ground level; and (3) that the wells will be at least 1,000 meters apart. The cost comparison is based on a large number of wells with lesser capacity as contrasted to a few wells with higher capacity, as using fewer wells would increase the cost of the distribution system. Under the alternative using induced infiltration wells beside the Pampanga River, it has been assumed that these wells: (1) will be 40 meters deep; (2) will have 300 mm pump housing pipe and 200 mm screens; (3) will each provide 5,450 cumd with pumping water level of 28 meters below ground level; and (4) will be 500 meters apart. Transmission mains will be constructed from the wells to the poblacion through San Isidro and will be staged so that a new pipeline would not have to be built with every additional well.

The comparative 1978 present worth costs of these 2 alternatives are presented in Table VIII-1. The comparison shows that supply from wells in the service area will be cheaper by approximately 4.4 million pesos based on costs through the year 2000.

C. TREATMENT ALTERNATIVES

Water quality test results for the existing GAF-WD production well, 4 other wells in Barrios near the Gapan poblacion are shown in Table IV-1, and the Peñaranda and Minalungao Rivers in Table VII-4.

Analysis of samples from the GAF-WD production well and three other barrio wells shows that all chemical constituents are within the acceptable limits of the Philippine National Standards for Drinking Water.

The well in Barrio Malimba has a 0.25 mg/l manganese content exceeding the permissible limit of 0.1 mg/l. The Peñaranda and a tributary, the Sumacbao River, have a manganese content of 0.2 mg/l and 0.45 mg/l, respectively, which also exceed the permissible limit for manganese. In concentrations not causing unpleasant tastes, manganese is regarded to be of no toxicological significance in drinking water.

Water samples from the Gapan test well indicated that there was excessive turbidity, color and iron (Table VII- 4) in that well. As discussed in Chapter VII, the turbidity and color may be due to incomplete well development and the iron may be due to incomplete well development or poor quality water from a single screened section which might be sealed.

Water from wells within the GAF-WD (the most economical alternative), if designed and constructed with proper safeguards, would probably not require any treatment. However, in order to preserve the good quality of water throughout the distribution system, disinfection would be necessary at the sources. Disinfection may be accomplished with various methods which are discussed in Appendix J, Volume II. For economic and practical reasons (ready availability of the equipment, easy supply and application, and lasting effectiveness), chlorination is the recommended process for disinfection.

D. DISTRIBUTION ALTERNATIVES

General

The distribution alternatives considered for the GAF-WD are presented in this section. The recommended improvement program for the water system is discussed in Chapter IX.

TABLE VIII-1

COMPARATIVE PRESENT WORTH COSTS OF ADDITIONAL SUPPLY ALTERNATIVES[1]

	Construction Cost (₱ x 1000)	Present Worth Cost[2] (₱ x 1000)
Wells in Service Area		
Wells and Pumphouses	₱ 7,410	₱ 1,581
Distribution Pipelines[3]	-	-
Transmission Pipelines	-	-
Operation and Maintenance	-	1,431
Total Present Worth Cost		₱ 3,012
Induced Infiltration Wells on Pampanga River		
Wells and Pumphouses	₱ 2,206	₱ 510
Distribution Pipelines[3]	1,436	794
Transmission Pipelines	12,120	3,408
Operation and Maintenance	-	2,657
Total Present Worth Cost		₱ 7,369

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 much smaller and the parameters presented in Appendices F and K must be applied with discretion.

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

2/Includes salvage values and replacement costs.

3/Cost for distribution pipelines only includes those costs in excess of distribution costs of other alternatives.

Particular attention has been given to the requirements of fire flow in the GAP-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 central 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 some fire protection should be provided. In this study, information is given 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 for the GAP-WD are as follows (see Water Demand Projections, Chapter VI):

	1980	1990	2000
Water Demand, lpcd	178	174	181
Served Population	12,880	38,300	91,900
Average Daily Water Demand, cumd	2,290	6,660	16,630
Maximum-Day Water Demand, cumd	2,750	7,990	19,960
Peak-Hour Water Demand, cumd	4,010	11,660	29,110

Pressure Zones

The ground elevation within the future service area of the GAP-WD through the year 2000 varies from a low of 13 meters in Barrio San Roque to a high of 22 meters in Barrio Santa Cruz. The larger portion of the service area including the poblacion is situated at an elevation of 18 meters. The system can be operated adequately at a HGL of 45 meters at the existing storage tank; therefore only a single pressure zone has been considered for the GAP-WD.

Storage Facilities

Storage facilities are provided in a distribution system to meet hourly fluctuations in demand over the day. The usual requirement for operational storage is 15-20 percent of the maximum-day volume, assuming the source of supply is capable of providing water at a rate equal to maximum-day demand.

In the flat areas of Central Luzon, storage is usually provided by means of an elevated storage tank. This type of tank is very costly in the Philippines because it must be designed to withstand high seismic loadings. An alternative method of meeting demand fluctuations has been investigated for Gapan.

As previously discussed the least-cost source alternative for Gapan is pumped groundwater. It is possible to install additional pumping capacity above the maximum-day demand rate in order to meet part of the peak-hour fluctuations and thereby reduce the amount of storage required. The rationale for providing additional pumping capacity and a curve to be used in estimating the required storage volume based on various supply rates is presented in Methodology Memorandum No. 5. An economic analysis comparing the costs of providing additional supply or storage for Gapan is presented in Table VIII-2.

Table VIII-2 shows that, in Gapan, providing additional pumping capacity to meet hourly fluctuations in demand would be less costly than providing extra storage volume. It is recommended that additional pumping capacity be provided in GAP-WD and the volume of storage be minimized.

Distribution System

The analysis for the distribution system of Gapan generally followed the guidelines given in Appendices F and K. Unlike the First Ten Areas Feasibility Studies, computer analysis for the Second Ten Provincial Urban Areas considered pipelines smaller than 200 mm in diameter. Gapan has very few pipelines greater than 200 mm even in the year 2000.

The distribution analysis did not include studies of various alternative pipeline configurations because the location of pipes is controlled by the location of roadways and the barrios to be served. However, the analysis included alternative locations of sources of supply.

The location of the well supplies is partially controlled by the distance between wells to minimize drawdown interference. Another criterion for well location is the location of the centers of demand. Generally it is cost effective to locate wells near centers of demand to reduce pipeline sizes in other parts of the distribution system. In locating wells at centers of demand, the capacity of the wells must be considered. Hydraulically, the most efficient well capacity would be equal to the water demand in the area of the well. However, it would be more practical to have wells of about the same capacity for easier operation and control of the pumping rate as demand fluctuates.

TABLE VIII-2

ALTERNATIVE STORAGE VERSUS ADDITIONAL SUPPLY ANALYSIS[4]

	Alternative 1 (Maximum Storage)	Alternative 2 (Intermediate Storage)	Alternative 3 (Minimum Storage)
Storage Required (Percent)[5]	12.9	3.9	1.9
(Volume, cum)	2,575	780	380
Present Worth Cost (₱ x 1000)			
Storage[6]	₱1,510	₱ 310	₱ -
Wells	910	1,250	1,410
Operation and Maintenance	150	210	230
Total	₱2,570	₱1,770	₱1,640

It appears that the maximum well capacity in Gapan would be about 63 lps (1,000 gpm). If wells of this capacity were constructed, relatively few wells would be required. Having few large-capacity wells presents two problems. The first is that the overall cost of pipelines would increase as larger sizes would be needed to supply water to remote parts of the system. The second problem is that, with relatively few large-capacity wells, flow rates could only be changed in large increments of flow. During periods of low demand the large pumps would have short cycling time. A more efficient method of operation is to have smaller-capacity wells so that the operator can control the flow to closely match the changes in demand.

Two alternatives were analyzed to determine the most economical capacity of wells for the design year 1990. Alternative 1 consists of 2 wells in the system, each of 63 lps (1,000 gpm) capacity. The first well would be constructed in 1979 as part of the immediate improvement program on Don Simeon Street near Freedom Park and the second well would be constructed in 1983 at the site of the existing well on Bonifacio Street. Alternative 2 consists of constructing a 63 lps (1,000 gpm) well on Don Simeon Street near Freedom Park; a 31.5 lps (500 gpm) well on Camino Street in Barrio San Nicolas in 1983; and a second 31.5 lps well at the existing well site on Bonifacio Street in 1987.

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[4] Analysis includes all facilities to the year 2000
[5] Percentage of maximum-day demand
[6] Only includes additional storage to existing 380 cm storage tank.

The computer distribution analysis was used to determine the size of the pipelines required for both alternatives. The capacitites of the 2 alternatives for peak-hour and fire flow conditions were matched as closely as possible so that a direct cost comparision would be valid.

Table VIII-3 shows the results of the present worth analysis comparing the pipeline costs and the total well costs. The analysis indicates that it is more cost effective to construct 3 wells located near the demand centers. Alternative 1 requires an additional ₱220,000 in pipeline construction costs, and is about 14 percent costlier than alternative 2. Given that the cost estimates are probably accurate only within 10 percent, the actual difference appears quite small in view of the entire project cost. However, even if the alternatives are essentially equal in costs, alternative 2 would still be more favorable because of operational advantages discussed previously.

The present worth analysis will serve as a basis for designing the year 2000 system with wells located as closely as possible to the demand centers.

Fire Protection

Fire protection does not exist in most sections of Gapan because there is little or no water pressure most of the day. In order to provide fire protection,there must be adequate pressure in all water pipelines 24 hours per day.

The alternatives considered for fire protection in Gapan took the consumers' "ability-to-pay" into account. The guidelines for system design in Appendices F and K were violated in some cases to mitigate the financial impact on consumers.

The immediate improvements program (1978-1979), which is aimed at providing adequate domestic service to existing consumers and increasing the number of consumers to provide a larger financial base to pay for future improvements, does not include full fire protection. If the program were designed to provide full fire protection to the consumers, the cost of the improvements required would become too high for the program to be feasible.

The distribution improvements recommended under the immediate improvement program, including the existing facilities, would be capable of providing about 50 percent of the required fire flow to most sections of Gapan, provided adequate supply and 24-hour operation were achieved. Some of the existing hydrants would require rehabilitation to provide partial fire protection.

TABLE VIII-3

PRESENT WORTH COMPARISON OF WELL SIZE AND LOCATION ALTERNATIVES[7]

	Present Worth
Alternative 1 (2 Wells)	
Well No. 1	₱ 960,000
Well No. 2	660,000
Pipelines constructed in 1980	10,000
Pipelines constructed in 1985	140,000
Pipelines constructed in 1990	10,000
Total	₱1,780,000
Alternative 2 (3 Wells)	
Well No. 1	₱ 960,000
Well No. 2	380,000
Well No. 3	220,000
Total	₱1,560,000

For design year 1990, the distribution improvements would be able to provide about 70 to 100 percent fire protection although full protection is not the goal for 1990. The 1990 improvements are designed to provide adequate average-day service under a number of operating configurations as described in the section on System Operation and consequently some pipelines were increased in size. The capacity for fire protection would increase due to changes required for operational considerations. Full fire protection is provided for in the year 2000 improvements.

The preceding discussion of fire protection relates only to the capacities of the distribution mains. In providing fire protection, an adequate number of fire hydrants also has to be considered for the various service areas. 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 in Gapan.

As outlined in Appendix K, fire protection is classified into two types - one for the high-value residential, commercial and industrial areas; and another for the single-family residential areas. In the high-value residential, commercial and industrial areas, an available

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[7] Includes replacement of mechanical equipment in 15 years and salvage value of all items at the end of 20 years.

fire flow of 20 lps at 2 adjacent fire hydrants should be provided; in the single-family residential areas, only 10 lps at 2 adjacent hydrants should be provided. The quoted percentages of fire protection for the design years 1980, 1990 and 2000 are based on the required flows for these two types of fire protection. Figure VIII-1 shows the outline of the fire service areas in Gapan.

System Operation

This section includes various operational aspects of the alternative distribution systems. While there are no different distribution alternatives for Gapan, there are alternative source locations and source capacities which could present definite operational problems.

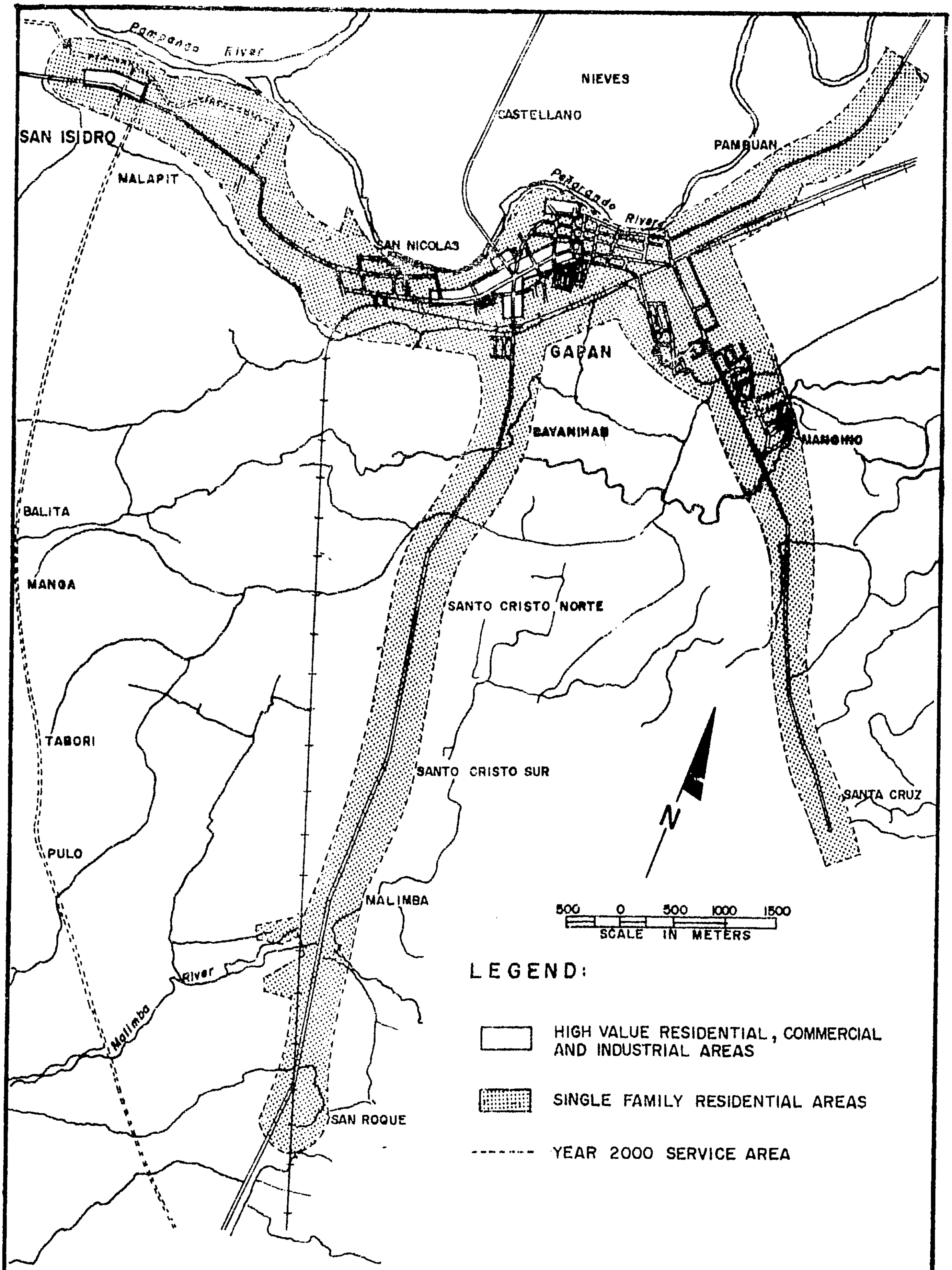
As previously discussed, the location and capacity of the wells can affect the operation of the system with regard to meeting demands and pressure requirements. Computer analyses were conducted on several combinations of demands and number of operating wells. In the analyses, only operating problems, that commonly occur such as one well being out of service or an error in judgment as to which wells should be operating, were considered while maintaining minimum pressures at average-day demand rates.

Unusual operating conditions, such as meeting maximum or peak demands at minimum pressures when 2 or more wells are not in operation, were not considered. The cost of providing adequate service under all possible operational conditions would be prohibitive so that only those operating conditions that would reasonably occur were analyzed.

The principal operating problem investigated in Gapan was when one well along one of the long extensions of the distribution system, radiating from its central section, has become inoperable. This may occur if one well breaks down or if a well is out of service for routine maintenance. Under this condition, the distribution system is assumed to have been designed to meet average-day demands at minimum pressures. It would be possible to meet peak-hour conditions with larger pipelines but the additional cost could not be justified for the limited periods when this condition might exist.

As a general rule, the distribution system should be operated by utilizing as many wells as possible outside the poblacion to meet water demands. This operational procedure has the effect of maintaining a high HGL in the outlying areas, while the storage tank maintains an adequate gradeline within the poblacion.

Besides problems of pressure in the system due to well operation, the schedule of operation has also to be considered. The pump operation schedule is based on the water level within the tank and pressures in various sections of the system. If the tank level drops, a suffi-



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

FIGURE VIII-1
FIRE PROTECTION AREAS
GAPAN WATER DISTRICT

cient number of wells would have to be operated to refill the tank. However, the major problem in this operation schedule is the time available to control the number of wells in operation as the water level and pressure fluctuate. In the year 2000, for instance, the recommended volume of storage (500 cum) would provide the operator about an hour to change the number of wells operating. This estimate is based on the assumption that the tank is one-half empty and that there is an excess supply rate of 63.0 lps.

As experience is gained in the operation of wells, a schedule of operation based on normal demand variations may be devised. If a satisfactory schedule is devised, the system may go unattended for several hours.

Internal Network

A general but complete discussion of the internal network for distribution system is included in Appendix K. The small size of the GAP-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 would 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 VIII-B-1

COMPARATIVE PRESENT WORTH COST OF SUPPLY FROM WELLS IN SOURCE AREA[1]

Item	Date Constructed	Construction Cost (₱ x 1000)	Present Worth Cost ₱ x 1000 (Less Year 2000 Salvage Value)
Well and Pump House	1979	730	645
Well and Pump House	1984	658	323
Well and Pump House	1988	658	190
Well and Pump House	1990	658	142
Well and Pump House	1992	658	102
Well and Pump House	1994	658	69
Replace Pump and Motor	1994	100	11
Well and Pump House	1996	658	41
Well and Pump House	1997	658	30
Well and Pump House	1998	658	19
Well and Pump House	1999	658	9
Well and Pump House	2000	658	-
Operation and Maintenance Costs	(1978-2000)	-	1,431
		₱7,410	
Total 1978 Present Worth Costs (₱ x 1000)			3,012

[1]Economic life taken as:

Well and Pumphouse - 25 Years

Replace Pump and Motor - 15 Years

For the remaining items, refer to Appendix F, Volume II.

ANNEX VIII-B-2

COMPARATIVE PRESENT WORTH COST OF SUPPLY FROM INDUCED INFILTRATION WELLS ALONG PAMPANGA RIVER[2/]

Item	Date Constructed	Construction Cost (₱ x 1000)	Present Worth Cost ₱ x 1000 (Less Year 2000 Salvage Value)
Well and Pump House	1979	730	645
Transmission Main	1979	3,200	2,700
Well and Pump House	1988	351	101
Transmission Main	1988	320	83
Well and Pump House	1992	351	54
Transmission Main	1992	3,700	504
Replace Pump and Motor	1994	100	11
Well and Pump House	1996	351	22
Transmission Main	1996	320	17
Well and Pump House	1998	351	10
Transmission Main	1998	4,260	104
Well and Pump House	2000	351	-
Transmission Main	2000	320	-
Operation and Maintenance Costs	(1978-2000)	-	2,657
Distribution Pipelines		1,436	794
Total 1978 Present Worth Cost (₱ x 1000)			₱7,369

2/ Economic life taken as:

Well and Pumphouse - 25 Years

Transmission and Distribution Pipelines - 50 Years

For the remaining items, refer to Appendix F, Volume II.

CHAPTER IX DESCRIPTION AND COST OF THE RECOMMENDED PLAN

A. GENERAL

The immediate improvement program, and the first and second stages of the long-term construction program are described in this chapter. In addition, the capital and operation and maintenance costs of the recommended program, concepts concerning sewerage and drainage, comments regarding the management of water resources and a statement regarding the environmental impact of this project are included. Appendices F, G, N and O, Volume II contain discussions of Design Criteria, Basis of Cost Estimates, Construction Methods and Materials, and Outline Specifications, respectively. The recommended construction program consists of the following five implementation steps:

1. Immediate Improvement Program (1978-79)
2. Stage I Phase A of the Long-Term Construction Program (1980-85)
3. Stage I Phase B of the Long-Term Construction Program (1986-90)
4. Stage II Phase A of the Long-Term Construction Program (1991-95)
5. Stage II Phase B of the Long-Term Construction Program (1996-2000)

Source

The current source of water supply to Gapan is a well located at the eastern extremity of Bonifacio Street, where it approaches the abandoned PNR Railway line. Because of the age (constructed in 1956) and poor productivity of this well, additional wells will be required to meet the projected demands of the GAP-WD by 1980. A test well was drilled near Don Simeon Street south of the public market, as part of the field work required for this study. During the immediate improvement program, this test well will be completed and furnished with pumping equipment, and a second production well will be constructed along the San Isidro Road in Barrio San Nicolas. Additional wells will be constructed in Phases I-A (one), I-B (one), II-A (two) and II-B (two). By year 2000, a total of 8 wells will have been constructed

Storage

At present, Gapan has a 380-cum storage tank located near the intersection of Tinio and Malgapo Streets. This reinforced concrete elevated tank was constructed in 1932. In Chapter VIII, the required volume of storage was studied. It was determined that the existing storage facilities would be adequate until 1996. Based on a well supply of 1.5 times the maximum-day demand, a total volume of storage equal to 500 cum is required by the year 2000.

The additional 120 cum of elevated storage will be provided in 1996 at the site of the test well and its cost has been included in this feasibility study. However, a 120-cum storage tank is only adequate for 4 years which is too short a design period for the proposed storage tank. It is recommended that the storage requirements beyond the year 2000 be investigated prior to construction of the tank.

Distribution System

The existing distribution system of GAP-WD serves the poblacion of Gapan and the barrios of San Nicolas, Sto. Niño, Mangino and Pambuan. The majority of the pipelines were constructed in 1932-34.

The existing distribution system will be expanded to serve the barrios of Bayanihan and Sto. Cristo Norte by 1990 and the barrios of Sto. Cristo Sur, Malimba, San Roque, Sta. Cruz, Malapit and the poblacion of San Isidro by the year 2000.

A total of 29 km of pipelines with sizes ranging from 100 to 300 mm will be constructed by 1990, including 12 km of pipelines to replace the existing mains that are undersized and in poor condition. An additional 18 km of 200 mm pipeline will be constructed between 1990 and 2000. This does not include new internal network pipelines to be installed in newly served areas.

Figure IX-1 (Appended) shows the overall recommended construction program by phases.

Administrative and Other Service Facilities

In addition to the source, storage and distribution facilities required for the production and transportation of water to consumers, it will be necessary to provide facilities to improve administrative, operation, maintenance and quality control capabilities within the water district. Administration and shop buildings will be constructed during the immediate improvement program. Water meter repair and laboratory facilities, which are required for effective operation of water supply facilities, will not be constructed in Gapan. It is recommended that the laboratory and meter repair facilities of nearby larger water districts (such as Tarlac or San Fernando, Pampanga) be constructed with adequate capacity to serve the needs of adjacent smaller water districts such as the GAP-WD.

Design Considerations

The recommended program of pipe construction presented in this chapter reflects the results of successive computer analyses on the GAP-WD distribution system. The general design criteria and method of analysis are discussed in Appendix K, Volume II, and Chapter XII, Methodology Manual.

The method of selecting pipeline sizes consists of analyzing a number of flow requirements and operating conditions, and designing each pipe for the worst set of conditions. Since each computer analysis is critical to a different series of pipes, there is no single program result that can be included herein as a "design run."

The computer printouts for the peak-hour and minimum-hour conditions are included in Annex IX-C as representative of the worst conditions for pipe design. The peak-hour condition can, in general, be considered as the "design run" for the majority of pipes. However, certain variations in operational modes, especially in systems with well supplies, can be more critical for some pipelines.

During final design of the recommended facilities, it is imperative that the design engineer re-run the computer program to determine the critical condition for each pipeline to be designed. It is also important to revise the program during each design phase to take into account the actual system conditions. It is recommended that a new series of hydraulic studies be conducted on the distribution system after some improvements are completed and the system operates with adequate pressures for 24 hours a day. The results of the new studies can be incorporated into any future designs. Other considerations in updating this report are discussed in Appendix Q, Volume II.

In some cases, facilities in the last phases of construction are only designed for a short term to the year 2000. These facilities are included in the cost analysis to determine their economic impact on the feasibility study. However, from a technical point of view, these short-term facilities may not be the most practical or economical to construct. During the design of the last phases of the recommended construction program, the design engineers should study alternatives beyond the year 2000 and design facilities accordingly.

B. IMMEDIATE IMPROVEMENT PROGRAM

While the findings and recommendations of this report are being reviewed, pending their approval by the GAP-WD, LWUA and financial agencies, certain steps may be taken to facilitate immediate improvements in the GAP-WD water supply system. These "high-impact" improvements will provide improved service to existing consumers and provide additional service to a limited number of new connections to the system, before implementation of the initial phase of the long-term construction program.

At present, about 13 percent of the service area population is actually served by the GAP-WD system. By 1980, the total population served within the 1980 service area boundary will be about 41 percent.

The immediate improvement program will increase service by the addition of source, distribution, administrative and operational facilities. The program consists of the following major items:

1) The provision of a structure and pumping facilities for the previously constructed test well, as well as the completion of a second well and installation of appurtenances;

2) The provision of effective and reliable disinfection equipment to provide full-time chlorination within the distribution system;

3) The construction of about 8.3 km of 100 to 350 mm diameter distribution pipelines;

4) The initiation of an extensive leakage detection survey and repair program;

5) The metering of 440 existing service connections, the provision of about 1,400 new connections, and the repair or replacement of 20 percent (88) of the existing connections.

6) The construction of new administrative and shop buildings and provision of appurtenant equipment such as shop tools, vehicles, office machines and furniture, etc., to increase the operational capabilities of the water district.

7) Repair leaks in the existing storage tank.

The test well, located near Don Simeon Street south of the public market will be equipped with a pumphouse, pumpset, flow meter, valves, etc., and will produce about 2,725 cumd. The well will be equipped with dual (diesel/electric) drive. A second well, also with capacity of 2,725 cumd, will be constructed along the San Isidro Road in Barrio San Nicolas. The second well will provide additional water and better pressure distribution in the system. The combined capacity of the wells, 5,450 cumd, will be approximately 10 times the present source capacity.

New distribution mains will be installed as shown in Figure IX-2, and summarized in Table IX-1. These mains will primarily serve areas outside the present service area. It is anticipated that the larger proposed pipelines will serve as main arteries in the future, while the proposed 100-mm pipelines will, in most cases, provide service to additional consumers within the present service area.

The provision of better pressure throught the GAP-WD distribution system on a 24-hour basis will tend to increase the current level of system leakage and wastage. It is, therefore, essential that an intensive program of leakage and wastage surveys and related system repairs be undertaken during the immediate improvement program.

Chlorination equipment, complete with structures, will be provided at the sites of the proposed wells to provide an initial dosage of 2.0 mg/l, to maintain a minimum chlorine residual of 0.1 mg/l at all points within the distribution system.

The existing 440 flat-rate service connections will be provided with water meters. About 20 percent (88) of these connections will be repaired or replaced. An additional 1,400 new connections will be installed, increasing the served population to approximately [illegible] percent of the total service area population in 1980.

The operational capabilities of the GAP-WD will be significantly improved by the construction of a new administrative building, complete with office space for administration, billing and record keeping, and small library. This new building will be furnished with desks, chairs, filing cabinets, typewriters, addressograph and validating machines. A plumbing shop will also be constructed and equipped with tools required for the installation of water meters and service connections, and for repair and installation work in the distribution system.

Table IX-2 presents the breakdown of costs (at July 1978 price levels) for the immediate improvement program. The total project cost of ₱5.83 million consists of ₱2.65 million in foreign exchange and ₱3.18 million in local currency.

TABLE IX-1

DISTRIBUTION PIPELINES
IMMEDIATE IMPROVEMENT PROGRAM

Pipe Number	Location/Description	Pipe Diameter (mm)	Pipe Length (m)
146	To Well at Node 55	350	15
			15
147	Tinio St.	300	30
			30
114	Manila Rd. (to Node 88)	200	750
115	Don Simeon St.	200	290
116	Don Simeon St.	200	155
120	Malgapo St.	200	95
122	Malgapo St.	200	40
123	Don Simeon St.	200	100
205	To Well at Node 2	200	15
			1,445
103	Camino St.	150	300
104	Camino St.	150	240
111	Don Simeon St.	150	195
126	Don Simeon St.	150	80
132	Jacinto St.	150	80
133	Jacinto St.	150	100
134	Bonifacio St.	150	315
135	Valmonte St.	150	185
140	Subdivision near Existing Well	150	300
143	Subdivision near Existing Well	150	250
144	Subdivision near Existing Well	150	150
157	Subdivision near Existing Well	150	280
			2,475
101	Bo. San Nicolas	100	270
102	Bo. San Nicolas	100	200
105	South of Tinio St. near Real St.	100	40
106	South of Tinio St. near Real St.	100	50
107	South of Tinio St. near Real St.	100	150
108	South of Tinio St. near Real St.	100	160
109	South of Tinio St. near Real St.	100	40
110	South of Tinio St. near Real St.	100	50
112	Cabanatuan Rd.	100	240
113	Cabanatuan Rd.	100	160
117	Bo. Sto. Niño near Peñaranda River	100	200
118	Bo. Sto. Niño near Pañaranda River	100	150
119	Malgapo St. near Peñaranda River	100	130
121	Bonifacio St.	100	200
124	Malgapo St.	100	130

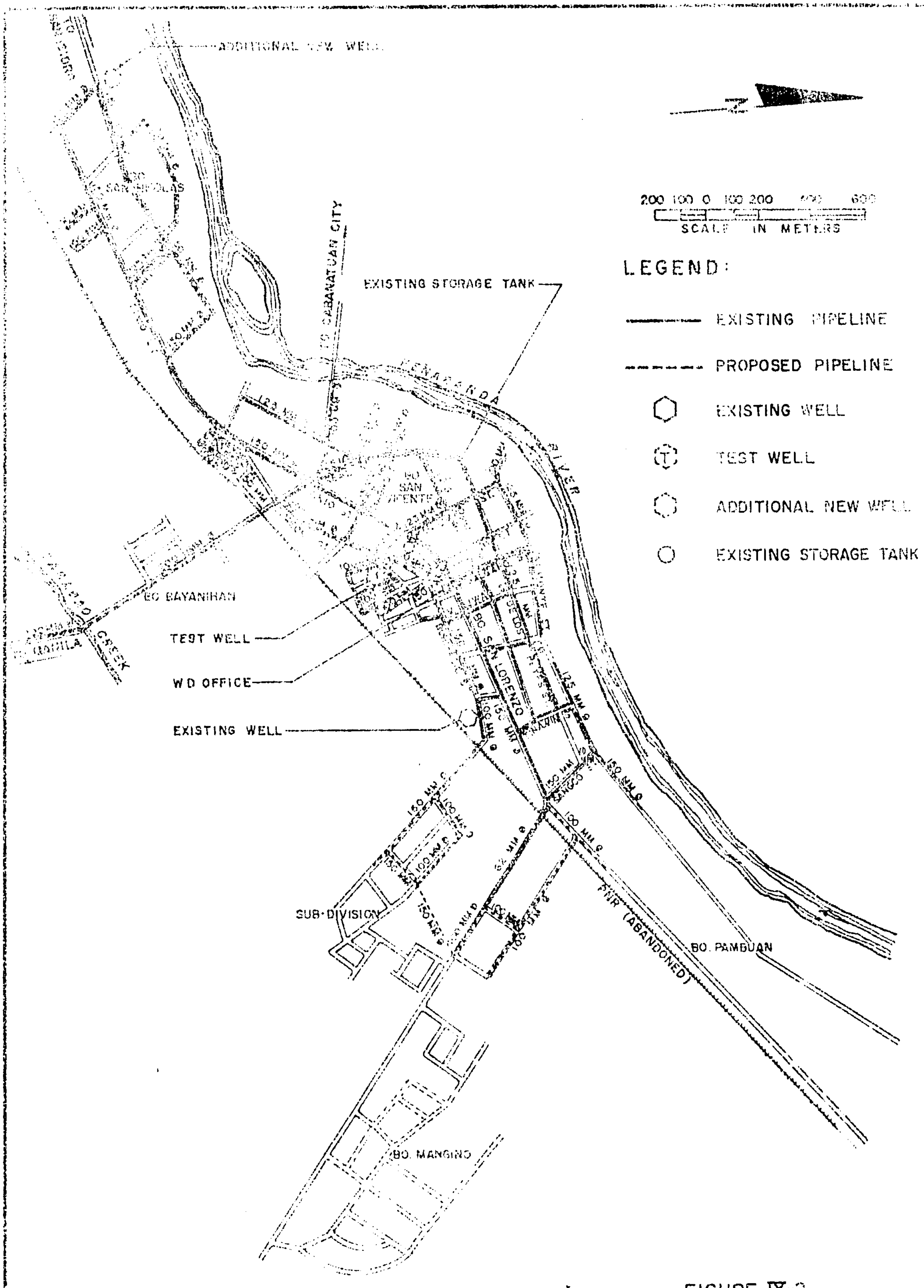


FIGURE IX-2
IMMEDIATE IMPROVEMENTS
GAPAN WATER DISTRICT

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

TABLE IX-1 (Continued)

Pipe Number	Location/Description	Pipe Diameter (mm)	Pipe Length (m)
125	South of Public Market near RR Track	100	105
127	South of Public Market near RR Track	100	170
128	South of Public Market near RR Track	100	55
129	Bonifacio St.	100	145
130	Jacinto St.	100	130
131	South of Public Market near RR Track	100	95
136	Tinio St. near Sangco St.	100	150
137	North of Bo. Mangino near RR Track	100	550
138	North of Bo. Mangino near RR Track	100	150
139*	Sangco St. North of Bo. Mangino	100	110
141	Subdivision near Existing Well	100	150
142	Subdivision near Exsiting Well	100	250
145	Bo. San Nicolas	100	150
			4,380
	Total		8,345

*Final design of this pipeline is recommended to be 150 mm although the computer printouts do not indicate it is hydraulically necessary. This is recommended to simplify overall pipeline design.

TABLE IX-2

COST SUMMARY
IMMEDIATE IMPROVEMENT PROGRAM

Item	Cost (P) Local	Foreign[1]	Total
Source Facilities			
(Pumphouse and Equipment for Test Well)			
Materials and Equipment	20,000	160,000	
Civil and Structural	80,000	10,000	
(Additional Production Well Complete)			
Materials and Equipment	20,000	265,000	
Civil and Structural	395,000	10,000	
(Disinfection Facilities for Two Wells)			
Materials and Equipment	4,800	34,600	
Civil and Structural	9,600	-	
	529,400	479,600	1,009,000
Distribution Facilities			
(Leakage Detection and Repair)			
Materials and Equipment	17,000	21,000	
Civil and Structural	18,000	86,000	
(350 mm x 15 m)			
Materials and Equipment	800	5,900	
Civil and Structural	3,100	-	
(250 mm x 30 m)			
Materials and Equipment	1,700	6,600	
Civil and Structural	3,600	-	
(200 mm x 1,445 m)			
Materials and Equipment	46,200	182,100	
Civil and Structural	122,800	-	
(150 mm x 2,475 m)			
Materials and Equipment	54,400	215,300	
Civil and Structural	180,700	-	
(100 mm x 4,380 m)			
Materials and Equipment	17,500	175,200	
Civil and Structural	232,100	-	
(Valves)			
Materials and Equipment	14,300	37,000	
Civil and Structural	12,900	-	
	725,100	729,100	1,454,200
Sub-Total[2]			
Materials and Equipment	196,700	1,102,700	1,299,400
Civil and Structural	1,057,800	106,000	1,163,800
	1,254,500	1,208,700	2,463,200

[1] Computed at US$1.00 to P7.00.
[2] Contingencies and engineering are 15 and 10 percent respectively, for these items.

TABLE IX-2 (Continued)

Item	Cost (₱) Local	Foreign	Total
Service Connections3/			
(Supply 440 connections with meters, replace 88 connections and install 1,400 new connections)			
Materials and Equipment	35,600	788,500	
Civil and Structural	499,200	-	
	534,800	788,500	1,323,300
Administrative and Miscellaneous Facilities3/			
(Administrative Building and Equipment)			
Materials and Equipment	18,000	26,000	
Civil and Structural	363,000	-	
(Two Vehicles)			
Materials and Equipment	60,000	60,000	
Civil and Structural	-	-	
(Plumbing Shop and Equipment)			
Materials and Equipment	2,000	26,000	
Civil and Structural	363,000	-	
(Miscellaneous Items)			
Materials and Equipment	5,000	8,000	
Civil and Structural	-	-	
	811,000	120,000	931,000
Sub-Total3/			
Materials and Equipment	120,600	908,500	1,029,100
Civil and Structural	1,225,200	-	1,225,200
	1,345,800	908,500	2,254,300
Total Construction Cost			
Materials and Equipment	317,300	2,011,200	2,328,500
Civil and Structural	2,283,000	106,000	2,389,000
Sub-Total	2,600,300	2,117,200	4,717,500
Contingencies			
@ 15 Percent2/	188,200*	181,300	369,500
@ 10 Percent3/	134,600	90,900	225,500
Sub-Total	2,923,100	2,389,400	5,312,500
Engineering4/			
@ 10 Percent2/	99,100	184,200	283,300
@ 5 Percent3/	43,400	80,600	124,000
Sub-Total	3,065,600	2,654,200	5,719,800
Land5/	111,000	-	111,000
Total Project Cost	3,176,600	2,654,200	5,830,800

3/ Contingencies and engineering costs are 10 percent and 5 percent respectively, for these items.

4/ Consists of 65 percent foreign exchange, as per recent similar contracts.

5/ 100 sqm at ₱60/sqm and 1,500 sqm at ₱10/sqm.

* Includes ₱20,000 for storage tank repair.

C. FIRST STAGE OF THE LONG-TERM CONSTRUCTION PROGRAM (1980-90)

As a result of alternative studies, a scheme for development of groundwater sources and construction of distribution facilities has been selected as the recommended program. The alternative studies are described in Chapter VIII. In the recommended scheme, the entire GAP-WD service area, up to the year 2000, will be served by groundwater abstracted from locally constructed wells. The water produced will be transported to consumers by distribution pipelines to be constructed in existing road rights-of-way.

The first stage of the recommended construction program, including source development, treatment and distribution facilities, will be implemented in 2 construction phases with duration of 6 years and 5 years, respectively.

Existing facilities are incorporated into the recommended program to as great an extent as practical. The existing distribution piping network, because of its extreme age and consequent poor hydraulic capacity, will be replaced between 1980 and 1990. Half of the existing piping will be replaced during Phase I-A (1980-85) and the remaining half, during Phase I-B (1986-90). Also because of age and poor service, the remaining 80 percent of the existing 440 service connections will be repaired or replaced during Phase I-A (20 percent of the existing connections will have been replaced during the immediate improvement program).

Provisions have been made in this feasibility study to replace all existing pipelines between 1980 and 1990 due to their age. During the leakage survey and design of Stage 1 improvements the condition of each of these pipelines should be verified by actual inspection. It may be possible to continue to use some of these pipelines inspite of their advanced age.

CONSTRUCTION PHASE I-A (1980-85)

Source Development

As previously discussed, alternative studies were made to determine the most economic and practical percentages of storage and source capacity to meet peak flow demands. The results of the studies indicate that the supply of 1.5 times maximum-day demand from wells is the most economical. Figure IX-3 shows the relationship between projected demand and well construction under these circumstances. As indicated, the wells constructed before 1980 will provide adequate capacity until approximately 1982. At that time, it is recommended that a larger pumpset be installed in the well constructed at node 55 (see Figure IX-5), during the immediate improvement program. This increase in source capacity will satisfy system demands until approximately 1986, at which time another well will be required. This well will be constructed at node 75 (along

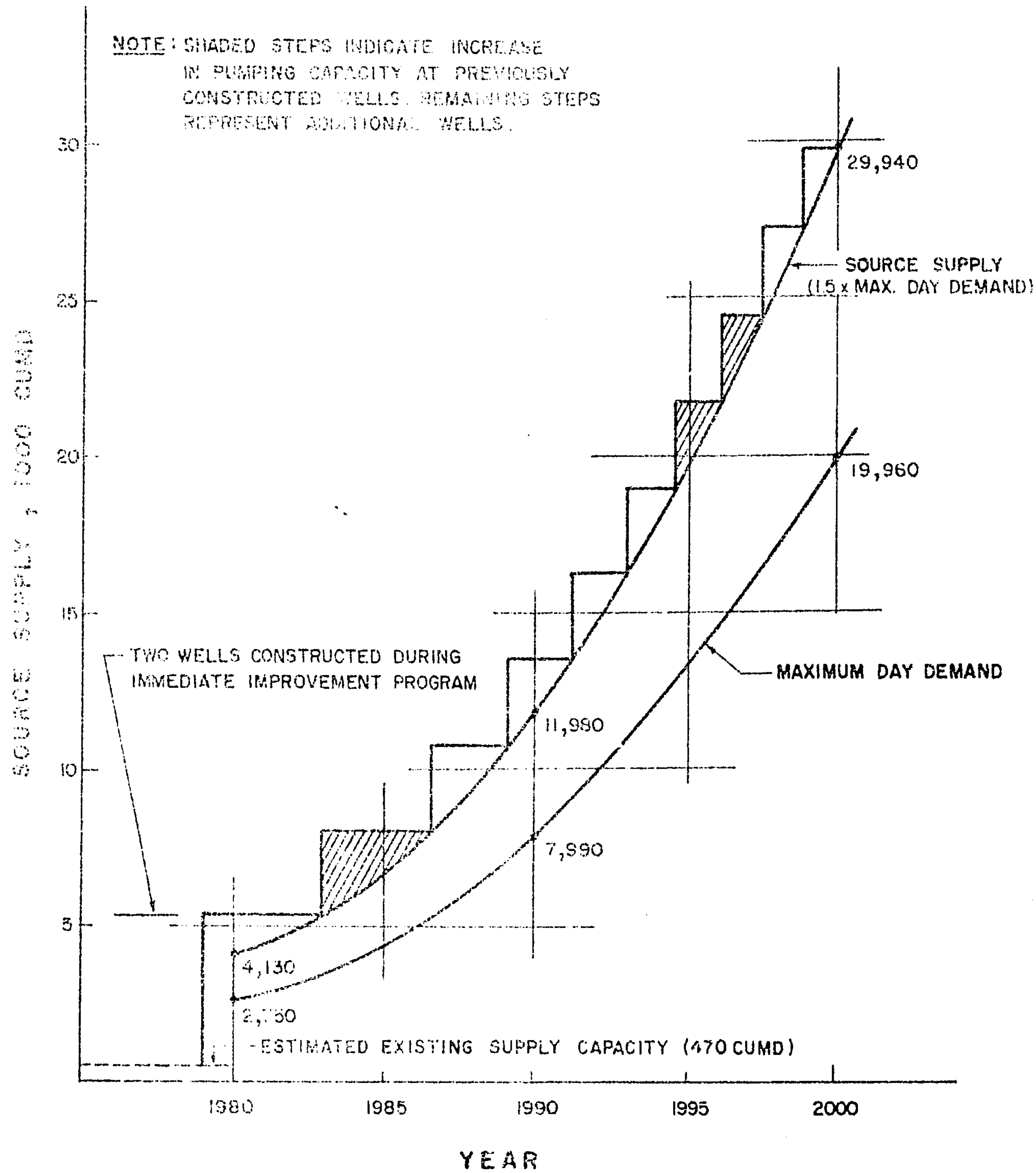


FIGURE IX-3
PROJECTED
WATER DEMAND AND SUPPLY
GAPAN WATER DISTRICT

Bonifacio Street, near the abandoned PNR railway lines), the site of the existing well, and will provide sufficient source capacity until about 1989. All Phase I-A wells will be furnished with necessary structures, piping, meters, valves and specials required for efficient operation. In addition, complete chlorination facilities will be installed in a chlorination building to be constructed at the site of every production well, to ensure adequate disinfection of water supplied to the distribution system.

Distribution System

The distribution system improvements included in construction Phase I-A are to replace 7,410 meters of existing pipelines; extend service to Barrios Malapit and Sto. Cristo Norte; and improve service to Barrios Mangino and Pambuan.

The salient features of system piping installed during Phase I-A are (1) the provision of a 200 mm diameter system "core" along Tinio Street, from Barrio San Nicolas to the center of Gapan Poblacion; (2) The completion of a 150 mm loop along the remainder of Tinio and Tinawin Streets, and De Los Reyes and Real Streets; (3) the expansion of 150 and 100 mm internal network piping throughout the service area; and (4) the extension of 200 mm pipelines to the barrios of Malapit, Sto. Cristo Norte, Mangino and Pambuan. Details of all pipelines to be constructed during this phase are listed in Table IX-3 and shown in Figures IX-4, IX-5 and IX-1 (appended).

All pipelines recommended for construction during Phase I-A will provide hydraulic capacity for expected peak flows, although some pipelines will require reinforcement before the year 2000. Where technically, practically and economically feasible, pipelines of 250 mm and larger have been considered for "phased" construction, with ultimate capacity made available only during the later phases of the project. All necessary valves and appurtenances have been included in the cost estimates for the project pipelines.

The final computer printouts for the year 2000 peak hour and minimum flow conditions are included in Annex IX-C.

Internal Network

The schedule of additions to the internal network system is presented in detail in Annex IX-C. The existing internal network system in Gapan will be reinforced by replacing a portion of the old 150 mm, 100 mm, and smaller pipes; installing new valves; and serving areas which are currently unserved.

