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REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF HOUSING BUILDING
PLANNING AND URBAN DEVELOPMENT (CIPTA KARYA)

MEDAN URBAN DEVELOPMENT, HOUSING,
WATER SUPPLY AND SANITATION PROJECT

VOLUME V

MASTER PLAN AND FIRST STAGE PROGRAM FOR WATER SUPPLY AND SANITATION

PART 1- MASTER PLAN AND FIRST STAGE PROGRAM FOR WATER SUPPLY

OCTOBER 1980

ENGINEERING-SCIENCE, INC.
SINOTECH ENGINEERING CONSULTANTS, INC.
A JOINT VENTURE
in association with
PADCO and P.T. DACREA

PREFACE

The feasibility reports emanating from the Medan Urban Development, Housing, Water Supply and Sanitation Project were submitted in draft form to the Government of Indonesia (GOI) in February 1980. These reports, together with the earlier master plan reports, were reviewed by GOI in July 1980 and discussed with the Consultant at a series of meetings at that time. The outcome of this review process was that certain changes in content and format were agreed. These changes have been incorporated into the final printed reports.

A result of adopting the new guidelines provided by GOI is that differences occur between the Repelita III investments proposed in the master plan studies and those contained in the first stage program recommendations. The latter incorporate the final adjustments and represent the recommended program for Repelita III.

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ORGANIZATION OF PROJECT REPORTS

The results of investigations carried out in connection with the Medan Urban Development, Housing, Water Supply and Sanitation Project are contained in the following series of reports:

Inception Report for Long Term Urban Development Plan and Feasbility Study on First Stage Housing Development Project

Volume I	Summary
Volume II	Interim Strategic Plan and Feasibility Study
Volume III	Long Range Urban Development Plan
Volume IV	Housing Development Program
	Part 1 - Housing Development Situation and Strategy
	Part 2 - Kampung Improvement Program
	Part 3 - Sites and Services / Low Cost Housing Program
Volume V	Master Plan and First Stage Program for Water Supply and Sanitation
	Part 1 - Master Plan and First Stage Program for Water Supply
	Part 2 - Master Plan and First Stage Program for Wastewater
	Part 3 - Master Plan and First Stage Program for Drainage
	Part 4 - Master Plan and First Stage Program for Solid Wastes

Note: Parts 1-3 of Volume IV and Parts 1-4 of Volume V are bound as separate report volumes. Appendices to Part 1, Volume V are also bound separately.

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LIST OF ABBREVIATIONS

ORGANIZATIONS

ADB	Asian Development Bank
DKKP	Medan Solid Waste Management Department
KIP	Kampung Improvement Program
LCH	Low Cost Housing
MUDS	Mudan Urban Development Study
SSCH	Sites and Services and Core Housing
UNDP	United States Development Program
USAID	United States Agency for International Development

TECHNICAL

mm	millimetre
m	metre
km	kilometre
sq m	square metre
ha	hectare
sq km	square kilometre
l	litre
cu m	cubic metre
s	second
min	minute
d	day
y	year
m/s	metres per second
l/min	litres per minute
cu m/s	cubic metres per second
cu m/d	cubic metres per day
mg/l	milligrams per litre
l/c.d	litres per capita per day
mg	milligram
g	gram
kg	kilogram
t	tonne (metric)
BOD	5-day, biochemical oxygen demand
TDS	Total dissolved solids
ES	Electrical conductivity
TU	Turbidity units
DO	Dissolved oxygen
TDH	Total dynamic head
LS	Lump sum
ea	each
na	not available or not known
Rp	Indonesian Rupiah

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SECTION 1

INTRODUCTION

1.1 AUTHORIZATION

On 12 October 1978, an agreement was signed by the Government of Indonesia, Ministry of Public Works, Directorate General of Housing Building and Planning, and Engineering Science, Inc., for consulting services in connection with the Medan Urban Development Housing, Water Supply, and Sanitation Project. The project was financed under the terms of a loan to the Government of Indonesia from the United States of America Agency for International Development (AID loan no.497-T-G40, dated 28 July 1976). Engineering Science, Inc. and Sinotech Consultants, Inc. a joint venture, carried out the work in association with Planning and Development Collaborative International and P.T. Dacrea. Additional architectural expertise was provided to the Project from P.T. Perencana Jaya through subcontractual arrangement with P.T. Dacrea.

1.2 OBJECTIVES OF THE PROJECT

The long range objective of the Project is to assist the Government of Indonesia in directing the long-term urban development of Medan, particularly with regard to: (1) the construction of new and improvement of existing urban settlements within the context of the governments kampung improvement (KIP), sites and services and core housing (SSCH), and Low Cost Housing (LCH) programs; and, (2), improvement and expansion of water supply, sewerage, drainage, and solid waste disposal systems.

The immediate objective of the Project is to assist the Government in the preparation of a Long-Term Urban Development Plan for Medan up to the year 2000 and to assist the government in preparing a Feasibility Study for a First Stage Housing Development Project which will permit appropriate investment decisions.

The housing development Feasibility Study is aimed at assisting the Government, as part of the Long-Term Urban Development Plan, to formulate a well defined first stage housing development project which will be ready for investment decisions. The first stage housing project will be designed to achieve an optimum balance between the City's short-term needs on the one hand, and resources, local capability and socio-economic aspects on the other, with due consideration of financial and economic benefits.

Another major objective is to develop, as part of the overall urban improvement program for the City of Medan, long-range Master Plans through the year 2000 for water supply, wastewater, drainage and solid waste systems which will assist Government in the management, operation, and financing those systems.

Feasibility Studies for the first stage development of the Master Plan are to include economic and technical evaluations of projects suitable and complete enough in detail to enable a consultant to proceed directly into final design and thereby allow the Government to obtain construction financing from an international or bilateral lending agency such as the World Bank, the Asian Development Bank, or AID.

1.3 SCOPE OF WORK

The scope of work is divided into five major components as follows:

1. Preparation of a long term urban development plan.

2. Preparation of a feasibility study for housing development projects including a Kampung Improvement Programme and a Sites and Services and Low Cost Housing Scheme.

3. Develop long-range Master Plans for water supply, wastewater, drainage and solid wastes systems in the study area through the year 2000.

4. Prepare First Stage Feasibility Studies for water supply, wastewater, drainage and solid wastes systems to meet needs through the year 1990.