The total area to be served by additional internal network is approximately 166 hectares. This will provide service to 100 percent of the 1976 service area; 100 percent of the additional

TABLE IX-3

PHASE I-A DISTRIBUTION PIPELINES

Pipe Number	Location/Description	Pipe Diameter (mm)	Pipe Length (m)
	REPLACEMENT		
2	Bo. San Nicolas	200	200
3	Tinio St. (Bo. San Nicolas)	200	225
6	Tinio St. (Bo. San Nicolas)	200	95
7	Tinio St. (Bo. San Nicolas)	200	90
8	Tinio St. (Bo. San Nicolas)	200	95
13	Tinio St. (Bo. San Nicolas)	200	120
14	Tinio St. (Bo. San Nicolas)	200	310
15	Tinio St. (Bo. San Nicolas)	200	340
16	Tinio St. near Del Pilar St.	200	30
17	Tinio St.	200	280
20	Manila Road to Cababao Creek	200	190
21	Manila Road to Cababao Creek	200	45
38	Malgapo St.	200	190
40	Tinio St.	200	130
47	Tinio St.	200	75
61	V. Liwag St.	200	80
80*	Sangco St. South of Tinio St.	200	500
81	Tinio St. East of Del Pilar St.	200	110
			3,125
1	San Isidro Road (Bo. San Nicolas)	150	250
23	Tinio St.	150	220
26	Real St. North of Ramos St.	150	100
29	Tinio St. West of Malgapo St.	150	170
36	Malgapo St.	150	115
54	Tinio St. East of Malgapo St.	150	130
62	V. Liwag St.	150	115
63	East End of Don Simeon St.	150	100
64	Tinio St.	150	155
69	Tinio St.	150	150

*Final design of this pipeline is recommended to be 150 mm although the computer printouts do not indicate it is hydraulically necessary. This is recommended to simplify overall pipeline design.

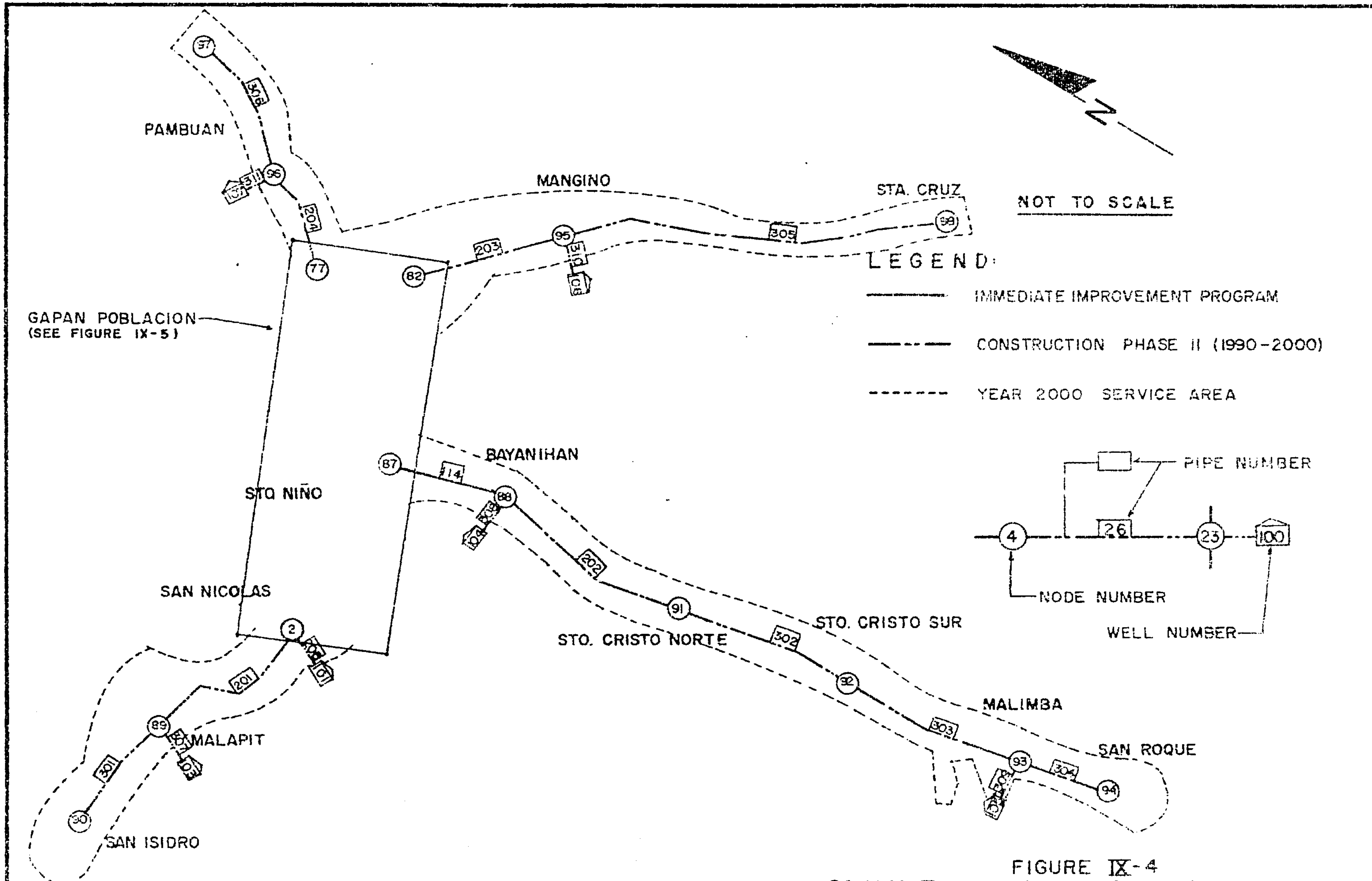
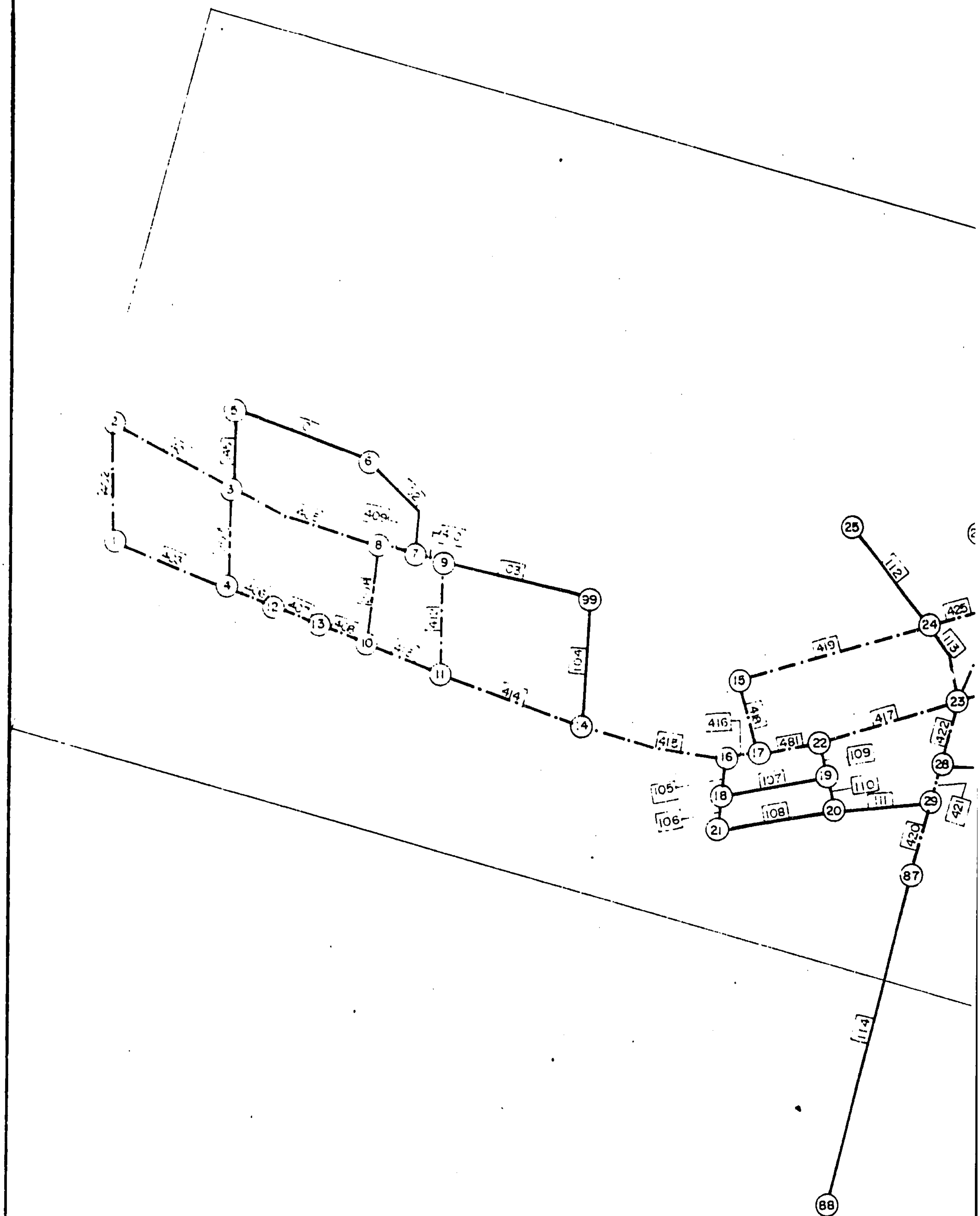
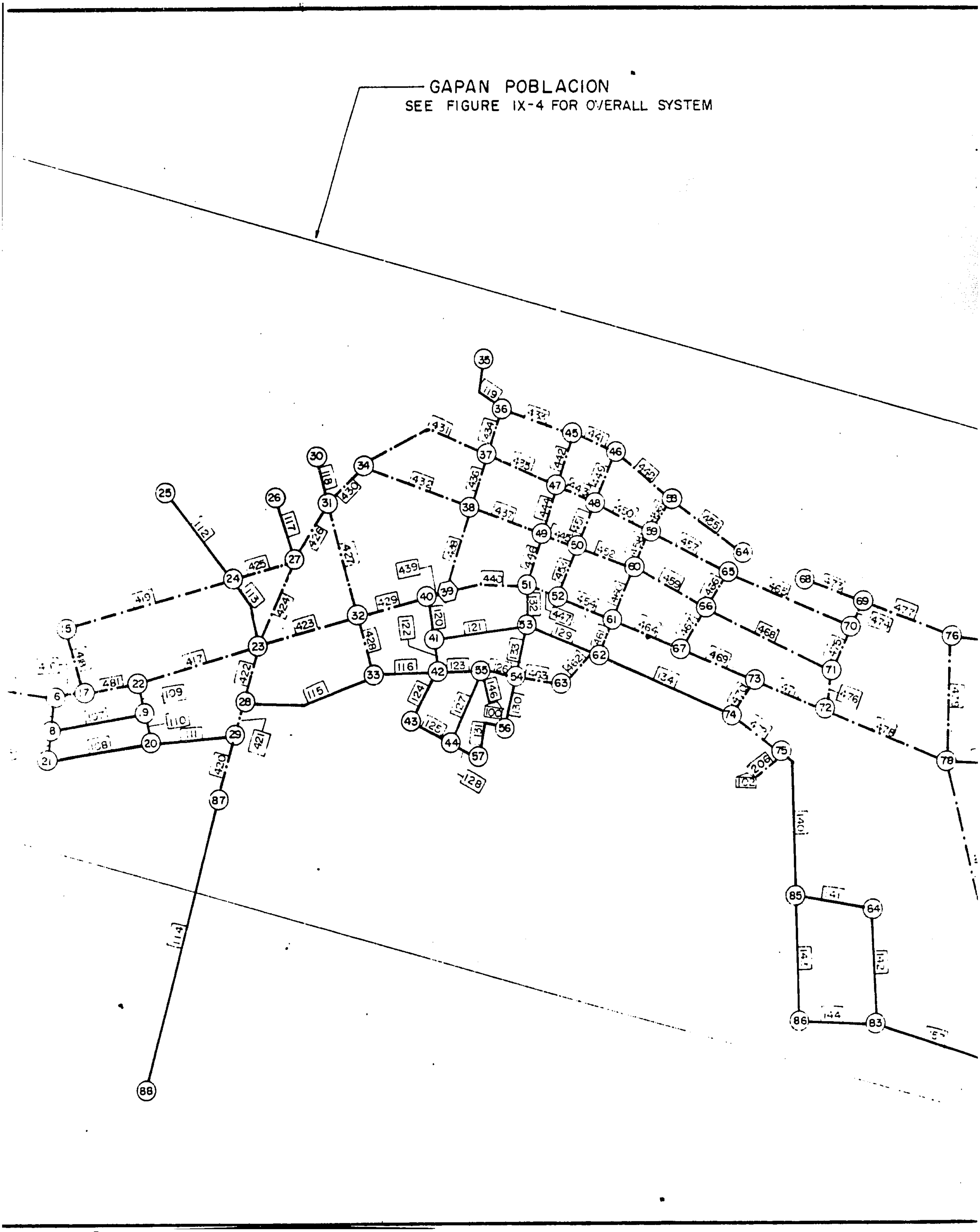


FIGURE IX-4
SCHEMATIC PLAN OF DISTRIBUTION SYSTEM
GAPAN WATER DISTRICT



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

GAPAN POBLACION
SEE FIGURE IX-4 FOR OVERALL SYSTEM



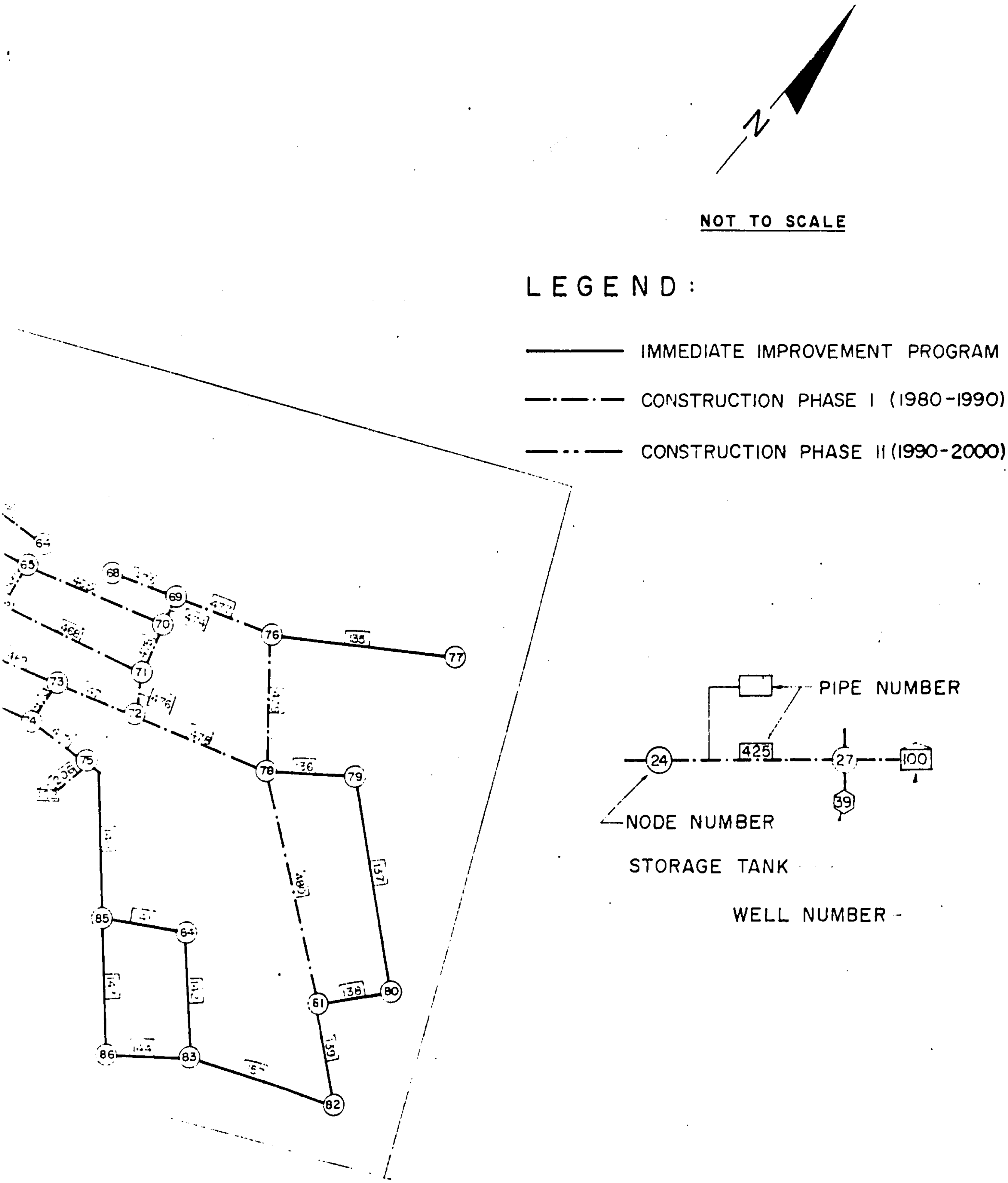


FIGURE IX-5
SCHEMATIC PLAN OF DISTRIBUTION SYSTEM
GAPAN WATER DISTRICT

TABLE IX-3 (Continued)

Pipe Number	Location/Description	Pipe Diameter (mm)	Pipe Length (m)
71	Tinio St.	150	185
75	Tinawin St.	150	125
76	Tinawin St.	150	100
78	Tinio St. West of Sangco St.	150	245
79	Sangco St. North of Tinio St.	150	220
			2,380
24	Real St. North of Tinio St.	100	210
30	Real St. North of Tinio St.	100	140
31	De los Reyes St.	100	300
34	Malgapo St.	100	95
35	De los Reyes St.	100	160
43	De los Reyes St.	100	90
50	De los Reyes St.	100	135
56	V. Liwag St.	100	85
57	De los Reyes St.	100	190
58	V. Liwag St.	100	80
60	V. Liwag St.	100	135
65	De los Reyes St.	100	285
			1,905
	Sub-Total (Replacement Pipelines)		7,410
	NEW PIPELINES		
201	Bo. San Nicolas to Bo. Malapit	200	1,700
202	Bo. Bayanihan to Bo. Cristo Norte	200	2,000
203	To. Bo. Mangino	200	1,300
204	To Bo. Pambuan	200	1,050
206	To Well at Node 75	200	15
	Sub-Total (New Pipelines)		6,065
	Total		13,475

area to be served by 1980; and 55 percent of the additional area to be served by 1990. Areas adjacent to distribution system pipelines will receive service directly from these pipelines and have been deducted from the total internal network requirements. A description of internal network systems is presented in Appendix K, Volume II.

Service Connections

During Phase I-A, a total of 2,270 new service connections will be installed at a rate of about 450 connections per year. By 1985 the GAP-WD will have a total of 4,110 service connections. In addition, about 350 existing service connections will be replaced or repaired, completing the improvement of the 440 existing service connections. The detailed installation schedule of service connections, is presented in Annex IX-C.

Fire Protection

The schedule for fire hydrant installation within the water district is presented in Annex IX-C. During Phase I-A, only Gapan poblacion will receive fire protection. During this period, 25 percent of the poblacion area (27 hectares) will be supplied with hydrants, increasing total fire protection service by 1985 to 33 percent of this area, including areas with existing hydrants. Because of the presence of commercial areas within the poblacion of Gapan, a higher level of hydrant service will be provided for the poblacion. Normal residential type of service will be provided for other areas.

Cost Summary - Phase I-A

The cost summary for the proposed construction during Phase I-A is presented in Table IX-4. Based on 1978 price levels, the total project cost for this phase is ₱9.05 million with a foreign exchange component (FEC) of ₱4.59 million which includes direct and indirect import items. Table IX-4 also presents a cost breakdown based on materials and equipment procurement and required civil and structural work. Materials and equipment considered in this breakdown include pumps, pipes, valves, water meters, hydrants and chlorinators.

CONSTRUCTION PHASE I-B (1980-90)

Source Facilities

A new well will be constructed at node 89, along the San Isidro Road in Barrio Malapit, in 1989. It will be equipped with a dual

TABLE IX-4

COST SUMMARY FOR CONSTRUCTION STAGE 1 PHASE A

Item	Cost (₱) Local	Foreign[6/]	Total
Source Facilities[7/]			
(New pumpset @ Node 55 in 1982 and complete well @ Node 75 in 1985			
Materials and Equipment	20,000	265,000	
Civil and Structural	395,000	10,000	
(Disinfection facilities for one well)			
Materials and Equipment	2,400	17,300	
Civil and Structural	4,800	-	
	422,200	292,300	714,500
Pipelines[7/]			
(200 mm x 9,[illegible]90 m)			
Materials and Equipment	294,100	1,157,900	
Civil and Structural	781,200	-	
(150 mm x 2,380 m)			
Materials and Equipment	52,400	207,100	
Civil and Structural	173,700	-	
(100 mm x 1,905 m)			
Materials and Equipment	7,600	76,200	
Civil and Structural	101,000	-	
(Valves)			
Materials and Equipment	13,800	41,000	
Civil and Structural	13,700	-	
	1,437,500	1,482,200	2,919,700
Sub-Total[7/]			
Materials and Equipment	390,300	1,764,500	2,154,800
Civil and Structural	1,469,400	10,000	1,479,400
	1,859,700	1,774,500	3,634,200
Internal Network[8/]			
(165.8 ha)			
Materials and Equipment	88,900	695,400	
Civil and Structural	877,900	-	
	966,800	695,400	1,662,200
Service Connections[8/]			
(2,270 New Connections and 350 Replacements)			
Materials and Equipment	63,000	1,200,800	
Civil and Structural	844,700	-	
	907,700	1,200,800	2,108,500

[6/] Computed at US$1.00 to ₱7.00.

[7/] Contingencies and engineering costs are 15 percent and 10 percent, respectively, for these items.

[8/] Contingencies and engineering costs are 10 percent and 5 percent, respectively, for these items.

TABLE IX-4 (Continued)

Item	Cost (₱) Local	Foreign	Total
Fire Hydrants[8] (27.2 ha)			
Materials and Equipment	13,900	47,400	
Civil and Structural	20,400	-	
	34,300	47,400	81,700
Sub-Total[8]			
Materials and Equipment	165,800	1,943,600	2,109,400
Civil and Structural	1,743,000	-	1,743,000
	1,908,800	1,943,600	3,852,400
Total Contruction Cost			
Materials and Equipment	556,100	3,708,100	4,264,200
Civil and Structural	3,212,400	10,000	3,222,400
Sub-Total	3,768,500	3,718,100	7,486,600
Contingencies			
@ 15%	279,000	266,200	545,200
@ 10%	190,900	194,400	385,300
Sub-Total	4,238,400	4,178,700	8,417,100
Engineering[9]			
@ 10%	146,300	271,600	417,900
@ 5%	74,200	137,700	211,900
Sub-Total	4,458,900	4,588,000	9,046,900
Land[10]	6,000	-	6,000
Total Project Cost	4,464,900	4,588,000	9,052,900

[8] Contingencies and engineering costs are 10 percent and 5 percent respectively, for these items.
[9] Consists of 65 percent foreign exchange.
[10] 100 sqm at ₱60/sqm.

(diesel/electric) drive. The well will have a capacity of 2,725 cumd, increasing the total source capacity to about 13,500 cumd which is sufficient to meet system demands until 1991 (see Figure IX-3).

Distribution System

About 5,035 meters of 100,150 and 200 mm pipelines will be constructed in Phase I-B to replace existing pipelines and to increase the hydraulic capacity of the basic large "loop" established by pipelines of Phase I-A. New pipelines, with a total length of 2,185 meters and diameter of 100,200 and 250 mm, will be constructed to reinforce previously installed pipelines, to connect new sources to the system and to provide service to unserved areas.

The proposed pipelines for Phase I-B are listed in Table IX-5 and shown in Figures IX-4, IX-5 and IX-1 (appended).

Internal Network

New internal network will be provided during Phase I-B in about 92 hectares, completing the area served within the 1990 service area. Internal network will be provided at an approximate rate of 18.3 hectares per year, uniformly over the period 1986-90 (see Annex IX-C for details).

Service Connections

During Phase I-B, 2,270 new service connections will be installed, at a rate of about 450 connections per year. By 1990, the GAP-WD will have a total of about 6,400 service connections. (See Annex IX-C.)

Fire Protection

During Phase I-B 23.0 hectares in Gapan Poblacion and 95.2 hectares in other communities within the service area will be provided with fire protection service by the installation of fire hydrants. This will increase total fire protection service to 55 percent of Gapan Poblacion and 26 percent of the other communities by 1990 (see Annex IX-C).

Cost Summary-Phase I-B

The cost summary for proposed construction during Phase I-B is presented in Table IX-6. Based on 1978 price levels, the total project cost for this phase is ₱5.86 million, with a foreign exchange component of ₱2.98 million.

TABLE IX-5

PHASE I-B - DISTRIBUTION PIPELINES

Pipe Number	Location/Description	Pipe Diameter (mm)	Pipe Length (m)
	REPLACEMENT		
70	South of Tinio St. near Existing Well	200	95
72	Bonifacio St. to Well at Node 75	200	225
			320
5	San Isidro Rd. (Bo. San Nicolas)	150	300
9	San Isidro Rd. (Bo. San Nicolas)	150	70
10	San Isidro Rd. (Bo. San Nicolas)	150	35
12	Calderon St.	150	205
22	Real St. South of Tinio St.	150	145
27	Between Real and Tinio St.	150	210
28	Between Tinio and Don Simeon St.	150	140
46	Jacinto St.	150	130
74	Tinawin St.	150	35
77	Valmonte St.	150	200
			1,470
18	Del Pilar St.	100	150
19	Ramos St.	100	370
25	Ramos St.	100	160
32	Del Cerro St.	100	240
33	Valmonte St.	100	155
37	Del Cerro St.	100	160
41	Valmonte St.	100	100
42	Jacinto St.	100	120
44	Jacinto St.	100	100
45	Del Cerro St.	100	85
48	Valmonte St.	100	150
49	Malgapo St.	100	120
51	Malgapo St.	100	90
52	Del Cerro St.	100	125
53	Malgapo St.	100	125
55	Valmonte St.	100	190
59	Del Cerro St.	100	180
66	E. Liwag St.	100	90
67	E. Liwag St.	100	100
68	Del Cerro St.	100	305
73	Valmonte St.	100	130
			3,245
	Sub-Total (Replacement Pipelines)		5,035

TABLE IX-5 (Continued)

Pipe Number	Location/Description	Pipe Diameter (mm)	Pipe Length (m)
	NEW PIPELINES		
307	To Well at Node 89 (Malapit)	250	15
201	To Bo. Malapit	200	1,700
123	Don Simeon St. (R)*	200	100
			1,800
207	Between Camino and Tinio St. (San Nicolas)	100	180
208	Between Camino and Tinio St. (San Nicolas)	100	190
			370
	Sub-Total (New Pipelines)		2,185
	Total		7,220

*Reinforcement to previously installed pipelines.

TABLE IX-6

COST SUMMARY FOR CONSTRUCTION STAGE 1 PHASE B

Item	Cost (₱)[11] Local	Foreign	Total
Source Facilities[12]			
(Complete well @ Node 89 in 1989)			
Materials and Equipment	20,000	265,000	
Civil and Structural	395,000	10,000	
(Disinfection Facilities for one well)			
Materials and Equipment	2,400	17,300	
Civil and Structural	4,800	-	
	422,200	292,300	714,500
Pipelines[12]			
(250 mm x 15 m)			
Materials and Equipment	900	3,300	
Civil and Structural	1,800	-	
(200 mm x 2,120 m)			
Materials and Equipment	67,800	267,100	
Civil and Structural	180,200	-	
(150 mm x 1,470 m)			
Materials and Equipment	32,300	127,900	
Civil and Structural	107,300	-	
(100 mm x 3,615 m)			
Materials and Equipment	14,500	144,600	
Civil and Structural	191,600	-	
(Valves)			
Materials and Equipment	10,500	25,100	
Civil and Structural	8,800	-	
	615,700	568,000	1,183,700
Sub-Total[12]			
Materials and Equipment	148,400	850,300	998,700
Civil and Structural	889,500	10,000	899,500
	1,037,900	860,300	1,898,200
Internal Network[13]			
(91.5 hectares)			
Materials and Equipment	49,000	383,800	
Civil and Structural	484,000	-	
	533,000	383,800	916,800
Service Connections[13]			
(2,270 New Connections)			
Materials and Equipment	54,500	1,098,700	
Civil and Structural	742,300	-	
	796,800	1,098,700	1,895,500

[11] Computed at US$1.00 to ₱7.00.

[12] Contingencies and engineering costs are 15 percent and 10 percent, respectively, for these items.

[13] Contingencies and engineering costs are 10 percent and 5 percent, respectively, for these items.

TABLE IX-6 (Continued)

Item	Cost (₱) Local	Foreign	Total
Fire Hydrants[13] (118.2 hectares)			
Materials and Equipment	30,500	104,200	
Civil and Structural	44,900	-	
	75,400	104,200	179,600
Sub-Total[13]			
Materials and Equipment	134,000	1,586,700	1,720,700
Civil and Structural	1,271,200	-	1,271,200
	1,405,200	1,586,700	2,991,900
Total Construction Cost			
Materials and Equipment	282,400	2,437,000	2,719,400
Civil and Structural	2,160,700	10,000	2,170,700
Sub-Total	2,443,100	2,447,000	4,890,100
Contingencies			
@ 15 Percent	155,700	129,000	284,700
@ 10 Percent	140,500	158,700	299,200
Sub-Total	2,739,300	2,734,700	5,474,000
Engineering[14]			
@ 10 Percent	76,400	141,900	218,300
@ 5 Percent	57,600	107,000	164,600
Sub-Total	2,873,300	2,983,600	5,856,900
Land[15]	6,000	-	6,000
Total Project Cost	2,879,300	2,983,600	5,862,900

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[13] Contingencies and engineering costs are 10 percent and 5 percent, respectively, for these items.

[14] Consists of 65 percent foreign exchange.

[15] 100 sqm at ₱60/sqm.

D. SECOND STAGE OF THE LONG-TERM CONSTRUCTION PROGRAM (1991-2000)

The second stage of the recommended program includes provision of additional source, storage and distribution facilities and expansion of internal network, service connection and fire protection facilities. These works will be implemented in two construction phases.

CONSTRUCTION PHASE II-A (1991-95)

Source Facilities

Two additional wells will be constructed at node 88 (south of Cababao Creek along the Manila Road) and node 95 (in Barrio Mangino) in 1991 and 1993, respectively. In addition, a larger pumpset will be installed in the we__ at node 89 (near Barrio Malapit). These source facilities will increase production capacity by 8,175 cumd, bringing the total capacity to about 21,900 cumd which is sufficient to meet system demands until 1996 (see Figure IX-3).

Distribution System

The distribution system improvements recommended for construction during Phase II-A will provide reinforcement to previously installed pipelines along Tinio Street, the Manila Road and the road to San Isidro. Approximately 13,300 meters of pipelines, 200 mm in diameter, will be constructed to provide additional or new service to barrios Sto. Cristo Sur, Malimba, Sta. Cruz, Pambuan and San Isidro poblacion. The pipelines for Phase II-A are described in Table IX-7 and shown in Figures IX-4, IX-5 and IX-1 (appended).

Internal Network

An additional 216 hectares of internal network will be provided during Phase II-A. This will provide service to 50 percent of the additional area to be served between 1990 and 2000, or 70 percent of the entire year 2000 service area.

Service Connections

An additional 4,470 service connections will be installed during Phase II-A, at a rate of about 890 connections per year. By 1995, the GAP-WD will have a total of about 10,800 service connections.

Fire Protection

During Phase II-A, 23 hectares in Gapan Poblacion and 134 hectares in other communities within the GAP-WD will be provided with fire protection service by the installation of fire hydrants. By 1995, 78 per-

TABLE IX-7

PHASE II-A - DISTRIBUTION PIPELINES

Pipe Number	Location/Description	Pipe Diameter (mm)	Pipe Length (m)
13	Tinio St. (San Nicolas) (R)	200	120
14	Tinio St. (San Nicolas) (R)	200	310
15	Tinio St. (West of Del Pilar St.) (R)	200	340
16	Tinio St. (West of Del Pilar St.) (R)	200	30
20	Manila Rd. (To Cababao Creek) (R)	200	190
21	Manila Rd. (Near PNR Railway Track)(R)	200	45
81	Tinio St. (East of Del Pilar St.) (R)	200	110
114	Manila Rd. (To Well at Node 88) (R)	200	750
202	Manila Rd. to Sto. Cristo Norte (R)	200	2,000
301	San Isidro Rd. to San Isidro	200	1,300
302	Manila Rd. to Sto. Cristo Sur	200	1,550
303	Manila Rd. to Malimba	200	1,750
305	From Bo. Mangino to Bo. Sta. Cruz	200	3,450
306	To Bo. Pambuan	200	1,350
308	To Well at Node 88 (Manila Rd.)	200	15
310	To Well at Node 95 (Bo. Mangino)	200	15
			13,325

Note: Pipelines marked (R) are reinforcements to previously installed pipelines.

cent of Gapan Poblacion and 62 percent of the other communities, representing 67 percent of the total year 2000 service area, will have fire protection.

Cost Summary: Phase II-A

A cost summary for construction during Phase II-A is presented in Table IX-8. Based on 1978 price levels, the total project cost for this phase is ₱13.28 million, with a foreign exchange component of ₱6.93 million.

CONSTRUCTION PHASE II-B (1996-2000)

Source Development

In order to provide the required source capacity in 1996, the pumping capacity of the previously constructed well at node 75 (along Bonifacio Street near the abandoned PNR Railway Track) will be increased. Two new wells will be constructed at node 93 (along the Manila Road near Barrio Malimba) and node 96 (near Barrio Pambuan) in 1997 and 1999, respectively. These wells will have a capacity of 8,175 cumd, bringing the total source capacity to about 30,000 cumd which is sufficient to meet projected demands through the year 2000.

Storage Facilities

In order to meet projected system demands by 1996, a 120-cum elevated storage tank will be constructed. It is recommended that this storage tank be located at, or as near as possible to, node 55 (the site of the test well currently under construction). This storage tank, together with the wells to be constructed during Phase II-B, will provide sufficient water supply to satisfy projected peak demands in the GAP-WD service area until the year 2000.

Distribution System

About 4,300 meters of 200 mm diameter pipelines will be constructed during Phase II-B to reinforce the previously constructed pipeline to Barrio Sta. Cruz; to provide service to Barrio San Roque beyond the well located at node 93; and to connect the wells located at nodes 93 and 96 (near Barrio Pambuan) to the distribution system. These pipelines are listed in Table IX-9 and shown in Figures IX-4, IX-5 and IX-1 (appended).

Internal Network

An additional 216 hectares of internal network will be provided during Phase II-B. This will provide service to 100 percent of the year 2000 service area by the end of the construction period in 2000.

TABLE IX-8

COST SUMMARY FOR CONSTRUCTION STAGE II PHASE A

Item	Cost (₱) Local	Cost (₱) Foreign[16]	Total
Source Facilities[17]			
(New pumpset @ Node 89 in 1994 and two complete wells @ Nodes 88 and 95 in 1991 and 1993)			
Materials and Equipment	50,000	690,000	
Civil and Structural	790,000	20,000	
(Disinfection facilities for two wells)			
Materials and Equipment	4,800	34,600	
Civil and Structural	9,600	-	
	854,400	744,600	1,599,000
Pipelines[17]			
(200 mm x 13,325 m)			
Materials and Equipment	426,400	1,679,000	
Civil and Structural	1,132,600	-	
(Valves)			
Materials and Equipment	10,800	37,000	
Civil and Structural	12,000	-	
	1,581,800	1,716,000	3,297,800
Sub-Total[17]			
Materials and Equipment	492,000	2,440,600	2,932,600
Civil and Structural	1,944,200	20,000	1,964,200
	2,436,200	2,460,600	4,896,800
Internal Network[18]			
(215.8 hectares)			
Materials and Equipment	115,700	905,100	
Civil and Structural	1,142,700	-	
	1,258,400	905,100	2,163,500
Service Connections[18]			
(4,470 New Connections)			
Materials and Equipment	107,300	2,163,500	
Civil and Structural	1,461,700	-	
	1,569,000	2,163,500	3,732,500
Fire Hydrants[18]			
(157.3 hectares)			
Materials and Equipment	38,300	130,800	
Civil and Structural	56,300	-	
	94,600	130,800	225,400

16/ Computed at US$1.00 to ₱7.00.

17/ Contingencies and engineering costs are 15 and 10 percent, respectively, for these items.

18/ Contingencies and engineering costs are 10 percent and 5 percent, respectively, for these items.

TABLE IX-8 (Continued)

Item	Cost (₱) Local	Foreign	Total
Sub-Total[18]			
Materials and Equipment	261,300	3,199,400	3,460,700
Civil and Structural	2,660,700	-	2,660,700
	2,922,000	3,199,400	6,121,400
Total Construction Cost			
Materials and Equipment	753,300	5,640,000	6,393,300
Civil and Structural	4,604,900	20,000	4,624,900
	5,358,200	5,660,000	11,018,200
Contingencies			
@ 15 Percent	365,400	369,100	734,500
@ 10 Percent	292,200	319,900	612,100
Sub-Total	6,015,800	6,349,000	12,364,800
Engineering[19]			
@ 10 Percent	197,100	366,000	563,100
@ 5 Percent	117,800	218,900	336,700
Sub-Total	6,330,700	6,933,900	13,264,600
Land[20]	12,000	-	12,000
Total Project Cost	6,342,700	6,933,900	13,276,600

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[18] Engineering @ 5 percent and contingencies @ 10 percent for these items.

[19] Consists of 65 percent foreign exchange.

[20] 200 sqm at ₱60/sqm.

TABLE IX-9

PHASE II-B -- DISTRIBUTION PIPELINES

Pipe Number	Location/Description	Pipe Diameter (mm)	Pipe Length (m)
304	Manila Rd. to Bo. San Roque	200	850
305	To Bo. Sta. Cruz (R)*	200	3,450
309	To Well at Node 93 (Manila Rd.)	200	15
311	To Well at Node 96 (Bo. Pambuan)	200	15
			4,330

Service Connections

During Phase II-B, about 4,470 connections will be installed at a rate of 800 connections per year. By 2000, about 15,300 service connections will have been provided within the GAP-WD.

Fire Protection

An additional 23 hectares within Gapan Poblacion and 134 hectares within the other communities of the GAP-WD will be provided with fire protection service. By 2000, total fire protection service will cover 100 percent of Gapan Poblacion and 68 percent of the entire year 2000 service area.

Cost Summary: Phase II-B

The cost summary for construction during Phase II-B is presented in Table IX-10. Based on 1978 price levels, the total projected cost of this phase is ₱12.72 million, with a foreign exchange component of ₱5.83 million.

E. CAPITAL COST SUMMARY

The capital costs for each phase of the recommended construction program, including the immediate improvement program, are summarized in Table IX-11. The total project costs shown in this table include engineering, contingencies and land costs. All construction cost estimates are based on 1978 price levels. The foreign exchange component of the total project cost includes the costs of direct and indirect import items.

F. ANNUAL OPERATION AND MAINTENANCE COSTS

Annual operation and maintenance costs include personnel, power, chemicals, maintenance, rentals, office supplies and other miscellaneous expenses which are necessary to sustain the overall water supply system. The total annual budgeted cost of the existing system in 1976 was ₱130,400. Following implementation of the proposed improvement and construction program, the annual cost will increase due to the additional costs for personnel, chemicals, power and maintenance.

The annual costs of operating and maintaning the GAP-WD facilities are estimated to be ₱270,300, ₱662,600 and ₱1,221,600 in 1980, 1990 and 2000, respectively. The estimated breakdown of these costs is shown in Table IX-12. All costs shown are based on projected 1978 price levels.

*Pipelines marked (R) are reinforcements to previously installed pipelines.

COST SUMMARY FOR CONSTRUCTION STAGE II PHASE B

Item	Cost (₱) Local	Foreign[21]	Total
Source Facilities[22]			
(New pumpset @ Node 75 in 1996, new well without pumpset @ Node 93 in 1997 and new well complete @ Node 96 in 1999)			
Materials and Equipment	40,000	530,000	
Civil and Structural	790,000	20,000	
(Disinfection facilities for two wells)			
Materials and Equipment	4,800	34,600	
Civil and Structural	9,600	-	
	844,400	584,600	1,429,000
Storage Facilities[22]			
(120-cum tank @ Node 55 in 1996)			
Materials and Equipment	1,169,400	390,000	
Civil and Structural	390,600	-	
	1,560,000	390,000	1,950,000
Pipelines[22]			
(200 mm x 4,330 m)			
Materials and Equipment	138,600	545,600	
Civil and Structural	368.000	-	
(Valves)			
Materials and Equipment	3,400	11,700	
Civil and Structural	3,800	-	
	513,800	557,300	1,071,100
Sub-Total[22]			
Materials and Equipment	1,356,200	1,511,900	2,868,100
Civil and Structural	1,562,000	20,000	1,582,000
	2,918,200	1,531,900	4,450,100
Internal Network[23]			
(215.7 hectares)			
Materials and Equipment	115,600	904,600	
Civil and Structural	1,142,100	-	
	1,257,700	904,600	2,162,300
Service Connections[23]			
(4,470 New Connections)			
Materials and Equipment	107,300	2,163,500	
Civil and Structural	1,461,700	-	
	1,569,000	2,163,500	3,732,500
Fire Hydrants[23]			
(157.5 hectares)			
Materials and Equipment	38,400	130,900	
Civil and Structural	56,400		
	94,800	130,900	225,700

21/ Computed at US$1.00 to ₱7.00.

22/ Engineering and contingencies are 15 percent and 10 percent, respectively, on these items.

23/ Engineering at 5 percent and contingencies at 10 percent for these items.

TABLE IX-10 (Continued)

Item	Cost (₱) Local	Foreign	Total
Sub-Total[23]			
Materials and Equipment	261,300	3,199,000	3,460,300
Civil and Structural	2,660,200	-	2,660,200
	2,921,500	3,199,000	6,120,500
Total Construction Cost			
Materials and Equipment	1,617,500	4,710,900	6,328,400
Civil and Structural	4,222,200	20,000	4,242,200
	5,839,700	4,730,900	10,570,600
Contingencies			
@ 15 Percent	437,700	229,800	667,500
@ 10 Percent	292,200	319,900	612,100
Sub-Total	6,569,600	5,280,600	11,850,200
Engineering[24]			
@ 10 Percent	179,100	332,700	511,800
@ 5 Percent	117,800	218,800	336,600
Sub-Total	6,866,500	5,832,100	12,698,600
Land[25]	18,000	-	18,000
Total Project Cost	6,884,500	5,832,100	12,716,600

23/ Engineering at 5 percent and contingencies at 10 percent for these items.

24/ Consists of 65 percent foreign exchange.

25/ 300 sqm at ₱60/sqm.

TABLE IX-11

CAPITAL COST SUMMARY

Construction Phase	Construction Period	Construction Cost (₱)	Project Cost (₱) Local	Foreign	Total
Immediate Improvement Program	1977–80	4,717,500	3,176,600	2,654,200	5,830,800
I-A	1980–85	7,486,600	4,464,900	4,588,000	9,052,900
I-B	1986–90	4,890,100	2,879,300	2,983,600	5,862,900
II-A	1991–95	11,018,200	6,342,700	6,933,900	13,276,600
II-B	1996–2000	10,570,600	6,884,500	5,832,100	12,716,600
Total		38,683,000	23,748,000	22,991,800	46,739,800

TABLE IX-12

ANNUAL OPERATION AND MAINTENANCE COSTS

Item	Annual Costs (₱)[26/] 1976	1980	1990	2000
Administration and Personnel	62,700	142,500	376,800	509,600
Power and Fuel	55,100	62,700	147,900	387,900
Chemicals	-	11,400	27,300	63,700
Maintenance	9,300	48,900	98,100	227,800
Miscellaneous	3,300	4,800	12,500	32,600
Total	130,400	270,300	662,600	1,221,600

[26/] Computed at 1978 price levels.

G. SEWERAGE/DRAINAGE CONCEPTS

Existing Drainage System

The existing drainage system in Gapan (see Figure IX-6) consists primarily of 600 and 1,000 mm concrete pipes and a 600 mm x 800 mm open concrete-lined canal traversing the municipality from east to west along Tinio Street. Five other conduits (two along Jacinto and Magno Streets in the poblacion, one along Del Pilar Street in Sto. Niño, and two open conduits along the eastern side of Barrio San Nicolas) transport storm water run-off to the Peñaranda River. Additional conduits, located adjacent to the public market and slaughterhouse, drain these facilities into nearby low-lying areas south of Tinio Street, where ponding often occurs near the railway embankment.

In addition to these permanent drainage facilities, many small open unlined peripheral street canals transport local drainage to the larger conduits or other local low-lying areas. These street canals consist mainly of earthen ditches varying in width from 0.30 to 0.60 meter with depths varying from 0.25 to 0.45 meter.

Over half of existing drainage facilities are old and currently inadequate. The municipality has a plan for additional drainage facilities, but no long-term engineering planning has been done. Drainage facilities are maintained by municipal staff, but inadequate funds are available for effective drainage system maintenance and expansion.

The existing drainage facilities were constructed primarily for the collection and disposal of storm water run-off. Most of the streets canals are dry during non-rainy periods. During rainy periods, surface run-off, as well as some miscellaneous solid wastes and an unknown amount of domestic wastewater, is carried by the street canals via the larger drainage conduits or various overland routes to the Peñaranda River.

Field observations of the drainage system in Gapan are as follows:

1. The major disposal area for storm water run-off is the Peñaranda River, which runs along the north side of the municipality. Some storm water is disposed of into areas between Tinio Street and the railway embankment south of the poblacion.

2. Domestic wastewater is discharged into septic tanks and pit privies. Some roof drainage is transported to these facilities, causing occasional flooding during rainy periods. Although direct discharge of domestic wastewater to storm water facilities appears to be uncommon, it is likely that an appreciable amount of domestic wastewater travels overland during rainy periods.

3. The public market and slaughterhouse drain their wastewaters into areas separated physically from the disposal area utilized by the remainder of the community. However, it is likely that pollution of surface flood-water takes place from these sources to some extent.

4. There are no existing industries producing significant wastewaters.

5. Approximately 20 cumd of solid wastes is collected by the municipal staff, and disposed of in an area adjacent to the Peñaranda River near the Gapan-Cabanatuan Road.

6. Clogging of drainage conduits is caused by deposition of locally eroded soils and the dumping of solid wastes into drainage canals. The lack of gratings on drainage conduit inlets aggravates this problem.

7. No significant flood problems have been experienced in Gapan, although periodic flooding between Tinio Street and the railway embankment is occasionally a nuisance.

Relationship With Infrastructure and Other Engineering and Economic Factors

The provision of sewerage and drainage facilities within the GAP-WD has a significant impact on water supply and other infrastructure components. However, economics (public's ability-to-pay) and the status of public health affect directly the feasibility of providing sewerage and drainage facilities.

In view of the relatively minor storm water drainage problems being experienced in the GAP-WD area, it appears that drainage facilities do not warrant high priority in Gapan's list of infrastructure components. Before decisions can be made concerning the implementation of sewerage and/or drainage programs, additional technical and economic data must be collected and evaluated.

Information from the Municipal Census Office indicates that in 1970, 28 percent of Gapan's households had water-borne toilet facilities; 32 percent had closed-pit type toilets; and 40 percent had no private toilet facilities. It is unlikely that such a low percentage of "modern" facilities can economically justify a near-future sewerage program.

The rationale for the provision of wastewater facilities has traditionally been based on aesthetics and public health benefits. At present, there is an obvious water supply problem in the GAP-WD. As the water supply problem is resolved, wastewater volumes will increase. Related aesthetic and public health standards will improve in time, increasing the urgency for solution of the wastewater problem.

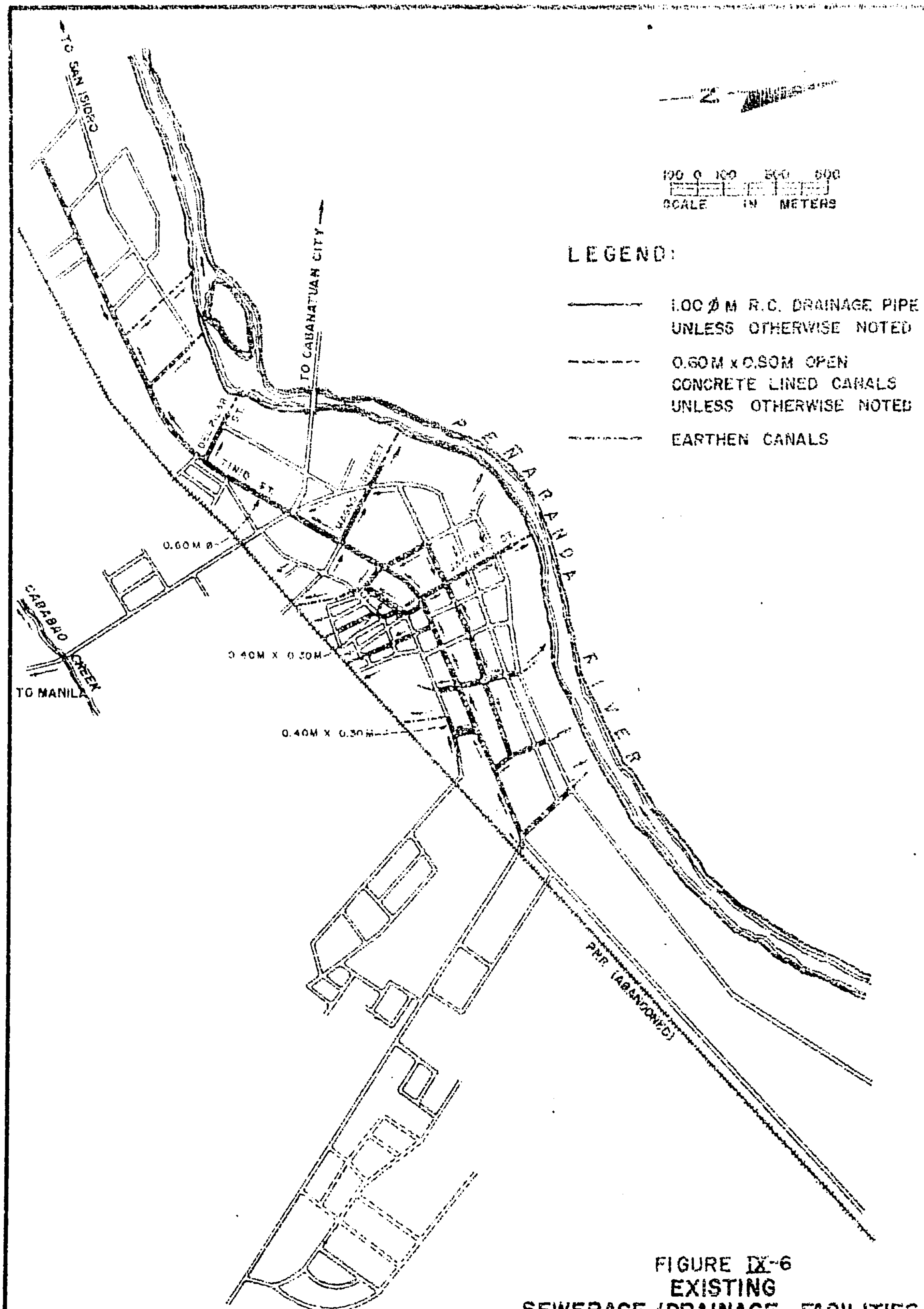

FIGURE IX-6
EXISTING
SEWERAGE / DRAINAGE FACILITIES
SCHEMATIC
GAPAN WATER DISTRICT

Projected Wastewater Volumes

Projections have been made for wastewater flows in the GAP-WD for the years 1990, 2005 and 2025. These estimates are shown in Table IX-13.

The service area considered for the wastewater projections was the core area to receive water supply by 1980. This area is the most densely populated area in the water district, and is the area where public health and nuisance problems associated with wastewater will be greatest.

The wastewater volume which could be collected was determined by estimating the percentage of water supply connections (domestic and commercial/industrial/institutional) with sewer connections during the design period from 1990 to 2025. It was assumed that all water supply connections would have sewer connections by 2025, and that in 1990, 30 percent of domestic and 50 percent of commercial/industrial/institutional water supply connections will have sewer connections. It was assumed that there would be no unusually large water-consuming connections during the design period, and that 90 percent of water consumed would, therefore, be returned to the sewers. An allowance was made for groundwater infiltration into the sewers, based on projected percentage of physical area with sewers and an infiltration rate of 0.15 lps/hectare. The number of sewer connections required during the design period was then checked to ensure that the annual rate of sewer connections was realistically within the capabilities of the water district.

Alternatives Available

The cost of sewerage/drainage facilities for the GAP-WD area is expected to be significant.

A financially self-sufficient sewerage/drainage system is seldom achieved even in developed countries. It is likely that the GAP-WD is no exception to this rule.

Feasible alternatives for sewerage in GAP-WD area appear to be as follows:

1. individual (septic tanks) or unified public collection system;
2. combined or separate sewerage/drainage systems;
3. various degrees of centralized sewage treatment;
4. disposal system (river or land disposal) for treated sewage.

TABLE IX-13

AVERAGE DAILY WASTEWATER FLOWS
GAPAN WATER DISTRICT

Served Area	Design Year	Wastewater Flows (cumd) Domestic	Commercial/ Industrial/ Institutional	Infiltration Allowance	Total
Poblacion	1990	396	92	739	1,227
	2005	1,415	341	1,064	2,820
	2025	5,507	1,211	1,477	8,195
Barrio	1990	175	41	544	760
San Nicolas	2005	626	151	784	1,561
	2025	2,434	536	1,089	4,059
Barrio	1990	90	21	259	370
Sto. Niño	2005	320	77	373	770
	2025	1,246	274	518	2,038
T o t a l	1990	661	154	1,542	2,357
	2005	2,361	569	2,221	5,151
	2025	9,187	2,021	3,084	14,292

The question of whether the GAP-WD should construct a combined or a separate sewerage/drainage system depends on economic circumstances.

An alternative to the combined system, which must be investigated in detail during the sewerage feasibility study, is the provision of open canals (peripheral drains).

Alternative treatment and disposal methods for intercepted wastewater may consist of:

(1) Screening of gross solids; high-rate lagoons and effluent discharge into the Peñaranda River.

(2) Some form of treatment such as conventional primary and/or high-rate secondary treatment may be applied. Treated wastes may be used potentially for agricultural irrigation.

Recommendations

As soon as the first phase of the water supply program is underway, a comprehensive sewerage/drainage feasibility study should be undertaken. This study must address the issue of combined versus separate sewers. It should also update the population and water demand projections of this water supply study.

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

A plumbing code should be developed by the GAP-WD to coordinate plumbing requirements for water, wastewater and surface run-off facilities. This code becomes very important and meaningful particularly if a separate system of sewers is adopted.

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

For residences and establishments that currently lack waste disposal facilities and are financially unable to provide the modern flush toilet with septic tank, the Department of Health (Division of Environmental Sanitation) has developed an inexpensive water-seal toilet.

Permanent rights-of-way should be acquired for the main routes that will be used for drainage/sewerage canals.

Dumping solid wastes into waterways, canals and manholes, should be strictly prohibited. Solid wastes not only pollute the water, but are also very unsightly and serve as habitats for flies, rodents and parasites. The proper handling of solid wastes should be studied and planned carefully.

H. MANAGEMENT OF WATER RESOURCES

In order to make the best use of water resources available for present and future demands of the GAP-WD, certain technical and management steps must be considered. These considerations are primarily related to the collection of data concerning the chemical quality and amount of water produced by the district, and a data storage and retrieval system which would provide easy accessibility to those organizations dealing with the subject. These are discussed further in Appendix P, Volume II of this report.

I. UPDATING THE WATER SUPPLY MASTER PLAN

To be a meaningful working document, this water supply master plan must be periodically updated. Changes related to technological developments, social goals, land use concepts, unforeseen population growth or movement, etc., must be reviewed for possible long-range impact on the programs recommended in this report. An outline of the steps required for such periodic updating is presented in Appendix Q, Volume II.

J. ENVIRONMENTAL CONSIDERATIONS

Appendix R, Volume II discusses some of the ways the construction program may affect the environment of the study area. Some of the natural resources affected by the program are irreplaceable, requiring due consideration before actual construction.

ANNEX IX-C

DISTRIBUTION SYSTEM GROWTH

ANNEX IX-C

DISTRIBUTION SYSTEM GROWTH

General

It is necessary to project the growth of the distribution system in order to estimate the required expenditures for internal network piping, service connections, and fire hydrant requirements. The projection of distribution system growth is based on (1) an apportionment of the served population among individual sections within the service area; (2) the projected number of people served by each connection; and (3) the individual areas of served sections within the service area. The details of these items are discussed below.

Served Population

The projections of served population presented in Chapter VI are also presented in Annex Table IX-C-1 according to individual community served and respective service areas in 1976, 1980, 1990 and 2000.

Number of Persons per Connection

Based on the pilot area survey conducted within the present service area, the average number of persons served by a single service connection is 7.0; this figure is expected to remain until 1980. As living standards improve during the design period, it is expected that the Household population will tend to decrease. It has, therefore, been assumed that population per service connection will decrease to 6.0. This figure has been used for 1990 and 2000 projections.

Total Served Area for Individual Communities

The total areas of individual served communities were projected on the basis of field studies and locations with potential consumers of the GAP-WD water supply. These projections are presented in Annex Table IX-C-2.

Area Served by Internal Network

In order to project the net area to be served by internal network, the gross served areas were reduced in proportion to the expected percentage of population served. This served area was further reduced based on the assumption that (1) some of the

ANNEX TABLE IX-C-1

SERVED POPULATION PROJECTIONS
GAPAN WATER IDSTRICT

Community Served	1976 Service Area	1980 Service Area	1990 Service Area	2000 Service Area
Gapan Poblacion	2,595	6,650	11,400	19,300
Bo. San Nicolas	51	2,940	8,400	13,800
Bo. Sto. Niño	195	1,505	4,080	5,820
Bo. Mangino	13	980	3,600	7,500
Bo. Pambuan	6	315	3,800	8,580
Bo. Bayanihan	-	490	1,500	2,700
Bo. Sto Cristo Norte	-	-	1,320	4,020
Bo. Malapit	-	-	4,200	8,400
Bo. Sto Cristo Sur	-	-	-	3,300
Bo. Malimba	-	-	-	2,220
Bo. San Roque	-	-	-	4,800
Bo. Sta Cruz	-	-	-	4,500
San Isidro Poblacion	-	-	-	6,960
Total Served Population	2,860	12,880	38,300	91,900
Total Service Area Population	22,038	31,330	63,830	131,290
Percent Served	13%	41%	60%	70%

ANNEX TABLE IX-C-2

TOTAL SERVED AREA FOR INDIVIDUAL COMMUNITIES
(in hectares)

Community Served	1976 Service Area	1980 Service Area	1990 Service Area	2000 Service Area
Gapan Poblacion	75	114	114	114
Bo. San Nicolas	57	84	112	132
Bo. Sto. Niño	28	40	40	40
Bo. Mangino	5	35	88	110
Bo. Pambuan	4	16	50	101
Bo. Bayanihan	-	12	68	128
Bo. Sto. Cristo Norte	-	-	55	100
Bo. Malapit	-	-	84	118
Bo. Sto. Cristo Sur	-	-	-	108
Bo. Malimba	-	-	-	43
Bo. San Roque	-	-	-	55
Bo. Sta. Cruz	-	-	-	115
San Isidro Poblacion	-	-	-	75
Total Served Area	169	301	611	1,239

distribution system pipes included in the analyses performed for this study are actually internal network pipes, and (2) some of the proposed distribution pipelines themselves will serve consumers directly. It has been assumed that relevant distribution system pipelines passing through the service areas can serve an area within 50 meters on each side of the pipelines. The resultant net areas to receive internal network are listed in Annex Table IX-C-3, according to service area, and Annex Table IX-C-4, according to construction phase.

Number of Service Connections

The number of service connections was projected by dividing the served population by the average number of persons per connection. The estimated number of service connections for each community within the service area is presented in Annex Table IX-C-5.

During the leakage survey which will be conducted as part of the immediate improvement program, it is expected that some existing service connections will be identified as major sources of leakage. It is projected that major repair and replacement will include 20 percent of existing service connections by 1980, and the remaining 80 percent during Phase I-A.

Areas to Receive Fire Protection

Because of the financial impact of the overall construction program on the served population, it is proposed that only the poblacion of Gapan receive full fire protection coverage by the year 2000. Barrios San Nicolas, Sto. Niño, Mangino, Pambuan, Bayanihan, Sto. Cristo Norte and Malapit will receive 50 percent coverage by that year; and barrios Sto. Cristo Sur, Malimba, San Roque and Sta. Cruz and San Isidro Poblacion will receive 30 percent coverage. All the communities within the service area, except the poblacion, will be provided with the normal residential type of hydrant coverage. Portions of the poblacion, because of higher property values associated with commercial areas, will be provided with a higher level of hydrant service. The schedule for fire hydrant installation is presented in Annex Table IX-C-6.

It should be noted that although a community may not receive complete fire hydrant coverage within the design period, it will be provided with full fire-flow pipeline capacity. The pipelines will be designed to provide the required fire flows, regardless of hydrant installation scheduling.

Distribution System Computer Printouts

The following computer printouts (see Annex Tables IX-C-7 and IX-C-8) indicate the estimated hydraulic conditions of the GAP-WD

ANNEX TABLE IX-C-3

NET AREA SERVED BY INTERNAL NETWORK SYSTEM, BY SERVICE AREA (in hectares)

Community Served	1980 Service Area	1990 Service Area	2000 Service Area
Gapan Poblacion	17.0	18.5	41.5
Bo. San Nicolas	8.0	39.8	67.8
Bo. Sto. Niño	8.0	16.0	20.0
Bo. Mangino	12.0	23.0	47.0
Bo. Pambuan	5.0	29.0	60.0
Bo. Bayanihan	6.0	50.0	113.0
Bo. Sto. Cristo Norte	-	12.0	60.0
Bo. Malapit	-	69.0	79.0
Bo. Sto. Cristo Sur	-	-	60.5
Bo. Malimba	-	-	11.0
Bo. San Roque	-	-	29.5
Bo. Sta. Cruz	-	-	54.0
San Isidro Poblacion	-	-	45.5
Total	56.0	257.3	688.8

ANNEX TABLE IX-C-4

NET AREA SERVED BY INTERNAL NETWORK SYSTEM, BY CONSTRUCTION PHASE

Construction Period	Construction Phase	Area Served (ha)
1980-85	I-A	165.8
1986-90	I-B	91.5
1991-95	II-A	215.8
1996-2000	II-B	215.7
		688.8

ANNEX TABLE IX-C-5

SCHEDULE FOR SERVICE CONNECTION INSTALLATION

Location	Immediate Improvements	Phase I-A (1981-85)	Phase I-B (1986-90)	Phase II-A (1991-95)	Phase II-B (1996-2000)
Gapan Poblacion (399)[1/]	551	475	475	660	660
Bo. San Nicolas (8)	412	490	490	450	450
Bo. Sto. Niño (30)	185	233	232	145	145
Bo. Mangino (2)	138	230	230	325	325
Bo. Pambuan (1)	44	292	293	400	400
Bo. Bayanihan	70	90	90	100	100
Bo. Sto. Cristo Norte	-	110	110	225	225
Bo. Malapit	-	350	350	350	350
Bo. Sto. Cristo Sur	-	-	-	275	275
Bo. Malimba	-	-	-	185	185
Bo. San Roque	-	-	-	400	400
Bo. Sta. Cruz	-	-	-	375	375
San Isidro Poblacion	-	-	-	580	580
Total	1,400	2,270	2,270	4,470	4,470
Cumulative Total	1,840	4,110	6,380	10,850	15,320

[1/] Numbers in parentheses indicate existing service connections.

ANNEX TABLE IX-C-6

SCHEDULE FOR FIRE HYDRANT INSTALLATION

Location	Area Receiving Fire Protection (ha)				
	Phase I-A (1981-85)	Phase I-B (1986-90)	Phase II-A (1991-95)	Phase II-B (1996-2000)	Total
Gapan Poblacion (6.8)	27.2	23.0	23.0	23.0	103.0
Bo. San Nicolas (1.7)	-	17.1	17.1	17.1	53.0
Bo. Sto. Niño (1.6)	-	4.8	4.8	4.8	16.0
Bo. Mangino	-	12.8	12.8	12.9	38.5
Bo. Pambuan	-	11.8	11.8	11.9	35.5
Bo. Bayanihan	-	21.3	21.3	21.4	64.0
Bo. Sto. Cristo Norte	-	11.7	11.7	11.6	35.0
Bo. Malapit	-	15.7	15.7	15.6	47.0
Bo. Sto. Cristo Sur	-	-	11.4	11.4	22.8
Bo. Malimba	-	-	3.9	3.9	7.8
Bo. San Roque	-	-	5.7	5.7	11.4
Bo. Sta. Cruz	-	-	10.3	10.4	20.7
San Isidro Poblacion	-	-	7.8	7.8	15.6
(10.1)	27.2	118.2	157.3	157.5	470.3

distribution system in the year 2000. The peak hour and minimum hour conditions are included as representative of the design conditions. The critical conditions for some pipelines are not necessarily the peak or minimum hour conditions but that the majority of the pipelines are at design capacity during peak-hour conditions.

The format of computer printouts is discussed in Chapter XII of the Methodology Manual. Pipeline numbers of the series 0 to 100 on the computer printouts are existing pipelines. If an existing pipeline is replaced at some point, the 0 to 100 series pipe is replaced with a 400 series pipeline. The 100 series pipelines are recommended for installation during the immediate improvement program. The 200 series pipelines are intended to satisfy 1990 design conditions, and the 300 series pipelines, to satisfy year 2000 design conditions.

Some of the pipelines in the recommended construction program may appear to be in a phase not indicated by their pipe number. This may result when other considerations govern the timing of recommended construction. An example might be that a 300 series pipeline is included for Phase I-B construction. The 300 series indicates that the pipe is not required in an area to serve people until after 1990. A well may be located along the pipeline, and if the well was required before 1990 to serve other areas, the 300 series pipe would need to be constructed prior to 1990.

These computer programs have been conducted based on tank overflow elevation of 41.0 meters as first reported by the GAP-WD. Subsequently, the tank was measured and assuming a ground elevation of 19 meters the tank overflow would be at elevation 45.0 meters. The effect on the program would be to raise the overall hydraulic gradeline 4 meters, which would improve service. The computer programs were not revised since there were no actual survey data in the GAP-WD. During the design phase these elevations should be determined accurately and the design adjusted accordingly.

ANNEX TABLE IX-C-7

COMPUTER PRINTOUT
YEAR 2000 PEAK HOUR
GAPAN WATER DISTRICT

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GAPAN 2000 PEAK HOUR


INPUT AND OUTPUT IN                     LPS
NO OF NODES                             107
NO OF PIPES                             146
MAX NO OF ITERATIONS                     20
PEAKING FACTOR                      1.75000
ALLOW P-DROP FR/STATIC - PCT          30.0
STATIC HGL FOR P-DROP CALC            41.0
MAX UNBAL - LPS                     0.05000
MAX ALLOW VEL -MPS                    3.000
MIN ALLOW VEL - MPS                   0.400
MAX ALLOW HL -  M/1000 M              10.00
MIN ALLOW HL -  M/1000 M               0.20
MAX ALLOW PRESS - ATM                 7.000
MIN ALLOW PRESS - ATM                 0.700
NO OF HEADS TO BE READ                    1
NO OF UNKNOWN CONSUMPTIONS                1
SUM OF FIXED DEMANDS                  19.49
BANDWIDTH                                 7
ITER  1 UNBAL    20.87 LPS
ITER  2 UNBAL    10.56 LPS
ITER  3 UNBAL     4.39 LPS
ITER  4 UNBAL     2.25 LPS
ITER  5 UNBAL     0.93 LPS
ITER  6 UNBAL     0.19 LPS
ITER  7 UNBAL     0.03 LPS