5. Carry out detailed engineering for the first stage Sites and Services Scheme and the Low Cost Housing Scheme.

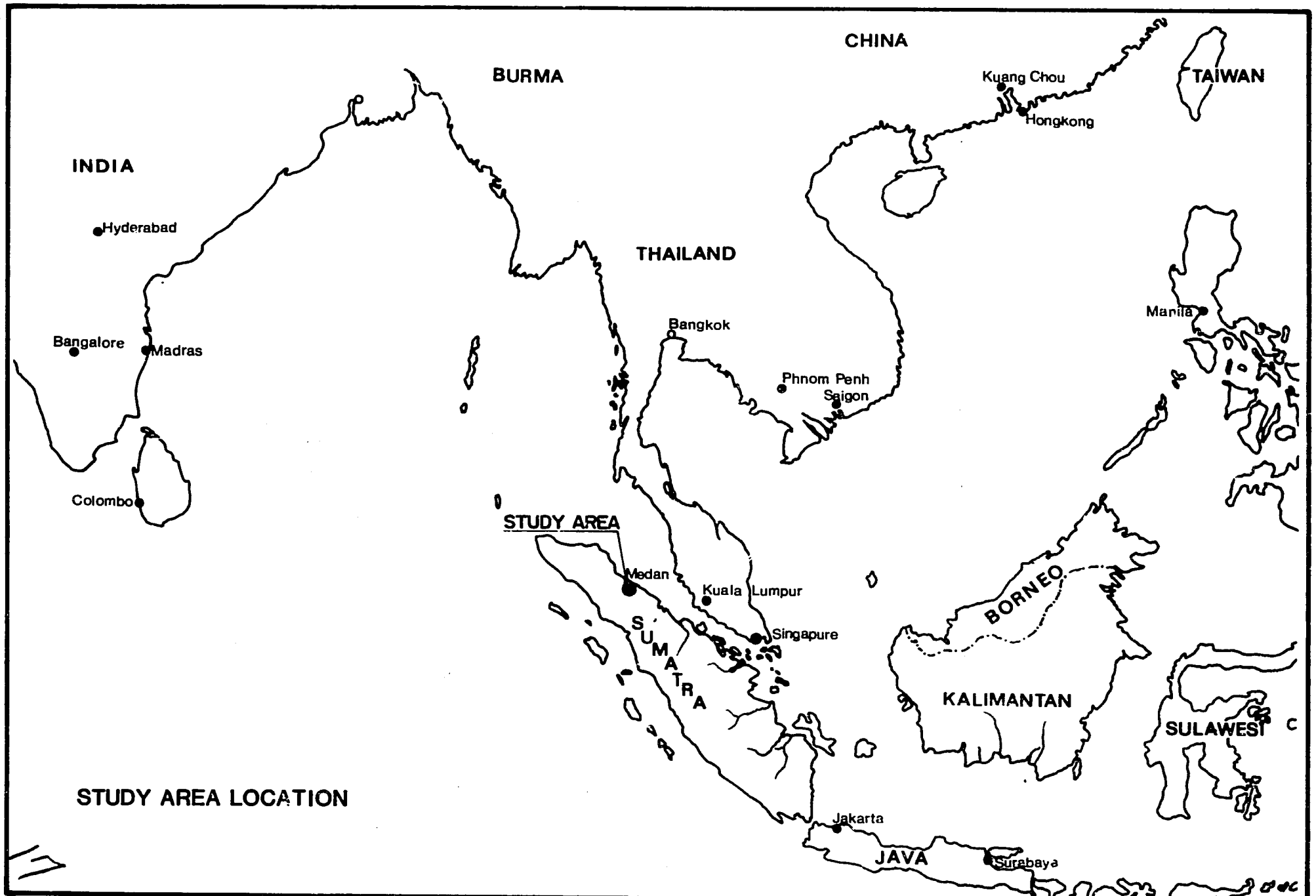
In addition, In-Service Professional Training Programs shall be conducted.

1.4 THE STUDY AREA

1.4.1 Description

Medan is located on the coastal plain of North Sumatra between the Malacca Straits and a range of volcanic mountains which run roughly north-west to south-east throughout the island of Sumatra. Geographic proximity to the major neighbouring cities such as Kuala Lumpur and Singapore gives the city an international character in terms of trading business (see Figure 1.1).

Medan and Belawan port are the hub for an entire region which extends beyond the provincial boundaries of North Sumatra to include Aceh, Riau and parts of West Sumatra (see Figure 1.2).



STUDY AREA LOCATION

FIGURE 1.1

A great portion of the influence over such a vast area is attributable to Belawan port, the third largest port of the country, and the presence of an international airport. Medan has grown to become the centre of the region in terms of international trading, finance, business, employment opportunity, higher education and industrial development, as well as being the processing and distribution centre for products of the surrounding agricultural areas.

The city has a population of approximately 1.2 million people and is the fourth largest city in the country. The total land area of the city is 26,500 hectares, divided into eleven political districts called Kecamatans. Geographically, the urban form of the city is rather irregular. Urban development has occurred mainly around the central area of Medan. Except in the oldest portions of the city, housing is primarily single storey and of relatively low density. In the oldest portion of the city, densities are much higher, consisting largely of three or four storey walk-up flats, with shops and businesses located on the ground floor. Growth trends are visible outside the city boundaries with village development parallelling the banks of rivers. Rivers and railroad alignments contain a small amount of high density informal housing for very low income groups. The rest of the city's area is made up of agricultural land, including tobacco and coconut plantations, rice paddie and swamp.

1.4.2 Topography

The study area lies between sea level and about 55 metres above sea level, on the northern end of regional basins which continue upward to the crest of the Barisan range (2000 metres in elevation) near Brastagi, 60 kilometres to the south. General contours for the study area are presented in Figure 1.3.

The northern end of the study area is in a coastal tidal zone which lies below 2.5 metres elevation. This zone is about seven kilometres wide in a north-south direction. The coastal plain lies above the zone of tidal influence and extends for about eight kilometres up to about 15 metres elevation. The plain is relatively low, poorly drained ground.

Above 15 metres elevation, the land is better drained and underlain by consolidated bedrock or more developed soils. This portion of the study area covers a zone about 12 kilometres wide (north-south) between 15 and 35 metres elevation. South of Medan, the land begins to rise as a series of low hills followed by broad ridges. From about 70 metres elevation, the hills and ridges gradually narrow and the flat valley floors shrink. At 300 metres elevation, the terrain consists of steep slopes between ridges and streams. This terrain has occasional broad ridges, particularly above 700 metres. The ridges and peaks of the Barisan Mountains separate the Belawan-Deli-Percut basin from the Brastagi basin.

Relief and gradients within the study area are generally small although some steep slopes of 5 to 10 percent may be found along rivers and low ridges on the southern margin of the study area. Most slopes

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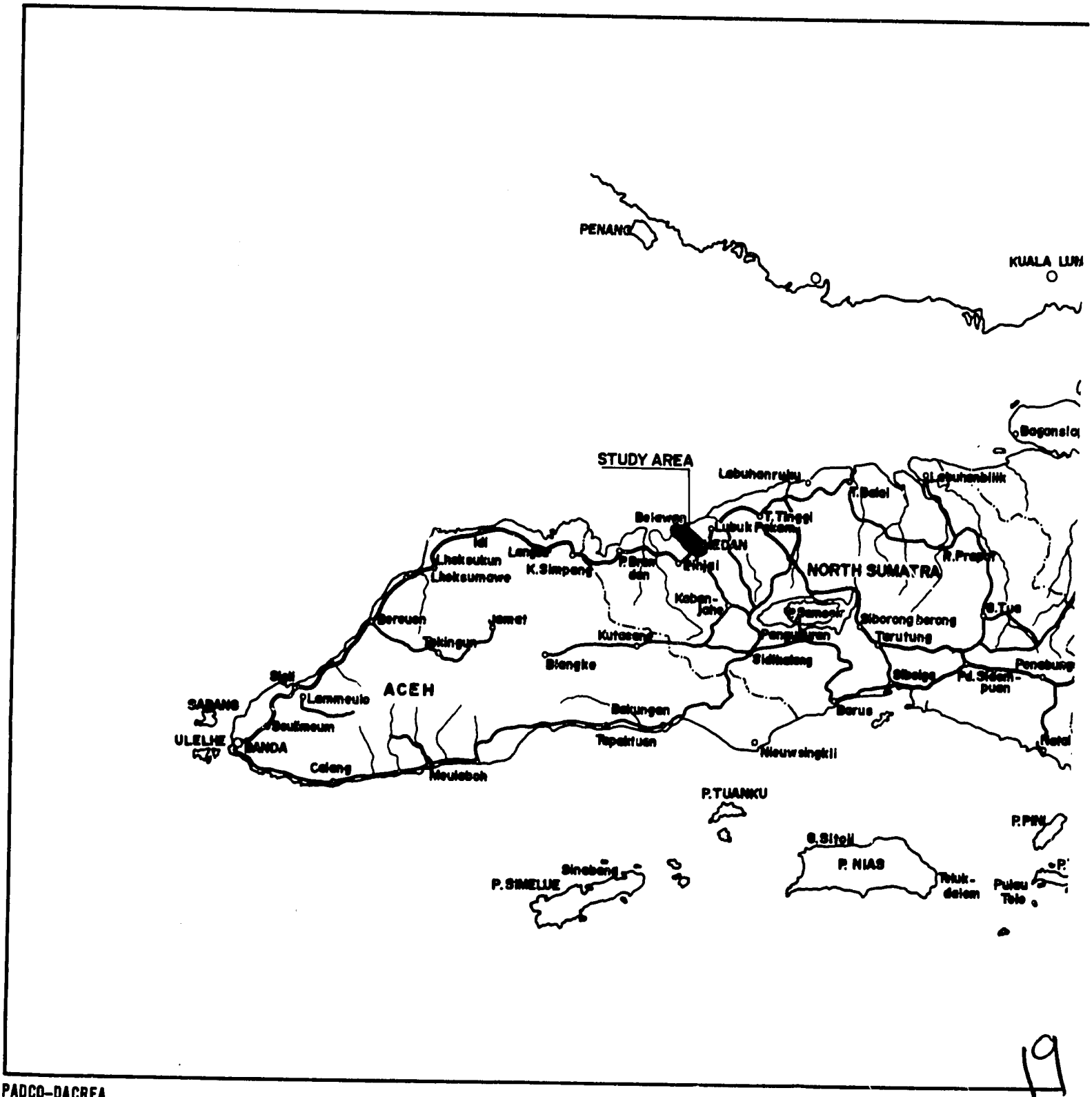