SOLUTION NO. 1 REACHED IN    7 ITERATIONS
        0.0262 GPM UNBALANCE
```

ANNEX TABLE IX-C-7 (continued)

PIPE NO	NODES FROM	NODES TO	DIA MM	L M	C-HW	K-VALUE	FLOW	--VEL-- MPS	CK	--HEADLOSS-- MT	MT/1000	CK
401	2	[illegible]	150	450.	100	[illegible]	12.27	0.69		1.55	6.21	
402	2	1	200	220.	110	[illegible]	[illegible].17	0.71		[illegible]	[illegible]	
403	1	4	200	225.	110	0.[illegible]E-02	18.66	0.59		0.63	2.79	
405	[illegible]	3	150	300.	100	0.1[illegible]E-01	5.22	0.30	LO	0.38	1.27	
406	4	12	200	95.	110	[illegible]	14.12	0.45		0.15	1.66	
407	12	17	200	90.	110	0.111[illegible]E-02	10.81	0.34	LO	0.09	1.01	
408	12	10	200	95.	110	0.1176E-02	7.56	0.24	LO	0.05	0.52	
409	9	7	150	70.	100	[illegible]	2.93	0.17	LO	0.03	0.44	
410	6	7	150	37.	100	0.2[illegible]E-02	2.90	0.16	LO	0.02	0.43	
412	11	9	150	205.	100	0.123[illegible]E-01	4.23	0.24	LO	0.19	0.87	
413	10	11	250	120.	110	0.530[illegible]E-03	2.53	0.05	LO	0.00	0.02	LO
414	14	11	250	310.	110	0.120[illegible]E-02	5.79	0.12	LO	0.03	0.11	LO
415	16	14	250	340.	110	0.142[illegible]E-02	12.48	0.25	LO	0.15	0.45	
416	17	16	200	[illegible]	110	[illegible]	14.29	0.45		0.05	1.70	
417	23	22	200	280.	110	[illegible]	17.83	0.57		0.72	2.56	
418	17	18	100	150.	100	[illegible]	0.12	0.01	LO	0.00	0.01	LO
419	24	18	100	370.	100	[illegible]	2.40	0.31	LO	0.81	2.19	
420	25	[illegible]	250	100.	110	[illegible]	0.37	0.01	LO	0.00	0.00	LO
421	28	29	250	45.	110	0.1[illegible]E-03	10.72	0.22	LO	0.02	0.34	
422	28	27	150	145.	100	[illegible]	9.07	0.46		0.41	2.86	
423	32	28	150	[illegible]	100	0.112[illegible]E-01	9.97	0.56		0.93	4.23	
424	27	23	100	210.	100	[illegible]E-01	1.58	0.20	LO	0.21	1.00	
425	27	24	100	160.	100	[illegible]E-01	1.79	0.23	LO	0.20	1.26	
426	31	27	150	100.	100	[illegible]E-02	7.14	0.40		0.23	2.29	
427	32	31	150	210.	100	0.126[illegible]E-01	7.25	0.41		0.49	2.34	
428	33	32	150	140.	100	[illegible]E-02	7.72	0.44		0.37	2.63	
429	40	32	150	170.	100	0.112[illegible]E-01	12.23	0.69		1.05	6.17	
430	34	31	100	140.	100	[illegible]E-01	1.64	0.21	LO	0.15	1.08	
431	37	34	100	300.	100	[illegible] 00	1.42	0.18	LO	0.25	0.82	
432	38	34	100	240.	100	[illegible] 00	3.06	0.39	LO	0.82	3.42	
433	45	36	100	155.	100	[illegible]E-01	1.76	0.22	LO	0.19	1.22	
434	37	35	100	95.	100	0.400[illegible]E-01	4.97	0.63		0.80	8.41	
435	37	43	100	160.	100	[illegible]E-01	1.99	0.25	LO	0.25	1.54	
436	38	37	150	115.	100	[illegible]E-02	10.92	0.62		0.58	5.00	
437	[illegible]	40	100	160.	100	[illegible]E-01	2.34	0.30	LO	0.33	2.07	
438	39	38	200	190.	110	[illegible]E-02	19.38	0.62		0.57	2.99	
439	[illegible]	40	150	20.	100	0.170[illegible]E-02	0.03	0.00	LO	0.00	0.00	LO
440	36	24	200	130.	110	[illegible]E-02	4.73	0.15	LO	0.03	0.22	LO
441	46	45	100	100.	100	[illegible]E-01	0.73	0.09	LO	0.02	0.24	LO
442	47	45	100	120.	100	[illegible]E-01	2.86	0.36	LO	0.36	3.02	
443	47	[illegible]	100	90.	100	[illegible]E-01	1.63	0.21	LO	0.10	1.06	
444	49	47	100	130.	100	[illegible]E-01	3.72	0.47		0.49	4.[illegible]	
445	[illegible]	[illegible]	100	[illegible]	100	0.366[illegible]E-01	2.98	0.38	LO	[illegible]	3.25	
446	51	49	150	130.	100	0.777[illegible]E-02	5.57	0.32	LO	0.19	1.44	
447	[illegible]	[illegible]	[illegible]	[illegible]	110	[illegible]E-03	2.63	0.08	LO	0.01	0.07	LO
448	46	52	100	150.	100	[illegible]E-01	0.63	0.08	LO	0.03	0.19	LO
449	48	46	100	120.	100	[illegible]E-01	2.30	0.29	LO	0.24	2.02	
450	48	50	100	[illegible]	100	[illegible]E-01	1.61	0.21	LO	0.14	1.04	
451	50	[illegible]	100	[illegible]	100	[illegible]E-01	3.08	0.39	LO	0.31	3.45	
452	50	60	100	127.	100	[illegible]E-01	2.10	0.27	LO	0.21	1.70	

ANNEX TABLE IX-C-7 (continued)

PIPE NO	NODES FROM	NODES TO	DIA MM	[illegible] MTRS	[illegible]	[illegible]	[illegible]	VEL MPS	CK	HEADLOSS MT	MT/1000	CK
453	52	51	100	125.	100	[illegible]	[illegible]	0.40		0.46	3.66	
454	61	52	150	127.	100	0.77??E-02	1.56	0.09	LO	0.02	0.14	LO
455	58	64	100	130.	100	0.3100E-01	1.07	0.14	LO	0.09	0.40	
456	56	57	100	85.	100	0.?6?E-01	1.97	0.25	LO	0.12	1.52	
457	59	55	100	100.	100	0.1???E-01	1.41	0.18	LO	0.15	0.81	
458	60	59	100	80.	100	0.?05?E-01	2.34	0.26	LO	0.24	2.99	
459	60	66	100	182.	100	0.??5?E-01	1.74	0.22	LO	0.22	1.20	
460	61	60	100	135.	100	[illegible]	3.80	0.48		0.69	5.00	
461	62	61	200	80.	110	0.?8??E-03	11.09	0.35	LO	0.09	1.02	
462	63	62	150	1??.	100	0.????E-02	7.81	0.44		0.31	2.60	
463	64	63	150	100.	100	0.??8?E-02	7.86	0.44		0.27	2.72	
464	61	67	150	155.	100	0.?27?E-02	4.13	0.23	LO	0.12	0.82	
465	65	70	100	235.	100	0.1???E 00	2.11	0.27	LO	0.40	1.72	
466	66	65	100	91.	100	0.????E-01	2.23	0.29	LO	0.18	1.99	
467	67	66	100	100.	100	0.??1?E-01	4.75	0.61		0.77	7.75	
468	66	71	100	200.	100	0.1317E 00	2.21	0.28	LO	0.57	1.97	
469	72	67	150	170.	100	0.?17?E-02	2.20	0.12	LO	0.04	0.26	LO
470	74	72	200	95.	110	0.117?E-02	16.94	0.54		0.22	2.33	
471	73	74	150	185.	100	0.1?1?E-01	13.09	0.74		1.30	7.00	
472	75	74	200	225.	110	0.?78?E-02	19.48	0.62		0.68	3.02	
473	69	63	100	135.	100	0.??05E-01	0.89	0.11	LO	0.05	0.35	
474	70	69	150	35.	100	0.??05E-02	4.07	0.23	LO	0.03	0.80	
475	71	70	150	125.	100	0.7?8?E-02	4.04	0.23	LO	0.10	0.79	
476	72	71	150	100.	100	0.????E-02	4.26	0.24	LO	0.09	0.89	
477	69	76	150	208.	100	0.1?08E-01	1.97	0.11	LO	0.04	0.21	LO
478	73	72	150	245.	100	0.1?7?E-01	6.38	0.36	LO	0.45	1.85	
479	76	72	150	220.	100	0.132?E-01	4.31	0.24	LO	0.20	0.90	
480	78	81	200	500.	110	0.?17?E-02	2.93	0.09	LO	0.05	0.09	LO
481	22	17	250	110.	110	0.??3?E-02	14.49	0.34	LO	0.08	0.75	
101	5	[illegible]	100	270.	100	0.116?E 00	0.79	0.10	LO	0.08	0.28	LO
102	7	[illegible]	100	220.	100	0.??2?E-01	2.59	0.33	LO	0.50	2.51	
103	??	[illegible]	150	300.	100	0.170?E-01	2.75	0.16	LO	0.12	0.38	
104	14	9?	150	240.	100	0.1?47E-01	2.73	0.16	LO	0.09	0.29	
105	18	1?	100	40.	100	0.172?E-01	0.42	0.05	LO	0.00	0.09	LO
106	21	13	100	5?.	100	0.??5?E-01	0.88	0.11	LO	0.02	0.34	
107	1?	1?	100	150.	100	0.?465E-01	1.56	0.20	LO	0.15	0.93	
108	20	21	100	160.	100	0.??0?E-01	2.87	0.37	LO	0.49	3.04	
109	1?	2?	100	40.	100	0.172?E-01	0.99	0.13	LO	0.02	0.42	
110	2?	1?	100	50.	100	0.215?E-01	4.56	0.58		0.36	7.14	
111	2?	20	150	105.	100	0.117?E-01	9.42	0.53		0.74	?.??	
112	24	2?	100	240.	100	0.1?2? 00	2.17	0.28	LO	0.43	1.81	
113	24	2?	100	1??.	100	0.?09?E-01	0.32	0.04	LO	0.01	0.05	LO
114	3?	37	250	75?.	110	0.31??E-02	4.64	0.09	LO	0.05	0.07	LO
115	3?	2?	200	25?.	110	0.?3?E-02	19.53	0.62		0.89	?.?5	
116	4?	3?	200	1??.	110	0.1?1?E-02	28.27	0.90		0.93	?.??	
117	27	2?	100	200.	100	0.?(?2?E-01	2.06	0.26	LO	0.33	1.65	
118	21	30	100	150.	100	0.?46?E-01	0.14	0.02	LO	0.00	0.01	LO
119	?6	25	100	12?.	100	0.?4?5E-01	0.37	0.05	LO	0.01	0.07	LO
120	41	4?	200	?5.	110	0.117?E-02	14.10	0.45		0.14	1.66	
121	41	53	100	200.	100	0.?(?2?E-01	2.72	0.35	LO	0.55	2.75	

ANNEX TABLE IX-C-7 (continued)

PIPE NO	NODES FROM-TO		DIA MM	L MTRS	H-W C	[illegible]	FLOW	--VEL-- MPS	--CK	--HEADLOSS--- MT	MT/1000
122	42	41	200	40.	110	[illegible]-02	17.01	0.54		0.09	2.2[illegible]
123	55	42	250	100.	110	0.417[illegible]-03	44.01	0.91		0.43	4.26
124	43	4[illegible]	100	1[illegible].	100	0.[illegible]-01	0.[illegible]	0.08	LO	0.02	0.19 LO
125	44	4[illegible]	100	10[illegible].	[illegible]	[illegible]-01	0.70	0.09	LO	0.02	0.23 LO
126	55	54	150	80.	100	0.[illegible]-02	13.45	0.87		0.76	9.5[illegible]
127	55	43	100	170.	100	0.[illegible]-01	2.60	0.2[illegible]	LO	0.43	2.57
128	44	57	100	5[illegible].	100	[illegible]-01	1.82	0.23	LO	0.07	1.31
129	53	62	100	145.	100	[illegible]-01	1.98	0.25	LO	0.22	1.53
130	56	54	100	130.	100	0.[illegible]-01	1.67	0.21	LO	0.14	1.11
131	57	56	100	9[illegible].	100	[illegible]-01	1.75	0.22	LO	0.12	1.2[illegible]
132	53	51	150	80.	100	[illegible]-02	9.67	0.55		0.32	3.99
133	54	5[illegible]	150	100.	100	[illegible]-02	9.12	0.5[illegible]		0.36	3.5[illegible]
134	74	5[illegible]	150	31[illegible].	100	0.1[illegible]-01	1.63	0.09	LO	0.05	0.15 LO
135	77	76	150	18[illegible].	100	0.[illegible]-01	6.1[illegible]	0.35	LO	0.32	1.75
136	78	79	100	150.	100	0.[illegible]-01	2.13	0.27	LO	0.26	1.75
137	7[illegible]	8[illegible]	100	5[illegible].	100	[illegible]	0.13	0.02	LO	0.01	0.01 LO
138	81	80	100	150.	100	[illegible]-01	1.95	0.25	LO	0.22	1.49
139	82	81	100	11[illegible].	100	0.[illegible]74[illegible]-01	2.41	0.32	LO	0.26	2.32
140	75	8[illegible]	150	300.	100	0.[illegible]-01	10.66	0.60		1.43	4.78
141	85	84	100	150.	100	0.[illegible]-01	2.8[illegible]	0.36	LO	0.44	2.95
142	84	83	100	250.	100	0.1[illegible]-00	1.44	0.18	LO	0.21	0.85
143	[illegible]	8[illegible]	150	250.	100	0.[illegible]-01	6.45	0.36	LO	0.47	1.89
144	86	83	150	150.	100	0.[illegible]-02	5.08	0.29	LO	0.18	1.22
145	3	[illegible]	100	150.	100	0.[illegible]-01	3.99	0.51		0.84	5.59
146	100	5[illegible]	350	15.	120	0.103[illegible]-04	63.00	0.65		0.02	1.43
147	7[illegible]	41	250	20.	110	0.[illegible]-02	0.09	0.00	LO	0.00	0.00 L
157	8[illegible]	82	150	280.	100	0.1[illegible]-01	5.16	0.29	LO	0.35	1.2[illegible]
201	89	[illegible]	250	1700.	110	0.[illegible]-02	6.69	0.14	LO	0.24	0.14 L
202	98	91	250	2000.	110	0.[illegible]-02	21.07	0.43		2.35	1.18
203	9[illegible]	9[illegible]	200	1300.	110	0.1411-01	0.50	0.02	LO	0.01	0.00 L
204	96	77	200	1050.	110	0.1[illegible]-01	8.29	0.26	LO	0.65	0.6[illegible]
205	101	[illegible]	200	15.	110	0.1[illegible]-03	31.50	1.00		0.11	7.35
206	102	7[illegible]	200	15.	110	0.1[illegible]-03	31.50	1.00		0.11	7.35
207	4	3	100	180.	100	0.77[illegible]-01	1.02	0.13	LO	0.08	0.45
208	10	[illegible]	100	190.	100	0.[illegible]-01	1.46	0.19	LO	0.16	0.86
301	89	90	200	1300.	110	0.1[illegible]-01	25.51	0.81		6.47	4.97
302	91	92	200	1550.	110	0.1[illegible]-01	6.34	0.20	LO	0.58	0.38
303	93	9[illegible]	200	1750.	110	0.21[illegible]-01	5.76	0.18	LO	0.55	0.32
304	9[illegible]	94	200	[illegible]50.	110	0.1[illegible]-01	17.60	0.56		2.13	2.50
305	95	9[illegible]	250	1450.	110	0.1[illegible]-01	15.50	0.34	LO	2.5[illegible]	0.75
306	96	97	200	1350.	110	0.1[illegible]-01	3.80	0.2[illegible]	LO	0.94	0.60
307	103	9[illegible]	250	15.	110	0.[illegible]-04	63.00	1.28		0.13	9.05
308	104	93	200	15.	110	0.1[illegible]-03	31.50	1.00		0.11	7.35
309	105	9[illegible]	200	15.	110	0.135[illegible]-03	31.50	1.00		0.11	7.35
310	106	9[illegible]	200	15.	110	0.13[illegible]-03	31.50	1.00		0.11	7.35
311	107	96	200	15.	110	0.13[illegible]-03	31.50	1.00		0.11	7.35

ANNEX TABLE IX-C-7 (continued)

[illegible]	ORIGINAL ELEV	TIDE	[illegible] ELEV	HEAD MTRS	--- PRESSURE --- ATM---CK		PCT DROP---CK	
1	18.0	-3.62	32.010	14.01	1.44		35.16	HI
2	18.0	-2.76	33.760	15.76	1.53		31.49	HI
3	18.0	-4.03	32.210	14.21	1.38		38.23	HI
4	18.0	-3.52	32.200	14.20	1.38		37.09	HI
5	18.0	-3.20	31.371	13.37	1.29		41.88	HI
6	18.0	-3.33	31.290	13.29	1.27		42.21	HI
7	18.0	-3.24	31.790	13.79	1.34		40.03	HI
8	18.0	-2.74	31.820	13.82	1.34		39.90	HI
9	18.0	-4.05	31.810	13.81	1.34		39.96	HI
10	18.0	-3.57	31.900	13.90	1.35		39.13	HI
11	18.0	-4.09	31.990	13.99	1.35		39.19	HI
12	18.0	-3.71	32.130	14.13	1.37		38.57	HI
13	18.0	-3.25	32.040	14.04	1.35		38.97	HI
14	18.0	-2.94	32.020	14.02	1.36		39.05	HI
15	18.0	-2.52	32.220	14.22	1.39		38.17	HI
16	18.0	-2.24	32.170	14.17	1.37		38.39	HI
17	18.0	-2.09	32.220	14.22	1.39		38.17	HI
18	18.0	-2.01	32.170	14.17	1.37		38.38	HI
19	18.0	-2.01	32.720	14.72	1.39		37.74	HI
20	18.0	-1.59	32.680	14.68	1.42		36.19	HI
21	18.0	-1.99	32.190	14.19	1.37		38.30	HI
22	18.0	-2.33	32.300	14.30	1.38		37.91	HI
23	18.0	-2.10	33.020	15.02	1.45		34.69	HI
24	18.0	-1.62	33.030	15.03	1.45		34.66	HI
25	18.0	-2.17	32.600	14.60	1.41		36.54	HI
26	18.0	-2.06	32.900	14.90	1.44		35.21	HI
27	18.0	-1.71	33.230	15.23	1.47		33.78	HI
28	18.0	-0.79	33.440	15.44	1.49		32.99	HI
29	18.0	-0.92	33.420	15.42	1.49		32.95	HI
30	18.0	-0.14	33.460	15.46	1.50		32.90	HI
31	18.0	-1.61	33.460	15.46	1.50		32.79	HI
32	18.0	-2.73	33.950	15.95	1.54		30.65	HI
33	18.0	-0.93	34.320	16.32	1.58		29.05	
34	18.0	-3.83	33.610	15.61	1.51		32.13	HI
35	18.0	-0.27	33.050	15.05	1.46		34.57	HI
36	18.0	-1.63	33.060	15.06	1.46		34.53	HI
37	18.0	-2.54	33.860	15.86	1.53		31.96	HI
38	18.0	-2.04	34.430	16.43	1.59		28.56	
39	18.0	14.490	35.00	17.00	1.65		26.09	
40	18.0	-1.93	35.000	17.00	1.65		26.09	
41	18.0	-0.13	35.160	17.16	1.66		25.40	
42	18.0	-0.14	35.250	17.25	1.67		24.99	
43	18.0	-0.09	35.270	17.27	1.67		24.89	
44	18.0	-0.07	35.300	17.30	1.67		24.79	
45	18.0	-1.94	33.250	15.25	1.48		33.71	HI
46	18.0	-0.94	33.270	15.27	1.48		33.60	HI
47	18.0	-1.22	33.610	15.61	1.51		32.13	HI
48	18.0	-0.70	33.510	15.51	1.50		32.55	HI
49	18.0	-1.21	34.100	16.10	1.56		30.00	
50	18.0	-0.98	33.320	15.32	1.53		31.20	HI

ANNEX TABLE IX-C-7 (continued)

NODE	GROUND ELEV	FLOW	HGL ELEV	HEAD MTRS	-------PRESSURE------- ATM---CK	PCT DROP---CK	
51	19.0	-1.47	34.990	16.20	1.58	25.10	
52	18.0	-1.01	34.290	16.28	1.59	20.21	
53	18.0	-0.10	34.510	16.51	1.61	27.90	
54	18.0	-1.15	34.971	16.97	1.64	26.24	
55	18.0	-0.14	35.731	17.73	1.72	22.93	
56	18.0	-2.50	35.110	17.11	1.66	25.61	
57	18.0	-0.07	35.230	17.23	1.67	25.11	
58	18.0	-1.54	33.240	15.24	1.47	32.72	HI
59	18.0	-1.07	33.370	15.37	1.49	33.16	HI
60	18.0	-1.31	33.610	15.61	1.51	32.13	HI
61	19.0	-1.50	34.?00	15.20	1.53	29.13	
62	19.0	-0.33	34.??	16.23	1.59	28.76	
63	18.0	-0.05	34.600	16.60	1.62	27.42	
64	18.0	-1.07	33.170	15.17	1.47	34.12	HI
65	18.0	-1.57	33.220	15.22	1.47	33.83	HI
66	18.0	-2.91	33.400	15.40	1.49	33.06	HI
67	18.0	-1.57	34.170	16.17	1.57	29.69	
68	18.0	-1.80	32.650	14.65	1.42	36.29	HI
69	18.0	-1.21	32.700	14.70	1.42	36.09	HI
70	18.0	-2.30	32.730	14.73	1.43	35.97	HI
71	18.0	-2.43	32.830	14.83	1.44	35.54	HI
72	18.0	-2.45	32.910	14.91	1.44	35.16	HI
73	18.0	-1.64	34.210	16.21	1.57	29.52	
74	18.0	-0.91	34.430	16.43	1.59	28.56	
75	18.0	-1.26	35.110	17.11	1.66	25.61	
76	18.0	-2.37	32.660	14.66	1.42	36.27	HI
77	19.0	-2.11	32.980	13.98	1.35	36.45	HI
78	18.0	-5.62	32.460	14.46	1.40	37.13	HI
79	18.0	-1.99	32.201	14.20	1.37	38.27	HI
80	18.0	-2.98	32.100	14.10	1.37	38.29	HI
81	18.0	-2.46	32.420	14.42	1.40	37.32	HI
82	18.0	-2.93	32.670	14.67	1.42	36.21	HI
83	18.0	-1.36	33.020	15.02	1.45	34.65	HI
84	18.0	-1.33	33.230	15.23	1.47	33.77	HI
85	18.0	-1.38	33.680	15.68	1.52	31.85	HI
86	18.0	-1.36	33.200	15.20	1.47	33.90	HI
87	18.0	-5.01	33.420	15.42	1.49	32.04	HI
88	18.0	-5.70	33.470	15.47	1.50	32.72	HI
89	17.0	-30.80	34.090	17.09	1.65	20.12	
90	16.0	-25.51	27.530	11.53	1.12	53.93	HI
91	16.0	-14.75	31.120	15.12	1.46	30.52	HI
92	15.0	-12.00	30.541	15.54	1.50	40.25	HI
93	14.0	-1.14	31.090	17.09	1.65	36.71	HI
94	13.0	-17.60	28.960	15.96	1.55	42.99	HI
95	19.0	-15.30	32.670	13.67	1.32	37.89	HI
96	20.0	-14.40	33.630	13.63	1.32	35.99	HI
97	21.0	-8.80	32.700	11.70	1.13	41.51	HI
98	22.0	-16.50	30.080	8.08	0.78	57.46	HI
99	18.0	0.0	31.930	13.93	1.35	39.46	HI
100	18.0	2.00	35.750	17.75	1.72	22.83	

ANNEX TABLE IX-C-7 (continued)

NODE	GROUND ELEV	FLOW	HGL ELEV	HEAD METERS	PRESSURE ATM	CK	PCT DROP	CK
101	18.0	31.50	33.870	15.87	1.54		31.01	HI
102	19.0	31.50	36.221	17.22	1.67		25.13	
103	17.0	63.00	34.130	17.13	1.66		28.62	
104	18.0	31.50	33.580	15.58	1.51		32.24	HI
105	14.0	31.50	31.200	17.20	1.66		36.30	HI
106	19.0	31.50	32.789	13.78	1.32		37.29	HI
107	20.0	31.50	32.740	12.74	1.33		34.55	HI

ANNEX TABLE IX-C-8

COMPUTER PRINTOUT
YEAR 2000 MINIMUM HOUR FLOW
GAPAN WATER DISTRICT

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GAPAN 2000 MINIMUM HOUR


INPUT AND OUTPUT IN                LPS
NO OF NODES                        107
NO OF PIPES                        146
MAX NO OF ITERATIONS                20
PEAKING FACTOR                 0.30000
ALLOW P-DROP FR/STATIC - PCT 30.0
STATIC HGL FOR P-DROP CALC    41.0
MAX UNBAL - LPS                0.05000
MAX ALLOW VEL -MPS               3.000
MIN ALLOW VEL - MPS              0.400
MAX ALLOW HL -   M/1000 M        10.00
MIN ALLOW HL -   M/1000 M         0.30
MAX ALLOW PRESS - ATM            7.000
MIN ALLOW PRESS - ATM            0.700
NO OF HEADS TO BE READ               1
NO OF UNKNOWN CONSUMPTIONS           1
SUM OF FIXED DEMANDS            -37.16
BANDWIDTH                            7
ITER  1 UNBAL    23.54 LPS
ITER  2 UNBAL    12.75 LPS
ITER  3 UNBAL     5.88 LPS
ITER  4 UNBAL     2.69 LPS
ITER  5 UNBAL     1.12 LPS
ITER  6 UNBAL     0.30 LPS
ITER  7 UNBAL     0.02 LPS

SOLUTION NO. 1 REACHED IN    7 ITERATIONS
       0.0241 GPM UNBALANCE
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ANNEX TABLE IX-C-8 (continued)

PIPE NO	NODES FROM	NODES TO	DIA MM	L MTRS	H-W C	K-VALUE	FLOW	--VEL-- MPS	--CK	--HEADLOSS--- MT	MT/1000	CK
401	2	3	150	250.	100	0.150E-01	7.65	0.4[illegible]		0.65	2.59	
402	2	1	200	220.	110	0.272E-02	13.56	0.43		0.34	1.54	
403	1	4	200	225.	110	0.270E-02	12.95	0.41		0.32	1.42	
405	3	8	150	300.	100	0.179E-01	4.85	0.27	LO	0.33	1.11	
406	4	12	200	95.	110	0.117E-02	12.71	0.40		0.13	1.37	
407	12	13	200	90.	110	0.111E-02	12.14	0.39	LO	0.11	1.26	
408	13	10	200	95.	110	0.117E-02	11.56	0.37	LO	0.11	1.15	
409	8	7	150	70.	100	0.419E-02	3.51	0.20	LO	0.05	0.65	
410	7	9	150	35.	100	0.209E-02	3.07	0.21	LO	0.02	0.67	
412	9	11	150	205.	100	0.125E-01	0.34	0.05	LO	0.01	0.04	LO
413	10	11	250	120.	110	0.500E-03	11.56	0.24	LO	0.05	0.3[illegible]	
414	11	14	250	310.	110	0.129E-02	11.70	0.24	LO	0.12	0.40	
415	14	16	250	340.	110	0.142E-02	13.16	0.27	LO	0.17	0.49	
416	16	17	200	30.	110	0.370E-03	10.71	0.34	LO	0.03	1.00	
417	22	23	200	280.	110	0.345E-02	6.30	0.22	LO	0.12	0.44	
418	17	15	100	150.	100	0.645E-01	1.65	0.21	LO	0.16	1.09	
419	15	24	100	370.	100	0.159E 00	1.22	0.15	LO	0.23	0.62	
420	29	67	250	190.	110	0.791E-03	10.85	0.22	LO	0.07	0.35	
421	26	29	250	45.	110	0.187E-03	8.39	0.16	LO	0.01	0.24	LO
422	23	23	150	145.	100	0.657E-02	0.46	0.03	LO	0.00	0.01	LO
423	23	32	150	220.	100	0.132E-01	2.69	0.15	LO	0.08	0.37	
424	23	27	100	210.	100	0.905E-01	1.35	0.17	LO	0.16	0.75	
425	27	24	100	160.	100	0.689E-01	1.15	0.15	LO	0.09	0.56	
426	31	27	150	100.	100	0.598E-02	0.44	0.03	LO	0.00	0.01	LO
427	32	31	150	210.	100	0.126E-01	2.52	0.15	LO	0.07	0.36	
428	33	32	150	140.	100	0.837E-02	6.54	0.37	LO	0.27	1.94	
429	32	40	150	170.	100	0.102E-01	6.14	0.35	LO	0.29	1.72	
430	31	34	100	140.	100	0.603E-01	1.88	0.24	LO	0.19	1.38	
431	34	37	100	300.	100	0.129E 00	0.59	0.08	LO	0.05	0.16	LO
432	34	38	100	240.	100	0.103E 00	0.80	0.10	LO	0.07	0.29	LO
433	36	45	100	155.	100	0.666E-01	1.46	0.19	LO	0.14	0.89	
434	36	37	100	95.	100	0.409E-01	1.89	0.24	LO	0.13	1.41	
435	37	47	100	160.	100	0.689E-01	0.23	0.03	LO	0.01	0.04	LO
436	37	38	150	115.	100	0.688E-02	1.77	0.10	LO	0.02	0.17	LO
437	49	36	100	150.	100	0.559E-01	0.71	0.09	LO	0.04	0.23	LO
438	38	39	200	190.	110	0.235E-02	2.76	0.09	LO	0.02	0.08	LO
439	40	39	150	50.	100	0.179E-02	6.60	0.37	LO	0.06	1.97	
440	24	36	200	130.	110	0.161E-02	3.71	0.12	LO	0.02	0.14	LO
441	45	46	100	100.	100	0.431E-01	0.93	0.12	LO	0.04	0.42	
442	45	47	100	120.	100	0.517E-01	0.18	0.02	LO	0.00	0.02	LO
443	47	48	100	90.	100	0.388E-01	0.95	0.12	LO	0.04	0.40	
444	49	47	100	100.	100	0.431E-01	0.72	0.09	LO	0.02	0.23	LO
445	49	50	100	85.	100	0.366E-01	1.07	0.14	LO	0.04	0.49	
446	51	49	150	130.	100	0.777E-02	2.71	0.15	LO	0.05	0.35	
447	51	52	200	75.	110	0.925E-03	5.18	0.16	LO	0.02	0.26	LO
448	40	56	100	150.	100	0.645E-01	1.05	0.13	LO	0.07	0.47	
449	46	46	100	120.	100	0.517E-01	0.25	0.03	LO	0.00	0.05	LO
450	46	59	100	135.	100	0.582E-01	1.26	0.16	LO	0.09	0.68	
451	50	48	100	90.	100	0.388E-01	0.66	0.08	LO	0.02	0.20	LO
452	50	60	100	125.	100	0.539E-01	1.41	0.18	LO	0.10	0.82	

ANNEX TABLE IX-C-8 (continued)

PIPE NO	NODES FROM	TO	DIA MM	L MTRS	H-W C	K-VALUE	FLOW	--VEL-- MPS	CK	--HEADLOSS-- MT	MT/1000	CK
453	52	50	100	125.	100	0.539E-01	1.16	0.15	LO	0.07	0.57	
454	52	61	150	130.	100	0.777E-02	3.34	0.22	LO	0.09	0.72	
455	58	64	100	190.	100	0.819E-01	0.15	0.02	LO	0.00	0.02	LO
456	58	59	100	85.	100	0.366E-01	0.50	0.08	LO	0.01	0.17	LO
457	59	65	100	190.	100	0.819E-01	2.01	0.26	LO	0.30	1.57	
458	50	59	100	80.	100	0.345E-01	0.33	0.04	LO	0.00	0.06	LO
459	60	65	100	180.	100	0.775E-01	2.04	0.26	LO	0.29	1.61	
460	61	60	100	135.	100	0.582E-01	1.13	0.15	LO	0.08	0.59	
461	62	61	200	80.	110	0.980E-03	4.43	0.14	LO	0.02	0.20	LO
462	63	62	150	115.	100	0.688E-02	8.34	0.47		0.35	3.04	
463	54	63	150	100.	100	✓ 0.598E-02	8.33	0.47		0.30	3.04	
464	61	67	150	155.	100	0.927E-02	6.38	0.39	LO	0.33	2.12	
465	65	70	100	285.	100	0.123E 00	2.28	0.29	LO	0.56	1.98	
466	66	65	100	90.	100	0.388E-01	0.54	0.07	LO	0.01	0.14	LO
467	67	66	100	100.	100	0.431E-01	0.97	0.12	LO	0.04	0.41	
468	66	71	100	305.	100	0.131E 00	2.12	0.27	LO	0.53	1.75	
469	67	73	150	150.	100	0.897E-02	5.53	0.32	LO	0.22	1.47	
470	74	75	200	95.	110	0.117E-02	1.02	0.03	LO	0.00	0.01	LO
471	75	72	150	185.	100	0.111E-01	6.30	0.35	LO	0.34	1.84	
472	74	75	200	225.	110	0.273E-02	5.09	0.16	LO	0.06	0.25	LO
473	69	68	100	130.	100	0.560E-01	0.15	0.02	LO	0.00	0.01	LO
474	70	69	150	35.	100	0.209E-02	4.72	0.27	LO	0.04	1.06	
475	71	70	150	125.	100	0.743E-02	2.30	0.13	LO	0.05	0.40	
476	72	71	150	100.	100	0.595E-02	1.10	0.06	LO	0.01	0.07	LO
477	69	76	150	200.	100	0.120E-01	4.36	0.25	LO	0.18	0.92	
478	72	73	150	245.	100	0.147E-01	4.84	0.27	LO	0.27	1.11	
479	78	76	150	220.	100	0.132E-01	0.54	0.04	LO	0.01	0.03	LO
480	78	81	200	500.	110	0.617E-02	2.06	0.08	LO	0.04	0.08	LO
481	17	22	250	110.	110	0.456E-03	6.70	0.14	LO	0.03	0.23	LO
101	5	6	100	270.	100	0.115E 00	1.20	0.15	LO	0.16	0.60	
102	6	7	100	200.	100	0.862E-01	0.62	0.08	LO	0.04	0.18	LO
103	9	99	150	300.	100	0.179E-01	2.14	0.12	LO	0.07	0.24	LO
104	99	14	150	240.	100	0.144E-01	2.14	0.12	LO	0.06	0.24	LO
105	16	18	100	40.	100	0.172E-01	2.07	0.26	LO	0.07	1.66	
106	18	21	100	50.	100	0.215E-01	1.16	0.15	LO	0.03	0.57	
107	18	19	100	150.	100	0.645E-01	0.55	0.07	LO	0.02	0.15	LO
108	21	20	100	160.	100	0.689E-01	0.82	0.10	LO	0.05	0.30	
109	22	19	100	40.	100	0.172E-01	1.43	0.18	LO	0.03	0.84	
110	19	20	100	50.	100	0.215E-01	1.65	0.21	LO	0.05	1.09	
111	20	29	150	195.	100	0.117E-01	2.13	0.12	LO	0.05	0.24	LO
112	24	25	100	240.	100	0.103E 00	0.37	0.05	LO	0.02	0.07	LO
113	23	24	100	160.	100	0.689E-01	1.99	0.25	LO	0.25	1.55	
114	87	88	250	750.	110	0.312E-02	10.30	0.20	LO	0.22	0.30	LO
115	53	28	200	290.	110	0.355E-02	6.56	0.27	LO	0.19	0.66	
116	42	33	200	155.	110	0.191E-02	15.27	0.49		0.30	1.92	
117	27	26	100	200.	100	0.862E-01	0.35	0.05	LO	0.01	0.06	LO
118	31	30	100	150.	100	0.646E-01	0.02	0.00	LO	0.00	0.00	LO
119	36	35	100	130.	100	0.560E-01	0.06	0.01	LO	0.00	0.00	LO
120	41	40	200	95.	110	0.117E-02	28.59	0.91		0.96	[illegible].14	
121	41	53	100	200.	100	0.862E-01	1.99	0.25	LO	0.31	1.55	

PIPE NO	NODES FROM	NODES TO	DIA MM	L MTRS	H-W C	K-VALUE	FLOW	--VEL-- MPS	--CK	--HEADLOSS--- MT	MT/1000	CK
122	42	41	200	40.	110	0.494E-03	20.62	0.97		0.28	6.97	
123	55	42	250	100.	110	0.417E-03	45.13	0.92		0.46	4.82	
124	43	42	100	130.	100	0.560E-01	0.79	0.10	LO	0.04	0.28	LO
125	44	43	100	105.	100	0.452E-01	0.80	0.10	LO	0.03	0.29	LO
126	55	54	150	80.	100	0.473E-02	15.29	0.87		0.75	9.33	
127	55	44	100	170.	100	0.732E-01	2.55	0.33	LO	0.42	2.45	
128	44	57	100	55.	100	0.237E-01	1.74	0.22	LO	0.07	1.20	
129	53	62	100	145.	100	0.625E-01	2.46	0.31	LO	0.33	2.27	
130	56	54	100	130.	100	0.560E-01	1.71	0.22	LO	0.15	1.17	
131	57	56	100	95.	100	0.409E-01	1.73	0.22	LO	0.11	1.19	
132	53	51	150	80.	100	0.473E-02	8.14	0.45		0.23	2.90	
133	54	53	150	100.	100	0.590E-02	8.63	0.49		0.32	3.24	
134	62	74	150	315.	100	0.183E-01	6.26	0.35	LO	0.56	1.79	
135	76	77	150	185.	100	0.111E-01	4.34	0.25	LO	0.17	0.91	
136	78	79	100	150.	100	0.646E-01	0.53	0.07	LO	0.02	0.15	LO
137	79	80	100	550.	100	0.237E 00	0.23	0.03	LO	0.02	0.03	LO
138	81	80	100	150.	100	0.643E-01	0.12	0.02	LO	0.00	0.01	LO
139	81	82	100	110.	100	0.474E-01	1.95	0.25	LO	0.16	1.48	
140	75	85	150	300.	100	0.175E-01	4.85	0.27	LO	0.33	1.11	
141	85	84	100	150.	100	0.643E-01	1.27	0.16	LO	0.10	0.67	
142	84	83	100	250.	110	0.106E 00	1.03	0.13	LO	0.11	0.45	
143	85	86	150	250.	100	0.150E-01	3.35	0.19	LO	0.14	0.55	
144	86	83	150	150.	100	0.897E-02	3.12	0.18	LO	0.07	0.49	
145	3	5	100	150.	100	0.646E-01	1.75	0.22	LO	0.18	1.21	
146	100	55	350	15.	120	0.103E-04	63.00	0.65		0.02	1.48	
147	40	39	250	30.	110	0.125E-03	27.30	0.57		0.06	1.97	
157	83	32	150	280.	100	0.167E-01	3.91	0.22	LO	0.21	0.75	
201	2	89	250	1700.	110	0.708E-02	9.55	0.20	LO	0.47	0.28	LO
202	88	91	250	2000.	110	0.833E-02	9.01	0.18	LO	0.49	0.24	LO
203	82	95	200	1300.	110	0.161E-01	5.50	0.18	LO	0.36	0.29	LO
204	77	96	200	1050.	110	0.130E-01	3.98	0.13	LO	0.17	0.16	LO
205	101	2	200	15.	110	0.185E-03	31.50	1.00		0.11	7.35	
206	75	102	200	15.	110	0.185E-03	0.0	0.0	LO	0.0	0.0	LO
207	3	4	100	180.	100	0.776E-01	0.30	0.03	LO	0.01	0.06	LO
208	8	10	100	190.	100	0.819E-01	0.59	0.08	LO	0.03	0.16	LO
301	89	90	200	1300.	110	0.161E-01	4.57	0.14	LO	0.25	0.19	LO
302	91	92	200	1550.	110	0.191E-01	6.49	0.21	LO	0.61	0.39	
303	92	93	200	1750.	110	0.216E-01	4.41	0.14	LO	0.34	0.19	LO
304	93	94	200	850.	110	0.105E-01	3.02	0.10	LO	0.08	0.10	LO
305	95	98	250	3450.	110	0.144E-01	2.33	0.06	LO	0.10	0.03	LO
306	96	97	200	1350.	110	0.167E-01	1.51	0.05	LO	0.04	0.03	LO
307	103	89	250	15.	110	0.625E-04	0.0	0.0	LO	0.0	0.0	LO
308	104	88	200	15.	110	0.185E-03	0.0	0.0	LO	0.0	0.0	LO
309	105	93	200	15.	110	0.185E-03	0.0	0.0	LO	0.0	0.0	LO
310	106	95	200	15.	110	0.185E-03	0.0	0.0	LO	0.0	0.0	LO
311	107	96	200	15.	110	0.185E-03	0.0	0.0	LO	0.0	0.0	LO

NODE	GROUND ELEV	FLOW	HGL ELEV	HEAD MTRS	PRESSURE ATM---CK	PRESSURE PCT DROP---CK
1	18.0	-0.66	36.620U	18.62	1.80	19.04
2	18.0	-0.64	36.960U	18.96	1.84	17.57
3	18.0	-0.70	36.310U	18.31	1.77	20.38
4	18.0	-0.60	36.300U	18.30	1.77	20.43
5	18.0	-0.55	36.130U	18.13	1.76	21.17
6	18.0	-0.58	35.970U	17.97	1.74	21.87
7	18.0	-0.55	35.930U	17.93	1.74	22.02
8	18.0	-0.64	35.980U	17.98	1.74	21.83
9	18.0	-0.70	35.910U	17.91	1.73	22.13
10	18.0	-0.61	35.950U	17.95	1.74	21.96
11	18.0	-0.70	35.900U	17.90	1.73	22.16
12	18.0	-0.57	36.170U	18.17	1.76	20.99
13	18.0	-0.56	36.060U	18.06	1.75	21.49
14	18.0	-0.67	35.780U	17.78	1.72	22.70
15	18.0	-0.43	35.420U	17.42	1.69	24.27
16	18.0	-0.38	35.610U	17.61	1.70	23.43
17	18.0	-0.36	35.580U	17.58	1.70	23.56
18	18.0	-0.34	35.550U	17.55	1.70	23.72
19	18.0	-0.34	35.520U	17.52	1.70	23.81
20	18.0	-0.34	35.470U	17.47	1.69	24.05
21	18.0	-0.34	35.520U	17.52	1.70	23.84
22	18.0	-0.40	35.560U	17.56	1.70	23.67
23	18.0	-0.36	35.430U	17.43	1.69	24.20
24	18.0	-0.28	35.190U	17.19	1.66	25.27
25	18.0	-0.37	35.170U	17.17	1.66	25.35
26	18.0	-0.35	35.260U	17.26	1.67	24.94
27	18.0	-0.29	35.280U	17.28	1.67	24.89
28	18.0	-0.13	35.430U	17.43	1.69	24.21
29	18.0	-0.16	35.420U	17.42	1.69	24.25
30	18.0	-0.02	35.280U	17.28	1.67	24.88
31	18.0	-0.28	35.280U	17.28	1.67	24.88
32	18.0	-0.47	35.350U	17.35	1.68	24.56
33	18.0	-0.17	35.620U	17.62	1.71	23.38
34	18.0	-0.49	35.080U	17.08	1.65	25.72
35	18.0	-0.06	35.170U	17.17	1.66	25.36
36	18.0	-0.28	35.170U	17.17	1.66	25.35
37	18.0	-0.43	35.040U	17.04	1.65	25.93
38	18.0	-0.52	35.020U	17.02	1.65	26.02
39	18.0	-37.16U	35.00	17.00	1.65	26.09
40	18.0	-0.34	35.060U	17.06	1.65	25.85
41	18.0	-0.03	35.640U	17.64	1.71	23.29
42	18.0	-0.02	35.920U	17.92	1.73	22.08
43	18.0	-0.01	35.960U	17.96	1.74	21.92
44	18.0	-0.01	35.990U	17.99	1.74	21.79
45	18.0	-0.31	35.030U	17.03	1.65	25.95
46	18.0	-0.16	34.990U	16.99	1.64	26.13
47	18.0	-0.21	35.030U	17.03	1.65	25.96
48	18.0	-0.13	34.990U	16.99	1.64	26.12
49	18.0	-0.21	35.050U	17.05	1.65	25.66
50	18.0	-0.17	35.010U	17.01	1.65	26.04

NODE	GROUND ELEV	FLOW	HGL ELEV	HEAD MTRS	PRESSURE ATM	CK	PCT DROP	CK
51	18.0	-0.25	35.10U	17.10	1.66		25.65	
52	18.0	-0.17	35.08U	17.08	1.65		25.73	
53	18.0	-0.03	35.33U	17.33	1.68		24.64	
54	18.0	-0.02	35.66U	17.66	1.71		23.23	
55	18.0	-0.02	36.40U	18.40	1.78		19.96	
56	18.0	-0.01	35.81U	17.81	1.72		22.57	
57	18.0	-0.01	35.92U	17.92	1.73		22.08	
58	18.0	-0.26	34.92U	16.92	1.64		26.44	
59	18.0	-0.18	34.90U	16.90	1.64		26.50	
60	18.0	-0.22	34.91U	16.91	1.64		26.49	
61	18.0	-0.27	34.99U	16.99	1.64		26.14	
62	18.0	-0.06	35.00U	17.00	1.65		26.07	
63	18.0	-0.01	35.35U	17.35	1.68		24.55	
64	18.0	-0.18	34.91U	16.91	1.64		26.46	
65	18.0	-0.27	34.61U	16.61	1.61		27.80	
66	18.0	-0.34	34.62U	16.62	1.61		27.74	
67	18.0	-0.27	34.66U	16.66	1.61		27.57	
68	18.0	-0.15	34.00U	16.00	1.55		30.42	HI
69	18.0	-0.21	34.00U	16.00	1.55		30.42	HI
70	18.0	-0.36	34.04U	16.04	1.55		30.25	HI
71	18.0	-0.42	34.09U	16.09	1.56		30.04	HI
72	18.0	-0.42	34.10U	16.10	1.56		30.00	HI
73	18.0	-0.28	34.44U	16.44	1.59		28.52	
74	18.0	-0.16	34.44U	16.44	1.59		28.52	
75	18.0	-0.23	34.38U	16.38	1.59		28.76	
76	18.0	-0.66	33.82U	15.82	1.53		31.21	HI
77	19.0	-0.36	33.65U	14.65	1.42		36.39	HI
78	18.0	-0.97	33.83U	15.83	1.53		31.19	HI
79	18.0	-0.34	33.80U	15.80	1.53		31.29	HI
80	18.0	-0.56	33.79U	15.79	1.53		31.36	HI
81	18.0	-0.39	33.79U	15.79	1.53		31.35	HI
82	18.0	-0.56	33.63U	15.63	1.51		32.06	HI
83	18.0	-0.23	33.84U	15.84	1.53		31.15	HI
84	18.0	-0.24	33.95U	15.95	1.54		30.65	HI
85	18.0	-0.24	34.05U	16.05	1.55		30.22	HI
86	18.0	-0.23	33.91U	15.91	1.54		30.83	HI
87	18.0	-0.86	35.36U	17.36	1.68		24.54	
88	18.0	-0.99	35.13U	17.13	1.66		25.51	
89	17.0	-5.28	36.49U	19.49	1.89		18.80	
90	16.0	-4.37	36.24U	20.24	1.96		19.04	
91	16.0	-2.53	34.65U	18.65	1.80		25.42	
92	15.0	-2.07	34.04U	19.04	1.84		26.79	
93	14.0	-1.39	33.70U	19.70	1.91		27.05	
94	13.0	-3.02	33.62U	20.62	2.00		26.37	
95	19.0	-2.67	33.25U	14.25	1.38		35.23	HI
96	20.0	-2.47	33.49U	13.49	1.31		35.78	HI
97	21.0	-1.51	33.45U	12.45	1.21		37.74	HI
98	22.0	-2.83	33.15U	11.15	1.08		41.31	HI
99	18.0	0.0	35.84U	17.84	1.73		22.44	
100	18.0	63.00	36.43U	18.43	1.78		19.89	

ANNEX TABLE IX-C-8 (continued)

NODE	GROUND ELEV	FLOW	HGL ELEV	HEAD MTRS	PRESSURE ATM	CK	PCT DROP	CK
101	18.0	31.50	37.070	19.07	1.85		17.09	
102	18.0	0.0	34.380	16.38	1.59		28.76	
103	17.0	0.0	36.490	19.49	1.89		18.80	
104	18.0	0.0	35.130	17.13	1.66		25.51	
105	14.0	0.0	33.700	19.70	1.91		27.05	
106	19.0	0.0	33.250	14.25	1.38		35.23	HI
107	20.0	0.0	33.490	13.49	1.31		35.78	HI

CHAPTER X FINANCIAL FEASIBILITY ANALYSIS

A. GENERAL

The financial feasibility analysis herein establishes a detailed set of guidelines that the water district management may use in making crucial decisions during the next few years. The technical aspects and project cost of the recommended plan have been presented in Chapter IX. Its economic justification follows in Chapter XI. In this chapter, a plan is developed to indicate how and when funds will be used to operate and maintain the system, implement the program, establish reserve funds, and retire indebtedness.

Water rates have been developed on the basis that the system will be financially self-supporting. Capital funds for the recommended plan will be obtained by borrowing from international lending agencies and LWUA. The water rates that have been developed appear to be within the ability-to-pay of the average householder in the water district.

The financial analysis includes only those revenues and disbursements for the proposed construction program from 1978 to 1990 (Immediate Improvements, Phase I-A and Phase I-B). All those revenues and disbursements shown between 1990 and 2000 are directly attributable to continued service and expenses occurring from facilities constructed between 1978 and 1990.

B. THE EXISTING SYSTEM

Personnel

As of October 1976, the water district was operated by 12 personnel, with some key positions vacant. In order to meet the needs of a developing organization, recent developments have been directed towards the expansion of its present staff and the adoption of LWUA guidelines in the area of personnel management.

Water Rates

The present system has a total of 440 flat-rate connections. As of October, 1976, the water rates were as follows:

Residential:

without booster pump and reservoir	₱12.15 per month
with booster pump and reservoir	12.20 per month

Commercial:

without booster pump and reservoir	15.00 per month
with booster pump but without reservoir	20.00 per month
with booster pump and reservoir	25.00 per month

Financial Statements

GAP-WD has been operating at a deficit of approximately ₱1,000.00 per month with a 1976 average monthly operation and maintenance cost amounting to about ₱9,000. Bigger losses are operated if allowances are made for depreciation. This has been the trend in spite of the subsidy it receives from the municipal government. The monthly subsidy was increased in January 1977 from ₱2,500 to ₱3,500 and would be discontinued altogether in June 1977. It is assumed that the financial situation will improve with the implementation of LWUA commercial practices and the proposed improvements on the system.

Historic financial records have not been based on organized basic accounting systems. Therefore, data on past finances of the present system are inadequate to form a sound basis for future projections. It is therefore necessary to made certain assumptions for the financial feasibility analysis. These are discussed later in this chapter. Validity of these assumptions will be tested as the project is implemented.

C. DEVELOPMENT COSTS

The cost estimates of the facilities needed to improve and expand water services of the water district over the development planning period are presented in Chapter IX. Cost estimates of the facilities are based on the projected July 1978 unit prices.

Project Costs

Project costs of facilities recommended for implementation through Phase I-B are summarized on an annual basis in Annex Table X-C-1. Engineering services for design and construction supervision are broken down. It has been assumed that 70 percent of the engineering services applies to surveys and design and 30 percent to construction supervision. Design costs are shown in the year preceding construction. Contingencies (15/10 percent) are distributed uniformly during the construction period. Foreign exchange component of total project cost includes cost of direct and indirect import items, as well as a portion of the engineering costs.

Escalation of Costs

To account for the effects of inflation, capital cost estimates are escalated. This has been done year by year on an item by-item basis using escalation factors computed from assumed inflationary trends and applied to the basic current cost data as shown in Annex Table X-C-2. The escalation factors used are based on an average annual rate of inflation of 10 percent per year from 1978 through 1980, 8 percent from 1981 to 1985 and 6 percent per year thereafter. On the other hand, annual operation and maintenance costs and family income are escalated at a rate of 8 percent all throughout the 23-year study period. These escalation factors have been assumed to apply equally to the local and foreign exchange costs.

D. OPERATING AND MAINTENANCE COSTS

This cost category covers cash expenses required to keep the system operating and adequately maintained. It assures the continued maintenance of the water district's revenue-producing capacity and protection of its investment. Included in this cost category are: personnel salary and benefits, power, chemicals, maintenance, rental, and other miscellaneous expenses which are necessary to run the overall water system. Most items increase in accordance with the quantity of water produced; the number of customers served; and the extent to which the physical plant will be operated and maintained.

The operating costs of the existing and future systems are presented in Chapter IX.

E. FINANCING POLICIES COVERING LOCAL WATER DISTRICT DEVELOPMENT

The following are the major potential sources of funds which can be utilized by the GAP-WD:

Operating Source

To the extent that revenues from the operations of the local water district exceed annual cash requirements for all other purposes, funds can be devoted to financing development costs. As a practical matter, it is highly desirable to finance a significant proportion of development costs in this manner in order to reduce the amount that must be borrowed and the associated debt service costs.

Non-Operating Sources

Non-operating sources of funds for development include 3 basic groups:

1. Loans - funds may be borrowed by the water district for development. One of LWUA's primary functions is lending funds for development to water districts. From the water district's point of view, LWUA is the primary, if not the

only realistic source of funds. LWUA borrows both foreign currencies and pesos at varying terms and relends needed funds to water district according to the composite terms needed to support the blend of debt service terms LWUA itself must meet. At present, LWUA's terms include:

	Immediate Improvements Loan	Phase I-A and I-B Loan
Interest -	9 percent per annum to be computed at $\frac{3}{4}$ percent per month. Interest due on the local component is paid annually. Interest on foreign exchange is capitalized during construction. Total loan outstanding at the end of construction period earns another full year interest before repayment.	9 percent per annum to be computed monthly at $\frac{3}{4}$ percent per month from the year following the date of disbursement.
Duration -	30-year loan, disbursement assumed made at mid-year, thus will earn interest for 6 months.	30-year loan from the date of initial disbursement.
Principal -	amortized equally for 30 years to start one year after construction.	No principal payments due during construction periods (Construction periods of Stage I-Phases A and B are explained in Chapter IX). Principal repayment period is 30 years less the duration of the disbursement period.

2. Charges and Assessments - consist of payments made by new customers and benefiting property owners for the costs of specific portions of the facilities being developed. Typically, such charges are made for the costs of new construction and water meters and for all or a portion of the costs of new distribution system extensions. LWUA guidelines suggest that new customers may pay for connections and water meters, but currently do not include an assessment for distribution system costs. For purposes of this analysis, new customers were assumed to be paying for the new connections and water meters on a revolving fund basis. These sources are referred to as "contributions

in aid of construction" in accounting terminology and have the effect of reducing the amounts to be borrowed. Since many new customers will not be in a position to pay connection fees (or benefit assessment charges) in cash, it will be necessary to provide financing assistance. Present practice is to allow such payments to be made at a flat monthly rate of ₱5.00 over a period of 10 years.

3. Grants or Credits - LWUA has access to loan funds on concessionary terms and is thus able to relend funds at rates that are below market rates. This in itself is a 'credit' available to the local water district borrower. In some countries, the national government makes outright grants to local water districts in recognition of the overall national benefit of having safe and reliable water systems. Another approach is for the government to advance a portion of the funds needed during the early years of development at little or no interest to assist the local utility in building its financial capacity. This is another form of 'credit' as referred to above. Later, as the revenue base expands and development expenditures decline, the local utility funds such advances as permitted by its cash position. At the present time, however, the local water district is expected to undertake its development programs with no equity participation by government or assistance other than the LWUA loans.

Reserve Requirements

Since reserve requirements are tied directly to obtaining development loans from LWUA, they are considered as funds required to support capital development. After total revenue requirements are determined, LWUA guidelines suggest that 10 percent be set aside for reserve funds. For purposes of this study, a lower percentage will be used, starting at 3 percent progressively increasing to 10 percent.

F. FUNDS FOR CAPITAL DEVELOPMENT

Once the basic data requirements are met and the financing policies outlined, funds required to cover development costs are then determined. The most important document in this regard is the breakdown of project costs as escalated and shown in Annex Table X-C-2.

Depreciable Assets/Depreciation Expenses

Capital assets acquired each year become subject to depreciation in their first full year of service. Thus a pipeline completed in 1978 becomes "depreciable" in 1979. If it has a 50-year life, depreciation continues for 50 years and it is assumed to be retired in the 51st year. The cost of large facilities that require several years to construct is carried as "work-in-process" until completed.

Annex Table X-F-1 shows the water district's assets and depreciable value forecasts, the initial purpose of which is to show the appropriate "depreciable" values for use in calculating replacement costs and annual depreciation expenses. At the same time, year-end book values of assets are shown as well as the value of work-in-process.

Based on the schedule of assets, annual depreciation expenses were calculated and are shown in Annex Table X-F-2.

Revolving Fund for Connections

To assist new customers in financing service connection charges, it is necessary to provide working capital for a revolving fund. It is proposed that LWUA's present policy which provides for the costs to be payable at ₱5.00/month over a 10-year period be increased to ₱6.83 by 1978 to cover the increased unit price of meters. Net inflow funds will be required over a period of 10 years to build sufficient income to support the annual costs of connections. At some future point, income exceeds annual expenditures and the revolving fund can be used to refund the earlier advances of working capital.

Annex Table X-F-3 indicates the working capital requirements. In this table, the two key assumptions are:

1. The monthly installment payments are based on actual costs of constructing service connections and meters; thus, the monthly payments by customers connected to the system in 1981 would be greater than those who would be connected to the system in 1978 to account for the escalation of construction costs.
2. Sixty (60) percent of all new customers would utilize the installment method of financing connection charges.

Revenue Unit Forecast

The present LWUA rate policy incorporates the use of "revenue units" (RU) in determining the basic cost per cubic meter of water to domestic consumers. Commercial and industrial customers are charged twice the unit price for domestic use and wholesale water distributors are charged thrice the basic price. As defined, a "revenue unit" is an arbitarary unit of measure into which discharges from pipes of various sizes are reduced to a 3/8-inch connection by the use of conversion factors.

Thus, the discharge of a 3/8-inch connection (actually a ½-inch connection, but regulated by a water meter to give the discharge of a 3/8-inch connection) is multiplied by 1.0; that of a ½-inch by 2.5; that of a ¾-inch by 4; that of a 1-inch by 8; and so forth, to get the total RUs delivered.

Two charges are levied on metered connections - the service charge and the commodity charge. The service charge is the fixed charge which covers the first 10 cum of water. It varies according to the size of the connection. The commodity charge is payment for water consumed after the first 10 cum. The unit price is uniform for every size and type of connection.

Annex Tables X-F-4a and X-F-4b give the revenue unit forecast.

G. ANALYSIS OF WATER RATES

Ability-To-Pay Issue

Presidential Decree No. 198 stipulates that water districts must be financially self-sufficient. In the past, most water system have not been able to generate sufficient revenues to cover even the operation and maintenance expenses due to various factors including poor pricing schemes, defective collection system and inadequate consumer promotion. The major reason for insufficient revenues, however, is that certain consumers being served by the water district have such low incomes and hence, are not in a financial position to pay the full costs of the system. Therefore, before a water system is improved and expanded, the ability-to-pay of the population targeted to be served must be ascertained first.

Since water districts are not expected to be extended government subsidy, the analysis of the factors affecting ability-to-pay has been significantly simplified. The factors that affect ability-to-pay are the annual income of families covered by the water district and the percentage of the their income allocated to water supply.

In March 1975, an informal survey was conducted among Water District General Managers to help gather data needed for the ability-to-pay studies. Questionnaires were distributed to 15 water districts covering provincial areas that differed in size, location and economic conditions.

The answers given by the general managers of the 15 water districts are summarized as follows:

1) Though 10 of the water districts were revenue-producing prior to the change in management of the water district, 13 imposed increased water rates upon takeover.

2) Water consumers generally accepted the increase after some explanations justifying it. Only five received formal complaints about the increased rates while eight received formal complaints about the poor quality of water supply.
3) Ten had difficulty in the collection of water bills primarily due to dissatisfaction of consumers to the water service.
4) Assuming that capital and service improvements were made, the general managers indicated they could increase their rates by as low as 25 percent and as high as 447 percent for the average and below average households.

A formal survey was conducted in April and May, 1975 in the city of Lipa and the Municipality of Tanauan. These pilot areas were selected because (a) they are at present experiencing water supply problems, (b) the income level of their families is similar to that of the national income figure, and (c) they are near Manila, only about 2 hours away by bus.

The survey covered 556 families, classified into 4 income groups. Approximately 28 percent came from the low-income class (below ₱220/month); 55 percent from the middle-income (₱221-₱750); 12 percent from the upper middle-income class (₱751-₱1,500); and 5 percent from the high-income group (above ₱1,500).

The table below presents the highlights and pertinent findings of the survey:

ESTIMATED ABILITY-TO-PAY INCOME GROUPING

Income Group	₱220	₱221-750	₱751-1,500	Above ₱1,500	Weighted Average
% Distribution	28%	55%	12%	5%	
Probable Ability-to-Pay on Basis of Improved Service	₱13.50	₱24.50	₱37.00	₱67.50	₱25.00/mo
Estimated Average Income	₱220	₱660	₱1,000	₱2,700	₱680/household
Ability-to-Pay Divided by Average Income	6.1%	3.7%	3.7%	2.5%	3.7%

The foregoing table indicates that the low-income group may be able to pay a maximum of ₱13.50 a month for water (about 6.1 percent of their average income). In the extreme end, the high-income group may be able to pay a maximum of ₱67.50 a month for water (only 2.5 percent of their average income). This disparity in the percentage of income allocated to water by the two income groups may well be the best argument of those advocating a socialized price structure.

The probable maximum ability-to-pay of the pilot area average household is about ₱25.00 per month.[1]

Family Income

In the Survey of Households Bulletin Series No. 34, published July 1973 by the NCSO, Manila, (page 3, Table 5), the following data are given:

	Total Families	Total Urban	Manila and Suburbs	Other Urban Areas	Rural
Median Family Annual Income, Pesos	₱2,454	₱3,972	₱5,202	₱3,650	₱1,954
Size of Sample, Families	6,347	1,913	525	1,388	4,434

The above data are for the 12-month period May 1970 to April 1971, more or less. The figure for "other urban areas", ₱3,650 median family annual income, may approximate, or may be a little less, than the median family income at the areas served with piped water. As the figures cited above show, in general, people in urban areas tend to be financially better off than people in rural areas. The term "urban areas" includes all urban areas in the country, in general, most urban areas of the city or municipality. The inhabitants of the central urban area are expected to be somewhat wealthier than the other areas of the city or municipality.

By July 1976, the annual income for "other urban areas" cited above, escalated at 10 percent per year, would be about ₱6,200 per year.

The report, "The Filipino Family, Community, and Nation" by Emma Porio, Frank Lynch and Mary R. Hollnsteiner published by the Institute of Philippine Culture of Ateneo de Manila University in April 1975, cites in Table A9, page 99 the results of a survey in April 1974. The families surveyed were distributed among 15 urban areas, and included 373 families in Metro Manila. Excluding the families in Metro Manila, mean monthly income of the remaining 1,599 families was ₱572, or ₱6,864 per year. Escalating this income at an

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1/This figure includes appropriate allowances for the respondents understating their income or willingness to pay and the increase in amount they are willing to pay as a result of improved services.

annual rate of 10 percent, by 1 July 1976, it would be an income of about ₱8,510 per year. These 14 urban areas are among the more urbanized in the country. They included, for instance, only 3 municipalities, the other eleven being classified as cities. The median population of the 14 urban areas in the 1970 census was about 70,000.

Based on these data, the mean family income of the people residing in the water service areas of the communities whose water system are proposed to be improved might be, by 1 July 1976, somewhere between the ₱6,200 per year (developed from the 1970/71 data of the NCSO) and the ₱8,510 per year (developed from the data of Porio, Lynch and Hollnsteiner). For lack of other data, the average water-using family may have an income of about ₱7,900 during 1976 (or ₱660 per month, which is close to the Lipa household survey). This is equivalent to an annual income of $1,000 for a family of six or seven.

Initial Rate Determination

Several trials were made to devise "revenue unit" (RU) prices that can be used for a period of several years. It is good practice for the water district to adjust prices approximately every 3 years instead of annually.

Based on the trials made, the water rates established at reasonable intervals are as follows:

Period	Water Rate ₱/RU
1978-1980	0.70
1981-1983	1.20
1984-1989	1.50
1990-1993*	1.60
1994-1996*	1.70
1997-2000*	1.80

The first step of ₱0.70/RU was selected as an intermediate rate, in anticipation of the second step (₱1.20/RU) which is indicative of the required cost to make the system financially viable. The rate of ₱1.20/RU in 1982 cost levels is equivalent to ₱0.82 in 1978 prices (based on 10 percent discount rate). Likewise ₱1.50/RU in 1986 is equal to ₱0.70 in 1978 prices.

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*These rates only cover expenses of debt service and operation and maintenance costs incurred for facilities constructed before 1990. Water rates from 1990 to 2000 would actually be higher if GAP-WD continues to construct facilities beyond 1990.

Feasibility of Charges

The question of feasibility is a matter of analyzing whether or not the customers of the water district are able to pay the required charges both now and in the future in order to obtain safe and reliable water services. Inasmuch as the proposed water rates represent the "mean", determination has been made for that group of households whose income (₱700/mo) also represents the "mean". Probable use of water by this group was calculated at 24 cum per month.[2/] For present purposes, the study covers consumers with ½-inch connections inasmuch as they comprise the bulk of the domestic/government consumers. Working back, the 1979 rate of ₱0.70 per revenue unit will yield a monthly service charge of ₱17.50. The commodity charge for a 24-cum consumption is ₱9.80 (0.70 x 14). For newly connected customers who avail of the 10-year installment plan, monthly expenditure for water will increase by ₱6.83 to account for the service connection charge. Since both water and household incomes increase each year, the impact of the installment charge on the expenditure pattern of the household will decline over the 10-year period of payment. The estimated impact of the increased rates and connection charges on household patterns is shown below for the mid-point of each rate block.

	1979	1982	1986	1991	1995	1999
Escalated income of household earning ₱700/mo in 1976 (8% per year)	882	1,111	1,511	2,220	3,021	4,110
Expenditure for 24 cum water consumption-service charge (first 10 cum)	17.50	30.00	37.50	40.00	42.50	45.00
Commodity charge (Rate/RU x 14 cum)	9.80	16.80	21.00	22.40	23.80	25.20
Income allocation to water for existing consumers (%)	3.1	4.2	3.9	2.8	2.2	1.7
Connection charge for new customers (₱6.83/mo in 1978)	7.51	9.63	12.86	17.20	21.71	27.40
Income allocation to water for new customers	3.9	5.1	4.7	3.6	2.9	2.4

2/Probable use of water by income groups:

Income Grouping	Below Average	Average	Upper Middle	High	Weighted Mean
Probable Water Use cum/mo	16	24	32	44	23.7

Since the mid-point of the period was selected for comparison, it should be noted that the proportions shown would be slightly higher in the year preceding the mid-point and lower in the succeeding year of each block.

In the example shown above, the proportions of the household income required for water services (except in 1982 and 1986 which are the crucial years) are considered within the limit of the ability-to-pay studies done in Naga City where willingness to pay fees for improved services was found to be about 3.7 percent of the household income.

In the final analysis, if any significant improvement is to be achieved in the scope and quality of public water service and if the requirement for commercially viable and financially self-supporting water districts is to be maintained, all groups of water customers will have to pay substantially higher charges for water services than they have paid in the past.

Socialized Water Rates

A policy guideline in the structuring of water rate charges is that they must be reasonable and realistic. Since water is a prime commodity both for the poor and the rich, the socialized rate may be determined such that a greater financial burden is carried by those who can afford (but not to the point that it becomes oppressive to them).

In the preceding sections, specific rates established meet the cash requirements for an improved system and at the same time fall within the average consumer's ability-to-pay. Under this scheme, the cost for the first 10 cum consumed is ₱17.50 and the subsequent consumption, ₱0.70/cum. Thus, the monthly rates for the following water consumption will be:

Usage (cum/mo)	Cost/month (₱)*
16	21.70
18	23.10
20	24.50
22	25.90
24	27.30
30	31.50
32	32.90
44	41.30

The estimated impact on the average income household (assumed to have a monthly 1976 income of ₱660) and the below average income household (assumed to have an adjusted monthly 1976 income of ₱300) is as follows:

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*For ½ inch connection domestic classification.

Income Level	Projected 1979 Monthly Income	Monthly Usage of Water	Cost of Water/mo	Percent of Income Allocated to Water
Below Average	₱380	16 cum	₱21.70	5.7
Average	830	24 cum	27.30	3.3

The preceding table shows that the financial burden to the below average income group is heavy.

A socialized pricing alternative has been developed to relieve the low income groups of the high financial cost of water with the following rate structure:

first 16 cum/mo at	₱0.85/cum
from 17-24 cum/mo at	₱1.70/cum
from 25 or more cum/mo at	₱2.70/cum

The resulting monthly rates for the various water usages will be:

Usage (cum)	Cost/month (₱)
16	13.60
18	17.00
20	20.40
22	23.80
24	27.20
30	43.40
32	48.80
44	81.20

The corresponding impact on the various income levels is as follows:

Income Level	Projected 1979 Monthly Income	Monthly Usage of Water	Cost of Water/mo	Percent of Income Allocated to Water
Below Average	₱ 380	16 cum	₱13.60	3.6
Average	830	24 cum	27.20	3.3
Upper Middle	1,260	32 cum	48.80	3.9
High	2,910	44 cum	81.20	2.8

The preceding table shows that across the income profile of the community, the monthly costs range from 2.8 - 3.9 percent of household income.

Revenue Forecasts

Estimated future levels of income from water sales are shown in Annex Table X-G-1.

H. FINANCIAL SUMMARY

Several trials have been conducted in developing the forecasts of financial statements of the CAP-WD. These statements are based on the following major assumptions:

1. Reserve Fund: 3 percent of sales for 1978-1990; 6 percent for 1991-1995; and 10 percent for 1996-2000.
2. Uncollectibles: 2 percent of gross revenue requirements for the first year of a new rate application, and 1 percent for the second and third years.
3. Accounts Receivable: equivalent to 3 months of sales.
4. Accounts Payable: equivalent to 2 months of operating expenses.

External Borrowing Required

Annex Table X-H-1 shows a summary of the external borrowing required and the annual debt servicing of the loans. Two separate analyses were made for the immediate improvement loan and the Phases I-A and I-B loans to comply with prevailing LWUA terms.

Borrowing will start in 1978 and continue through 1990. The immediate improvement loan (1978-1981) will amount to ₱6.914 million. The Phase I-A loan will cover the 8-year period 1978-85 inclusive and will amount to ₱11.098 million. The Phase I-B loan will cover the 5-year period 1986-90 inclusive and will be about ₱9.226 million.

Projections of Financial Statements

Annex Table X-H-2 shows the net income (loss) on a yearly basis. Net loss is forecasted in 1978 through 1980 and in 1982 through 1983. Net income cumulative would show positive values in fifteen of the 23-year study period.

Other related data such as water production, water sales, unaccounted-for-water and rate of return based on net fixed asset in operation are also presented in the table.

Cash Flow Statements

The cash flow statement provides an indication of the adequacy of working capital. It is not generally sufficient to cover cash outlays with revenues because of the tendency of cash receipts to lag behind cash outlays. In general, an expanding organization with an active capital development program and increasing level of activities will require similarly increasing quantities of working capital.

Annex Table X-H-3 presents the annual "Sources and Applications of Funds." Potential net decreases are expected in the year 1978, 1979, 1983, 1994 and 1998. By 2000, positive net cumulative cash balance will be ₱11.723 million even if "cash at the beginning of 1978" has been assumed equal to zero.

Other Financial Statements

Appendix Table X-H-4 presents the "Projected Balance Sheet" which shows the projected fixed and current assets, liabilities and equity of the water district from 1978 to 2000.

Rate of Return

Discount rate of return on total investments (Annex Table X-H-5) measures the true efficiency of mobilizing investments on the project from a broader perspective. Taken from a different perspective, it measures the effective utilization of total investments employed in the project. It shows what the compounded growth of investment within the project cycle would be based on the interplay of cash outflows and the resulting inflows from such investment.

Net asset salvage value of ₱4,663 million is added to net cash inflow in the year 2000. This is done based on the assumption that the project will terminate in the last projection year. Hence, assets are to be liquidated and all liabilities are to be paid from the proceeds of the assets.

Several trials were made in finding the rate of interest that equated the present value of the cash inflows to the unrecovered investments. In the GAP-WD, the rate of return, with the assumptions made, is estimated to be 7.03 percent.

I. FINANCIAL RECOMMENDATIONS

1. The water district should establish a revolving fund to assist new customers in financing servie connection charges.
2. The proposed water rates (for domestic consumers) to effect self-sufficiency are as follows:

Period	Water Rate ₱/RU
1978-1980	0.70
1981-1983	1.20
1984-1989	1.50
1990-1993*	1.60
1994-1996*	1.70
1997-2000*	1.80

*This rate is recommended to cover expenses incurred by implementing and operating facilities in immediate improvement program and Stage I only.

It is recommended, however, that in the implementation of these rates, the water district follow the socialized pricing approach which will generate the same amount of income to meet its requirements.

3. The recommended plan for the first construction phase (Phase I-A) of CAP-WD is financially feasible. Borrowing for that period would be ₱11.098 million.

External borrowing would still be necessary for the Phase I-B period.

ANNEX X-C

DEVELOPMENT COSTS

ANNEX TABLE X-C-1

PROJECT COST OF RECOMMENDED PROGRAM
GAPAN WATER DISTRICT
(WITHOUT ESCALATION)
(₱ x 1000)

Item			1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
Source Facilities	a) Equipment		6	18	-	-	347	-	-	-	-	-	8	232	-	611
	b) Structure		2	5	-	-	107	-	-	-	-	-	4	127	-	245
	c) Wells		7	20	-	-	392	-	-	-	-	-	17	516	-	952
Distribution Facilities			59	176	576	1,153	1,153	576	-	47	398	701	351	-	-	5,1[illegible]
Internal Network			16	48	186	371	371	371	371	204	145	256	256	256	128	[illegible]
Fire Hydrants			1	2	-	11	23	23	23	15	29	50	50	50	25	[illegible]
Service Connection	a) Meters		5	15	-	73	146	146	146	82	83	146	146	146	72	1,206
	b) Pipes		15	46	-	221	443	443	443	248	218	383	383	383	192	3,418
Immediate Improvements	a) Source Facilities	1. Equipment	474													474
		2. Structure	271													271
		3. Well	531													531
	b) Distribution Facilities		1,840													1,840
	c) Service Connection	1. Meters	174	158	157											489
		2. Pipes	370	335	335											1,040
	d) Administration building	1. Equipment	51													51
		2. Structure	419													419
	e) Plumbing Shop	1. Equipment	30													30
		2. Structure	421													421
	f) Vehicles		139													139
	g) Miscellaneous Items		15													15
Feasibility Studies[1]			58		149											207
Sub-total[2]			4,904	823	1,403	1,829	2,982	1,559	983	596	873	1,536	1,215	1,710	417	20,830
Land			111		6						6					123
TOTAL PROJECT COST[3]			5,015	823	1,409	1,829	2,982	1,559	983	596	879	1,536	1,215	1,710	417	20,953

[1] Calculated at 1 percent of total project cost.
[2] Includes design (first year of each major segment of development), supervision of construction and contingencies spread uniformly during the period of construction.
[3] Does not include interest during construction. For calculated interest see Table X-B-1.

ANNEX TABLE X-C-2

PROJECT COST OF RECOMMENDED PROGRAM
GAPAN WATER DISTRICT
(WITH ESCALATION)
₱ x 1000

Item				1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
ESCALATION FACTOR				1.000	1.100	1.210	1.307	1.412	1.525	1.647	1.779	1.886	1.999	2.119	2.246	2.381	
Source Facilities	a) Equipment			6	20			490						17	521		1,054
	b) Structure			2	6			151						8	235		452
	c) Well			7	22			554						36	1,159		1,778
Distribution Facilities				59	194	697	1,507	1,528	578		84	751	1,401	744			7,543
Internal Network				16	53	225	485	524	566	611	363	273	512	542	575	305	5,050
Fire Hydrants				1	2		14	32	35	38	27	55	100	106	112	60	582
Service Connection	a) Meters			5	17		95	206	223	240	146	157	292	309	328	171	2,189
	b) Pipes			15	51		289	626	676	730	441	411	766	812	860	457	6,134
Immediate Improvements	a)	Source Facilities	1. Equipment	474													
			2. Structure	271													
			3. Well	531													531
	b)	Distribution Facilities		1,840													1,840
	c)	Service Connection	1. Meters	174	174	190											538
			2. Pipes	370	369	405											1,144
	d)	Administrative Building	1. Equipment	51													51
			2. Structure	419													419
	e)	Plumbing Shop	1. Equipment	30													30
			2. Structure	421													421
	f)	Vehicles		139													139
	g)	Miscellaneous Items		15													15
Feasibility Studies				58		180											238
Sub-total				4,904	908	1,697	2,390	4,211	2,378	1,619	1,061	1,647	3,071	2,574	3,840	993	31,293
Land				111		7						11					129
TOTAL PROJECT COST				5,015	908	1,704	2,390	4,211	2,378	1,619	1,061	1,658	3,071	2,574	3,840	993	31,422

ANNEX X-F

FUNDS FOR CAPITAL DEVELOPMENT

ANNEX TABLE X-P-1

ASSET AND DEPRECIATION VALUE FORECAST
GAPAN WATER DISTRICT
(₱ x 1000)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
I. WORK-IN-PROCESS																							
Source Facilities																							
a) Equipment	6	26	26	26	516						17	538											
b) Structure	2	8	8	8	159						8	233											
c) Wells	7	29	29	29	583						36	1195											
Immediate Improvements – Source Facilities																							
a) Equipment	474																						
b) Structure	271																						
c) Wells	531																						
Total Work-In Process	1291	63	63	63	1258						61	2026											
II. ASSETS ADDED BY YEAR END																							
Distribution Facilities	59	194	697	1507	1628	878	–	84	751	1401	744												
Internal Network	16	53	225	485	524	566	611	363	273	512	542	575	305										
Fire Hydrants	1	2	–	14	32	35	38	27	55	100	106	112	60										
Service Connections																							
a) Meters	5	17	–	95	206	223	240	146	157	292	309	328	171										
b) Pipes	15	51	–	289	626	676	730	441	411	766	812	860	457										
Feasibility Studies	58		180																				
Immediate Improvements																							
a) Distribution Facilities	1840																						
b) Service Connection 1. Meters	174	174	190																				
2. Pipes	370	369	405																				
c) Administration Bldg 1. Equipment	51																						
2. Structure	419																						
d) Plumbing Shop 1. Equipment	30																						
2. Structure	421																						
e) Vehicles	139																						
f) Miscellaneous Items	15																						
Replacements																							
a) Source Facilities – Equipment																	1335				1317		
b) Service Connection – Meters																	475	503	530	261	554	587	623
c) Administration Bldg. – Equipment																	147						
d) Plumbing Shop – Equipment																	90						
e) Vehicles									253								403						
f) Miscellaneous Items																	45						
Total Assets Added By Year End	3613	860	1697	2390	3016	2378	1619	1061	1900	3071	2513	1875	993				2495	503	530	261	1871	587	623
III. DEPRECIABLE VALUES																							
A. 50 Years Service Life																							
Existing Facilities	3794	3794	3794	3794	3794	464	413	299	248	248	248	248	248	248	248	248	248	248	248	248	248	248	248
Source Facilities – Structure	–	271	271	271	271	430	430	430	430	430	430	430	723	723	723	723	723	723	723	723	723	723	723
Distribution Facilities	–	1899	2093	2790	4297	5925	6803	6803	6887	7638	9039	9783	9783	9783	9783	9783	9783	9783	9783	9783	9783	9783	9783
Internal Network	–	16	69	294	779	1303	1869	2480	2843	3116	3628	4170	4745	5050	5050	5050	5050	5050	5050	5050	5050	5050	5050
Fire Hydrants	–	1	3	3	17	49	84	122	149	204	304	410	522	582	582	582	582	582	582	582	582	582	582
Service Connection – Pipes	–	385	805	1210	1499	2125	2801	3531	3972	4383	5149	5961	6821	7278	7278	7278	7278	7278	7278	7278	7278	7278	7278
Administration Building – Structure	–	419	419	419	419	419	419	419	419	419	419	419	419	419	419	419	419	419	419	419	419	419	419
Plumbing Shop – Structure	–	421	421	421	421	421	421	421	421	421	421	421	421	421	421	421	421	421	421	421	421	421	421
Total 50 Years Life	3794	7206	7875	9202	11497	11136	13240	14505	15369	16859	19636	21842	23682	24504	24504	24504	24504	24504	24504	24504	24504	24504	24504

ANNEX TABLE X-F-1 (CONTINUED)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
B. 30 Years Service Life												
Feasibility Studies	–	58	58	238	238	238	238	238	238	238	238	238
Total 30 Years Life	–	58	58	238	238	238	238	238	238	238	238	238
C. 25 Years Service Life												
Source Facilities – Wells	–	531	531	531	531	1114	1114	1114	1114	1114	1114	1114
Total 25 Years Life	–	531	531	531	531	1114	1114	1114	1114	1114	1114	1114
D. 15 Years Service Life												
Source Facilities – Equipment	–	474	474	474	474	990	990	990	990	990	990	990
Service Connection – Meters	–	179	370	560	655	861	1084	1324	1470	1627	1919	2228
Administration Building – Equipment	–	51	51	51	51	51	51	51	51	51	51	51
Plumbing Shop – Equipment	–	30	30	30	30	30	30	30	30	30	30	30
Miscellaneous Items	–	15	15	15	15	15	15	15	15	15	15	15
Total 15 Years Life	–	749	940	1130	1225	1947	2170	2410	2556	2713	3005	3314
E. 7 Years Service Life												
Vehicles	–	139	139	139	139	139	139	139	–	253	253	253
Total 7 Years Life	–	139	139	139	139	139	139	139	–	253	253	253
TOTAL DEPRECIABLE VALUES	3794	8683	9543	11240	13630	14574	16901	18406	19277	21177	24248	26761
BOOK VALUE OF ASSETS OTHER THAN LAND	8698	9606	11303	13693	17904	16952	18520	19467	21177	24248	26822	30662
LAND	111	111	118	118	118	118	118	118	129	129	129	129
TOTAL BOOK VALUE OF ALL CAPITAL ASSETS	8809	9717	11421	13811	18022	17070	18638	19585	21306	24377	26951	30791

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
B. 30 Years Service Life											
Feasibility Studies	238	238	238	238	238	238	238	238	238	238	238
Total 30 Years Life	238	238	238	238	238	238	238	238	238	238	238
C. 25 Years Service Life											
Source Facilities – Wells	2309	2309	2309	2309	2309	2309	2309	2309	2309	2309	2309
Total 25 Years Life	2309	2309	2309	2309	2309	2309	2309	2309	2309	2309	2309
D. 15 Years Service Life											
Source Facilities – Equipment	1528	1528	1528	1528	1054	2389	2389	2389	1873	[illegible]	3190
Service Connection – Meters	2556	2727	2727	2727	2548	2832	3145	3530	3635	3966	4313
Administration Building – Equipment	51	51	51	51	–	147	147	147	147	147	147
Plumbing Shop – Equipment	30	30	30	30	–	90	90	90	90	90	90
Miscellaneous Items	15	15	15	15	–	45	45	45	45	45	45
Total 15 Years Life	4180	4351	4351	4351	3602	5503	5816	6251	5730	7438	7765
E. 7 Years Service Life											
Vehicles	253	253	253	253	–	403	403	403	403	403	403
Total 7 Years Life	253	253	253	253	–	403	403	403	403	403	403
TOTAL DEPRECIABLE VALUES	30662	31655	31655	31655	30653	32957	33270	33705	33244	34892	35239
BOOK VALUE OF ASSETS OTHER THAN LAND	31655	31655	31655	31655	33148	33460	33800	33966	35115	35479	35862
LAND	129	129	129	129	129	129	129	129	129	129	129
TOTAL BOOK VALUE OF ALL CAPITAL ASSETS	31784	31784	31784	31784	33277	33589	33929	34095	35244	35608	35991

ANNEX TABLE X-F-2

SCHEDULE OF DEPRECIATION EXPENSES
GAPAN WATER DISTRICT
(₱ x 1000)

Year	Service Life Category					Total Annual Depreciation Expenses	Accumulated Depreciation Prior Year	Book Value of Assets Retired During the Year					Net Accumulated Depreciation Year End
	50 Years	30 Years	25 Years	15 Years	7 Years			50 Years	25 Years	15 Years	7 Years	Total	
1978	76	–	–	–	–	76	3,589						3,665
1979	144	2	21	50	20	237	3,665						3,902
1980	158	2	21	63	20	264	3,902						4,166
1981	184	8	21	75	20	308	4,166						4,474
1982	230	8	21	82	20	361	4,474						4,835
1983	223	8	45	130	20	426	4,835	3,330				3,330	1,931
1984	265	8	45	145	20	483	1,931	51				51	2,363
1985	290	8	45	161	20	524	2,363	114				114	2,773
1986	307	8	45	170	–	530	2,773	51			139	190	3,113
1987	337	8	45	181	36	607	3,113						3,720
1988	393	8	45	200	36	682	3,720						4,402
1989	437	8	45	221	36	747	4,402						5,149
1990	474	8	92	279	36	889	5,149						6,038
1991	490	8	92	290	36	916	6,038						6,954
1992	490	8	92	290	36	916	6,954						7,870
1993	490	8	92	290	36	916	7,870						8,786
1994	490	8	92	240	–	830	8,786			749	253	1,002	8,614
1995	490	8	92	367	58	1,015	8,614			191		191	9,438
1996	490	8	92	388	58	1,036	9,438			190		190	10,284
1997	490	8	92	417	58	1,065	10,284			95		95	11,254
1998	490	8	92	386	58	1,034	11,254			722		722	11,566
1999	490	8	92	496	58	1,144	11,566			223		223	12,487
2000	490	8	92	519	58	1,167	12,487			240		240	13,414

ANNEX TABLE X-F-3

WORKING CAPITAL REQUIREMENTS
GAPAN WATER DISTRICT

Year	Number of New Connections	Number of Installment Plan Added	Number of Installment Plan Paid	Total Paying Monthly Installment (Cumulative)	Monthly Installment Plan (Escalated)	₱ x 1000: Increment Added[4]	Increment Deducted[5]	Cash Receipts: Lump Sum Payments[6] (Escalated)	Cash Receipts: Installment Payments (Cumulative)	Total Payments	Annual Construction Cost[7]	Working Capital Required	Cumulative Capital Requirements
1978	467	280	θ	280	6.83	23		118	12	130	296	166	166
1979	467	280	↓	560	7.51	25		130	36	166	326	160	326
1980	466	280	↓	840	8.26	28		143	62	205	357	152	478
1981	454	272	↓	1,112	8.92	29		150	91	241	376	135	343
1982	454	272	↓	1,384	9.63	31		162	121	283	406	123	466
1983	454	272	↓	1,656	10.40	34		176	153	329	439	110	576
1984	454	272	↓	1,928	11.23	37		190	189	379	474	95	671
1985	454	272	↓	2,200	12.13	40		205	227	432	512	80	751
1986	454	272	↓	2,472	12.86	42		217	268	485	543	58	809
1987	454	272	θ	2,744	13.63	44		230	311	541	576	35	844
1988	454	272	140	2,876	14.45	47	12	244	345	589	610	21	865
1989	454	272	280	2,868	15.31	50	24	259	369	628	647	19	884
1990	454	272	280	2,860	16.23	53	27	274	393	667	686	19	865
1991	θ	θ	276	2,584	17.20	θ	29		391	391	θ	(391)	474
1992	↓	↓	272	2,312	18.23	↓	30		361	361	↓	(361)	113
1993	↓	↓	272	2,040	19.32	↓	33		328	328	↓	(328)	(215)
1994	↓	↓	272	1,768	20.48	↓	36		292	292	↓	(292)	(507)
1995	↓	↓	272	1,496	21.71	↓	39		253	253	↓	(253)	(760)
1996	↓	↓	272	1,224	23.01	↓	41		212	212	↓	(212)	(972)
1997	↓	↓	272	952	24.39	↓	43		169	169	↓	(169)	(1,141)
1998	↓	↓	272	680	25.85	↓	46		123	123	↓	(123)	(1,264)
1999	↓	↓	272	408	27.40	↓	49		74	74	↓	(74)	(1,338)
2000	θ	θ	272	136	29.04	θ	52		22	22	θ	(22)	(1,360)

4/ Accumulated installment payments are calculated on the basis of 100 percent incremental additions during previous years and 50 percent of the last year.
5/ Based on the assumption that installment plan will be paid back in 10 years.
6/ Assumed to be 40 percent of construction cost.
7/ Amount to be shouldered by the customers which is: 2/3 of pipes + meters.

ANNEX TABLE X-F-4a

STRATIFICATION OF SERVICE CONNECTIONS
GAPAN WATER DISTRICT

Year	Domestic/government 1/2"	3/4"	1"	Sub-total	Commercial/Industrial 1/2"	3/4"	1"	Sub-total	Total Connections
1978	758	32	8	798	82	18	9	109	507
1980	1,538	65	16	1,619	166	36	19	221	1,840
1985	3,436	145	36	3,617	370	79	44	493	4,110
1990	5,333	225	56	5,614	575	123	68	766	6,380

ANNEX TABLE X-F-4b

REVENUE UNIT FORECAST[8]

Year	Domestic/Government 1/2" (2.5)	3/4" (4.0)	1" (8.0)	Sub-total	Commercial/Industrial 1/2" (5.0)	3/4" (8.0)	1" (16.0)	Sub-total	Grand Total[9]	Service Charge[10]	Estimated Consumption (cum) Domestic	Government	Commodity Charge (RUs) Domestic[11]	Commercial[12]	Total RUs
1978	1,895	128	64	2,087	410	144	144	698	2,785	334,200	179,945	20,440	84,185	14,720	433,105
1980	3,845	260	128	4,233	830	288	304	1,422	5,655	678,600	446,760	56,210	252,480	59,380	990,460
1985	8,590	580	288	9,458	1,850	632	704	3,186	12,644	1,517,280	835,120	105,485	401,080	92,650	2,011,010
1990	13,333	900	448	14,681	2,875	984	1,088	4,947	19,628	2,355,360	1,537,745	209,875	864,065	235,910	3,455,335

8/ Computation of revenue units based on current LWUA guidelines on structuring of water rates.
9/ Grand total of number pf connections multiplied by their respective conversion factors for computing revenue units (in RUs).
10/ Multiply grand total by 120 (derived from 10 cum/month, the minimum amount covered by the service charge 12 months/year) in RUs.
11/ Domestic consumption - (120 x number of domestic connections) x use factor. Use factor for domestic/institutional classification is 1.
12/ Commercial consumption - (120 x number of commercial connections) x use factor. Use factor for commercial classification is 2.

ANNEX X-G

ANALYSIS OF WATER RATES

ANNEX TABLE X-G-1

REVENUE FORECAST
GAPAN WATER DISTRICT

Year	Rate/RU ₱	Estimated Number of R.U.s Yearly (in 1000's)	₱ x 1000 Income from Sales	Bad Debt	Other Income 13/	Total Net Income
1978	0.70	433	303	6	6	303
1979	0.70	712	498	5	10	503
1980	0.70	990	693	7	14	700
1981	1.20	1,194	1,433	27	27	1,433
1982	1.20	1,398	1,678	17	34	1,695
1983	1.20	1,603	1,924	19	38	1,943
1984	1.50	1,807	2,711	54	54	2,711
1985	1.50	2,011	3,017	30	60	3,047
1986	1.50	2,300	3,450	35	69	3,484
1987	1.50	2,589	3,884	39	78	3,923
1988	1.50	2,877	4,316	43	86	4,359
1989	1.50	3,166	4,749	47	95	4,797
1990	1.60	3,455	5,528	111	111	5,528
1991	1.60	↓	5,528	55	111	5,584
1992	1.60		5,528	55	111	5,584
1993	1.60		5,528	55	111	5,584
1994	1.70		5,874	117	117	5,874
1995	1.70		5,874	59	117	5,932
1996	1.70		5,874	59	117	5,932
1997	1.70		5,874	59	117	5,932
1998	1.80		6,219	124	124	6,219
1999	1.80		6,219	62	124	6,281
2000	1.80	3,455	6,219	62	124	6,281

13/ Other income (derived from meter replacement charges, contingency fees of new connections, service fees, etc) is about 2% of sales.

ANNEX X-H

FINANCIAL SUMMARY

ANNEX TABLE X-H-1

DEBT SERVICE SCHEDULE OF TOTAL PROJECT LOAN
GAPAN WATER DISTRICT
(₱ x 1000)

	Outstanding Loan End of Year			Capital Repayments			Interest Payments			
Year	Immediate Improvement	Phase 1-A and 1-B	Total	Immediate Improvement	Phase 1-A and 1-B	Total	Immediate Improvement	Phase 1-A and 1-B	Total	Total Debt Service
1978	4,999	-	4,999	-	-	-	126	-	126	126
1979	5,754	199	5,953	-	-	-	262	-	262	262
1980	6,612	1,103	7,715	-	-	-	282	18	300	300
1981	6,914	3,252	10,166	-	-	-	293	99	392	392
1982	6,863	7,180	14,043	51	-	51	622	293	915	966
1983	6,808	9,229	16,037	55	-	55	618	646	1,264	1,319
1984	6,748	10,469	17,217	60	-	60	613	831	1,444	1,504
1985	6,682	11,098	17,780	66	-	66	607	942	1,549	1,615
1986	6,610	12,188	18,798	72	83	155	601	999	1,600	1,755
1987	6,532	14,635	21,167	78	83	161	595	1,097	1,692	1,853