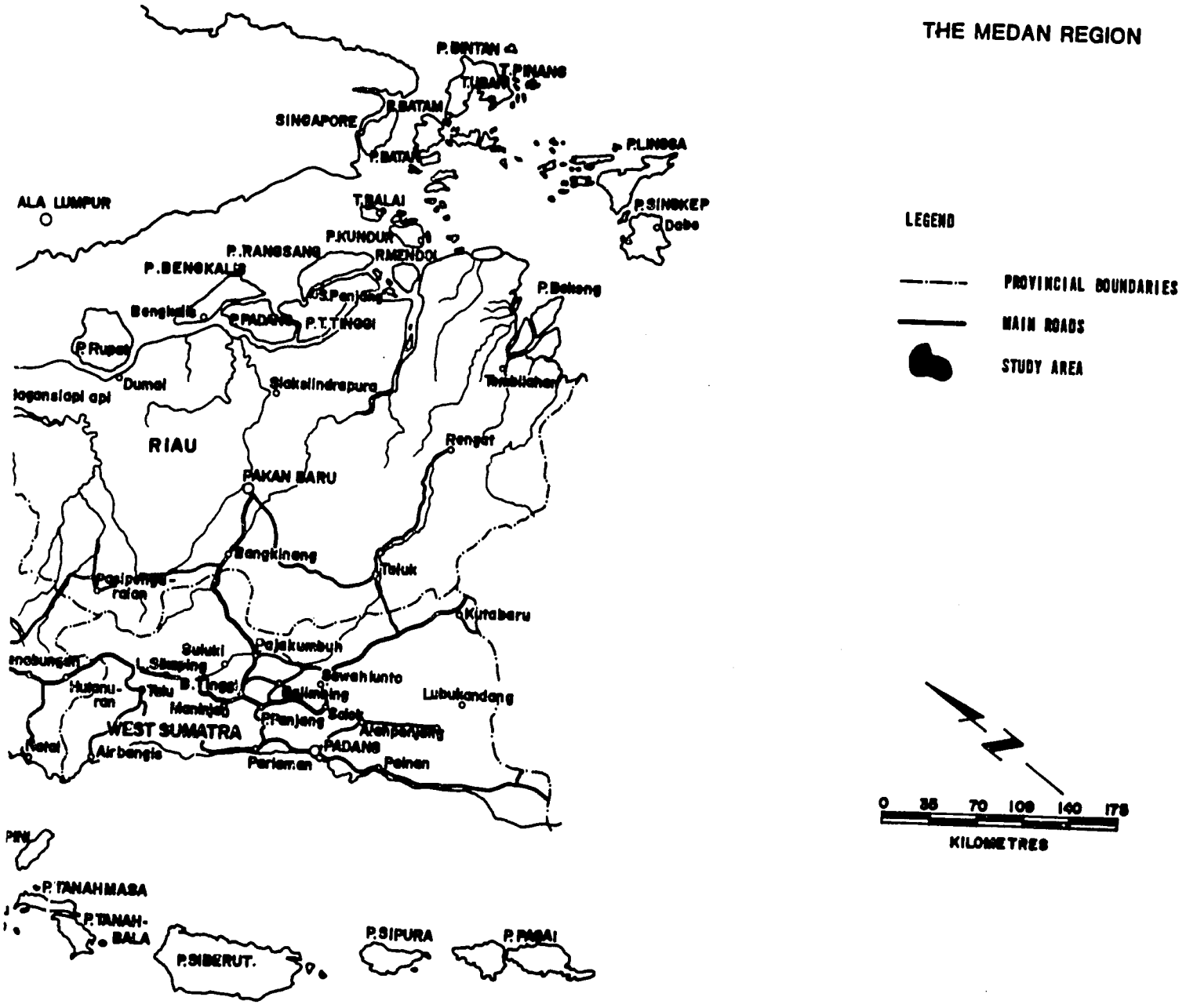

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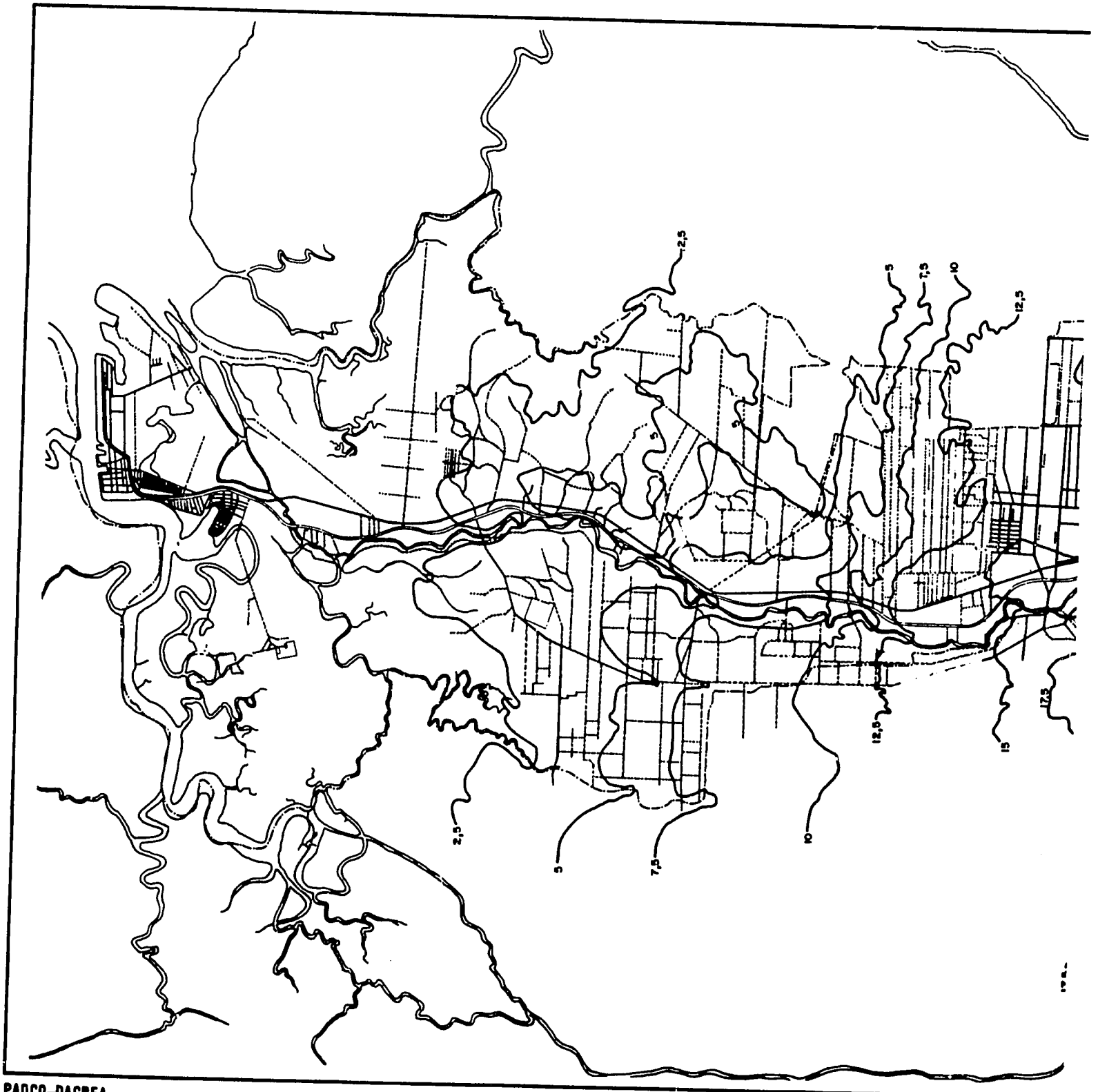

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FIGURE

GENERALIZED CONTOUR MAP
OF
THE STUDY AREA

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and river gradients are less than 0.4 percent within heavily urbanized areas and 0.1 to 0.2 percent in the coastal plain and tidal zones. Interpretations of 2.5 metre contour maps indicate somewhat steeper slopes on the east side of the Deli between 5 and 12.5 metres elevation and between 15 and 25 metres elevation. Numerous benches (wide, relatively gentle terrain) are located in the southwestern and southeastern sectors of the study area above 25 metres while very small benches lie among the steep valley and ravines in the south central sector. Above 50 metres elevation, wide ridges or benches are separated from the lower benches but many of these join in the Belawan River valley in the southwestern sector.

1.4.3 Climate

The equatorial location and low elevation of Medan largely determines the tropical climate of the region. Although rainfall, temperatures and sunshine show some seasonal periods, these seasons are not as distinctly marked as in Java and many other areas of Asia. Two rainy periods occur during the fall and spring rather than during the more typical "monsoon" seasons which occur over much of Asia. These rainy periods closely resemble those in southern India, Sri Lanka, and Equatorial Africa. Medan rainfall has been recorded since 1879 at three stations. During the period of record annual rainfall has varied from 1,352 to 2,873 mm with 10 percent of the years having rainfall above 2,400 mm and 10 percent below 1,600 mm. About 80 percent of the annual rainfall ranged from 2,000 to 2,400 mm, and the average annual rainfall for 40 years was about 2,050 mm. Distribution of rainfall throughout the year shows two high rain months: October and May, although the longer "rainy season" extends from September to January. Eighty percent of the months have rainfall between 60 and 300 mm, while about sixty percent have rainfalls of 300 to 400 mm.

Long-term rainfall data for Medan indicated only three days with 250 to 290 mm of rain in 24 hours. Although these storms occurred in December or January, they occurred at widely different years: 1907, 1937, and 1956, and these storms coincide with high monthly rainfalls but not with highest rainfall years. Such scattered temporal distribution indicates that the storms were of limited areal extent and period and that rainfall quickly decreased beyond the intense centre of rainfall.

Diurnal rainfall data shows a strong tendency towards afternoon and night rains and relatively dry morning periods. Records indicate that periods of 6 to 12 hours separate the rainy periods of each day and thereby allow runoff to occur before the next day's rains.

1.4.4 Soils

Soil type and relatively high groundwater levels have strongly influenced urban growth patterns and agricultural land uses in the study area. The general distribution of soils and groundwater tables may be separated into three zones: (1) coastal tidal zone; (2) coastal plain; and, (3), piedmont. Within the coastal tidal zone, alluvial

soils are generally rich in organic material and clay and the water table is at or close to the ground surface.

Along the major rivers, some alluvial sands and gravels may be found and the water table is usually at the same level as the river. On the coastal plain, soils have developed on older alluvial deposits which are higher and somewhat coarser than those in the coastal tidal zone. Better drainage allows the water table to drop to about 1.5 metres below ground surface, although localized water tables may be higher due to poor local drainage.

The highly organic and fine-grained sediments in the tidal zone requires substantial filling and extra foundation work in order to develop even the simplest structural uses. Some long-term subsidence or differential settlement could be expected even with special foundation preparations. Most organic and fine-grained sediments and high soil moisture content form corrosive acid conditions with a high sulphate content.

Within the study area and general vicinity, eight different soil types in five elevation zones have been identified. In the coastal tidal zone, two alluvial soils are recognized: (1) grey humus soil of clay and grey alluvium phases and; (2), grey hydromorph soils. The grey, brown and yellow-brown regosol and grey hydromorphic soils are most common on the coastal plains and lower hills. A brown andosol on pre-Toba and a brown podosol on Toba volcanics extends from the Percut River to the north and south. Above the study area, a brown podosol extends from about 150 metres up to 400 metres, where it is replaced by a brown andosol developed on the volcanics which form the source for the Sibolangit springs. High moisture content increases the acidity in the clay soils and sediment derived from acid-volcanic bedrock. All soils are acidic and many are highly acidic; some have a high hydrogen sulfide content and are corrosive.

1.5 REGIONAL WATER RESOURCES

Northern North Sumatra contains a large number of perennial rivers and large springs, and groundwater aquifers underlie the coastal plains. Rainfall is evenly distributed through the year. River flows show little fluctuation during the year, although runoff rates tend to increase in October and January. Water quality in all sources is generally acceptalbe for potable supply given appropriate treatment and disinfection. Surface waters within and downstream from urban centers such as Medan, Binjei, Tanjung Morawa, and Lubuk Pakam are grossly polluted. There is some evidence of groundwater pollution in shallow aquifers underlying heavily populated areas.

1.5.1 Rivers

There are several rivers within the study area, all of which flow into the straits of Malacca: The Deli, Percut, Belawan, Bedra and Kera Rivers. In addition, the Deli river has two major tributaries, the Babura and the Sikambing. The most important rivers for the purposes of this investigation are the Deli, Percut, and Belawan and tributaries of the Deli.

The Deli river catchment basin covers an area of 390 sq km, and has a total length of 80 km of which 42 km lies within the study area. The headwaters of the Deli are in mountainous areas where the slopes of river channels are 6 to 18 percent. Downstream where the river bed is 300 metres above mean sea level, the slope decreases to 0.5 to 1.0 percent. Below the city of Medan the river channel slope decreases to 0.1 percent. The Babura has slopes of 0.5 to 1.0 percent and the Sikambing tributary has slopes ranging from 0.1 to 0.5 percent.