1988	6,447	16,537	22,984	85	83	168	588	1,317	1,905	2,073
1989	6,354	19,624	25,978	93	125	218	580	1,488	2,068	2,286
1990	6,253	19,825	26,078	101	125	226	572	1,766	2,338	2,564
1991	6,143	19,631	25,774	110	194	304	563	1,784	2,347	2,651
1992	6,023	19,354	25,377	120	277	397	553	1,767	2,320	2,717
1993	5,892	19,077	24,969	131	277	408	542	1,742	2,284	2,692
1994	5,749	18,681	24,430	143	396	539	530	1,717	2,247	2,786
1995	5,593	18,285	23,878	156	396	552	517	1,681	2,198	2,750
1996	5,423	17,807	23,230	170	478	648	503	1,646	2,149	2,797
1997	5,238	17,260	22,498	185	547	732	488	1,603	2,091	2,823
1998	5,036	16,712	21,749	202	547	749	471	1,553	2,024	2,773
1999	4,816	16,097	20,913	220	616	836	453	1,504	1,957	2,793
2000	4,576	15,397	19,973	240	700	940	433	1,449	1,882	2,822

ANNEX TABLE X-H-2

PROJECTED INCOME STATEMENT
GAPAN WATER DISTRICT
(₱ x 1000)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Water Production per Year (1,000 x cum)	385		837					1427					2432										2432
Water Sales per Year (1,000 x cum)	153	Increasing to →	503		— Increasing to →			941		— Increasing to →			1748				— Increasing to →						1748
Unaccounted-for-Water (%)	60		40					34					28										28
Connections – Metered	907		1840					4110					6380										6380
Consumption (lpcd)																							
OPERATING REVENUE																							
Water Sales	303	493	593	1433	1678	1924	2711	3017	3450	3884	4316	4749	5528	5528	5528	5528	5874	5874	5874	5874	6219	6219	6219
Less: Uncollectibles	6	5	7	27	17	19	54	30	35	39	43	47	111	55	55	55	117	59	59	59	124	62	62
Other Revenue	6	10	14	27	34	38	54	60	69	78	86	95	111	111	111	111	117	117	117	117	124	124	124
Total Revenue	303	503	700	1433	1695	1943	2711	3047	3484	3923	4359	4797	5528	5584	5584	5584	5874	5932	5932	5932	6219	6281	6281
OPERATING EXPENSES																							
Administration and Personnel	65	97	167	259	294	368	409	457	529	579	625	685	950	1025	1106	1194	1292	1394	1507	1628	1756	1895	2050
Power and Fuel	58	65	73	90	108	130	154	180	211	245	263	325	373	402	435	469	507	547	582	639	689	744	805
Chemicals	7	10	13	16	20	22	28	34	39	45	52	60	69	74	80	87	94	101	109	118	127	137	149
Maintenance	18	37	57	69	82	97	114	133	151	172	194	219	247	267	288	311	336	363	392	424	457	493	534
Miscellaneous	4	5	6	7	8	9	11	13	16	19	22	27	32	34	37	40	43	46	50	54	58	63	68
Depreciation	76	237	264	308	361	426	483	524	530	607	702	747	889	916	918	916	830	1015	1036	1065	1034	1144	1157
Total Operating Expenses	228	451	580	749	873	1052	1199	1341	1476	1667	1858	2063	2560	2718	2864	3017	3102	3466	3685	3928	4121	4476	4773
Operating Income	75	52	120	684	822	891	1512	1706	2008	2256	2501	2734	2968	2866	2720	2567	2772	2466	2246	2004	2098	1805	1508
Plus: Interest on Reserves	1	3	5	9	16	24	34	46	60	75	92	111	133	168	214	260	309	358	424	506	561	678	765
Net Income Before Interest	76	55	125	693	838	915	1546	1752	2068	2331	2593	2845	3101	3034	2934	2827	3081	2824	2670	2510	2659	2483	2273
Interest on Debt	126	262	300	392	915	1264	1444	1549	1600	1692	1905	2068	2338	2347	2320	2284	2247	2198	2149	2091	2024	1957	1882
Net Income (Loss)	(50)	(207)	(175)	301	(77)	(349)	102	203	468	639	688	777	763	687	614	543	834	626	521	419	665	526	391
Cumulative Net Income (Loss)	(50)	(257)	(432)	(131)	(208)	(557)	(455)	(252)	216	855	1543	2320	3083	3770	4384	4927	5761	6387	6908	7327	7992	8518	8909
Appropriation to Reserves	9	15	21	43	50	58	81	91	104	117	129	142	166	332	332	332	352	352	587	587	622	622	622
Average Net Fixed Assets in Operation	2077	5004	6911	8954	11474	14406	16579	17416	18375	20297	22445	23924	25553	26160	25244	24328	24703	25279	24770	24115	24132	24272	23721
Rate of Return	1.9	0.7	1.7	7.6	7.2	6.2	9.1	9.8	10.9	11.1	11.1	11.4	11.6	11.0	10.8	10.6	11.2	9.8	9.1	8.3	8.7	7.4	6.4

ANNEX TABLE X-H-3

PROJECTED SOURCES AND APPLICATIONS OF FUNDS
GAPAN WATER DISTRICT
(₱ x 1000)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
SOURCES OF FUNDS																							
Net Income Before Interest	76	55	125	693	838	915	1546	1752	2068	2331	2593	2845	3101	3034	2934	2827	3081	2824	2670	2510	2689	2483	2273
Add: Depreciation	76	237	264	308	361	426	453	524	530	607	683	747	889	916	916	916	830	1015	1036	1065	1034	1144	1167
Total Internal Cash Generation	152	292	389	1001	1199	1341	2029	2276	2598	2938	3275	3592	3990	3950	3850	3743	3911	3839	3706	3575	3723	3627	3440
Long-Term Borrowing	4999	954	1762	2451	3928	2049	1240	629	1173	2530	1985	3212	326										
Capital Contributions	111	166	205	241	283	329	379	432	455	541	589	628	667	391	361	328	292	253	212	169	123	74	22
Total External Cash Generation	5110	1120	1967	2692	4211	2378	1619	1061	1658	3071	2574	3840	993	391	361	328	292	253	212	169	123	74	22
Total Sources of Funds	5262	1412	2356	3693	5410	3719	3648	3337	4256	6009	5849	7432	4983	4341	4211	4071	4203	4092	3918	3744	3846	3701	3462
APPLICATIONS OF FUNDS																							
Capital Expenditures	5015	908	1704	2390	4211	2378	1619	1061	1658	3071	2574	3840	993										
Capitalized Interest	95	212	263	302																			
Debt Service : Interest	126	262	300	392	915	1264	1444	1549	1600	1692	1905	2068	2338	2347	2320	2284	2247	2198	2149	2091	2024	1957	1852
Principal	–	–	–	–	51	55	60	66	155	161	168	218	226	304	397	408	539	552	648	732	749	836	970
Sub-total	126	262	300	392	966	1319	1504	1615	1755	1853	2073	2286	2564	2651	2717	2692	2786	2750	2797	2823	2773	2793	2822
Replacements									253								2495	503	530	261	1871	557	623
Increase in Working Capital	207	60	53	90	206	62	199	(76)	81	269	112	109	(55)	(214)	(21)	(23)	203	(3)	(22)	(122)	133	(10)	(30)
Total Applications of Funds	5443	1442	2320	3174	5383	3759	3322	2600	3747	5193	4759	6235	3492	2437	2694	2669	5484	3250	3305	2962	4777	3370	3415
INCREASE (DECREASE) IN CASH BALANCE	(181)	(30)	36	519	27	(40)	326	737	509	816	1090	1197	1491	1904	1517	1402	(1281)	842	613	782	(931)	331	47
CASH BALANCE BEGINNING OF YEAR	0	(181)	(211)	(175)	344	371	331	657	1394	1903	2719	3809	5006	6497	8401	9918	11320	10039	10881	11494	12276	11345	11676
CASH BALANCE YEAR END	(181)	(211)	(175)	344	371	331	657	1394	1903	2719	3809	5006	6497	8401	9918	11320	10039	10881	11494	12276	11345	11676	11723
DEBT-SERVICE RATIO	0.92	1.05	1.30	2.55	1.24	1.02	1.35	1.41	1.48	1.59	1.58	1.57	1.56	1.49	1.42	1.39	1.40	1.40	1.32	1.27	1.34	1.30	1.22
RATIO OF INTERNAL CASH GENERATION Less Debt Service to Capital Expenditure (%)	–	1	5	23	6	1	32	62	51	35	47	34	144										

ANNEX TABLE X-H-4

PROJECTED BALANCE SHEET
GAPAN WATER DISTRICT
(P x 1000)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
ASSETS												
Fixed Assets:												
Gross Value of Fixed Assets	7613	9961	11928	14620	17636	17942	19510	20457	22178	25249	27762	29637
Less: Accumulated Depreciation	3665	3902	4166	4474	4835	1931	2363	2773	3113	3720	4402	5149
Net Value of Fixed Assets	3948	6059	7762	10146	12801	16011	17147	17684	19065	21529	23360	24488
Work in Process	1291	63	63	63	1258	–	–	–	–	–	61	2026
Total Fixed Assets	5239	6122	7825	10209	14059	16011	17147	17684	19065	21529	23421	26514
Current Assets:												
Cash	(181)	(211)	(175)	344	371	331	557	1374	1903	2719	3809	5006
Accounts Receivable	66	120	173	358	420	481	678	754	863	971	1079	1187
Provision For Bad Debts	1	1	2	7	4	5	14	8	9	10	11	12
Inventory	167	184	202	133	285	306	332	191	186	367	391	416
Total Current Assets	51	92	198	828	1072	1113	1653	2331	2943	4047	5268	6597
Total Assets	5290	6214	8023	11037	15131	17124	18800	20015	22008	25576	28689	33111
EQUITY AND LIABILITIES												
Current Liabilities:												
Accounts Payable	25	36	53	74	85	104	119	136	158	177	196	219
Current Maturities on Long-Term Debt	–	–	–	51	55	60	66	155	161	168	218	226
Total Current Liabilities	–	36	53	125	140	164	185	291	319	345	414	445
Long-Term Debt (Less Current Maturities)	4999	5953	7715	10115	13986	15977	17151	17625	18637	20999	22766	25752
Equity:												
Government Contribution	205	205	205	205	205	205	205	205	205	205	205	205
Capital Contribution	111	277	482	723	1006	1335	1714	2146	2631	3172	3761	4389
Reserves	9	24	45	88	138	196	277	368	472	583	718	860
Unappropriated Retained Earnings	(59)	(28)	(477)	(219)	(346)	(753)	(732)	(620)	(256)	266	825	1460
Total Equity	266	225	255	797	1003	983	1464	2099	3052	4232	5509	6914
Total Equity and Liabilities	5290	6214	8023	11037	15131	17124	18800	20015	22008	25576	28689	33111

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
ASSETS											
Fixed Assets:											
Gross Value of Fixed Assets	32656	32656	32656	32656	34149	34461	34801	34967	36116	36450	36863
Less: Accumulated Depreciation	6038	6954	7870	8786	8614	9438	10283	11254	11566	12457	13414
Net Value of Fixed Assets	26618	25702	24786	23870	25535	25023	24517	23713	24550	23993	23449
Work in Process	–	–	–	–	–	–	–	–	–	–	–
Total Fixed Assets	26618	25702	24786	23870	25535	25023	24517	23713	24550	23993	23449
Current Assets:											
Cash	6497	8401	9918	11320	10039	10881	11494	12276	11345	11676	11723
Accounts Receivable	1382	1382	1382	1382	1469	1469	1469	1469	1555	1555	1555
Provision For Bad Debts	28	14	14	14	29	15	15	15	31	16	16
Inventory	232	25	27	29	189	202	213	126	227	242	258
Total Current Assets	8083	9794	11313	12717	11668	12537	13161	13856	13096	13457	13520
Total Assets	34701	35496	36099	36587	37203	37560	37678	37569	37646	37450	36969
EQUITY AND LIABILITIES											
Current Liabilities:											
Accounts Payable	279	300	325	350	379	409	442	477	515	555	601
Current Maturities on Long-Term Debt	304	397	408	539	552	648	732	749	836	940	1030
Total Current Liabilities	583	697	733	889	931	1057	1174	1226	1351	1495	1631
Long-Term Debt (Less Current Maturities)	25774	25377	24969	24430	23878	23230	22498	21749	20913	19973	18943
Equity:											
Government Contribution	205	205	205	205	205	205	205	205	205	205	205
Capital Contribution	5056	5447	5889	6136	6428	6681	6893	7062	7185	7259	7281
Reserves	1026	1358	1670	2023	2374	2726	3313	3900	4522	5144	5766
Unappropriated Retained Earnings	2057	2412	2634	2904	3387	3661	3595	3427	3470	3374	3143
Total Equity	8344	9422	10397	11268	12394	13273	14006	14594	15382	15982	16395
Total Equity and Liabilities	34701	35496	36099	36587	37203	37560	37678	37569	37646	37450	36969

ANNEX TABLE X-H-5

RATE OF RETURN ON TOTAL INVESTMENT
(DISCOUNTED CASH FLOW METHOD)
GAPAN WATER DISTRICT
(₱ x 1000)

Year	Debt Service	Net Increase In Cash	Total Cash Inflow	Investments	Net Cash Inflow	1st Trial Present Value: 6% Factor	1st Trial Present Value: 6% Value	2nd Trial Present Value: 8% Factor	2nd Trial Present Value: 8% Value
1978	126	(181)	(55)	5,110	(5,165)	1.000	(5,165)	1.0	(5,165)
1979	262	(30)	232	1,120	(888)	.943	(837)	.906	(822)
1980	300	36	336	1,967	(1,631)	.890	(1,452)	.857	(1,398)
1981	392	519	911	2,692	(1,781)	.843	(1,501)	.794	(1,414)
1982	966	27	993	4,211	(3,218)	.792	(2,549)	.735	(2,365)
1983	1,319	(40)	1,279	2,378	(1,099)	.747	(820)	.681	(748)
1984	1,504	326	1,830	1,619	211	.705	149	.630	133
1985	1,615	737	2,352	1,061	1,291	.665	859	.583	753
1986	1,755	509	2,264	1,911	353	.627	221	.540	191
1987	1,853	816	2,669	3,071	(402)	.592	(238)	.500	(201)
1988	2,073	1,090	3,163	2,574	589	.558	329	.463	273
1989	2,286	1,197	3,483	3,840	(357)	.527	(188)	.429	(153)
1990	2,564	1,491	4,055	993	3,062	.497	1,522	.397	1,216
1991	2,651	1,904	4,555	-	4,555	.469	2,137	.368	1,676
1992	2,717	1,517	4,234	-	4,234	.442	1,871	.340	1,440
1993	2,692	1,402	4,094	-	4,094	.417	1,707	.315	1,290
1994	2,786	(1,281)	1,505	2,495	(990)	.394	(390)	.292	(289)
1995	2,750	842	3,592	503	3,089	.371	1,146	.270	834
1996	2,797	613	3,416	530	2,880	.350	1,008	.250	720
1997	2,823	782	3,605	261	3,344	.331	1,107	.232	776
1998	2,773	(931)	1,842	1,871	(29)	.312	(9)	.215	(6)
1999	2,793	331	3,124	587	2,537	.294	746	.199	505
2000	2,822	47	2,869	623	6,909*	.278	1,921	.184	1,271
							+1,574		-1,471

RATE OF RETURN = 7.03%

*Includes net asset value of ₱4,663

Total assets	₱36,969
Total liabilities	20,574
Cash	11,732
Net Asset Value	₱ 4,663

CHAPTER XI ECONOMIC FEASIBILITY ANALYSIS

A. WATER AND THE ECONOMY

Introduction

Water is a basic requirement in any country's economic development and no economic activity can take place without it. However, this basic function diminishes in relative importance as a higher level of economic development is attained by a country. In most instances, the availability of water alone will not spur economic growth for there are other significant factors that influence development, such as peace and order, political stability, rate of taxation and availability of infrastructure facilities. Hence, a water supply project must be considered as only one part of a regional development program. It must be viewed within the context of the overall government program.

Considering that the Philippines is still a developing country, water supply plays a fairly important role in the national or regional economy. Traditionally, water has been made available to the consuming public at very nominal rates. There is a tendency for the consumers to use water wastefully. As a consequence, the regard given to it is far below its true importance.

To the water consumer, the value of water is measured by its contribution to the satisfaction of the family group which uses the water. His perpective includes himself and his household and all the health, well being and productivity aspects of family life. To the businessman, water is valued for all it does to improve business. From the national viewpoint, the benefits to the water user, both householder and businessman, are only a part of the total.

Major Uses of Water Supply

Domestic. Water for domestic use is usually given top priority because water is essential to life and, up to a point, essential to general well-being. Estimation of the beneficial value of water for domestic purposes is best viewed in terms of average willingness to pay for water rather than do without it. It will be noted that willingness to pay is higher than the price charged insofar as most users are concerned.

Industrial Use. Water is used by industry primarily as a factor of production. In some instances, it goes into the production process as an input. This is the case for the soft drinks industry. One method of determining the value of water to industry is to analyze the cost of alternative industrial processes which produce the same product but use less water. This is not, however, always possible and may be unduly laborious.

Other Uses. Crop irrigation is one of the major uses of water. The value of water used for irrigation purposes can be estimated by an elaborate calculation of "with" and "without" project conditions. All other costs are assumed to be paid and water becomes the residual claimant under "without" and "with" project conditions. Detailed analysis of the area to be irrigated is required.

Another important use is hydropower generation. Water used for this purpose may be valued by comparison with the lowest-cost alternative of providing electric power. Lastly, bodies of water serve a basic role in many recreational activities. Ordinarily, water quality is not adversely affected by recreational use. Water value in this case depends on a number of factors such as accessibility, setting, beauty and quality.

In the Philippines, the National Water Resources Council establishes the water priorities, in pursuance of the policies laid down by its charter, Presidential Decree No. 424. In general, the system of priorities for the development, conservation and utilization of the country's water resources reflects the current usage of water and is responsive to the changing demand for water. Another presidential decree (Presidential Decree No. 198) has declared that the creation, operation, maintenance and expansion of water supply and wastewater disposal systems are a national policy of high priority.

B. METHODOLOGY

Recommended and Next-Best System

One approach in determining the economic feasibility of a water supply project involves a comparison of the benefits and costs of the recommended system and those of the next best system. In this method, the capital expenditure costs and the operating and maintenance costs for both alternative systems are transformed to an equivalent annual cost basis during the projection period. The comparison will show which of the alternative systems will generate the same level of benefits at less cost.

Benefit-Cost Ratio

A second approach in determining the economic feasibility of water supply project involves the following steps:

1. The identification of the economic benefits and costs that can be attributed to the establishment, operation and maintenance of an improved water supply system;

2. The determination of the possible bases for quantifying these benefits and costs; and

3. The comparison of the present value of the benefits likely to be generated and the present value of the costs.

The results of the economic analysis are then expressed as a single ratio called the benefit-cost ratio. The project is considered feasible if the ratio is equal to or greater than 1:1.

Internal Rate of Return

Another method involves the calculation of the economic internal rate of return of the proposed project. The total amount of the benefits as well as of the costs is determined throughout the projection period. By trial and error, the interest rate at which the present worth of the benefits is equal to the present worth of the costs is then calculated. The project is considered desirable if its internal economic rate of return is higher than the minimum rate generally acceptable in such projects, which is usually the opportunity cost of capital.

Method(s) Adopted

Both the second and third methods were employed in determining this project's economic feasibility. These two were considered more appropriate than the first method because in this case, the recommended plan has already been selected from several alternatives on the basis of present worth cost comparisons (as discussed in Chapters VIII and IX).

Calculation of Benefit and Cost Streams

The economic studies cover only Stage I of the proposed water supply program, which extends from 1978 to 1990. Benefits, however, were projected up to 2000. This is because the benefits from the facilities to be constructed up to 1990 would continue to accrue beyond their construction period.

The construction costs included in the analysis are those which will be incurred up to 1990, except replacement costs and the operation and maintenance costs which were projected up to 2000. This is due to the fact that proper maintenance of the facilities will have to be undertaken regularly for as long as benefits are desired to be realized from the system.

Estimates of benefits and costs were based on 1978 prices. In recognition of inflationary pressures, all benefits were escalated by 10 percent from 1978 to 1980, by 8 percent from 1980 to 1985 and by 6 percent from 1985 to 1990. All project costs were also escalated in the same manner, with the exception of operation and maintenance costs which were escalated uniformly by 8 percent all throughout the study period. In both cases, however, the escalation factor for 1990 was held constant up to 2000. This is because only Stage I of the proposed project is being considered in the economic analysis; hence only partial inflation has been adopted.

C. QUANTIFIABLE BENEFITS

The economic benefits that will be derived from the proposed water supply improvement program for the water district may be classified into quantifiable and non-quantifiable. Quantifiable benefits are those which can be expressed in monetary terms. On the other hand, non-quantifiable benefits are intangible but real, and are extremely difficult to express in monetary terms.

Benefits resulting from the proposed project were evaluated on an incremental basis, i.e., on a "with" or "without" principle. Hence, the benefit figures reflect only those that will accrue to the service area as a result of the improvement of the water supply system. They exclude the benefits arising from the present system.

The quantifiable benefits that are discussed in the following sections are: increase in land values, improved health conditions, reduction in fire damage, and beneficial value of water.

Increase in Land Values

The implementation of the water supply project will result in an increase in the land values of the service area. However, it must be pointed out that the increase in land values cannot be attributed solely to the water supply project. Any difference between the acquisition cost and the present market value of a piece of land evolves from a series of market and public forces which exist whether or not the water supply project is undertaken. Such forces include the general pace of industrialization, construction activity, inflation, land speculation, taxation, public land acquisition and selling. More particularly, such difference could be the result of a general estimation of productivity due to infrastructure investments which include a water supply project.

The section of land values attributable to the provision of an improved public water supply system was estimated in the household survey in Lipa City (May 1975) to be about 22.6 percent of the market value of a piece of land. It is reasonable to assume that this figure represents the incremental value of a piece of land given access to water supply. In a specific instance, a residential lot about 400 sqm has the following market values:

Without Water	400 sqm x ₱50	=	₱20,000
With Water	400 sqm x ₱65	=	₱26,000
	Ratio	=	1.3 or 30% increase

In this particular case, the incremental cost of ₱6,000 closely represents the market value of a private well (complete with pumps, electric controls etc.) to serve the premises.

On the basis of this information, it may be conservative to assume that 20 percent of the value of land served by the water distribution system could be attributed to the water supply project.

Assumptions made for this analysis are explained in Annex XI-C. Annex Table XI-C-1 shows the computations of this benefit, which amounts to a present value of ₱11.6 million.

Health Benefits

The establishment of a water supply system in a community will necessarily bring about health benefits to the population. Undoubtedly, the provision of safe, potable water to the population is a prerequisite for the maintenance of minimum health standards. These health benefits are ordinarily manifested in the following:

1. A significant reduction in the incidence of water-borne diseases such as cholera, dysentery, gastro-enteritis, and typhoid/paratyphoid. As a result, there will be a decrease in the amount of time lost by income earners who are afflicted with such diseases.

2. A subsequent reduction in premature deaths due to the lower incidence of water-borne diseases.

3. A corresponding reduction in medical expenses for the same reason.

Calculation for the health benefits and associated assumptions used are presented in Annex XI-C. Annex Table XI-C-2 shows the health benefits on a yearly basis, with a total present value of ₱71,107.

Reduction in Fire Damage

With the installation of suitable fire hydrants especially in the high-value as well as the residential districts in the service area as part of the proposed project, savings due to reduced fire damages will result from the availability of an adequate amount of water and increased water pressure for fire-fighting purposes. Calculations relative to this benefit are explained in Annex XI-C and shown in detail in Annex Table XI-C-3. The present value of this benefit amounts to ₱1.6 million.

No attempt was made to quantify the inconvenience to the people rendered homeless and the value of human lives lost due to fire.

Beneficial Value of Water

This benefit (sometimes called "consumer satisfaction") is quantified by the additional revenue generated by the water district as a result of an improved water supply project. In the case of a community which previously did not have any piped water system, the "consumer satisfaction" benefit may be measured by the full amount of the economic value of the accounted-for-water.

For a community where the proposed project involves merely the expansion and improvement of the existing system, this benefit may be measured by the economic value of the incremental water production directly resulting from the improvement of the system.

For this benefit, the concept of 'consumers' surplus was adopted. This concept takes into account not only what households and commercial establishments are actually paying for water but also how much more the consumers are willing to pay for this essential commodity. Calculations for the beneficial value of water are shown in Annex XI-C and Annex Table XI-4. The present value of this benefit amounts to ₱14.3 million.

D. NON-QUANTIFIABLE BENEFITS

The non-quantifiable benefits arising from a water supply project are generally as important as the quantifiable benefits. However, they do not easily lend themselves to valuation. The approach taken herein is to acknowledge their existence and importance. No attempt has been made to quantify or include them in the benefit-cost calculations.

The proposed water supply project will set off a chain of events beyond its construction period. Those activities include among others the inducement to industry to establish plants in the service area due to availability of a dependable water supply. Without such supply, new industrial and commercial establishments would be forced to develop their own supply system or relocate elsewhere. The overall cost of providing separate water systems is normally large and represents a deterrent to invest in the area and consequently to industrial development.

Because of the employment generated by the project, hired laborers are able to spend their wages for purchasing goods at the local stores. Hence, each peso they spend is generated back into the income stream of the local economy. In the operation and maintenance of the project, the water district would find it advantageous to purchase required supplies locally and engage local service.

E. ECONOMIC COSTS

General

The total cost of the proposed water supply system is the sum of all expenditures required to realize project objectives and benefits.

Costs have been divided into the following:

1. Project Costs
2. Replacement Costs
3. Operating and Maintenance Costs

In general, economic costs are easier to identify and quantify than benefits. This is because most of the costs are incurred in real, monetary terms to pay for either goods or services while benefits are usually intangible.

Project Costs

Project costs include the construction cost of the proposed facilities such as pipes, meters and equipment, as well as, engineering service and contingencies, land cost, administrative and legal fees. The cost of the feasibility studies has also been included.

Annex Table XI-E-1 shows the construction costs of the proposed water supply project for the water district. They are listed by component as to type of expenditure, in 1978 prices. They are further broken down into foreign and domestic components.

The cost of unskilled labor is shown separately from the domestic component of the project. From the balance of the domestic cost, five percent was assumed to be in the form of hidden taxes.

Adjustment on Project Costs

In the determination of the project costs, adjustments were made for those items which are not properly valued by the price mechanism. A price other than the market price (called the shadow price) was applied to these items. In this way, most of the effects of price discrepancies which could be identified, whether primary or secondary, were incorporated directly into the project analysis and included as direct costs to project investment. The 'shadow prices' used in this analysis are those employed by international lending institutions and the Planning and Project Development Office (PPDO) of the Department of Public Works, Transportation and Communication.

One of the items where 'shadow pricing' was applied is the price of unskilled labor (otherwise known as common labor). In a perfectly competitive market, the price of labor is determined by the marginal value of its product. In this case, therefore, the price of labor is equal to the value of the output which an extra laborer hired would produce. However, this is not applicable in an economy such as that of the Philippines where there is a surplus of labor. Since there is widespread disguised unemployment in such an economy, unskilled labor is normally valued below the actual wage rate likely to be paid. In this study, the opportunity cost of unskilled labor or its potential in other employment was valued at one half of its estimated cost in the project. The net effect is to reduce the cost of unskilled labor by 50 percent, thereby reducing the summation of project cost.

Skilled labor, on the other hand, was valued at its going rate. It was assumed that if skilled labor were not employed in the service area, it would probably migrate elsewhere to obtain employment of better wage.

Adjustments were also made with respect to cost of project facilities which use up the limited foreign exchange reserves. Foreign exchange used to import project components was valued at 1.2 times their actual peso cost. This effectively increased foreign exchange cost by 20 percent, thereby affecting project cost in a similar mmaner. This was done to reflect the opportunity cost or alternative value of foreign exchange. Domestic components, on the other hand, were priced at their actual cost.

Interest was likewise not included since this is considered a financial instead of an economic cost.

Annex Table XI-E-1 shows the conversion of financial costs to economic costs through shadow pricing and other adjustments. The total economic project cost for GAP-WD amounts to ₱21.6 million with a present worth of ₱18.7 million as shown in Annex Table XI-E-4.

Replacement Costs

Based on the criteria used in the financial studies, vehicles have a life expectancy of seven years while water meters are expected to be replaced every 15 years. Other items which have a service life of 15 years are the electrical/mechanical equipment for the source facilities, the administration building, the plumbing shop and miscellaneous items of the immediate improvement program. The feasibility studies were assumed to be good for 30 years, while the wells and their structures were assumed to last for 25 years. All other facilities in the system are expected to last for 50 years.

During the 23-year period from 1978 to 2000, therefore, vehicles, meters, equipment with a service life of 15 years and the miscellaneous items will have to be replaced. Annex Table XI-E-2 shows the replacement schedule and costs of vehicles, meters, equipment and miscellaneous items. The present value of total replacement costs for GAP-WD amounts to ₱723,300 (see Table XI-E-4).

Salvage Value

Annex Table XI-E-3 shows the salvage value in 2001 of all the capital equipment to be used in the project. The percentage of salvage value was based on the remaining service life of the facilities in 2001. For GAP-WD, the present worth of the salvage value is ₱1.9 million (see Table XI-E-4).

Operating and Maintenance Cost

Operating and maintenance costs refer to the costs associated with the maintenance, operation and management of the project. Otherwise known as annual costs, they include personnel salary and benefits, power, chemicals, and other miscellaneous maintenance expenses such as fuel and lubrication, repairs, communication needs and office rental. Only the operating and maintenance costs of the proposed project (i.e., excluding those of the present system) were considered in this financial analysis.

Annex Table XI-E-4 presents the incremental annual recurring costs associated with running and operating the water district up to 2000. The present value of these costs amount to ₱4.8 million.

Calculation for Economic Costs

The economic cost may be expressed as the adjusted (shadow priced) project cost plus replacement cost plus operating/maintenance cost less salvage value. Appendix Table XI-E-4 shows the computation of the present value of total economic costs for GAP-WD, amounting to ₱22.4 million.

F. BENEFIT-COST ANALYSIS

The summary of the quantifiable economic benefits and economic costs for GAP-WD is shown below. They are expressed in their present values (discounted at 12 percent) after the 1978 prices have been escalated.

SUMMARY OF BENEFITS AND COSTS
(in M ₱)

Benefits		Costs	
Increase in Land Values	₱11.639	Project Cost	₱18.730
Health	.071	(+)	
Reduction in Fire Damage	1.594	Replacement Cost	.723
Beneficial Value	14.332	(+)	
	₱27.639	Operating and Maintenance Cost	4.837
		Sub-total	₱24.290
		(-)	
		Salvage Value	1.920
			₱22.370

Benefit-Cost Ratio - 1.24 : 1

The preceding table shows that the quantifiable benefits exceed the economic costs associated with the improvement of the water supply system in GAP-WD. Under the principle of benefit-cost ratio, the project is, therefore, considered economically feasible.

The actual benefits of the proposed project may actually be greater than what the benefit-cost ratio represents because the non-quantifiable benefits have not been incorporated into the analysis for obvious reasons.

G. INTERNAL ECONOMIC RATE OF RETURN

The internal economic rate of return (IERR) is the rate of which the present value of the quantifiable benefits is equal to the present value of the economic costs of the proposed project. It is generally held that for a project to be feasible and desirable, its IERR should be higher than the prevailing opportunity cost of capital. In this particular study, the opportunity cost of capital is 12 percent.

For GAP-WD, the IERR is 20.6 percent as shown in Annex Table XI-G-1. On the basis of the above stated principle of IERR, therefore, the proposed project appears to be economically feasible and justified.

ANNEX XI-C

QUANTIFIABLE BENEFITS

ANNEX XI-C

QUANTIFIABLE BENEFITS

Portion of Land Values Attributable to Water Supply Project

Annex Table XI-C-1 shows the present value of the portion of land values attributable to the proposed water supply project, based on the following assumptions:

1. In accordance with the staging program of the construction of facilities, the 1980 service area of 301 hectares was projected to increase in the following manner; by 22 hectares from 1980 to 1981; by 24 hectares from 1981 to 1982; by 25 hectares from 1982 to 1983; by 28 hectares from 1983 to 1984; by 29 hectares from 1984 to 1985; by 31 hectares from 1985 to 1986; by 34 hectares from 1986 to 1987; by 36 hectares from 1987 to 1988; by 39 hectares from 1988 to 1989; and by 42 hectares from 1989 to 1990.

2. Land use was assumed to be 89 percent residential and 11 percent commercial/institutional/industrial throughout the projection period. This classification was based on the water demand projections in 1980 by consumer category, as shown in Chapter VI.

3. In the absence of specific data on Gapan, the 1977 costs of land based on estimated assessed values in Urdaneta were used:

Residential	:	₱ 10 per sqm
Industrial/Commercial/Institutional	:	₱ 20 per sqm

   These costs were assumed to be constant over the projection period.

4. The portion of the total cost of land specifically attributable to the provision of water supply was assumed to be 20 percent of the cost of land. This land value benefit was escalated by 8 percent from 1980 to 1985, by 6 percent from 1985 to 1990, after which the escalation factor was held constant up to 2000.

5. A discount factor of 12 percent was used to obtain the present values of the benefits. This is believed to be the opportunity cost of capital and is commonly used for public investment projects like water supply development.

For GAP-WD, the land value benefit in its present worth amounts to ₱11.6 million.

ANNEX TABLE XI-C-1

PORTION OF LAND VALUES ATTRIBUTABLE TO PROJECT
GAPAN WATER DISTRICT
(1978 PRICES)

Year	Land Use (sqm)		Cost of Land (₱ x 1000)		Total Cost of Land (₱ x 1000)	20 Percent Benefit Due to Project (₱ x 1000)	Escalation Factor	Escalated Benefit (₱ x 1000)	Discount Factor	Present Value of Benefit (₱ x 1000)
	Residential	Com./Inst./Ind.	Residential	Com./Inst./Ind.						
1980	2,678,900	331,100	₱26,789.0	₱6,622.0	₱33,411.0	₱6,682.2	1.210	₱ 8,085.5	.797	₱ 6,444.1
1981	195,800	24,200	1,958.0	484.0	2,442.0	488.4	1.307	638.3	.712	454.5
1982	213,600	26,400	2,136.0	528.0	2,664.0	532.8	1.412	752.3	.636	478.5
1983	222,500	27,500	2,225.0	550.0	2,775.0	555.0	1.525	846.4	.567	479.9
1984	249,200	30,800	2,492.0	616.0	3,108.0	621.6	1.647	1,023.8	.507	519.1
1985	258,100	31,900	2,581.0	638.0	3,219.0	643.8	1.779	1,145.3	.452	517.7
1986	275,900	34,100	2,759.0	682.0	3,441.0	688.2	1.886	1,297.9	.404	524.4
1987	302,600	37,400	3,026.0	748.0	3,774.0	754.8	1.999	1,508.8	.361	544.7
1988	320,400	39,600	3,204.0	792.0	3,996.0	799.2	2,119	1,693.5	.322	545.3
1989	347,100	42,900	3,471.0	858.0	4,329.0	865.8	2.246	1,944.6	.288	560.0
1990	373,800	46,200	3,738.0	924.0	4,662.0	932.4	2.381	2,220.0	.257	570.6
								₱21,156.4		₱11,638.8

Health Benefits

To determine the amount of benefit arising from the reduction of income lost of those afflicted with water-borne diseases, pertinent statistics on morbidity rate were gathered from the Department of Health. From 1964 to 1974, an average of 70.9 out of every 100,000 population in the province of Nueva Ecija were afflicted with primary water-borne diseases every year, regardless of age, sex, and income class. The same rate was assumed for the municipality of Gapan in the absence of specific data. The morbidity rate in the service area was assumed to remain constant during the 20-year projection period.

Since not all of those afflicted with said diseases are wage-earners, an adjustment was made accordingly. Based on the 1970 Census on Population and Housing of the National Census and Statistics Office, 29 percent of the municipality's population was economically active.[2/] It was assumed, therefore, that only 29 percent of 70.9 per 100,000, who were afflicted with primary water-borne diseases were economically active. Hence, this is the only segment of the population who would suffer a reduction in income due to said diseases. Furthermore, these afflicted wage-earners were assumed to be earning ₱8 a day and unable to work for 15 days on the average because of their illness. The final figure corresponding to the economic cost of time lost due to water-borne diseases was thereby arrived at by multiplying the number of people afflicted with water-borne diseases by 29 percent, by ₱8 a day and then by 15 days.