The Belawan river catchment basin is somewhat smaller than the Deli, with a 270 sq km catchment area and a 66 km length, of which 26 km are within the study area. The Percut river is the smallest; its catchment basin covering 210 sq km with a total length of 78 km, of which only 8 km are within the study area.

The flows of these rivers vary substantially between low and high flows. Actual measurements are not available as to high flows and the historical data for low flows on the Deli and Belawan rivers is extremely limited.

The major rivers of interest outside of the study area are the Wampu and Ular, located about 30 kilometres west and east of Medan, respectively. Both of these rivers have drainage areas and flows far larger than any rivers flowing through the study area.

1.5.2 Springs

The earliest municipal water supply in Medan was obtained from natural springs and seeps in the vicinity of Sibolangit and Sembahe, about 40 km south of Medan. Three other significant springs are located in the hills south of Medan, 20 to 40 km away from the city center. Estimated total flow from the springs at Sibolangit is 80,000 - 90,000 cu m/d. Unused flows from the springs pass into the Binjei, Belawan, Deli, and Belumai rivers.

1.5.3 Groundwater

Groundwater resources in the study area provide flows to the springs and much of the low flows in rivers and appear to underlie the entire study area. Significant deep groundwater production was begun in the Medan area in the 1880's in order to provide safe potable sources for the Belawan port. Three groundwater aquifers can be identified in the Study Area: (1) the shallow groundwater table; (2) an intermediate zone; and, (3), a deep aquifer at about 200 m below surface. The shallow groundwater table is unsuitable for large scale municipal water supply, but the intermediate and deep aquifers may represent a substantial potential water resource. Shallow, hand-dug wells provide water for most people in the study area. Further study of the groundwater resources was undertaken in the Medan Groundwater Program. Results confirmed the geological context and the widespread potential of moderate production pumping from standard municipal production wells (see Appendix A).

SECTION 2

THE PRESENT WATER SUPPLY AND SANITATION SYSTEMS

2.1 WATER SUPPLY SYSTEM

2.1.1 The Municipal Water Supply System

The municipal water supply system is operated by PAM Tirtanadi, which was originally organized by the Dutch as a private water company in the early 1880's. In 1966, Tirtanadi become a Local Enterprise under Local Enterprise Law No.5. The Board of Directors of Tirtanadi is appointed by the government of the Province of North Sumatra, which has overall responsibility for all Local Enterprises.

2.1.1.1 Spring Supplies

The Medan Water Supply Scheme was begun in 1908 with water obtained from the springs at Sibolangit (Figure 2.1). The Rumah Sumbul source, consisting of 3 springs, was the first to be developed. Aeration is provided but not lime addition or chlorination due to the relative inaccessibility of the site. The Lau Bengklewang group (17 springs) was the next to be developed in 1912 with aeration; addition of lime was provided later around 1929. It is understood that 11 of these springs are now in operation. The fact that there has been no reduction in the amount of water supplied daily from this source indicates that the other 6 springs have not dried up as such but that the flow has merged, at some points further upstream, with the 11 that are now functioning. The third and final spring source, the Lau Kaban and Puangaja group consisting of 4 main springs was developed and commissioned in 1958 with treatment facilities being completed in 1968.

Water from the 3 groups of springs is transmitted to the city through three pipelines, the number varying at different points along the route. Input to the distribution system is at several points along the southern boundary of the city.

The springs are located on steep, sloping hillsides which are too far from any habitable area to be subject to contamination. The main infiltration units are arches of stone with open joints and are approximately 2 metres in diameter or smaller, dug into the hillside to distances of up to 20 metres. The bottoms of the arched sections are paved and slope into larger shallow paved basins from which water flows to the treatment facilities through cast iron collector pipes. The collector pipe diameters vary from 125 mm to 500 mm and a number are cement-lined.

Overflow arrangements divert the surplus water to natural water courses. One diversion is provided with a V-notch weir and gauge enabling the overflow to be measured. The whole unit is protected by a masonry foundation extending well above grade and earth cover has been laid to divert surface drainage. The springs are well constructed, with the danger of contamination reduced to a minimum.

Spring water quality measurements made between 1974 and 1978 are summarized in Table 2.1. The first stage of treatment is aeration, the purpose of which is presumably the removal or reduction of free carbon dioxide. The second step is the addition of a solution of lime. This treatment has resulted in an encrustation of lime in the transmission pipelines as thick as 20 mm in some places. This encrustation has reduced the capacity of the transmission lines.

The addition of lime is standard procedure for a corrosive water, i.e., a water that is undersaturated in calcium carbonate. However, the encrustation found in the pipes indicates that too much lime has been applied.

One measure of a water's tendency to dissolve or deposit calcium carbonate is the Langelier Saturation Index:

$$I_s = pH - pH_s$$

where I_s = the saturation index

pH = the pH of the water

pH_s = the saturation pH

If the index is negative, the water will dissolve calcium carbonate; if the index is positive, calcium carbonate will be deposited.

The saturation pH can be determined by calculation from a laboratory analysis of the water or empirically by saturating a sample of the water with pure calcium carbonate and measuring the pH. To calculate the saturation pH, a modified form of Langelier's equation can be used.

$$pH_s = 8.313 - \log [Ca^{++}] - \log [A] + S$$

where

pH_s = the saturation pH

Ca^{++} = the calcium concentration in me/l

A = the alkanity in me/l

$S = 2.5 \sqrt{\mu}/(1 + 5.3\sqrt{\mu} + 5.5\,\mu)$

$\mu = 2.5 \times 10^{-5}$ (total dissolved solids in mg/l)

If the extreme values for calcium, alkalinity, and total residue in Table 2.1 are used in this equation, the saturation pH is estimated to be from 7.8 to 8.5. The measured pH of the spring waters is between 6.1 and 7.2. Thus, the index would be negative and addition of some lime appears to be justified.

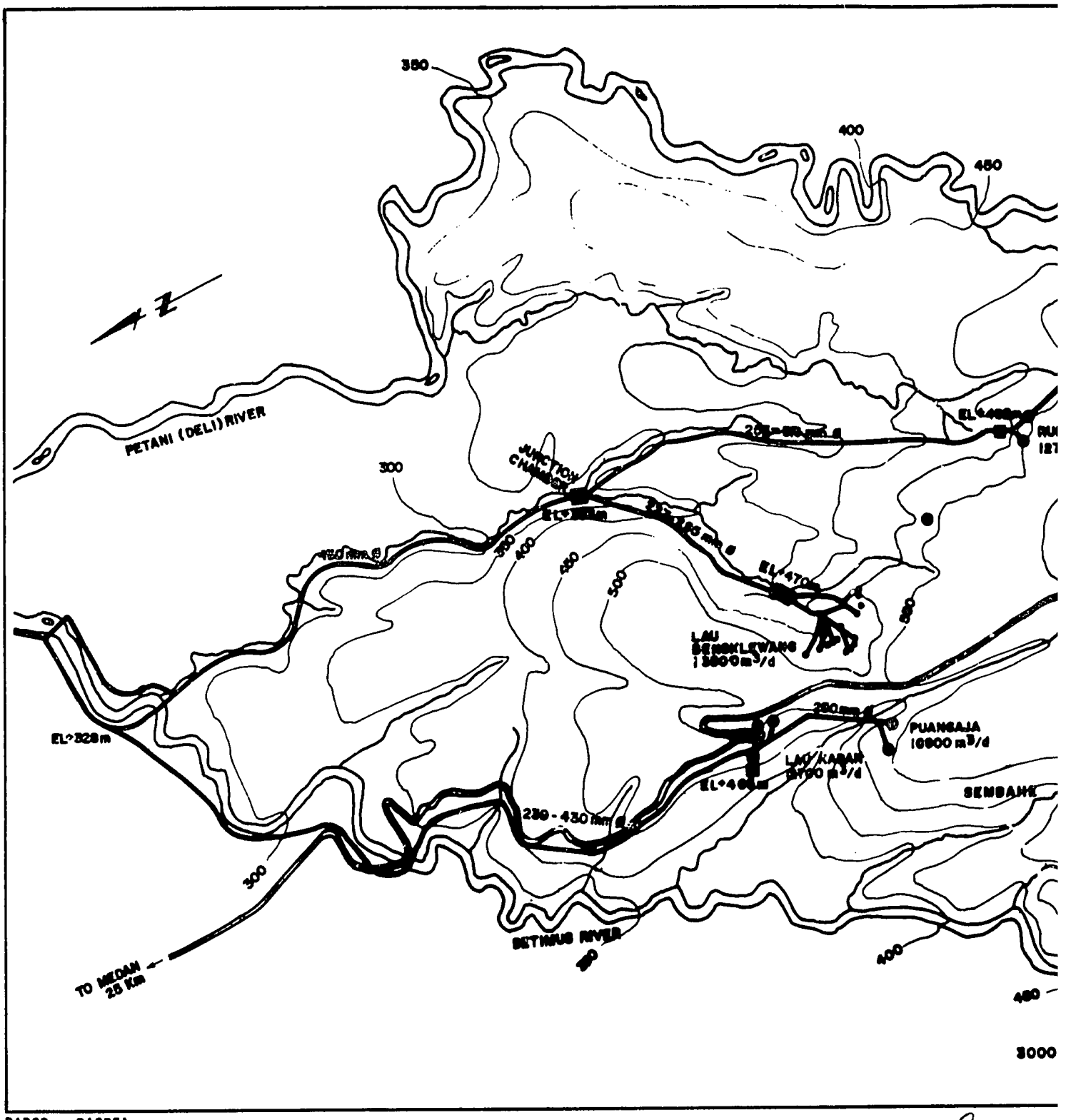

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FIGURE

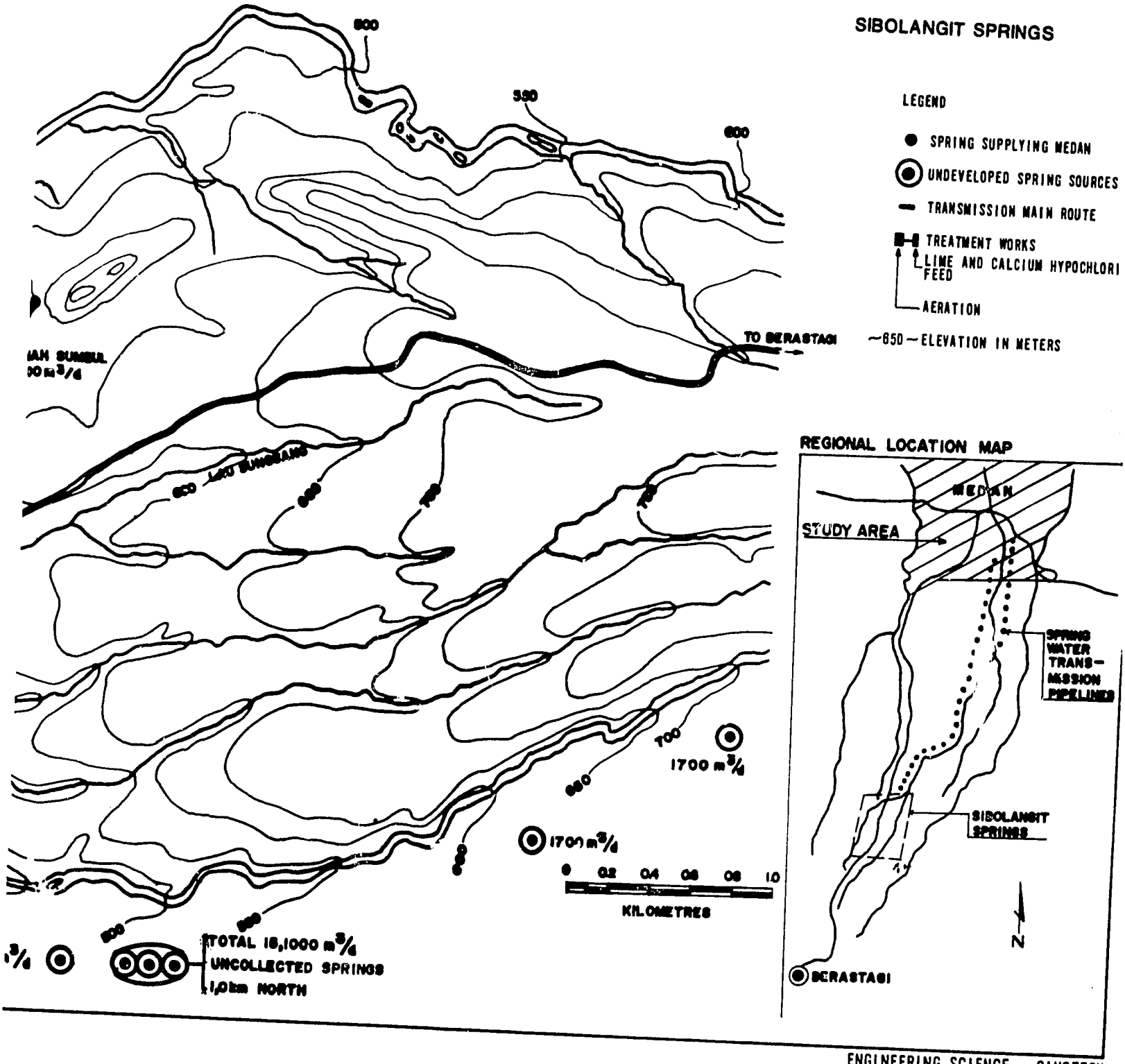

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TABLE 2.1

WATER QUALITY FROM SPRING SOURCES

Parameter	Unit	Rumah Sumbul		Lau Kaban		Lau Bengklewang	
		Raw Water	Aerated Water	Raw Water	Aerated Water	Raw Water	Aerated Water
Temperature	°C				23 - 24		
Turbidity	FTU				.01 - .15		
pH		6.1 - 6.2	6.9	6.2 - 6.3	6.7 - 7.2	6.3	6.9
Alkanity		-	-	-	50.5 - 78	-	-
Bicarbonate	mg/1	69 - 71	69	6.1 - 7.2	60 - 130	63	63
Carbonate	mg/1	N.D.	-	-	-	-	-
Total Residue	mg/1	205 - 226	227	203 - 210	210	223	221
Non Filterable residue	mg/1	1 - 2	1	1	1	1	2
Total Fixed residue		161 - 167	171	143 - 156	155	163	163
Carbon dioxide	mg/1	23.9 - 25.7	9	18.4 - 28.3	8.0 - 41.6	22.1	6.2
Total hardness	mg/1 CaC03	86 - 100	97	77 - 81	37.2 - 98.5	91	91
Calcium	mg/1	21.7 - 25 3	23.1	19.5 - 23.1	13.6 - 28.6	22.4	22.4
Magnesium	mg/1	7.9 - 9.2	9.2	5.7 - 7.0	5.1 - 11.0	8.8	8.8
Iron	mg/1	0.03	0.05	0.02	0.02	0.02	0.02
Manganese	mg/1	N.D.	N.D.	0.01	N.D.	N.D.	N.D.
Copper	mg/1	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Chloride	mg/1	12 - 14	13	11	9 - 7	13	13
Sulfate	mg/1	39 - 45	42	34 - 48	48	43	44
Silica	mg/1	52 - 56	52	56	56	52	52
Fluoride	mg/1	0	-	0.08	-	-	-
Mercury	mg/1	-	-	0.003	-	-	-
Conductivity	μ mho/cm	-	-	-	197.5 - 269.5	-	-

The proper amount to be added can be determined from laboratory tests of the relationships for the spring waters between calcium, alkanity, and pH. This should be done by Tirtanadi staff.