Another health benefit that could be associated with the establishment of a safe public water supply system is the reduction of the economic cost of the premature death of those afflicted with water-borne diseases in the service area. Obviously, the reduction of the life span of the population caused by said diseases is an economic loss to the community.

This economic loss due to premature death was determined by multiplying the number of people who die because of water-borne diseases (assuming that a water supply improvement program were not undertaken) by 29 percent and then by ₱11,629. The projected number of such deaths was based on the average of the 11-year mortality rate for primary water-borne diseases in the province of Nueva Ecija, as gathered from the Department of Health. These figures indicated that 14.9 persons died of the 70.9 per 100,000 who

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[2/] Economically active population includes these who are 10 years old and over, whether employed or unemployed, excluding retired persons, students and housewives.

were afflicted with water-borne diseases. This mortality rate was assumed to be constant over the projection period. The 29 percent corresponds to the portion of the service area population who are income earners. The ₱11,629, on the other hand, represents the monetary value of each death. This was derived from the estimated income to be earned by the average wage-earner over a period of five years discounted at 12 percent plus 20 percent associated economic costs (summation of ₱200 a month x 12 months x discount factor + 20 percent associated costs).

The third health benefit that can be derived from the improvement of the water supply in the service area is to reduction of the medical expenses of persons afflicted with water-borne diseases. According to the Lipa City pilot survey on "Ability-to-Pay",3/ an afflicted person spends ₱113.00 annually on the average for medical expenses, which include hospitalization, medicine and doctors' fee. Based on this finding, the total medical expenses incurred due to water-borne diseases were arrived at by multiplying ₱113.00 by the number of people afflicted with such diseases in the service area.

The sum of all three economic costs related to health benefits had to undergo three final adjustments to arrive at more meaningful figures. First, 40 percent of the total economic loss due to water-borne diseases was taken as the health benefit directly resulting from the water supply improvement program. This reduction was made to account for the fact that not all water-borne diseases are caused by a poor water system and may also be due to less than ideal personal hygiene or lack of sewerage facilities. Second, the 40 percent health benefit was escalated by 8 percent from 1980 to 1985, by 6 percent from 1985 to 1990, after which the escalation factor was held constant up to 2000. Third, the escalated health benefit was discounted to its present worth at 12 percent. Annex Table XI-C-2 shows the calculations associated with the health benefits for GAP-WD. The total present value of said benefits after the adjustments amounts to ₱71,107.

Reduction in Fire Damage

The proposed water supply improvement program will result in increased water pressure and reliable supply for domestic as well as for fire-fighting purposes. At present, none of the 30 fire hydrants in Gapan is operational. With the implementation of the

3/Refer to Methodology Manual, Chapter 20 for "Ability-to-Pay" studies.

ANNEX TABLE XI-C-2

HEALTH BENEFITS
GAPAN WATER DISTRICT

Year	Served Population	Cost of Time Lost Due To Illness	Economic Loss Due To Premature Death	Cost of Medical Expenses	Total Economic Losses Due To Illness	40 Percent Reduction Due To Project (Benefit)	Escalation Factor	Escalated Reduction Due To Project	Discount Factor at 12 Percent	Present Value of Health Benefit
1980	12,880	₱318	₱ 6,472	₱1,032	₱ 7,822	₱3,129	1.210	₱ 3,786	.797	₱ 3,017
1981	14,141	349	7,106	1,133	8,588	3,435	1.307	4,490	.712	3,197
1982	15,526	383	7,802	1,244	9,429	3,772	1.412	5,325	.636	3,387
1983	17,046	421	8,565	1,366	10,352	4,141	1.525	6,315	.567	3,580
1984	18,715	462	9,404	1,499	11,365	4,546	1.647	7,487	.507	3,796
1985	20,548	507	10,325	1,646	12,478	4,991	1.779	8,879	.452	4,013
1986	22,560	557	11,336	1,807	13,700	5,480	1.886	10,335	.404	4,175
1987	24,769	611	12,446	1,984	15,041	6,016	1.999	12,027	.361	4,342
1988	27,194	671	13,665	2,179	16,515	6,606	2.119	13,998	.322	4,507
1989	29,857	737	15,003	2,392	18,132	7,253	2.246	16,290	.288	4,691
1990	32,780	809	16,472	2,626	19,907	7,963	2.381	18,959	.257	4,873
1991	32,780	809	16,472	2,626	19,907	7,963	2.381	18,959	.229	4,342
1992	32,780	809	16,472	2,626	19,907	7,963	2.381	18,959	.205	3,887
1993	32,780	809	16,472	2,626	19,907	7,963	2.381	18,959	.183	3,469
1994	32,780	809	16,472	2,626	19,907	7,963	2.381	18,959	.163	3,090
1995	32,780	809	16,472	2,626	19,907	7,963	2.381	18,959	.146	2,768
1996	32,780	809	16,472	2,626	19,907	7,963	2.381	18,959	.130	2,465
1997	32,780	809	16,472	2,626	19,907	7,963	2.381	18,959	.116	2,199
1998	32,780	809	16,472	2,626	19,907	7,963	2.381	18,959	.104	1,972
1999	32,780	809	16,472	2,626	19,907	7,963	2.381	18,959	.093	1,763
2000	32,780	809	16,472	2,626	19,907	7,963	2.381	18,959	.083	1,574
										₱71,107

Total Municipal Population : 45,426
Economically Active : 29%

Morbidity : 70.9/100,000
Mortality : 14.9/100,000

1) $29\% \times \frac{70.9}{100,000} \times$ S.P. x ₱8 x ₱15

2) $29\% \times \frac{14.9}{100,000} \times$ S.P. x ₱11,629

3) $\frac{70.9}{100,000} \times$ S.P. x ₱113

program which will involve the installation of new fire hydrants, fire protection coverage will be extended to the service area in an increasing basis. Hence, a reduction in fire damage is expected in the service area.

This reduction was assumed to be 0.75 percent of the combined assessed values of all structures in the service area. For Gapan, the average assessed value of each structure was assumed to be ₱18,800.[4/] The number of structures was derived from the projected population to be served by the system, assuming that each household has an average of 6.1 members.[5/]

The fire protection benefit was based on the assumed overall reduction in fire damage, but correlated with the schedule of fire hydrant installation in the service area. Percentage of fire protection starts at 6 percent in 1980, gradually increasing to 35 percent in 1990 in accordance with the extent of the service area to be covered by the fire hydrants.

The net reduction in fire damage was escalated by 8 percent from 1980 to 1985, by 6 percent from 1985 to 1990, after which the escalation factor was held constant up to 2000. It was then discounted at 12 percent. The present value of the fire protection benefit, as shown in Annex Table XI-C-3 amounts to ₱1.6 million.

Beneficial Value of Water

Since water is essential to human life, all members of the served population in the service area presumably would be willing to obtain it in sufficient quantities at some given price. With the proposed improvement of the system's facilities, the volume of water production is expected to increase considerably to serve the needs of the growing population. This will bring about additional revenues to the water district, especially since a price increase of water may be justified in view of the improved service.

In general, water rates charged by the water district do not reflect the true value of water. Moreover, it is recognized that households and commercial users are really willing to pay more than what they are actually being charged for water consumed. From the economic viewpoint, therefore, there is a consumers' surplus. This consumers' surplus refers to the additional amount consumers are willing to pay over and above what they are paying for water. For

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4/ Based on the records of the assessor's office in Gapan.
5/ Based on the 1970 Census on Housing in Nueva Ecija province.

ANNEX TABLE XI-C-3

REDUCTION IN FIRE DAMAGE
GAPAN WATER DISTRICT

Year	Number of Structures[6]	Total Value at ₱18,800 each[7] (₱ x 1,000)	Overall Reduction in Fire Damage (.0075) ₱ x 1,000	Percentage of Fire Protection	Net Reduction in Fire Damage (₱ x 1,000)	Escalation Factor[8]	Escalated Value of Net Reduction	Discount Factor at 12%	Present Value of Net Benefit
1980	2,111	₱39,686.8	₱297.7	6%	₱17.9	1.210	₱21.6	.797	₱17.2
1981	2,318	43,578.4	326.8	7	22.9	1.307	29.9	.712	21.3
1982	2,545	47,846.0	358.8	7	25.1	1.412	35.5	.636	22.6
1983	2,794	52,527.2	394.0	9	35.5	1.525	54.1	.567	30.7
1984	3,068	57,678.4	432.6	10	43.3	1.647	71.2	.507	36.1
1985	3,369	63,337.2	475.0	11	52.3	1.779	93.0	.452	42.0
1986	3,698	69,522.4	521.4	14	73.0	1.886	137.7	.404	55.6
1987	4,060	76,328.0	572.5	17	97.3	1.999	194.5	.361	70.2
1988	4,458	83,810.4	628.6	22	138.3	2.119	293.0	.322	94.4
1989	4,895	92,026.0	690.2	28	193.3	2.246	434.0	.288	125.0
1990	5,374	101,031.2	757.7	35	265.2	2.381	631.5	.257	162.3
1991	5,374	101,031.2	757.7	35	265.2	2.381	631.5	.229	144.6
1992	5,374	101,031.2	757.7	35	265.2	2.381	631.5	.205	129.5
1993	5,374	101,031.2	757.7	35	265.2	2.381	631.5	.183	115.6
1994	5,374	101,031.2	757.7	35	265.2	2.381	631.5	.163	102.9
1995	5,374	101,031.2	757.7	35	265.2	2.381	631.5	.146	92.2
1996	5,374	101,031.2	757.7	35	265.2	2.381	631.5	.130	82.1
1997	5,374	101,031.2	757.7	35	265.2	2.381	631.5	.116	73.3
1998	5,374	101,031.2	757.7	35	265.2	2.381	631.5	.104	65.7
1999	5,374	101,031.2	757.7	35	265.2	2.381	631.5	.093	58.7
2000	5,374	101,031.2	757.7	35	265.2	2.381	631.5	.083	52.4
									₱1,594.4

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[6] Derived from the served population projections in Chapter VI, assuming that there are 6.1 members per household according to the 1970 Census on Housing in Nueva Ecija province.

[7] Based on the assessed value records in Gapan.

[8] Escalated annually by 10 percent from 1978 to 1980, by 8 percent from 1980 to 1985 and by 6 percent from 1985 to 1990, after which the escalation factor was held constant to 2000.

purposes of this study, this additional value has been estimated to be 25 percent higher than commercial/industrial/institutional water rates and 50 percent higher than domestic water rates.[9]

In the determination of this benefit, the following steps were taken:

1. Only the incremental volume of accounted-for-water was considered; hence, the 1976 accounted-for-water amounting to 73,920 cum was deducted from total accounted-for-water projections in Chapter VI. The water demand projections in Chapter VI, expressed in liters per capita per day, were converted to cubic meters per year.

2. Classification of accounted-for-water into domestic and others (commercial/institutional/industrial) was based likewise on Chapter VI. For GAP-WD, water use was classified into 89 percent domestic and 11 percent commercial/institutional/industrial.

3. The price per cubic meter of water was obtained from the unescalated rate per revenue unit in Chapter X, Annex Table X-G-1. The rates were, however, adjusted upwards to reflect consumers' surplus: 50 percent higher for domestic water and 25 percent higher for others.

4. The net economic revenues were obtained by subtracting the assumed 1977 revenues of GAP-WD of ₱64,950 from total economic revenues. The net economic revenues may be considered as benefits of the proposed project since revenues of the existing system have been duly excluded.

5. The net economic revenues were then escalated by 10 percent from 1978 to 1980, by 8 percent from 1980 to 1985, by 6 percent from 1985 to 1990, after which the escalation factor was held constant up to 2000. Finally, the escalated values were discounted at 12 percent to obtain their present values.

For GAP-WD, the beneficial value of water amounts to ₱14.3 million, as shown in Annex Table XI-C-4.

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[9] Refer to Procedures for the Economic and Financial Analysis of Water Projects, LWUA, May 1976.

ANNEX TABLE XI-C-4

BENEFICIAL VALUE OF WATER
GAPAN WATER DISTRICT

Year	Incremental Accounted-For-Water[10] (cum/year)	Domestic (cum/year)	Others (cum/year)	Price Per cum[11] Domestic	Price Per cum[11] Others	Economic Value Per cum[12] Domestic	Economic Value Per cum[12] Others	Economic Water Revenues (000) Domestic	Economic Water Revenues (000) Others	Total Economic Revenue (000)	Escalation Factor[13]	Escalated Economic Revenue (000)	Discount Factor at 12 Percent	Present Value of Economic Revenue (000)
1976	75,920													
1977														
1978	119,502	106,357	13,145	.70	1.40	1.05	1.75	111.7	23.0	134.7	1.000	134.7	1.000	134.7
1979	237,613	211,476	26,137	.65	1.30	.98	1.63	207.2	42.6	249.8	1.100	274.8	.893	245.4
1980	427,108	380,126	46,982	.60	1.20	.90	1.50	342.1	70.5	412.6	1.210	499.2	.797	397.9
1981	493,815	439,495	54,320	.95	1.90	1.43	2.38	628.5	129.3	757.8	1.307	990.4	.712	705.2
1982	569,369	506,738	62,631	.88	1.76	1.32	2.20	668.9	137.8	806.7	1.412	1,139.1	.636	724.4
1983	654,941	582,897	72,044	.82	1.64	1.23	2.05	717.0	147.7	864.7	1.525	1,318.7	.567	747.7
1984	751,862	669,157	82,705	.94	1.88	1.41	2.35	843.5	194.4	1,137.9	1.647	1,874.1	.507	950.2
1985	861,635	766,855	94,880	.88	1.76	1.32	2.20	1,012.2	208.7	1,220.9	1.779	2,172.0	.452	981.7
1986	985,966	877,510	108,456	.81	1.62	1.22	2.03	1,070.6	220.2	1,290.8	1.886	2,434.4	.404	983.5
1987	1,126,784	1,002,838	123,946	.75	1.50	1.13	1.88	1,133.2	233.0	1,366.2	1.999	2,731.0	.361	985.9
1988	1,286,277	1,144,787	141,490	.69	1.38	1.04	1.73	1,190.6	244.8	1,435.4	2.119	3,041.6	.322	979.4
1989	1,466,920	1,305,559	161,361	.64	1.28	.96	1.60	1,253.3	258.2	1,511.5	2.246	3,394.6	.288	977.7
1990	1,671,518	1,487,651	183,867	.63	1.26	.95	1.58	1,413.3	290.5	1,703.8	2.381	4,056.7	.257	1,042.6
1991				.59	1.18	.89	1.48	1,324.0	272.1	1,596.1		3,800.3	.229	870.3
1992	↓	↓	↓	.54	1.08	.81	1.35	1,205.0	248.2	1,453.2	↓	3,460.1	.205	709.3
1993				.50	1.00	.75	1.25	1,115.7	229.8	1,345.5		3,203.6	.183	586.3
1994				.50	1.00	.75	1.25	1,115.7	229.8	1,345.5		3,203.6	.163	522.2
1995				.49	.98	.74	1.23	1,100.9	226.2	1,327.1		3,159.8	.146	461.3
1996				.43	.86	.65	1.08	967.0	198.6	1,165.6		2,775.3	.130	360.8
1997				.42	.84	.63	1.05	937.2	193.1	1,130.3		2,691.2	.116	312.2
1998				.39	.78	.59	.98	877.7	180.2	1,057.9		2,518.9	.104	262.0
1999				.36	.72	.54	.90	803.3	165.5	968.8		2,306.7	.093	214.5
2000	1,671,518	1,487,651	183,867	.33	.66	.50	.83	743.8	152.6	896.4	2.381	2,134.3	.083	177.2
												53,315.3		14,332.4

[10] The 1977 volume of 75,920 cum per year of accounted-for-water was deducted from the water demand projections throughout the study period to obtain the incremental volume.

[11] The price per cum of water for domestic use was derived by de-escalating the rate per revenue unit of water in Table X-C-1, Chapter X; the rate of water for other uses (commercial, institutional and industrial) was assumed to be twice that for domestic use.

[12] Assumed to be 50 percent higher than domestic rates and 25 percent higher than rate for 'others'.

[13] Escalated annually by 10 percent from 1978 to 1980, by 8 percent from 1980 to 1985, by 6 percent from 1985 to 1990, after which the escalation factor was held constant up to 2000.

ANNEX XI-E

ECONOMIC COSTS

ANNEX TABLE XI-E-1

CONVERSION OF FINANCIAL COST TO ECONOMIC COST
GAPAN WATER DISTRICT

	Financial Project Cost	Foreign Exchange Component	Domestic Cost Component	Unskilled Labor	Balance of Domestic Component 15/	Taxes 16/ (5%)	Others (95%)	Shadow Pricing: Foreign Exchange Component x 1.2	Shadow Pricing: Unskilled Labor x.5	Shadow Pricing: Others x 1.0	Economic Project Cost 17/	Economic Construction Cost 18/
Source Facilities												
a) Equipment	611,000	196,708	414,292	12,688	401,604	20,080	381,524	236,050	6,344	381,524	623,918	493,216
b) Structure and Wells	1,197,000	582,400	614,600	18,822	595,778	29,789	565,989	698,880	9,411	565,989	1,274,280	1,007,336
Distribution Facilities	5,190,000	2,664,460	2,525,540	480,930	2,044,610	102,231	1,942,380	3,197,352	240,465	1,942,380	5,380,197	4,253,120
Internal Network	2,979,000	1,279,320	1,699,680	330,880	1,368,800	68,440	1,300,360	1,535,184	165,440	1,300,360	3,000,984	2,598,255
Fire Hydrants	302,000	176,102	125,898	28,710	97,188	4,859	92,329	211,322	14,355	92,329	318,006	275,330
Service Connections												
a) Meters	1,206,000	1,006,210	199,790	60,117	139,673	6,984	132,689	1,207,452	30,059	132,689	1,370,200	1,186,320
b) Pipes	3,418,000	1,666,383	1,751,617	527,063	1,224,554	61,228	1,163,326	1,999,660	263,532	1,163,326	3,426,518	2,966,631
Immediate Improvements												
1. Source Facilities												
a) Equipment	474,000	435,791	38,209	1,679	36,530	1,827	34,704	522,949	840	34,704	558,493	441,496
b) Structure and Wells	802,000	191,172	610,828	26,841	583,987	29,199	554,788	229,406	13,421	554,788	797,615	630,526
2. Distribution Facilities	1,840,000	947,166	892,834	178,365	714,469	35,723	678,746	1,136,599	89,183	678,746	1,904,528	1,505,555
3. Service Connections												
a) Meters	489,000	407,829	81,171	25,652	55,519	2,776	52,743	489,395	12,826	52,743	554,964	480,438
b) Pipes	1,040,000	506,829	533,171	168,498	364,673	18,234	346,439	608,195	84,249	346,439	1,038,883	893,466
4. Administration Building												
a) Equipment	51,000	30,173	20,827	2,920	17,907	895	17,012	36,208	1,460	17,012	54,680	47,342
a) Structure	419,000	12,977	406,023	56,920	349,103	17,455	331,648	15,572	28,460	331,648	375,680	325,264
5. Plumbing Shop												
a) Equipment	30,000	29,601	399	58	341	17	324	35,521	29	324	35,874	31,060
b) Structure	421,000	12,977	408,023	59,782	348,241	17,412	330,829	15,572	29,891	330,829	376,292	325,794
6. Vehicles	139,000	70,290	68,710	-	68,710	3,436	65,275	84,348	-	65,275	149,623	129,544
7. Miscellaneous Items	15,000	9,265	5,735	-	5,735	287	5,448	11,118	-	5,448	16,566	14,343
Feasibility Studies	207,000	115,920	91,080	-	91,080	4,554	86,526	139,104	-	86,526	225,630	178,354
Sub-total	20,830,000	10,341,573	10,488,427	1,979,925	8,508,502	425,425	8,083,079	12,409,887	989,965	8,083,079	21,482,931	17,789,500
Land	123,000	-	123,000	-	123,000	6,150	116,850	-	-	116,850	116,850	92,372
Total Project Cost	20,953,000	10,341,573	10,611,427	1,979,925	8,631,502	431,575	8,199,929	12,409,887	989,965	8,199,929	21,599,781	17,881,872

15/ Domestic cost component less unskilled labor cost.
16/ Computed at 5 percent of domestic cost component after unskilled labor cost was deducted from it.
17/ Obtained by adding foreign exchange cost, unskilled labor cost and cost of 'others' after they have been adjusted through shadow pricing.
18/ Derived by subtracting contingencies and engineering services from the economic project cost.

ANNEX TABLE XI-E-2

REPLACEMENT COST
GAPAN WATER DISTRICT
1978 PRICES ₱ x 1000

Year	Vehicles	Meters	Equipment	Miscellaneous Items	Total
1978					
1979					
1980					
1981					
1982					
1983					
1984					
1985					
1986	₱129.5				₱129.5
1987					
1988					
1989					
1990					
1991					
1992					
1993					
1994	129.5	₱176.0	₱525.0	₱14.3	844.8
1995		169.4	14.3		183.7
1996		154.2			154.2
1997		72.4			72.4
1998		143.5	280.0		423.5
1999		143.5			143.5
2000		143.5			143.5
TOTAL	₱259.0	₱1,002.5	₱819.3	₱14.3	₱2,095.1

ANNEX TABLE XI-E-3

SALVAGE VALUE IN 2001
GAPAN WATER DISTRICT
1978 PRICES
(₱ x 1000)

	50 Years			30 Years			25 Years			15 Years			7 Years			Infinite			
Year	Economic Value	Remaining Service Life in 2001 (Percent)	Salvage Value	Economic Value	Remaining Service Life in 2001 (Percent)	Salvage Value	Economic Value	Remaining Service Life in 2001 (Percent)	Salvage Value	Economic Value	Remaining Service Life in 2001 (Percent)	Salvage Value	Economic Value	Remaining Service Life in 2001 (Percent)	Salvage Value	Economic Value	Remaining Service Life in 2001 (Percent)	Salvage Value	Total[19]
1978	2,549.5	56%	1,427.7	50.0	27%	13.5	638.6	12%	76.6							83.2	100%	83.2	1,601.0
1979	516.3	58	299.5				21.2	16	3.4										302.9
1980	922.8	60	553.7	128.4	33	42.2										4.6	100	4.6	600.7
1981	1,471.7	62	912.5																912.5
1982	1,675.5	64	1,072.3				420.0	28	117.6										1,189.9
1983	1,203.6	66	794.4																794.4
1984	731.4	68	497.4																497.4
1985	439.6	70	307.7																307.7
1986	670.7	72	482.9							81.9	7%	5.7				4.6	100	4.6	493.2
1987	1,175.7	74	870.0							143.5	13	18.7							888.7
1988	890.7	76	676.9				18.0	52	9.4	149.9	20	30.0							716.3
1989	601.5	78	469.2				540.0	56	302.4	330.9	27	89.3							860.9
1990	300.6	80	240.5							71.2	33	23.5							264.0
1991																			–
1992																			–
1993																			–
1994										715.3	60%	429.2	129.5	14%	18.1				447.3
1995										183.7	67	123.1							123.1
1996										154.2	73	112.6							112.6
1997										72.4	80	57.9							57.9
1998										423.5	87	368.4							368.4
1999										143.5	93	133.5							133.5
2000										224.2	100	224.2							224.2
	₱13,149.6		₱8,604.7	₱178.4		₱55.9	₱1,637.8		₱509.4	₱2,694.2		₱1,616.1	₱129.5		₱18.1	₱92.4		₱92.4	₱10,896.6

[19] Salvage values for each year represent the salvage value of the item in year 2001.

Total Economic Value ₱17,881.9
Total Salvage Value ₱10,896.6

ANNEX TABLE XI-E-4

SUMMARY OF ECONOMIC COSTS
GAPAN WATER DISTRICT
(₱ x 1000)

Year	Project Cost	Replacement Cost	Salvage Value[20]	O and M Cost	Total Cost	Escalation Factor For Other Costs[21]	Escalation Factor For O and M Cost[22]	Escalated Project Cost	Escalated Replacement Cost	Escalated O and M Cost	Escalated Total Cost	Discount Factor at 12 Percent	Present Value of Project Cost	Present Value of Replacement Cost	Present Value of O and M Cost	Present Value of Total Cost
1978	₱ 5,116.0		1,601.0	₱ 20.4	₱5,136.4	1.000	1.000	₱ 5,116.0		₱ 20.4	₱5,136.4	1.000	₱5,116.0		₱ 20.4	₱ 5,136.4
1979	852.7		302.9	66.8	919.5	1.100	1.080	938.0		72.1	1,010.1	.893	837.6		64.4	902.0
1980	1,464.3		600.7	139.6	1,603.9	1.210	1.166	1,771.8		162.8	1,934.6	.797	1,412.1		129.8	1,541.9
1981	1,887.2		912.5	218.9	2,106.1	1.307	1.260	2,466.6		275.8	2,742.4	.712	1,756.2		196.4	1,952.6
1982	3,090.8		1,189.9	245.9	3,336.7	1.412	1.360	4,364.2		334.4	4,698.6	.636	2,775.6		212.7	2,988.3
1983	1,607.8		794.4	296.5	1,904.3	1.525	1.469	2,451.9		435.6	2,887.5	.567	1,390.2		247.0	1,637.2
1984	1,010.6		497.4	320.1	1,330.7	1.647	1.587	1,664.5		508.0	2,172.5	.507	843.9		257.6	1,101.5
1985	605.2		307.7	347.0	952.2	1.779	1.714	1,076.7		594.8	1,671.5	.452	486.7		268.9	755.6
1986	911.2	129.5	493.2	380.3	1,421.0	1.886	1.851	1,718.5	₱ 244.2	703.9	2,666.6	.404	694.3	₱ 98.7	284.4	1,077.4
1987	1,586.8		888.7	398.8	1,985.6	1.999	1.999	3,172.0		797.2	3,969.2	.361	1,145.1		287.8	1,432.9
1988	1,257.4		716.3	414.0	1,671.4	2.119	2.159	2,664.4		893.8	3,558.2	.322	857.9		287.8	1,145.7
1989	1,780.6		860.9	433.8	2,214.4	2.246	2.332	3,999.2		1,011.6	5,010.8	.288	1,151.8		291.4	1,443.2
1990	429.5		264.0	531.9	961.4	2.381	2.518	1,022.6		1,339.3	2,361.9	.257	262.8		344.2	607.0
1991			-		531.9					1,339.3	1,339.3	.229			306.6	306.6
1992			-		531.9					1,339.3	1,339.3	.205			274.5	274.5
1993			-		531.9					1,339.3	1,339.3	.183			245.0	245.0
1994		844.8	447.3		1,376.7				2,011.5	1,339.3	3,350.8	.163		327.9	218.3	546.2
1995		183.9	123.1		715.8				437.9	1,339.3	1,777.2	.146		63.9	195.5	259.4
1996		154.2	112.6		686.1				367.2	1,339.3	1,706.5	.130		47.7	174.1	221.8
1997		72.4	57.9		604.3				172.4	1,339.3	1,511.7	.116		20.0	155.4	175.4
1998		423.5	368.4		955.4				1,008.4	1,339.3	2,347.7	.104		104.9	139.3	244.2
1999		143.5	133.5		675.4				341.7	1,339.3	1,681.0	.093		31.8	124.6	156.4
2000		143.5	224.2	531.9	675.4	2.381	2.518		341.7	1,339.3	1,681.0	.083		28.4	111.2	139.6
	₱21,600.1	₱2,095.1		9,133.0	32,957.5			₱[illegible],426.4	₱5,232.4	₱20,542.7	₱57,894.1		₱18,730.2	₱723.3	₱4,837.3	₱24,290.8
	Salvage Value		10,896.6		10,896.6	2.381					25,944.8	.074				1,919.9
					21,931.8						₱31,949.3					₱22,370.9

20/ Project cost, replacement cost and salvage value were escalated annually by 10 percent from 1978 to 1980, by 8 percent from 1980 to 1985 and by 6 percent from 1985 to 1990.

21/ Project cost and replacement cost were escalated annually by 10 percent from 1978 to 1980, by 8 percent from 1980 to 1985, by 6 percent from 1985 to 1990, after which the escalation factor was held constant up to 2000.

22/ Operating and maintenance costs were escalated annually by 8 percent from 1978 to 1990, after which the escalation factor was held constant up to 2000.

ANNEX XI-G

INTERNAL ECONOMIC RATE OF RETURN

ANNEX TABLE XI-G-1

INTERNAL ECONOMIC RATE OF RETURN
GAPAN WATER DISTRICT
(₱ x 1000)

Year	Escalated Values: Benefits	Escalated Values: Costs	Discount Factor at 20 Percent	Present Value at 20 Percent: Benefits	Present Value at 20 Percent: Costs	Discount Factor at 25 Percent	Present Value at 25 Percent: Benefits	Present Value at 25 Percent: Costs
1978	134.7	5,136.4	1.000	134.7	5,136.4	1.000	134.7	5,136.4
1979	274.8	1,010.1	.833	228.9	841.4	.800	219.8	808.1
1980	8,610.1	1,934.6	.694	5,975.4	1,342.6	.640	5,510.5	1,238.1
1981	1,663.1	2,742.4	.579	962.9	1,587.9	.512	851.5	1,404.1
1982	1,932.2	4,698.6	.482	931.3	2,264.7	.410	792.2	1,926.4
1983	2,225.5	2,887.5	.402	894.7	1,160.8	.328	730.0	947.1
1984	2,976.6	2,172.5	.335	997.2	727.8	.262	779.9	569.2
1985	3,419.2	1,671.5	.279	954.0	466.3	.210	718.0	351.0
1986	3,880.3	2,666.6	.233	904.1	621.3	.168	652.0	448.0
1987	4,446.3	3,969.2	.194	862.6	770.0	.134	595.8	531.9
1988	5,042.1	3,558.2	.162	816.8	576.4	.107	539.5	380.7
1989	5,789.7	5,010.8	.135	781.6	676.5	.086	497.9	430.9
1990	6,927.0	2,361.9	.112	775.8	264.5	.069	478.0	163.0
1991	4,450.8	1,339.3	.094	418.4	105.9	.055	244.8	73.7
1992	4,110.6	1,339.3	.078	320.6	104.5	.044	180.9	58.9
1993	3,854.1	1,339.3	.065	250.5	87.1	.035	134.9	46.9
1994	3,854.1	3,350.8	.054	208.1	180.9	.028	107.9	93.8
1995	3,810.3	1,777.2	.045	171.5	80.0	.023	87.6	40.9
1996	3,425.8	1,706.5	.038	130.2	64.8	.018	61.7	30.7
1997	3,341.7	1,511.7	.031	103.6	46.9	.014	46.8	21.2
1998	3,169.4	2,347.7	.026	82.4	61.0	.012	38.0	28.2
1999	2,957.2	1,681.0	.022	65.1	37.0	.009	26.6	15.1
2000	2,784.8	1,681.0	.018	50.1	30.3	.007	19.5	11.8
	83,080.6			17,020.5			13,448.5	
		57,894.1			17,255.0			14,756.1
Salvage Value		25,944.8	.015		389.2	.006		155.7
		31,949.3			16,865.8			14,600 4
	2.60	1.00		1.01	1.00		0.92	1.00

Present Value at 20% = 154.7
Present Value at 25% = (1,151.9)
1,306.6

$$IERR = .20 + .05 \left(\frac{154.7}{1,306.6} \right)$$
$$= .20 + .0059$$
$$= 20.6\%$$

M E T H O D O L O G Y

M E M O R A N D A

Methodology Memorandum No. 1

To : L. V. Gutierrez, Jr.

From : A. de Vera

Date : 4 January 1977

Subject: Pilot Area Survey

A. Need

In estimating water accountability, data on the ratio of borrowers to primary users, average persons per household, and per capita consumption are necessary. Information on capacity and willingness-to-pay would greatly aid financial analysis. In all cases, these data are not readily available in the Philippines. The only way to get these data would be to actually perform a house-to-house survey within the served areas of the water district (WD). Considering time and financial constraints, a pilot area survey would be the best approach. This is merely surveying a representative area within the WD and projecting the data obtained for the entire served area of the WD.

B. Methodology

1. Choose a pilot area within the WD. Desirable requirements for the area are as follows:

   a. adequate line pressures, preferably with 24-hour service;
   b. metered connections;
   c. presence of domestic as well as commercial connections. Ratio of commercial to domestic connections for the area must not exceed that for the entire WD;
   d. representative income levels of the concessionaires.

2. Devise a one-page questionnaire so that it:

   a. is easily understood by WD personnel (who will serve as interviewers);
   b. provides relevant information;
   c. provides a means of cross-checking some answers given by respondents;
   d. would make tabular analysis easy.

   A sample questionnaire is attached.

3. Get assistance from the WD personnel in the house-to-house survey. It is suggested that they do the actual interview because of their familiarity with local customs and dialects. However, before allowing the WD enumerators to proceed on their own, it is necessary that:

   a. the enumerators be given a thorough briefing on the importance of the survey, as well as the purpose of each item in the questionnaire.
   b. the enumerators be accompanied to the first few houses, and given additional pointers or feedback before they proceed on their own.

4. Conduct a house-to-house survey of all households within the pilot area. A map at this point indicating the existing houses (with their code numbers) would be necessary. The following would be helpful during the survey:

   a. brief the respondents about the purpose of the survey before asking questions. It is very important that they be receptive to the interviewers. Otherwise data given could be misleading.
   b. in asking for estimates of consumption, avoid using technical terms, i.e., liters, gallons, etc. Use local containers like pails, drums or whatever they use. Note the capacity of the container in the questionnaire.

C. <u>Data</u>

The following data may be obtained from the survey:

1. Pilot area density
2. Average persons/household
3. Borrowers from connected households and percentage of households dependent on the WD
4. Potential concessionaires
5. Consumption estimates
6. Income levels and the respective rates showing willingness to pay for improved service
7. Water accountability

______ WATER DISTRICT
PILOT AREA QUESTIONNAIRE

DATE ________
TIME ________

INTERVIEWEE ________ ADDRESS ________

TYPE OF DWELLING ________ CONSTRUCTION MATERIAL ________

WD CONCESSIONAIRE

1. NO. OF OCCUPANTS: ________

2. CLASSIFICATION:
   - ☐ Domestic
   - ☐ Commercial
   - ☐ Institutional
   - ☐ Industrial
   - ☐ ________

3. SIZE OF CONNECTION:
   - ☐ ½" ☐ 1" ☐ 2"
   - ☐ ¾" ☐ 1½" ☐ ____

4. TYPE OF CONNECTION:
   - ☐ metered: meter functioning
   - ☐ metered: meter damaged
   - ☐ flat rate (unmetered)

5. APPURTENANCES (Connected to System)
   - ☐ with hand pump
   - ☐ with electric motor pump
     - HRS used/day ________
     - Pump rated HP ________
     - GPM ________
     - ________

6. OTHER SOURCE ASIDE FROM WD:

Own	Other HH
☐ wells	☐ wells
☐ springs	☐ springs
☐ rainwater	☐ rainwater
☐ ________	☐ ________

NON-WD CONCESSIONAIRE

1. NO. OF OCCUPANTS: ____

2. SOURCE OF SUPPLY:
   - ☐ own private well
   - ☐ rainwater
   - ☐ spring
   - ☐ public faucet
   - ☐ WD concessionaire HH Code No. ____
   - ☐ public well
   - ☐ others' private well
   - ☐ ________

3. CONSUMPTION:
   - ☐ free
   - ☐ paying
     - volume used per day ________
     - Paying ₱ ________
     - for ________.

REMARKS:

FOR ALL HOUSEHOLDS

1. WD-WATER AVAILABLE:
   - No. of hours ________
   - Time ________

2. FAUCETS:
   - ☐ 1 ☐ 3 ☐ 5
   - ☐ 2 ☐ 4 ☐ ____

3. SHOWERS:
   - ☐ 1 ☐ 2 ☐ 3 ☐ ____

4. FLUSH WATER CLOSET:
   - ☐ 1 ☐ 2 ☐ 3 ☐ ____

5. MANUAL WATER CLOSET:
   - ☐ 1 ☐ 2 ☐ 3 ☐ ____

6. ☐ w/septic tank ☐ w/o septic tank

7. AVERAGE MONTHLY:

	Consumption	Billing/PMT
WD:	________	________
wells:	________	________
others:	________	________

8. USER:
   - ☐ w/ borrowers
   - ☐ w/o borrowers
   - Total no. of HH borrowers ________
   - Total no. of HH borrowers' occupants ________

9. How much would you be willing to pay if water service were improved? ________/month.

(TO BE FILLED UP AT THE WD OFFICE)

1. HOUSEHOLD CODE NO. ________

2. INCOME:
   - ☐ below average (₱220 below)
   - ☐ average (₱221 - 750)
   - ☐ upper middle (₱751 - 1,500)
   - ☐ high (₱1,500 above)

3. WD CONCESSIONAIRE:
   - ☐ registered
   - ☐ unregistered

4. PAYMENTS:
   - ☐ up-to-date
   - ☐ delinquent

____
ENUMERATOR

____
POSITION

Methodology Memorandum No. 2

To : L. V. Gutierrez, Jr.

From : A. de Vera

Date : 31 January 1977

Subject: Estimating Water Accountability

A. Need

To be able to determine future water demand per capita, need for leak detection and survey program, and the level of development possible for reducing wastage and leakage, the following information must first be available.

1. Ratio of accounted-for and unaccounted-for-water.

2. Ratio of wastage and leakage in relation to total production.

3. Domestic consumption per capita.

Although there are various methods for estimating water accountability, the selection of a method depends on the purpose for which it is to be used and the level of accuracy desired. Accounted-for-water as used herein refers to the revenue-producing water for the water district. It is the sum of the billed metered consumption and inferred water consumption at flat-rate connections.

B. Methodology

1. Pilot Area Survey

a. Objective - To be able to estimate total accounted-for and unaccounted-for-water. Accuracy will depend on the reliability of the consumption figures as obtained in the pilot area survey.[1]

b. Data Necessary - Monthly production; number of metered and unmetered connections; water rate schedule; pilot area data; and total monthly metered consumption.

---

[1] Refer to Methodology Memorandum No. 1.

c. Steps

1) Obtain total number of households dependent on water system. To do this, first obtain ratio of households dependent on the system to total households in the pilot area and apply ratio to the whole service area. Compute for number of primary and secondary users.

2) Compute for inferred flat-rate use per month.

3) Compute total accounted-for-water by adding average monthly metered consumption and total inferred flat-rate use per month.

4) Unaccounted-for-water is total production less accounted-for-water. It is also the total of potentially billable water plus wastage, leakage and other uses.

5) Potentially billable water is the sum of:

   o Usage of borrowers from flat-rate primary users;

   o Unbilled flat-rate use

   o Wastage of flat-rate users

2. Weighted Average of First 10-City Survey

a. Objective - In a water system with all functions billed as flat-rate, computing for water accountability is impossible without resorting to detailed surveys. However, this method implies that the figures obtained during the first 10-area survey (CDM - 1975) approximate those of other water districts. Accuracy, however, is not determined.

b. Data Necessary - Total monthly production and figures obtained during the First 10-Area Survey of CDM.

c. Steps

Multiply monthly production by:

.31 to get accounted-for-water
.11 to get underestimated flat-rate use
.26 to get wastage
.25 to get leakage
.07 for others

3. Field Study Method

a. Objective - To be able to determine within ± 5 percent accuracy water accountability figures. This method, however, is time-consuming and very expensive.

b. Data Necessary - All data received shall be generated in the field. The number of concessionaires and the water rate schedule are basic requirements.

c. Steps

1) For each section of transmission and distribution line in the water system, appropriate measuring devices shall be installed in order to determine the amount of water flowing in and out, water used by the concessionaires, and water leakage.

2) Desk-top analysis is then necessary to determine water accountability.

METHODOLOGY MEMORANDUM NO. 3

To : L. V. Gutierrez, Jr.

From : P. del Rosario

Date : 8 February 1977

Subject: Classification of Water Districts According to Future Water Requirements

A. Introduction

The purpose of this methodology manual is to classify water districts (WD) so that future water requirements may be estimated. The factors to be considered in classifying WD's are economic and social development in the district's boundaries, probable sources of additional water supply and the people's ability-to-pay for improved water service.

The group with the probable highest per capita consumption is labelled Group I; and the group with the probable lowest water consumption, Group V. Affluent and highly urbanized water districts may fall under Group I, while less developed and small water districts, under Group V.

B. Methodology

The initial service area of the WD will most likely include the central urban area or core city (poblacion). To classify it according to future water demands, the WD and its central urban area are judged according to 5 grouping criteria - 1975 urban income, 1975 standard of living, 1975 business index, 1980 cost of water, and served population in 1980. For each criterion, a number of points, from 0 to 20, are allotted to each water district. The total number of points under the 5 criteria determines the classification of the WD.

Table MM 3-1 lists the 5 criteria by which the WD can be classified, and the points allotted to rankings in each criterion.

The grouping of the WD's based on the range of total points under the 5 criteria is as follows:

TABLE MM 3-1

WATER DISTRICT GROUPING CRITERIA

1975 Urban Income		1975 Standard of Living				1975 Business Index		1980 Cost of Water		1980 Served Population	
Income Taxes Paid by Urban Residents (P)	Points 20	% of Households with Refrigerators in Urban Area	Points 10	% of Households with Flush Toilets in Urban Area	Points 10	% of Commercial Establishments in Urban Area	Points 20	Source of Additional Water Supply	Points 20	Population Served in Urban Area	Points 20
more than 30,000,000	20	more than 30	10	more than 60	10	more than 6.6	20	Spring, gravity type	20	more than 150,000	20
10,000,001-30,000,000	18	25.1 - 30	9	50.1 - 60	9	4.6 - 6.6	16			100,001 - 150,000	18
5,000,001-10,000,000	16	20.1 - 25	8	40.1 - 50	8	3.1 - 4.5	11	Spring with booster pump	17	80,001 - 100,000	16
1,000,001- 5,000,000	14	15.1 - 20	7	30.1 - 40	7	1.7 - 3.0	7	Infiltration with short transmission line/ well points	14	65,001 - 80,000	14
500,001- 1,000,000	12	10.1 - 15	6	20.1 - 30	6	1.0 - 1.6	4			52,001 - 65,000	12
100,001- 500,000	10	5 - 10	5	10 - 20	5	less than 1	2	Infiltration with long transmission line/ wells	11	41,001 - 52,000	10
50,001- 100,000	8	less than 5	4	less than 10	4					31,001 - 41,000	9
20,001- 50,000	6							Surface water without reservoir	7	22,001 - 31,000	8
8,001- 20,000	4							Surface water with reservoir	5	15,001 - 22,000	7
4,001- 8,000	2									10,001 - 15,000	6
4,000 or less	1									less than 10,000	5

Group	Total Points
I	70 and above
II	60 - 69
III	50 - 59
IV	40 - 49
V	39 and below

In allotting points under each criterion, readily available data are taken from the latest NCSO report (1970 or 1975 census). These data are: total population in the city or municipality; total households; number of urban households; number of commercial establishments; number of industrial establishments; number of households with refrigerators; and number of households using flush water-sealed toilets. The data on total income taxes paid in the city/municipality in 1975 were obtained from the BIR office. Data on the probable sources of additional water supply were taken from the recent preliminary hydro-survey conducted by LWUA and the WD.