In any event, the addition of lime should be discontinued temporarily to reduce the encrustation in the pipes and increase their carrying capacity. After this has occurred, treatment with the proper lime dosage can be started.

Chlorination is done at Lau Bengklewang and the Lau Kaban and Puangaja groups of springs. According to the operators, no chlorination in done at the Rumah Sumbul group but this is not a serious problem as the water from the three groups of springs mix together over a long distance before it reaches the city, and the adjustment of chlorine dosages at the other two groups could easily compensate for lack of chlorination at the Rumah Sumbul group.

Chlorination is achieved by the addition of calcium hypochlorite. Facilities for the storage, mixing and addition of lime and calcium hypochlorite, a field chlorine and pH kit and a few other accessories are maintained at Sibolangit. Transporting chemical to the springs is difficult, but investigations have revealed no suitable alternative locations along the route of the transmission lines. A low-pressure point where chlorine could be administered without pumping is not available in the existing system. On the other hand, injection of chlorine solution is not feasible due to lack of electricity along the route. There appears to be no alternative to the present arrangements, at least for the present.

2.1.1.2 Sunggal Treatment Plant

The Sunggal Water Treatment Plant supplies about one-half of the total water demand of the city of Medan. Until summer, 1979, the production of the new section was consistently below expectation, producing about 39,000 cu m/d of the planned 52,000 cu m/d. Recent improvements to the pumping facilities have enabled the operators to force the full 52,000 cu m/d through the plant.

Phase No.1 was constructed nearly 10 years ago and commissioned in December 1970. Situated on the right bank of the Belawan River, it consists of the following works:

1. Dam and intake structure
2. Presettling tank
3. Raw water pumphouse and sump
4. Clearator
5. Set of six filters and a pipe and control gallery
6. Chemical house.

7. Filtered water pumphouse.

8. Filtered water tank.

9. Generator house.

In the second phase, another clearator, a filter gallery, and pumps were added and commissioned in December 1978. This represented about one-half of the originally planned second stage. Figures 2.2, 2.3, and 2.4 show the general layout, process diagram and hydraulic profiles of the plant, respectively.

The Sunggal Intake and Treatment Plant was designed (based on the description and manual of operations of the original plant) to be constructed in three phases, as follows:

Phase No.	Treated Water Capacity cu m/d
1	25,920
2	51,840
3	51,840
	129,600

Dam and Intake Structure: The dam has been constructed across the Belawan River leaving a narrow channel on the right bank, ending in a sluice gate. The raw water outlet channel takes off from this channel and the flow is controlled by another sluice gate immediately in front of which is a bar screen to prevent the entry of logs and other large material carried down by the river. The intake has been designed to provide sufficient water for all three phases.

Presettling Tank: From the intake, the raw water flows into the presettling tank through an open channel. The tank has been divided into two compartments with two separate inlets, each controlled by a sluice gate to facilitate cleaning. The retention time, with only Phase No.1 in operation, was 37 minutes and with the addition of Phase No.2 it is approximately 24 minutes.

Provision has been made for prechlorination of the raw water, when necessary, at a point between the intake and the presettling tank. A wire-mesh screen fixed a few feet upstream of the presettling tank prevents the entry of leaves and other floating debris that escape the bar screen. The presettling tank is expected to be cleaned, one compartment at a time, when sand and sediment piles up to a height of 60 cm. Cleaning, at present, is done once in two to three months. The presettling tanks have a capacity of approximately 700 cu m.

Raw Water Pump House: Presettled water flows through a covered channel to a raw water sump, 7 m deep, 2 m wide, and 36.5 m long. Originally, five horizontal axis centrifugal pumps were installed, each capable of pumping 6,900 cu m/d against a 15 m head. Four of these were sufficient to pump approximately 27,600 cu m/d of raw water with the fifth as a stand-by. When the second phase was implemented, three addi-

tional larger centrifugal pumps were provided, each having a capacity of 13,000 cu m/d against a 15 m head. Two of these operating simultaneously had a combined capacity of 26,000 cu m/d with the third as a stand-by.

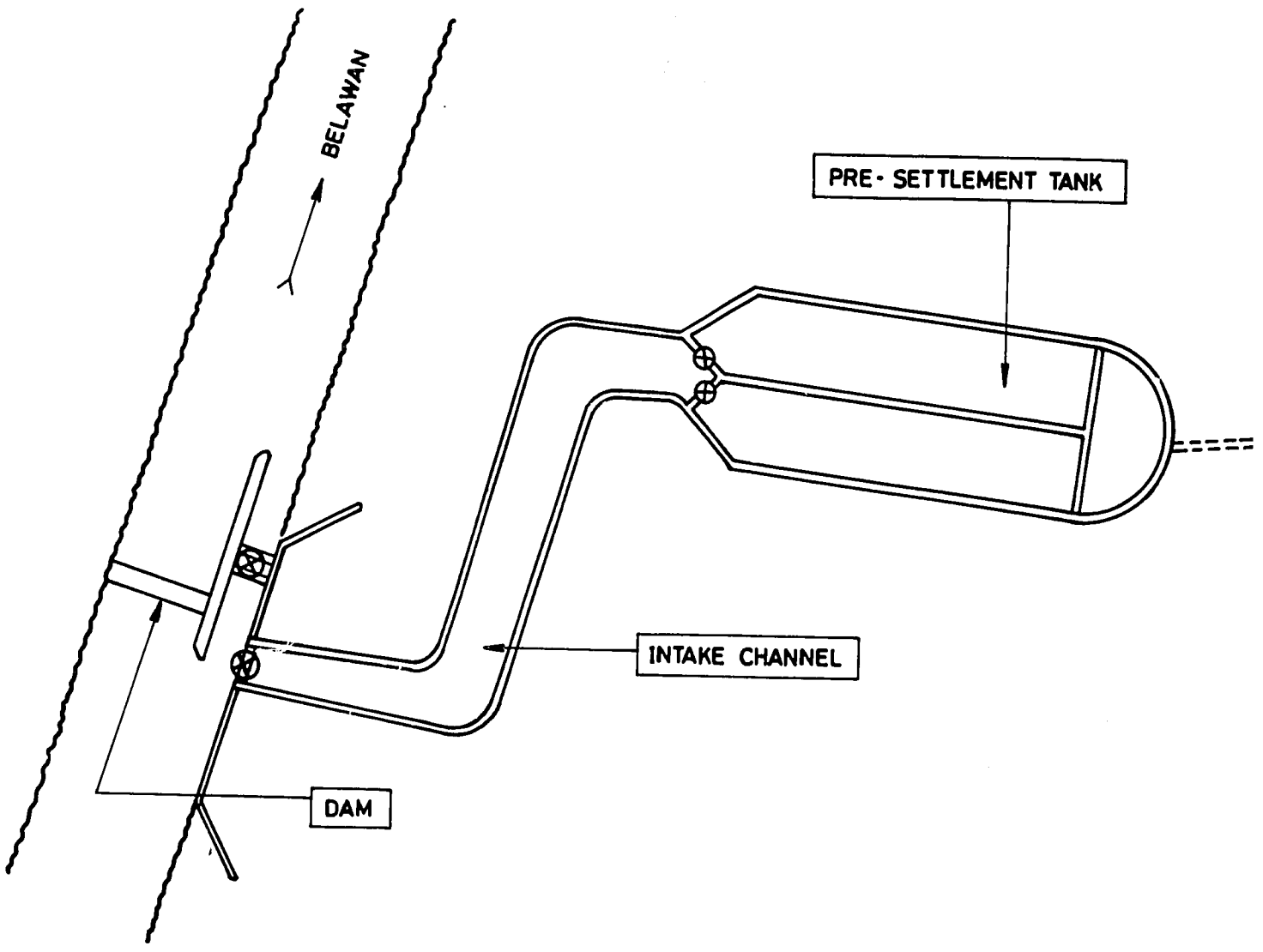
With the passage of time the performance of the five original pumps has deteriorated and now, almost invariably, all five pumps have to be operated together to give an adequate supply. In fact, there are times when all five old pumps and the three new ones are operated together for appreciable periods. Provision has been made in the raw water pump station for the installation of additional pumps which would increase the capacity of the raw water pump station to 83,000 cu m/d.