The following is a procedure for assigning points to a WD on the basis of the 5 criteria.

1. 1975 Urban Income

   Urban income is based on the total income taxes paid by individuals and business entities and the percentage of urban households with respect to total households in the city/municipality. If the 1975 data are not available, the percentage of urban households is projected to 1975 by applying an increase of 0.1 to 0.4 percent per year. In projecting the percentage of urban households, growth characteristics and urban development must be considered. The projected percentage is multiplied by 1975 total income. Table MM 3-1 shows the breakdown of the annual income with points ranging from 1 to 20.

2. 1975 Standard of Living

   The standard of living is measured by the number of households in the urban area with refrigerators and those with flush water-sealed toilets.

   The percentage of urban households with refrigerators with respect to total urban households is projected to 1975, if the 1975 census is not available. An increase of 1 to 4 percent per annum is applied, depending upon the recent economic and social development in the city/municipality. The same procedure is applied to the percentage of urban households using flush water-sealed toilets. Table MM 3-1 shows the percentages of households with refrigerators and those with flush toilets with respect to total urban households, with points ranging from 4 to 10.

3. 1975 Business Index

The business index is measured by the percentage of commercial establishments with respect to total urban households in 1975. One industrial establishment (data from NCSO census) is assumed to be equivalent to 10 commercial establishments (except when the 1975 census is available). An increase of 1 to 20 establishments per year is applied, depending on the recent business activities and urban development in the city/municipality. The number of urban households in 1975 is obtained by multiplying the 1975 total households (total population + average of 7 persons/household) by the 1975 percentage of urban households as derived in the methodology for 1975 urban income. The 1975 sum of commercial establishments divided by the number of 1975 urban households is the business index of the city/municipality. Table MM 3-1 shows the various levels of business index, with corresponding points ranging from 2 to 20.

4. 1980 Cost of Water

The cost of water is inferred from the probable source of additional water supply by 1980. The probable source of additional water supply is weighted according to its apparent economic viability. A spring source that is located within the 1980 service area and can flow by gravity is considered the most economical. Surface water requiring complete water treatment with impounding reservoir is the most expensive. Infiltration galleries with short or long transmission lines, wells, or spring source requiring booster pump, are considered to have weights between the most and least expensive (see Table MM 3-1).

5. Served Population in 1980

The served population in 1980 is projected by delineating the future service areas of the WD and projecting the population of the city/municipality and of the service areas. The 1980 served population is determined as a portion of the service area population. In projecting the population served and the future service areas, economic growth and urban development, availability of water supply and capability of the water district to provide service must be considered.

C. Expected Water Demand By Class of WD

The experience of the LWUA-CDM staff, especially during the First Ten Urban Areas Project in the Philippines, has been used to assign values of expected water demand to the 5 classes of water districts. These expected water demands are shown in Table MM 3-2.

D. Example of Water District Classification

This method of classifying a water district is illustrated, with the Silay City Water District as an example. Available data for Silay City are taken from the NCSO and BIR reports, and from the preliminary hydro-survey by LWUA and the SIL-WD. The following data were obtained:

Total income taxes paid in the city - ₱20,049,139 (1974-1975)

Total population in the city - 103,493 (1975)

Total number of households in the city - 10,915 (1970)

Total number of households in the urban area - 3,693 (1970)

Total number of commercial establishments in the city - 36 (1970)

Total number of industrial establishments in the city - 1 (1970)

Total urban households with refrigerators - 266 (1970)

Total urban households using flush water-sealed toilets - 807 (1970)

Probable source of additional water supply - wells (1980)

Population in the service area - 21,280 (1980)

To determine the specific weights of the above data for each grouping criterion, the methodology developed is applied as follows:

TABLE MM 3-2

WATER DEMAND OF WATER DISTRICT GROUPINGS

Classification	Year 1980	1990	2000
Group I			
Domestic use, lpcd	140	155	175
Commercial/Industrial/Institutional			
% of domestic	17	21	25
Equivalent, lpcd	24	33	35
Accounted-for-water, lpcd	164	188	210
Unaccounted-for-water			
% of production	40	28	20
Equivalent, lpcd	109	73	52
Total production required, lpcd	273	261	262
Group II			
Domestic use, lpcd	120	135	150
Commercial/Industrial/Institutional			
% of domestic	15	17	20
Equivalent, lpcd	18	23	30
Accounted-for-water, lpcd	138	158	180
Unaccounted-for-water			
% of production	40	28	20
Equivalent, lpcd	92	62	45
Total production required, lpcd	230	220	225
Group III			
Domestic use, lpcd	105	120	135
Commercial/Industrial/Institutional			
% of domestic	13	16	18
Equivalent, lpcd	14	19	24
Accounted-for-water, lpcd	119	139	159
Unaccounted-for-water			
% of production	40	28	20
Equivalent, lpcd	79	54	40
Total production required, lpcd	198	193	199

TABLE MM 3-2 (Continued)

WATER DEMAND OF WATER DISTRICT GROUPINGS

Classification	Year 1980	1990	2000
Group IV			
Domestic use, lpcd	95	110	125
Commercial/Industrial/Institutional			
% of domestic	12	14	16
Equivalent, lpcd	12	15	20
Accounted-for-water, lpcd	107	125	145
Unaccounted-for-water			
% of production	40	28	20
Equivalent, lpcd	71	49	36
Total production required, lpcd	178	174	181
Group V			
Domestic use, lpcd	90	100	110
Commercial/Industrial/Institutional			
% of domestic	10	13	15
Equivalent, lpcd	9	13	17
Accounted-for-water, lpcd	99	113	127
Unaccounted-for-water			
% of production	40	28	20
Equivalent, lpcd	66	44	32
Total production required, lpcd	165	157	159

1. 1975 Urban Income

In 1970, the urban households accounted for 33.8 percent of the total households in the city. But due to recent developments in the local economy and subdivision housing projects in the urban sector of the city, the number of urban households was projected to increase to 35 percent in 1975. The product of the total 1974-1975 income taxes and the 1975 percentage of urban households represents the urban income taxes which amount to about ₱7.017 million. Table MM 3-1 gives this a weight of 16 points.

2. 1975 Standard of Living

This is measured by:

a. 1975 urban households using refrigerators

In 1970, 7.2 percent of the urban households had refrigerators. Due to economic and housing developments, the percentage was estimated to increase to about 12 percent in 1975. Table MM 3-1 gives this a weight of 6 points.

b. 1975 urban households using flush water-sealed toilet facilities

In 1970, the households with toilet facilities represented 21.9 percent of urban households. Due to the recent housing developments in the urban area, the households with toilet facilities were projected to be about 32 percent in 1975. Table MM 3-1 gives this a weight of 7 points.

3. 1975 Business Index

It is assumed that one industrial establishment is equivalent to 10 commercial establishments. Based on the 1970 census, the number of commercial establishments (equivalent industrial establishments included) was 46 (36 + 10). These establishments were expected to have increased to 96 (at 10 establishments per year) in 1975. Total urban households increased from 3,693 in 1970 to about 5,180 in 1975 (1975 population of 103,493 + average 7 persons/household). Hence, the business index in 1975 was 1.9 percent (commercial establishments divided by the number of urban households in 1975). Table MM 3-1 gives this a weight of 7 points.

4. 1980 Cost of Water

Based on the hydro-survey of LWUA-CDM and SIL-WD, deepwells appear to be the most probable economical source of additional supply. Table MM 3-1 gives a weight of 11 points for this source.

5. 1980 Served Population

By 1980, the served population is expected to be about 15,630[1] as projected from the 1975 NCSO Census of Population and Housing. Table MM 3-1 gives this a weight of 7 points.

Therefore, the SIL-WD has a total of 54 points under the 5 criteria, indicating that it belongs to Group III. The water demands of this group from 1980 to year 2000 are listed in Table MM 3-2.

Table MM 3-3 classifies 16 water districts in the Philippines according to the 5 grouping criteria.

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[1] See Chapter VI, Table VI-3, of the Silay City Feasibility Study Report.

TABLE MM 3-3

SUMMARY OF CITIES/MUNICIPALITIES SUBJECTED TO THE WATER DISTRICT GROUPING CRITERIA

City/Municipality	1975 Urban Income (Points)	1975 Standard of Living: Urban Households with Refrigerators (Points)	1975 Standard of Living: Urban Households with Flush Toilets (Points)	1975 Business Index (Points)	1980 Cost of Water Source of Supply (Points)	1980 Served Population (Points)	Total Points	Group
Bislig, Surigao del Sur	14	6	7	11	14	7	59	3
Urdaneta, Pangasinan	6	7	9	11	11	6	50	3
Calamba, Laguna	14	9	10	7	17	6	63	2
Gapan, Nueva Ecija	6	8	9	7	11	6	47	4
Silay City	16	6	7	7	11	7	54	3
Cebu City	20	10	10	7	5	20	72	1
Davao City	16	9	9	16	11	10	71	1
Bacolod City	20	9	9	7	11	18	74	1
Zamboanga City	14	7	9	7	7	16	62	2
Digos, Davao del Sur	12	6	9	7	11	5	50	3
Bacacay, Albay	1	5	9	11	20	5	51	3
Bangued, Abra	1	6	8	7	20	6	48	4
Dalaguete, Cebu	1	5	8	4	11	5	34	5
Baybay, Leyte	10	9	8	16	9	6	58	3
Roxas City	10	9	8	16	7	6	56	3
Cotabato City	12	9	8	11	11	7	58	3
Olongapo City	18	9	10	20	11			1
Subic	4	5	6	16	11	5	47	4
San Fernando (Pampanga)	14	6	7	20	11	7	65	2
Tarlac	12	8	8	16	11	8	63	2
Cabanatuan City	12	8	10	11	11	9	61	2
Lipa City	8	8	10	16	11	7	60	2
Lucena-Pagbilao-Tayabas	14	6	8	7	17	12	64	2
Daet	10	5	4	4	20	10	53	3

CAMP DRESSER & McKEE INTERNATIONAL INC.

Methodology Memorandum No. 4

To : L. V. Gutierrez, Jr.

From : E. Jacildo

Date : 20 January 1977

Subject: Probability Analysis of Stream Flows by Gumbel

A. Need

In evaluating the surface water sources for water supply purposes, the analyst has to focus his interest on statistical frequency of extreme low flows. Since the exact sequence of streamflow for future years can not be predicted, he also has to consider the probable variations in flows in order to develop a design on the basis of calculated risk.

In 1941, E. J. Gumbel devised a probability method by which recurring flows can be computed for design requirements. Under this method, the hydrologic data are analyzed as an "extreme value" distribution and the sets of hydrologic data are plotted as straight lines. Gumbel's method has been found advantageous to use.

B. Basic Data

The hydrologic data are found in Surface Water Supply Bulletins published by the Water Resources Division of the Bureau of Public Works (BPW). Data are presented in the following sequence:

1. Name of river basin
2. Name of stream
3. Location of gaging station in latitude and longitude
4. Drainage area in square kilometers
5. Records available: months and year
6. Gage elevation
7. Extremes; magnitude and dates of maximum and minimum flows
8. Remarks
9. Revisions
10. Presentation of daily discharge for one year

It should be noted that Surface Water Supply Bulletins after 1967 have not been published; they are on file at the BPW Water Resources Division.

C. Methodology

Below are the steps in Gumbel's probability analysis of streamflows.

Table MM4-1

1. Tabulate the monthly flows (mean, minimum or maximum, whatever is desired).
2. Take note of any changes in the yearly records as stated under "Remarks" or "Revisions" of the Bulletin. Write them under remarks in Table MM4-1.

Table MM4-2

1. Arrange all monthly flows in ascending order, i.e., from lowest to highest. Any flow that occurs more than once should be listed.
2. Rank the arranged flows under "m".
3. Take the logarithm of Q.
4. Solve for the probability flow by the formula

   $$\frac{m}{n+1} \times 100$$

   where, m is the rank of a particular flow
   n is the total number of recorded flows.
5. Solve for the return period by the formula

   $$\frac{n+1}{m}.$$

Figure MM4-1

1. Plot log Q as ordinate against probability as abscissa. Figure MM4-1 is Gumbel's special probability paper.
2. Draw a straight line (month line) passing through the points marked in step C-1. If not all the points fall on the line, adjust the line such that it passes on the average path of the points. Any return period which falls on the line is in month's term. The line may be extended in order to reach periods not covered by it.
3. Take the antilogarithms of the values of return periods in months as projected on the log Q scale (ordinate). The antilogs are the recurring flows in cubic meters per day.

TABLE MM4-1

MEAN-DAY DISCHARGE PER MONTH

Basin: Pampanga (San Vicente)
Station: Peñaranda River
Location: lat. 15°18'46"; long. 120°56'30"
Drainage Area: 575 sqkm

Gage Elevation: 11,050 m
Units: cumd x 1,000

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Minimum-Day Discharge/ Year	Remarks
1965	-	2,283	753	351	372	1,313	-	-	-	3,239	5,156	4,358		
1966	-	2,915	-	-	8,941	1,595	2,682	4,215	5,425	1,413	9,801	5,380		
1967	4,922	857	1,189	547	873	425	1,012	6,614	4,415	5,707	5,896	125		
1968	66	77	120	540	96	-	-	-	-	-	-	117		
1969	141	32	336	689	664	301	3,203	2,394	2,248	1,175	1,785	2,190		
1970	1,989	814	279	17	17	3,561	2,928	1,628	9,590	11,726	9,689	6,915		
1971	3,123	642	732	294	1,499	4,567	4,021	1,824	1,377	11,161	5,229	15,007		
1972	5,992	4,873	406	1,461	767	415	18,347	15,977	6,306	216	4,701	2,896		
1973	697	823	82	108	95	686	2,525	2,650	4,405	14,582	4,149	2,124		
1974	1,405	1,332	2,191	471	621	3,781	3,497	10,761	10,014	12,567	16,317	13,693		

TABLE MM4-2

MEANFLOW (PEÑARANDA RIVER, SAN VICENTE)
GAPAN WATER DISTRICT

m	Q cumd x 10^3	Log Q	Probability $(\frac{m}{n+1} \times 100)$	Return Period (Months) $(\frac{n+1}{m})$
1	17	4.230	0.93	108.00
2	17	4.230	1.85	54.00
3	32	4.505	2.78	36.00
4	66	4.820	3.70	27.00
5	77	4.886	4.63	21.60
6	82	4.914	5.56	18.00
7	95	4.978	6.48	15.43
8	96	4.982	7.41	13.50
9	108	5.033	8.33	12.00
10	117	5.068	9.26	10.80
11	120	5.079	10.18	9.82
12	125	5.097	11.11	9.00
13	141	5.149	12.04	8.31
14	216	5.334	12.96	7.71
15	279	5.446	13.89	7.20
16	294	5.468	14.82	6.75
17	301	5.478	15.74	6.35
18	336	5.526	16.67	6.00
19	351	5.545	17.59	5.68
20	372	5.570	18.52	5.40
21	406	5.608	19.44	5.14
22	415	5.618	20.37	4.91
23	425	5.628	21.30	4.70
24	471	5.673	22.22	4.50
25	540	5.732	23.15	4.32
26	547	5.738	24.07	4.15
27	621	5.793	25.00	4.00
28	642	5.808	25.93	3.86
29	664	5.822	26,85	3.72
30	686	5.836	27.78	3.60
31	689	5.838	28.70	3.48
32	697	5.843	29.63	3.38
33	732	5.864	30.56	3.27
34	753	5.877	31.48	3.18
35	767	5.885	32.41	3.08
36	814	5.911	33.33	3.00
37	823	5.915	34.26	2.92
38	857	5.933	35.18	2.84

TABLE MM4-2 (continued)

MEANFLOW (PEÑARANDA RIVER, SAN VICENTE)
GAPAN WATER DISTRICT

m	Q cumd x 10^3	Log Q	Probability ($\frac{m}{n+1}$ x 100)	Return Period (Months) ($\frac{n+1}{m}$)
39	873	5.941	36.11	2.77
40	1,012	6.005	37.04	2.70
41	1,175	6.070	37.96	2.63
42	1,189	6.075	38.889	2.57
43	1,313	6.118	39.815	2.51
44	1,332	6.124	40.741	2.45
45	1,377	6.139	41.667	2.40
46	1,405	6.148	42.592	2.35
47	1,413	6.150	43.518	2.30
48	1,461	6.165	44.444	2.25
49	1,499	6.176	45.370	2.20
50	1,595	6.203	46.296	2.16
51	1,628	6.212	47.222	2.12
52	1,785	6.252	48.148	2.08
53	1,824	6.261	49.074	2.04
54	1,989	6.299	50.000	2.00
55	2,124	6.327	50.926	1.96
56	2,190	6.340	51.852	1.93
57	2,191	6.341	52.778	1.89
58	2,248	6.352	53.704	1.86
59	2,283	6.358	54.630	1.83
60	2,394	6.379	55.555	1.80
61	2,525	6.402	56.481	1.77
62	2,650	6.423	57.407	1.74
63	2,680	6.428	58.333	1.71
64	2,896	6.462	59.259	1.69
65	2,915	6.465	60.185	1.66
66	2,928	6.466	61.111	1.64
67	3,123	6.494	62.037	1.61
68	3,203	6.506	62.963	1.59
69	3,209	6.510	63.889	1.56
70	3,497	6.544	64.815	1.54
71	3,561	6.552	65.741	1.52
72	3,781	6.578	66.667	1.50
73	4,021	6.604	67.592	1.48
74	4,149	6.618	68.518	1.46
75	4,215	6.625	69.444	1.44
76	4,358	6.639	70.370	1.42

TABLE MM4-2 (continued)

MEANFLOW (PEÑARANDA RIVER, SAN VICENTE)
GAPAN WATER DISTRICT

m	Q cumd x 10^3	Log Q	Probability $(\frac{m}{n+1} \times 100)$	Return Period (Months) $(\frac{n+1}{m})$
77	4,405	6.644	71.296	1.40
78	4,415	6.645	72.222	1.38
79	4,567	6.660	73.148	1,37
80	4.701	6.672	74.074	1.35
81	4,873	6.688	75.000	1.33
82	4,922	6.697	75.926	1.32
83	5,156	6.712	76.852	1.30
84	5,229	6.718	77.778	1.28
85	5,380	6.731	78.704	1.27
86	5,425	6.734	79.630	1.26
87	5,707	6.756	80.556	1.24
88	5,896	6.770	81.481	1.23
89	5,992	6.778	82.407	1.21
90	6,306	6.800	83.333	1.20
91	6,614	6.820	84.259	1.19
92	6,915	6.840	85.185	1.17
93	8,941	6.951	86.111	1.16
94	9,590	6.982	87.037	1.15
95	9,689	6.986	87.963	1.14
96	9,801	6.991	88.889	1.12
97	10,014	7.001	89.815	1.11
98	10,761	7.032	90.741	1.10
99	11,161	7.048	91.667	1.09
100	11,726	7.069	92.592	1.08
101	12,567	7.099	93.518	1.07
102	13,693	7.136	94.444	1.06
103	14,582	7.164	95.370	1.05
104	15,007	7.176	96.296	1.04
105	15,977	7.203	97.222	1.03
106	16,317	7.213	98.148	1.02
107	18,347	7.264	99.074	1.01

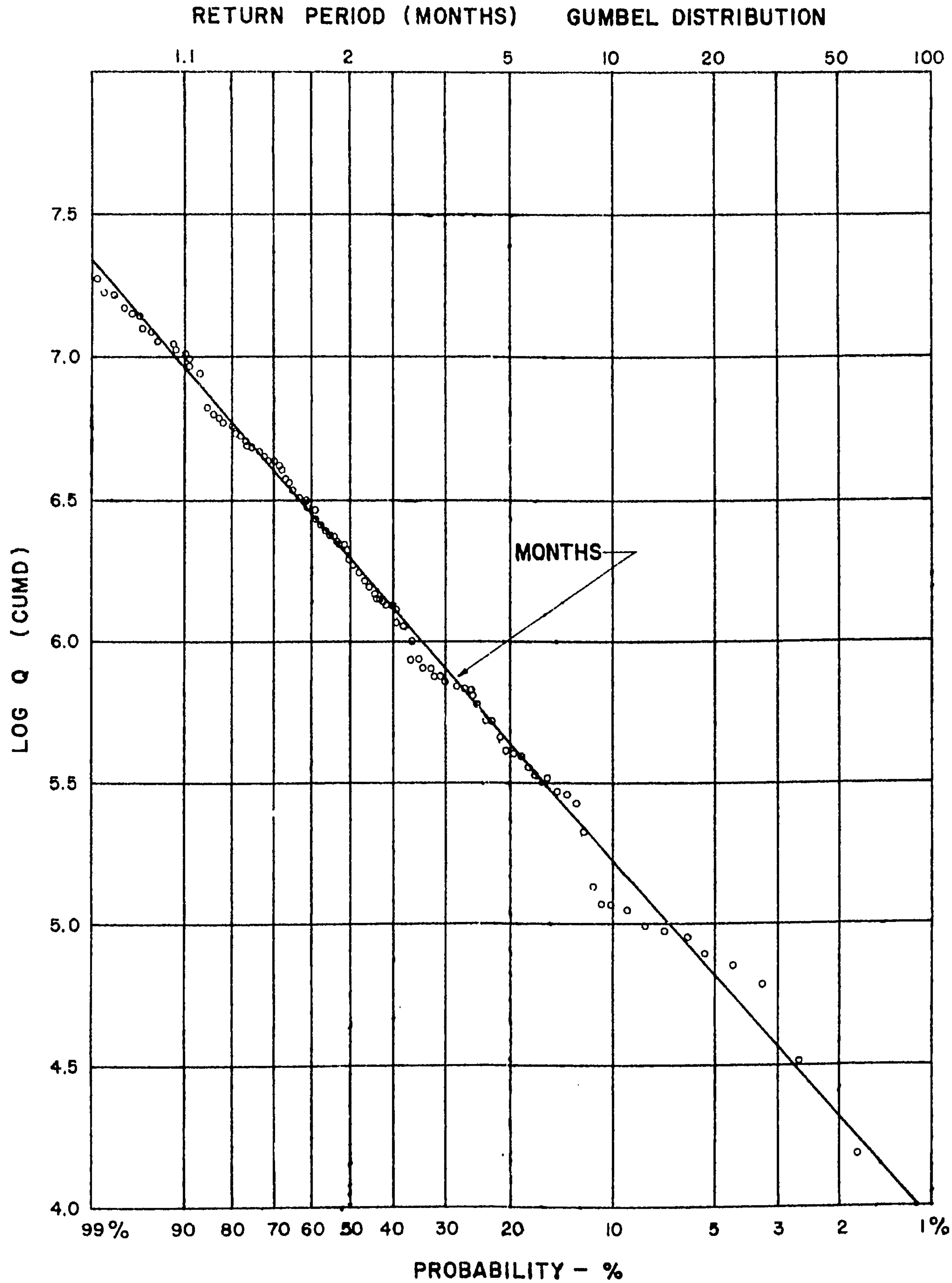


FIGURE MM4-1
MONTHLY MEANFLOW
(PENARANDA RIVER, SAN VICENTE)
GAPAN WATER DISTRICT

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

Methodology Memorandum No. 5

To : L. V. Gutierrez, Jr.

From : J. B. Arbuthnot/B. R. Conklin

Date : 16 May 1977

Subject: Quantity of Storage Versus Rate of Supply

A. General

The demand for water in a water system is not uniform, therefore, the system must be designed to supply water at varying rates of demand.

One common method of supplying water at varying rates is to provide a specific amount of source pumping capacity and supply the difference between demand and pumping capacity from a water storage facility.

The most economical amount of pumping capacity and storage volume is selected based on cost studies of alternative combinations of facilities that would meet a community's needs. Some of the factors that should be considered in these cost studies and some basic guidelines for selecting properly sized facilities are presented in this memorandum.

B. Discussion

The amount of water a community needs at any particular instant is primarily dependent on the following factors:

1. The number of people within the community
2. The number of water-consuming facilities within the average home (faucets, toilets, showers, automatic washing appliances, etc.)
3. The habits of people (what times people eat, shower, sleep, etc.)

In general, daily usage of water follows a pattern with two peak usage periods during the day and low usage late at night. Figure MM5-1 shows a typical variation measured in a section of the Cebu City distribution system.

The relationship of the peak usage on an average day can be determined statistically for a given community. The statistical peak is an average of each person's peak usage and has two important properties:

1. The statistical peak is a function of the number of people in the community. The fewer people, the higher the peak may be because each person's peak usage could more easily affect the total flow.

2. The statistical peak should be recognized as a mathematical average, and on some days the peak usage could be much higher or lower than the statistical peak.

The common engineering practice for water systems is to supply water from a source at maximum-day rates either by pumping or gravity. Maximum-day demand is the maximum quantity of water used during an entire day in a single year. Water usage can be at or near maximum-day demand for a period of weeks during summer months. Source capacity must equal maximum-day demand because it would be impractical to store sufficient water to supply maximum-day demand rates for more than a few days.

The difference in demand between the peak-hour demands and the supply (which is equal to maximum-day demands) occurs during a period of short duration where demand exceeds supply. Stored water is used to meet this short period of excess demand and is called operational storage. It should be noted at this time that there are three categories of storage:

1. Operational storage - used to meet hourly fluctuations in demand.

2. Emergency storage - used to meet demands in case of breakdowns in source facilities; typically equal to a full day's demand.

3. Fire storage - used to meet the required volume of water used to extinguish the worst fire expected in the community.

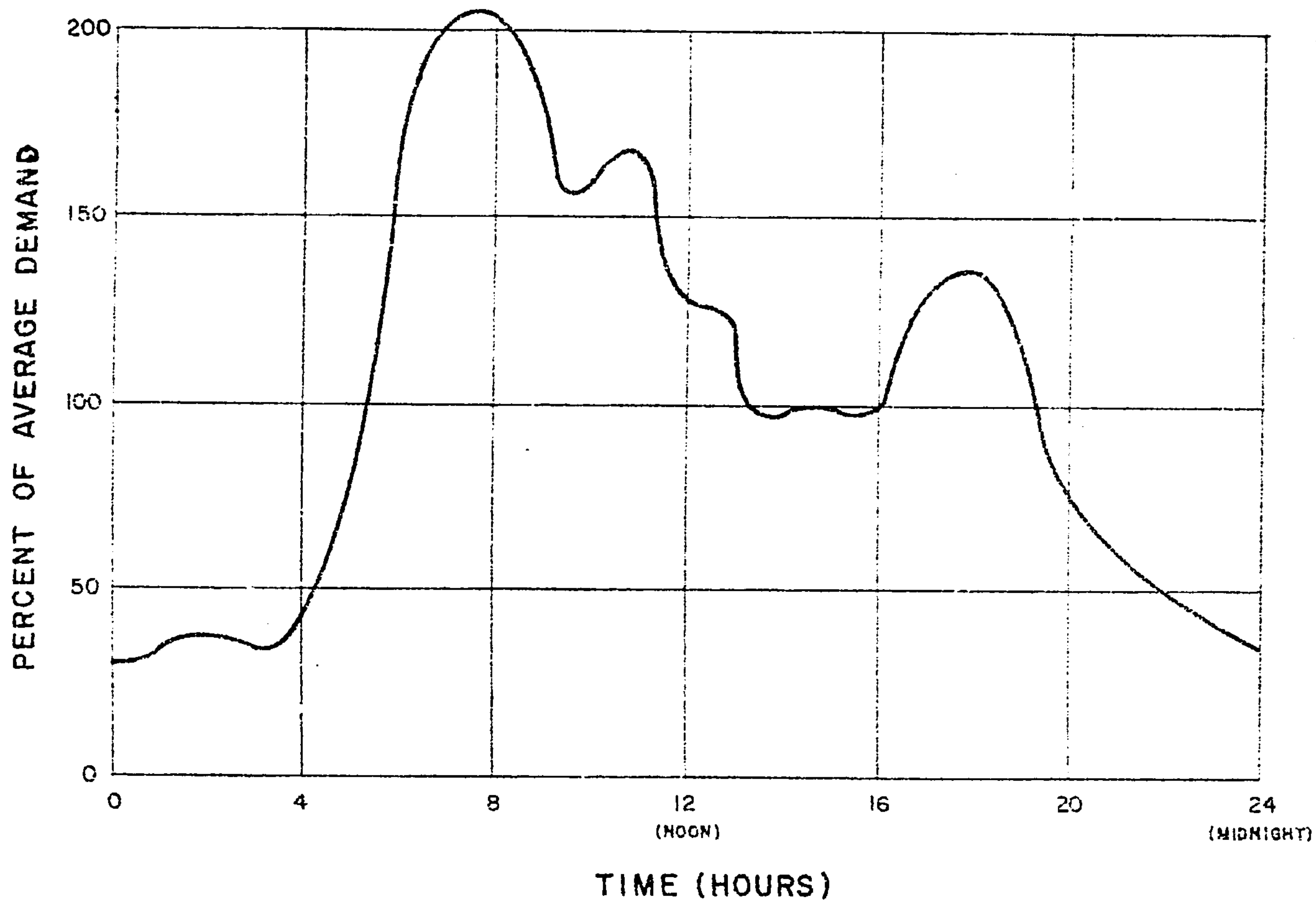


FIGURE MM5-1
DAILY USAGE PATTERN

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

Storage requirements for the last two categories have been largely neglected in these studies because of the excessive cost involved to provide the storage.

C. Methodology

The engineer must determine the amount of storage and source capacity to meet the demands in a specific community. A set of curves that relate the peak hourly usage to the number of people in a community has been developed by CDM and others.[1] Practice has shown that a volume of about 15 to 20 percent of the maximum-day usage is required as operational storage if source facilities can supply maximum-day demands. Combining the "peaking curves" with the operational storage requirement, a second set of curves relating the quantity of storage to the number of people, at different rates of source supply, has been developed (see Figure MM5-2).

Up to this point, the only option that has been discussed is to supply peak-hour demands from storage facilities. In many cases, the cost of storage facilities is so high that it may be more economical to provide additional source capacity and reduce the quantity of storage. This is especially true where storage is provided in elevated structures that are very costly, since they are built to withstand earthquakes. The curves in Figure MM5-2 have been used in this study to determine the requirements for storage at various supply rates in order to prepare cost comparisons of alternative supply and storage combinations.

[1] ASCE Manual of Practice No. 37.

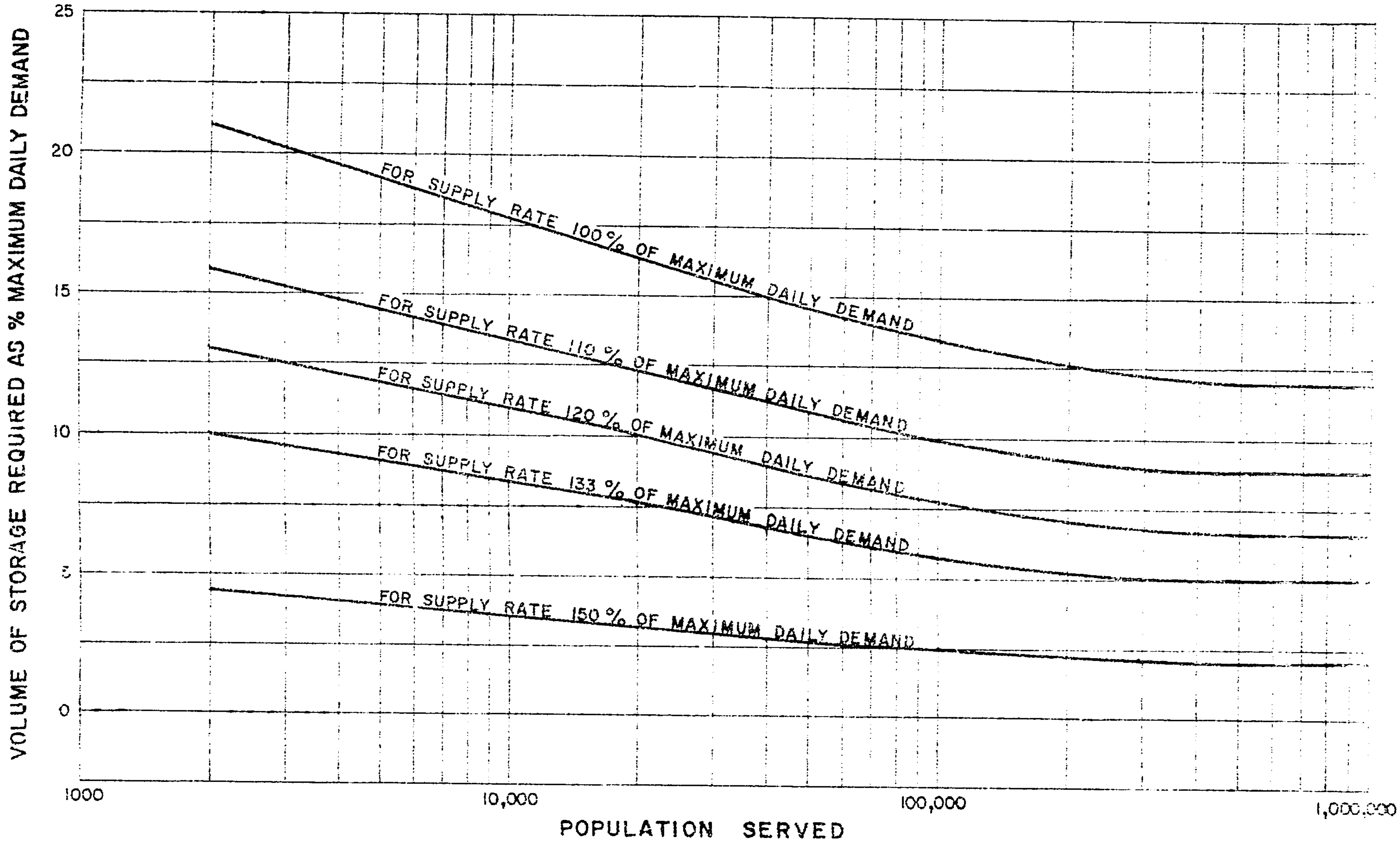


FIGURE MM 5-2
STORAGE REQUIRED
TO MEET
DAILY PEAK WATER DEMAND

Methodology Memorandum No. 6

To : L. V. Gutierrez, Jr.

From : J. Arbuthnot; B. Conklin

Date : 22 March 1977

Subject: Economical Sizing of Pumped Waterlines

A. General

This memorandum develops an expression for the most economic size of a pipeline for pumped water systems based on two cost factors: cost of pipe-in-place and cost of pumping (energy). The larger the pipe the greater the cost of construction. Also, the larger the pipe the lesser the cost of energy required to pump water through the pipe. The most economic pipe sizes would be where the incremental cost of pumping is equal to the incremental cost of pipe construction.

In most situations, the above cost factors are the most important factors in determining the economical size of transmission mains. Even when these are not the only important factors, it is still advantageous to know what is the most economic size of pipe with regard to these two factors.

B. General Relationship

The total annual cost of a pipe line is equal to the sum of its construction cost (expressed on an amortized annual basis) plus its annual pumping cost.

$$C_t = C_c + C_p \text{ [1/]}$$

To determine the most economic pipe diameter both the factors on the right hand side of the equation were expressed in terms of the diameter of the pipe. The equation was then differentiated with respect to the diameter, and solved for the diameter for which the resulting expression was equal to zero.[2/]

[1/] Total Annual Cost = Annual Construction Cost + Annual Pumping Cost.

[2/] $\frac{d(C_t)}{dx} = \frac{d(C_c)}{dx} + \frac{d(C_p)}{dx} = 0$, where X = pipe diameter

C. Annual Construction Cost

The construction cost of the pipe was taken from Table G-4 of Appendix G, Basis of Cost Estimates, in Volume II of the final report. Costs were adjusted by adding a value for necessary valves and by escalating these by 10 percent per year for 2 years to obtain July 1978 construction costs. These costs were then increased by 15 percent for contingencies and then by 10 percent for engineering. The following equation was derived and represents the adjusted construction costs in Table G-4 in terms of the diameter.

$$C = 2845\ (\text{Dia.})^{1.292} \quad \text{- - - - Equation 1}$$

C is the installed cost of pipe in pesos per meter, and Dia, the diameter of the pipe in meters.

The amortized annual cost of construction is the cost of construction multiplied by the capital recovery factor (as influenced by the economic life of the pipe and discount factor). The general equation is:

$$\text{Annual Cost of Construction} = \text{CRF} \times 2845(\text{Dia.})^{1.292} \quad \text{- - - - Equation 2}$$

where CRF is the capital recovery factor; for $n = 50$ years, discount rate = 12%, CRF is equal to 0.12042.

D. Annual Pumping Cost

The annual cost of pumping energy may be expressed in terms of the amount of water pumped, the energy required to overcome the frictional loss in the pipe, the price of electrical energy and the efficiency of the pumping machinery. The general equation may be written as:

$$\text{Annual Cost of Pumping Energy} = \frac{\text{Mass/Year} \times g \times \text{Hf} \times \text{₱/kwh}}{\text{efficiency} \times 3.6 \times 10^{6}} \quad \text{- - - - Equation 3}$$

where mass/Year is the amount of water pumped in kilograms; g, the gravitational constant; Hf, the energy lost by friction of flow in the pipe expressed in meters; ₱/kwh, the cost of energy in pesos per kilowatt hour; and 3.6×10^{6}, the number of newton-meters per kilowatt hour.

The friction loss of energy in the pipe may be expressed in terms of the diameter utilizing the Hazen-Williams (H&W) equation,

$$\text{Hf} = \frac{\text{L} \times \text{MLD}^{1.852}}{361.27\ C^{1.852}\ D^{4.87}} \quad \text{- - - - Equation 4}$$

where L is the length of pipe in meters; MLD, the flow of water in million liters per day; C, the Hazen & Williams roughness coefficient; and Dia, the diameter of the pipe in meters.

E. Minimum Cost Diameter

The expression for minimum cost diameter may be obtained by inserting the expression for Hf in the equation for the cost of pumping energy, combining this with the expression for the annual cost of construction, differentiating, setting the resulting expression equal to zero and solving for the diameter:

$$\text{Minimum Cost Diameter} = \frac{MLD^{0.4628} \times (\text{pesos/kwh})^{0.1623}}{2.391\ (\text{efficiency})^{0.1623}\ C^{0.3005}\ (A/P,\ i\%,\ n)^{0.1623}}$$

using a C value of 120 and a capital recovery factor of 0.12042, the following equation is obtained:

$$\text{Minimum Cost Diameter} = \frac{MLD^{0.4628}(\text{pesos/kwh})^{0.1623}}{7.149\ (\text{efficiency})^{0.1623}} \text{ - - - - Equation 5}$$

The above equation is expressed graphically in Figure MM 6-1.

F. Limitations of the Analysis

How reliable is the preceding relationship (Equation 5), between water carried and economic pipe diameter? The derivation is rigorous but the relation is no more exact than are the simplifying assumptions upon which the derivation was based:

1. Construction Cost Relationship

The construction cost relation (Equation 1) has a standard deviation of just under 10 percent. This means that two-thirds of the time the formula will represent the adjusted costs tabulated, within 10 percent. The largest difference observed was 20 percent. Even so, economic conditions and the cost of pipe may change in time. Probably, a new table of pipe costs has to be made every 2 or 3 years, and the formulas, along with Figure MM 6-1, adjusted accordingly.

2. Other Assumptions

Other assumptions are:

C = 120 (Hazen & Williams coefficient)
i = 12% (Discount rate)
n = 50 years (Economical life of pipe)

The derivation also assumes that for the changes in pumping head, using various pipe sizes for a design flow, the total construction cost of the pumping station remains constant. This assumption is reasonable since the difference in cost between one pump selection and another for different heads at the same flow would not alter the cost of the complete station by significant amount. Generally, the installed motor horsepower would also be the same since the motors come in standard sizes and one size may be used for a number of different pump selections at a given flow.

The relative rate of inflation for pipeline construction is assumed equal to that of power costs.

3. Flow Quantities are Based on Constant Flow

The derivation of the most economic pipe diameter is based on a constant rate of flow within the pipe. This is probably the most general and therefore the least accurate of any of the assumptions.

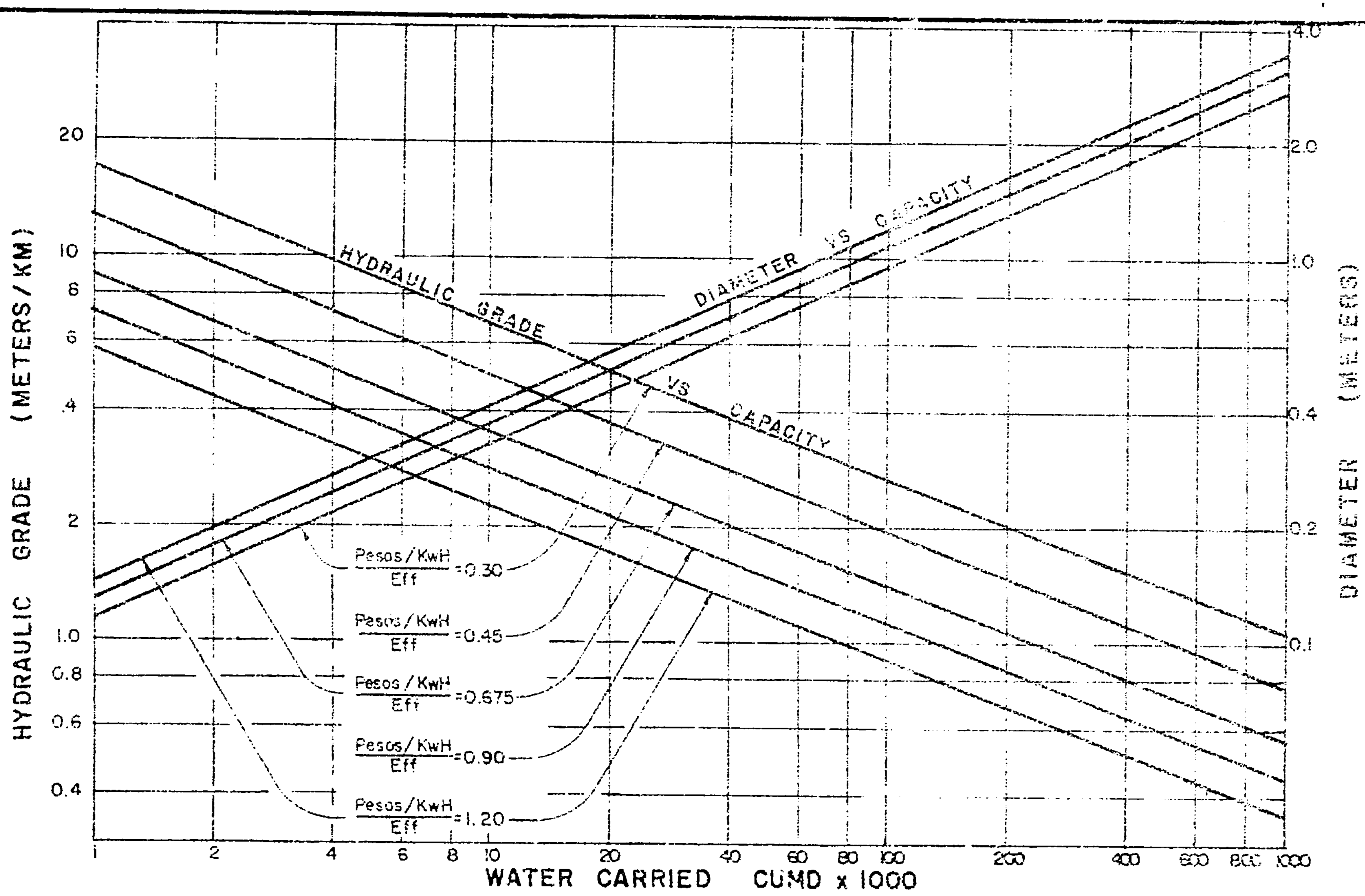
Normally a pipeline is designed for a specific flow condition; even under design conditions that flow may occur only part of the time. The flow in a transmission main could be expected to nearly equal the design flow for long period of time. However, in a distribution main, sized for peak-hour flows, the flow may not be equal to the design flow except for very short periods of time.

The variation in energy costs due to a fluctuating pumping rate through a pipeline can be calculated and applied to adjust the most economic pipe diameter determined from Figure MM 6-1. This so-called "energy variability factor" is discussed in the following section.

G. Energy Variability Factor

Figure MM 6-1 is based on selecting a pipeline where the flow will be constant throughout the year. In most cases, pipeline sizes are selected on a maximum expected rate of flow. If the flow through the pipeline is less than the design flow, the pumping head (which directly affects energy costs) would decrease according to the 2.852 power of the flow (Q). Conversely, if flow greater than design flow rate is pumped through a pipeline, the energy cost would be increased by the 2.852 power.

The overall difference in energy costs over the day or year can be calculated by comparing the costs of pumping at a constant flow rate with the cost of pumping at the expected flow variation. This value is the so-called "energy variability factor" (EVF). The design flow for the pipe is used as the base flow and the actual flow to the design flow over the day is expressed as a percent.



Note : 1. CONSIDERS CONSTRUCTION AND PIPELINE FRICTION COSTS ONLY INCLUDING ENGINEERING AND CONTINGENCIES

2. AVERAGE C = 120 OVER 50 YEARS

3. ECONOMIC DISCOUNT RATE = 12 %

4. PIPE COST (MID 1978 PRICES) = $2845D^{1.29}$ PER METER, (D IN METERS)

FIGURE MM6-1

MOST ECONOMIC WATER TRANSMISSION

The method used is to raise the difference between actual flow and the base flow (expressed as a percentage) to the 2.852 power. The ratio of the sum for the day of the actual flow to the design flow each raised to the 2.852 power is equal to the EVF. Figure MM 6-2 and Table MM 6-1 present two possible flow variations and the calculated energy variability factor for each.

The two flow patterns selected for Figure MM 6-2 are not commonly used design curves. Pattern 1 was selected to show that if a higher rate of flow than the design flow is pumped through the pipeline during a portion of the day, the EVF is greater than 1.0. Pattern 2 shows that if the actual flow rate is nearly equal to the design flow, the EVF would be nearly equal to 1.0.

An EVF of less than 1.0 would be a more common occurrence since the majority of pipelines are designed for some maximum future flow. The suggested EVF in a following section is an example of an EVF less than 1.0.

I. Application of EVF

The EVF can be used with Figure MM 6-1 in calculating the minimum cost pipe diameter. The EVF is inserted into the annual energy cost equation (equation 3) and then included in the differentiation, resulting in a revised equation as follows:

$$\text{Minimum Cost Diameter} = EVF^{0.1623} \frac{MLD^{0.4628}\ (\text{Pesos/kwh})^{0.1623}}{7.149\ (\text{efficiency})^{0.1623}} \quad \text{-- Equation 6}$$

The application of EVF requires 2 steps: first, design a minimum economic pipeline for some flow using Figure MM 6-1; and second, calculate the EVF for the actual flow variation and multiply the pipe size calculated in Step 1 by the EVF raised to the 0.1623 power.

J. Suggested EVF

The feasibility report on the Second Ten Provincial Urban Areas deals mainly with distribution pipelines; therefore, a suggested EVF that is applicable to distribution systems is presented herein.

The calculation of an EVF depends entirely on the flow data or assumed flow within a specific pipeline. The only accurate data produced during the feasibility studies are the diurnal flow variations measured in a portion of Cebu. The peak flow in the Cebu data was 2.06 which is greater than the design flows

TABLE MM 6-1

SAMPLE "EVF" FOR DIFFERENT FLOW PATTERNS

Hour	Flow Pattern No. 1 Percent of Average Day Demand	Flow Pattern No. 1 Energy Variation	Flow Pattern No. 2 Percent of Average Day Demand	Flow Pattern No. 2 Energy Variation
1	32	0.039	48	0.123
2	36	0.054	48	0.123
3	39	0.068	48	0.123
4	33	0.042	100	1.000
5	46	0.109	100	1.000
6	95	0.864	100	1.000
7	193	6.522	120	1.682
8	206	7.855	120	1.682
9	198	7.016	120	1.682
10	156	3.554	120	1.682
11	169	4.466	120	1.682
12	129	2.067	120	1.682
13	123	1.805	120	1.682
14	95	0.864	120	1.682
15	99	0.972	120	1.682
16	96	0.890	120	1.682
17	107	1.212	120	1.682
18	133	2.255	120	1.682
19	130	2.113	120	1.682
20	87	0.672	100	1.000
21	64	0.280	100	1.000
22	54	0.172	100	1.000
23	42	0.084	48	0.123
24	38	0.063	48	0.123
		44.038		28.481

$EVF_1 \frac{44.038}{24.000} = 1.83$ $EVF_2 \frac{28.481}{24.000} = 1.19$

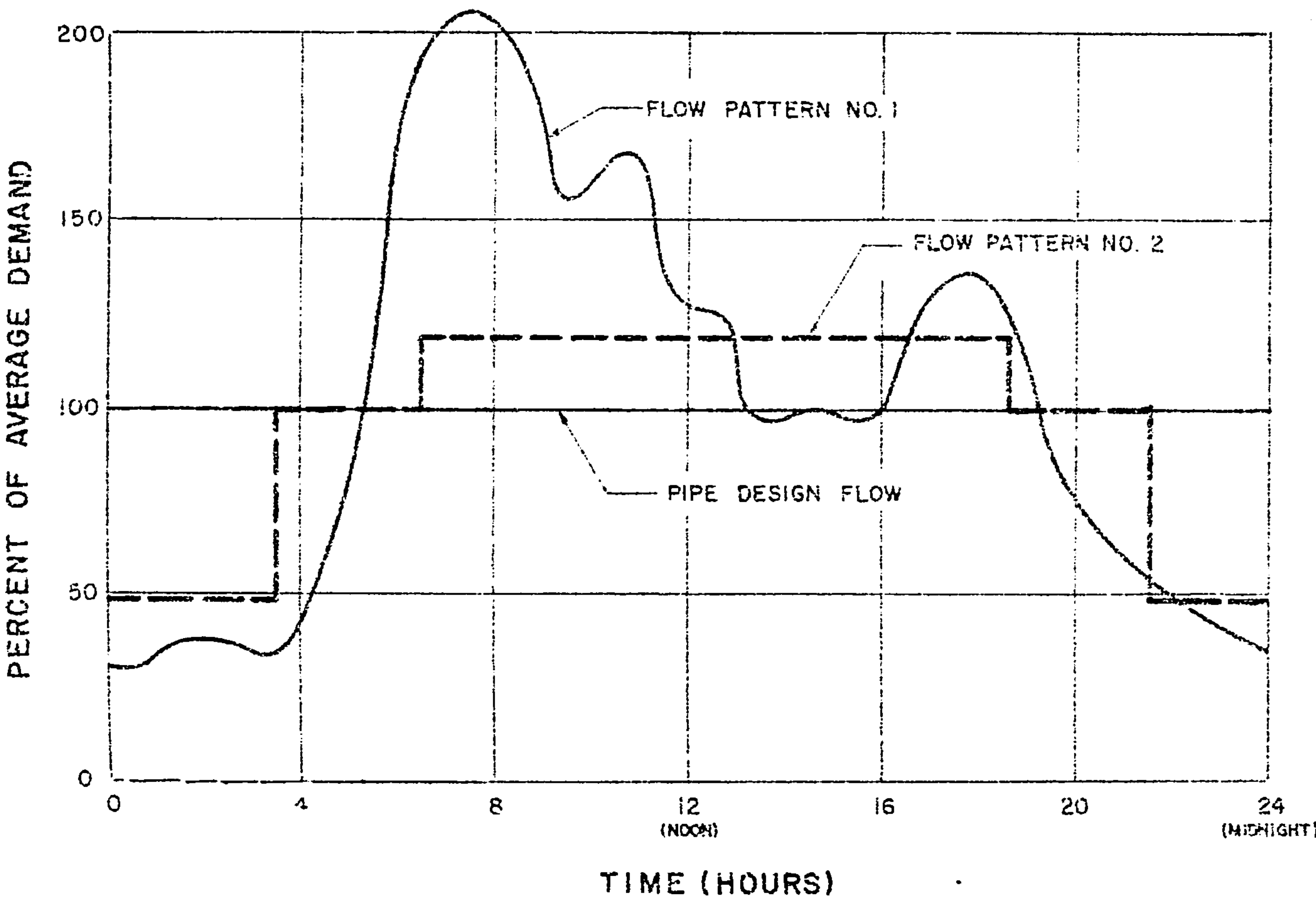


FIGURE MM6-2
SAMPLE FLOW PATTERNS

used for this study. Figure MM 6-3 presents an adjusted graph of diurnal flow using the shape of the Cebu curve but a maximum peak of 1.75. The EVF for this curve is equal to 0.32 (see Table MM 6-2) and when raised to the 0.1623 power, equals 0.83.

In practice, the EVF used for distribution systems in this study is only significant when the pipeline size is greater than 300 mm (significant means that EVF changes the recommended pipe size by a large incremental size).

K. Example

Problem: Select an economical distribution pipe size to convey a peak-hour flow of 20 MLD. The cost of power is 49 centavos per kilowatt hour, the pump efficiency is 81 percent, and the motor efficiency is equal to 90 percent.

Solution:

$$\frac{\text{Pesos/kwh}}{\text{Eff}} = \frac{.49}{.81 \times .90} = .672, \quad \text{say } .675$$

From Figure MM 6-1 using the flow of 20 MLD and Pesos/kwh/Eff = .675 select a pipe size of 500 mm.

For a flow variation in a distribution main, the EVF is equal to 0.32 and the EVF raised to the 0.1623 power is equal to 0.83. The most economical pipe size for the actual flow variation is equal to 0.83 x 500 m or 415 mm; so choose 400 mm pipe size.

TABLE MM 6-2

"EVF" FOR DISTRIBUTION SYSTEM

Hour	Percent of Average Day Demand	Percent of Design Flow 3/	Energy Variation 4/
1	35	20	0.010
2	40	23	0.015
3	39	22	0.013
4	37	21	0.012
5	73	42	0.084
6	134	77	0.475
7	164	94	0.838
8	175	100	1.000
9	174	99	0.972
10	163	93	0.813
11	162	93	0.813
12	134	77	0.475
13	118	67	0.317
14	94	54	0.172
15	94	54	0.172
16	94	54	0.172
17	105	60	0.233
18	129	74	0.424
19	123	70	0.362
20	96	55	0.182
21	72	41	0.079
22	58	33	0.042
73	47	27	0.024
24	40	23	0.015
			7.716

$$EVF = \frac{7.716}{24.000^{*}} = -.32 \qquad EVF^{0.1623} = 0.83$$

3/ Using 175 percent of average day as base flow for pipe design.
4/ Equals Percent Design Flow raised to the 2.852 power.
* Energy variation at constant flow

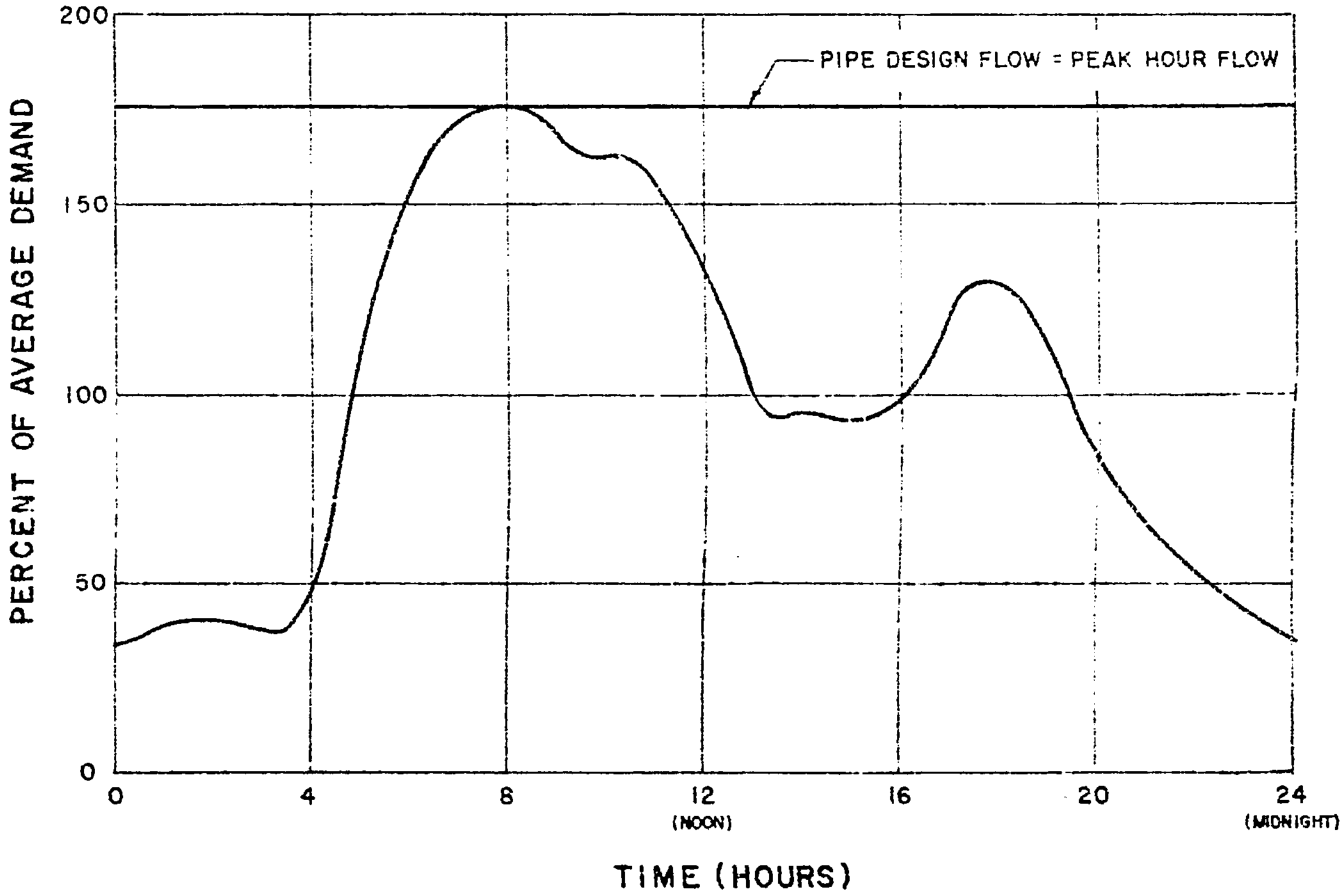
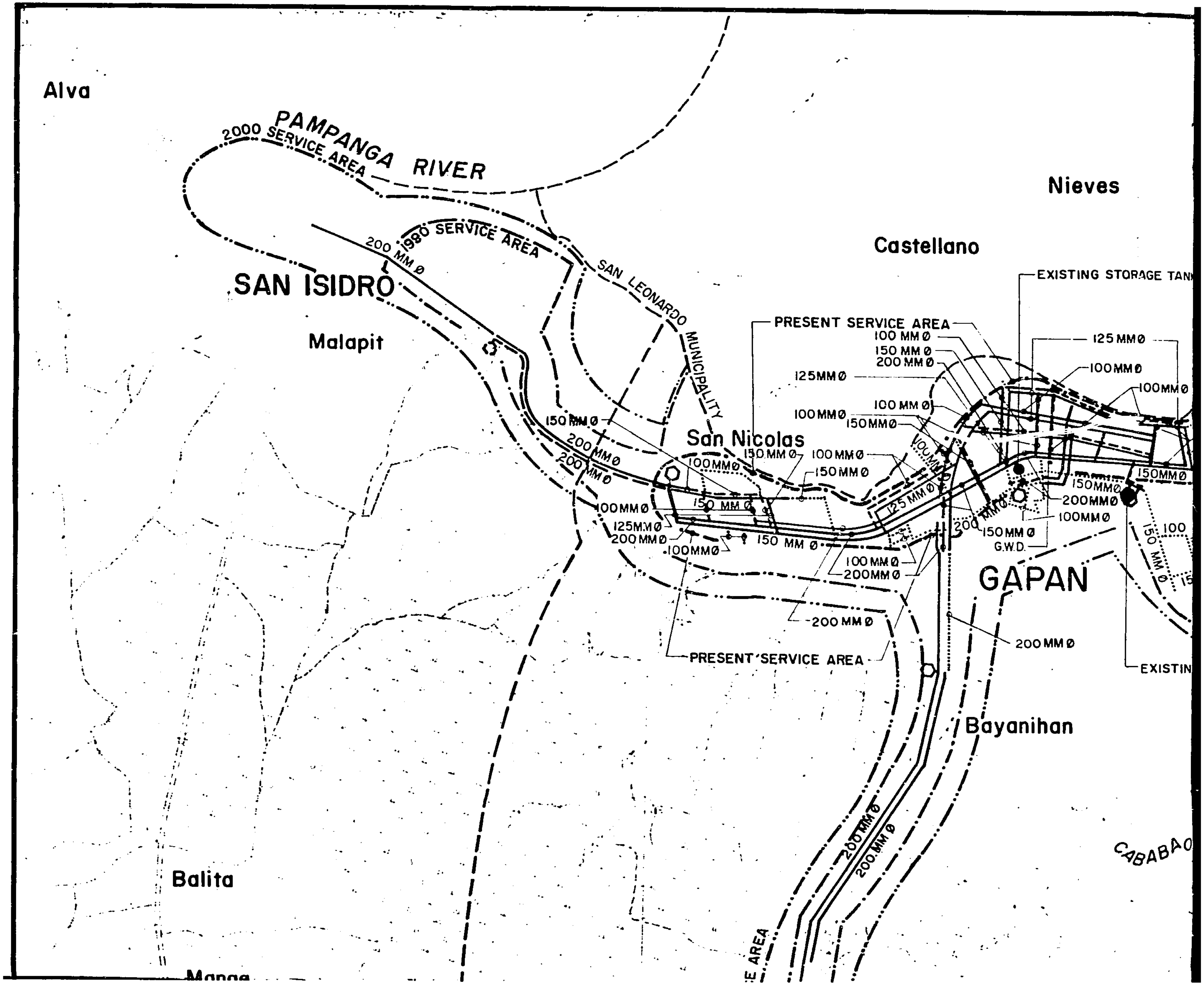
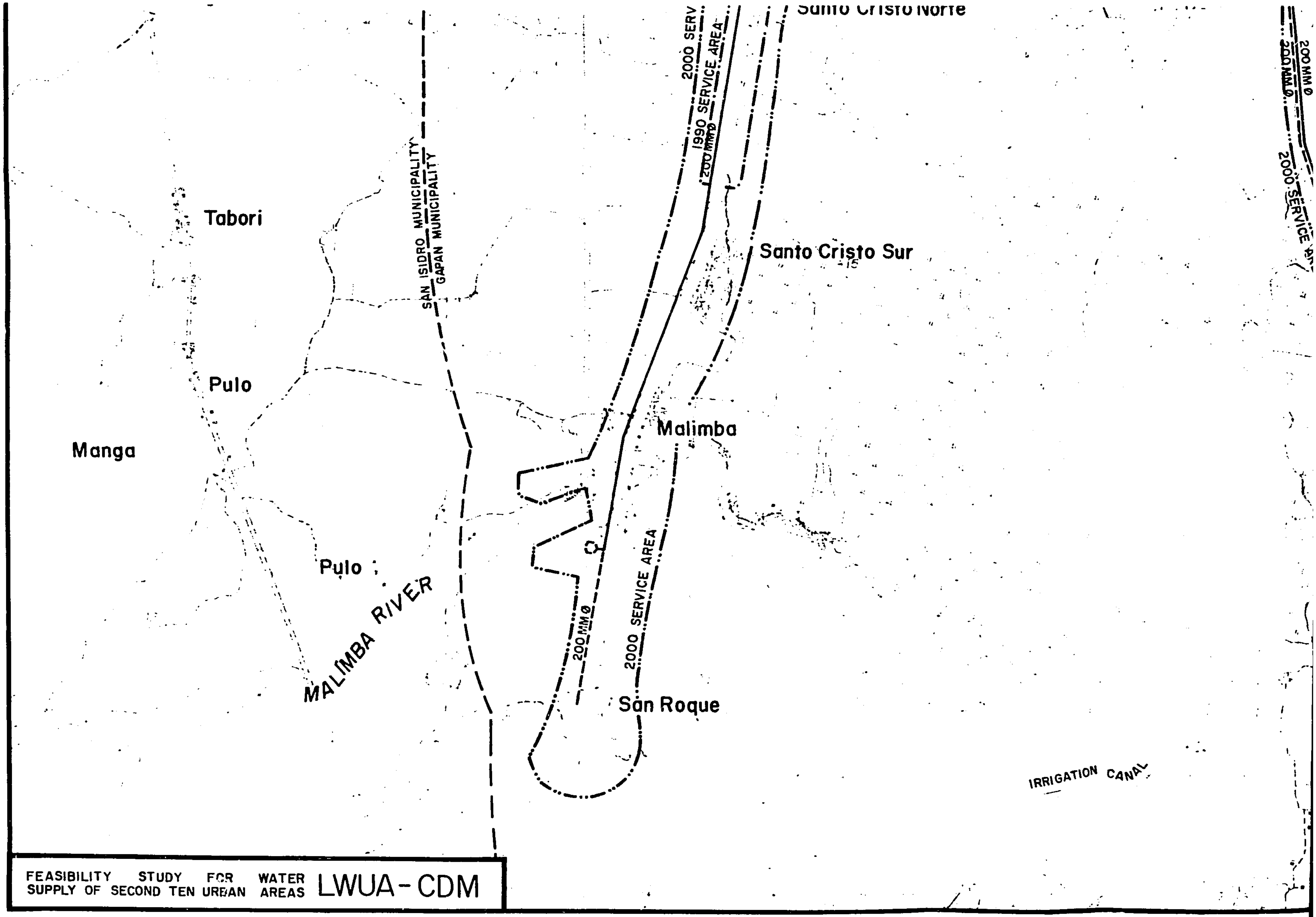
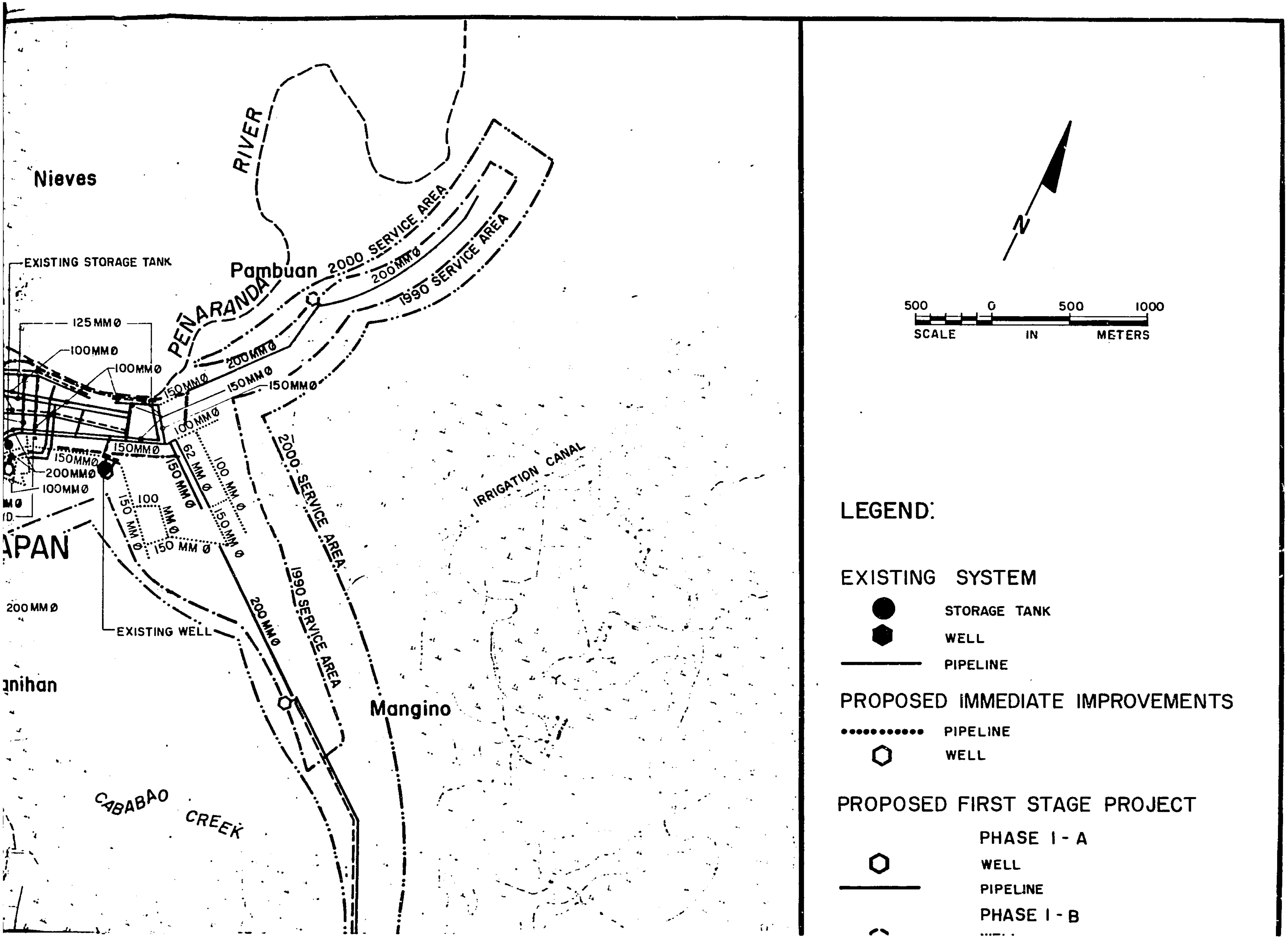


FIGURE MM6-3
TYPICAL FLOW VARIATION
FOR DISTRIBUTION MAINS


Alva
PAMPANGA RIVER
2000 SERVICE AREA
1980 SERVICE AREA
Nieves
Castellano
SAN ISIDRO
200 MM Ø
SAN LEONARDO MUNICIPALITY
EXISTING STORAGE TANK
Malapit
PRESENT SERVICE AREA
100 MM Ø
150 MM Ø
200 MM Ø
125 MM Ø
San Nicolas
G.W.D.
GAPAN
PRESENT SERVICE AREA
EXISTIN
Bayanihan
CABABAO
Balita
Manga



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



Nieves
RIVER
EXISTING STORAGE TANK
Pambuan
PEÑARANDA
2000 SERVICE AREA
200 MMØ
1990 SERVICE AREA
125 MMØ
100MMØ
100MMØ
200MMØ
150MMØ
150MMØ
150MMØ
100 MMØ
150MMØ
150MMØ
200MMØ
100MMØ
62 MM Ø
100 MM Ø
150 MM Ø
150 MM Ø
100 MM Ø
150 MM Ø
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200 MMØ
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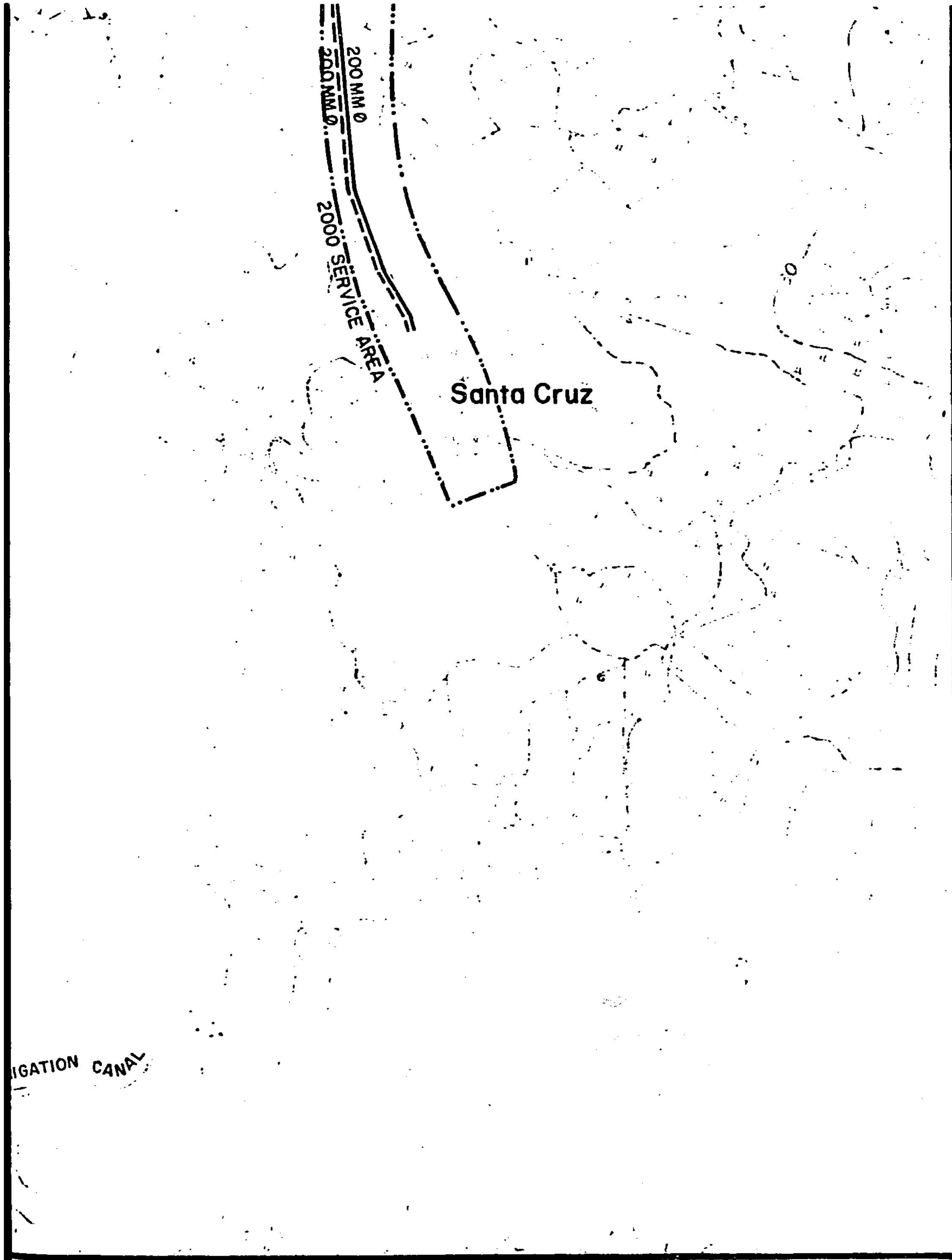
EXISTING WELL
2000 SERVICE AREA
1990 SERVICE AREA
IRRIGATION CANAL
Mangino
CABABAO CREEK
N
500 0 500 1000
SCALE IN METERS
LEGEND:
EXISTING SYSTEM
STORAGE TANK
WELL
PIPELINE
PROPOSED IMMEDIATE IMPROVEMENTS
PIPELINE
WELL
PROPOSED FIRST STAGE PROJECT
PHASE I - A
WELL
PIPELINE
PHASE I - B



PIPELINE

PROPOSED SECOND STAGE PROJECT

PHASE II-A

WELL

PIPELINE

PHASE II-B

WELL

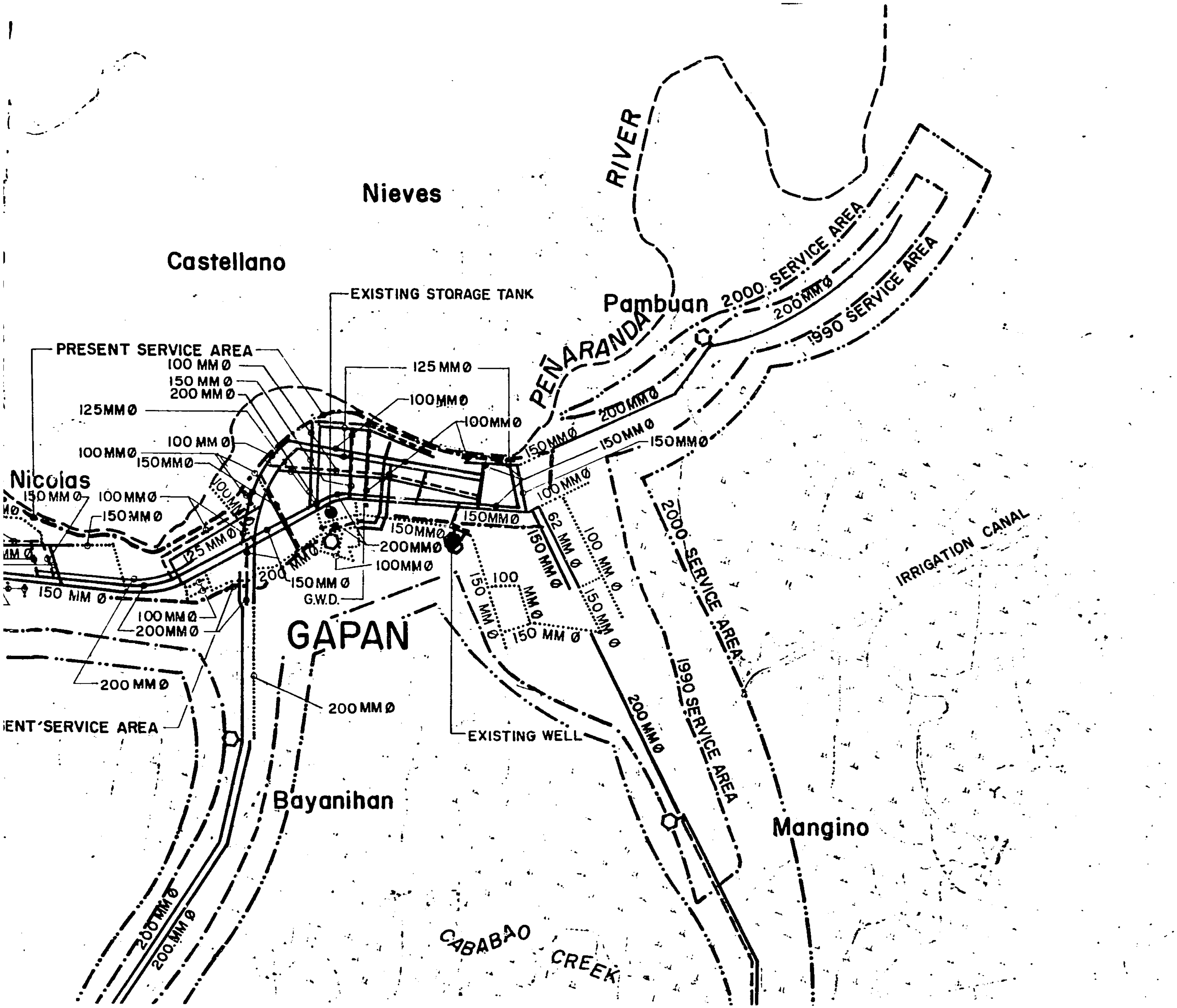
PIPELINE

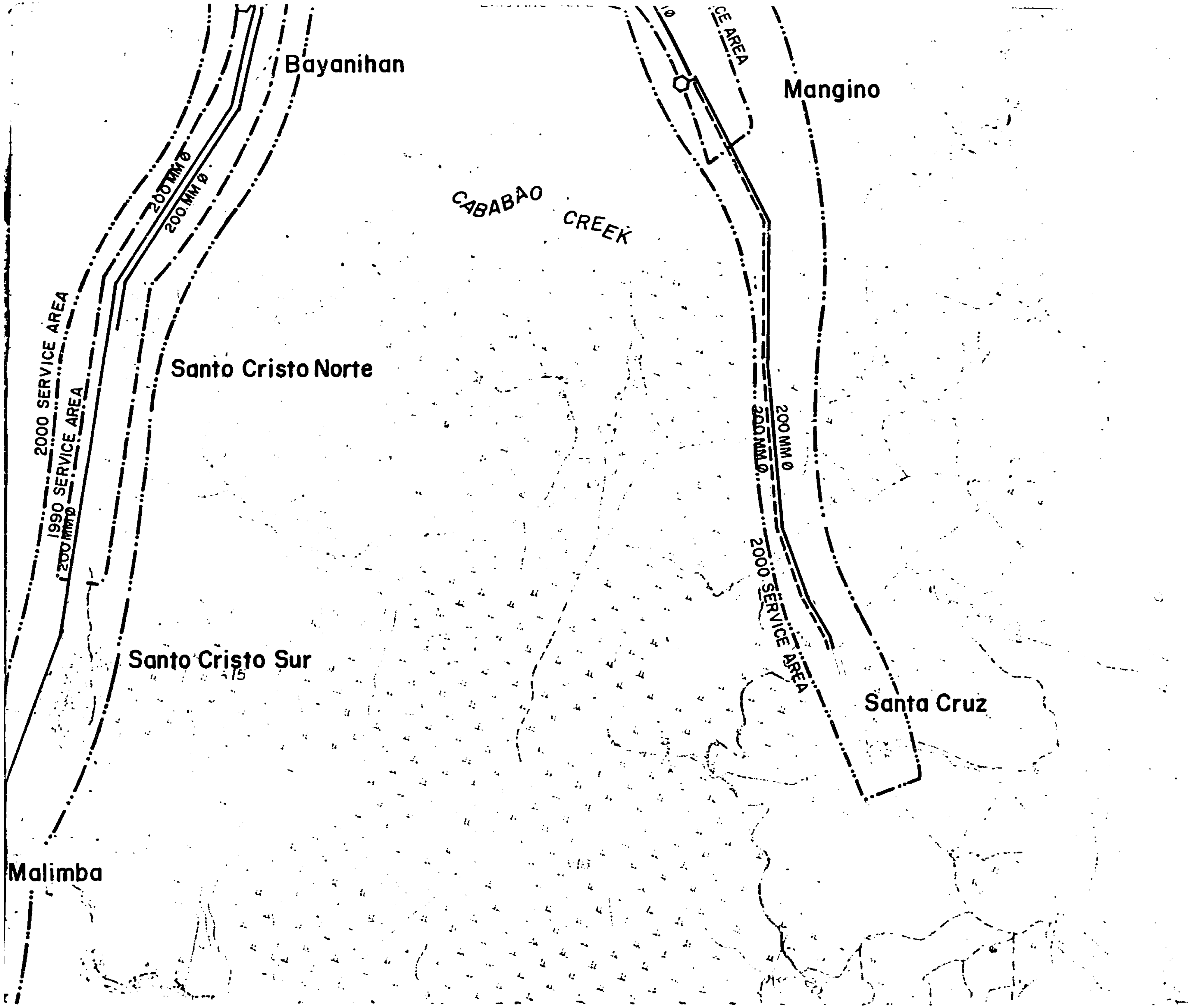
FIGURE IX-1

WATER SUPPLY SOURCE
TRANSMISSION AND DISTRIBUTION SYSTEM
MAP SHOWING

EXISTING FACILITIES
RECOMMENDED STAGE I FACILITIES
RECOMMENDED STAGE II FACILITIES

GAPAN WATER DISTRICT


Nieves
Castellano
RIVER
Pambuan
PEÑARANDA
2000 SERVICE AREA
1990 SERVICE AREA
200 MM Ø
EXISTING STORAGE TANK
PRESENT SERVICE AREA
100 MM Ø
150 MM Ø
200 MM Ø
125 MM Ø
100 MM Ø
150 MM Ø
Nicolas
125 MM Ø
150 MM Ø
150 MM Ø
200 MM Ø
100 MM Ø
G.W.D.
62 MM Ø
GAPAN
IRRIGATION CANAL
ENT SERVICE AREA
EXISTING WELL
Bayanihan
Mangino
CABABAO CREEK


Bayanihan
Mangino
CABABAO CREEK
200 MM Ø
200 MM Ø
2000 SERVICE AREA
1990 SERVICE AREA
200 MM Ø
Santo Cristo Norte
200 MM Ø
200 MM Ø
2000 SERVICE AREA
CE AREA
Santo Cristo Sur
Santa Cruz
Malimba