Clearators: The original clearator is an upward flow "accentrifloc" clarifier based on the original Peterson Candy International prototype. This clearator is continuously operated near its full capacity. The effluent obtained appears to be of fairly good quality, particularly in the mornings. The staff at Sunggal state that there is a marked deterioration in efficiency by afternoon, with the sludge blanket breaking up and large amounts of floc being carried over to the filters. They attribute this to the rise in temperature of the water. However, measurements of the temperature of the water, both at the surface and at reasonable depths, at the intake, presettling tanks, and clearators do not confirm this theory. It is not uncommon for convectional currents to be set up during the hotter parts of the day, but more careful operation of the concentrator is likely to improve the performance if regular attention is paid to this feature.

The second clearator was planned to be identical to the earlier one, with one exception. Though the main original structure was built with reinforced concrete, the internal compartments were made of steel. The second clearator has been constructed almost entirely of reinforced concrete. No detailed examination of the second clearator in an empty state was possible, but this should be done to identify any unintentional structural changes which might adversely affect performance. There is a fairly noticeable difference in the appearance of the coagulated and flocculated water in the central secondary reaction zones of the two clearators. The degree of flocculation appears to be different, and no stirring is visible. A smaller, different, or less effective type of agitator could be the cause. If so, an inexpensive modification might rectify the situation.

The overflow rate in the two clearators is 86 cu m/sq m/d and the upward rate of flow is 3.58 m/h for the design flow rate. Both these figures are acceptable for sludge blanket type upward flow clarifiers. The detention period at average flow is 1.66 hours, which is within the allowable limits for this type of clarifier.

Alum is used as the coagulant with soda ash (Na_2CO_3) as an auxiliary chemical. Both are added to the inlet pipe just before the raw water enters the primary reaction zone. Alum as a coagulant is generally most effective in the acid range of pH values from 4.0 to 7.0. In practice, a value of 6.5 is good. Analyses of the raw water of the Belawan River indicates that the pH value is above 7.1 almost all of the time.



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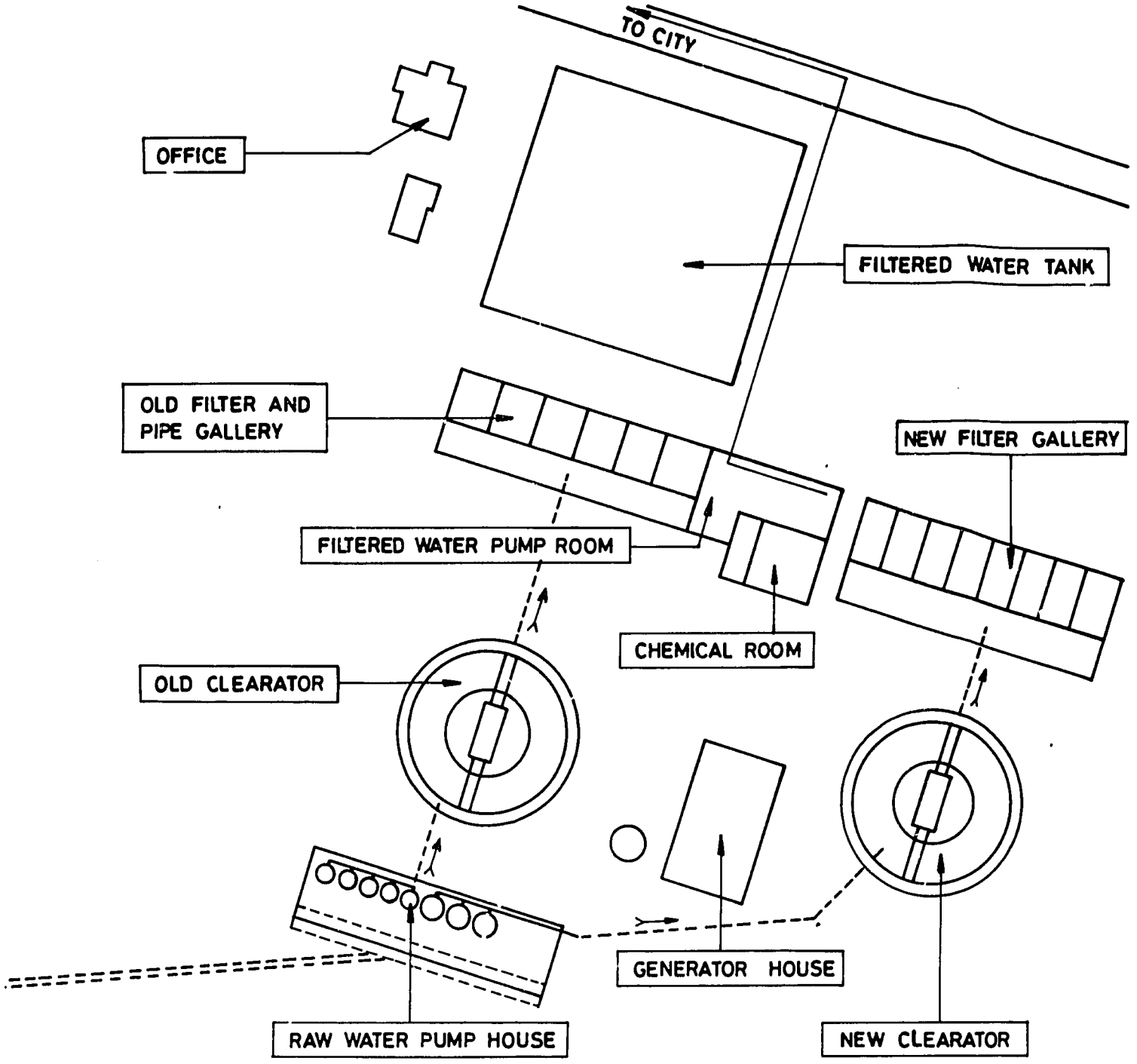

SUNGGAL WATER TREATMENT PLANT
GENERAL LAYOUT

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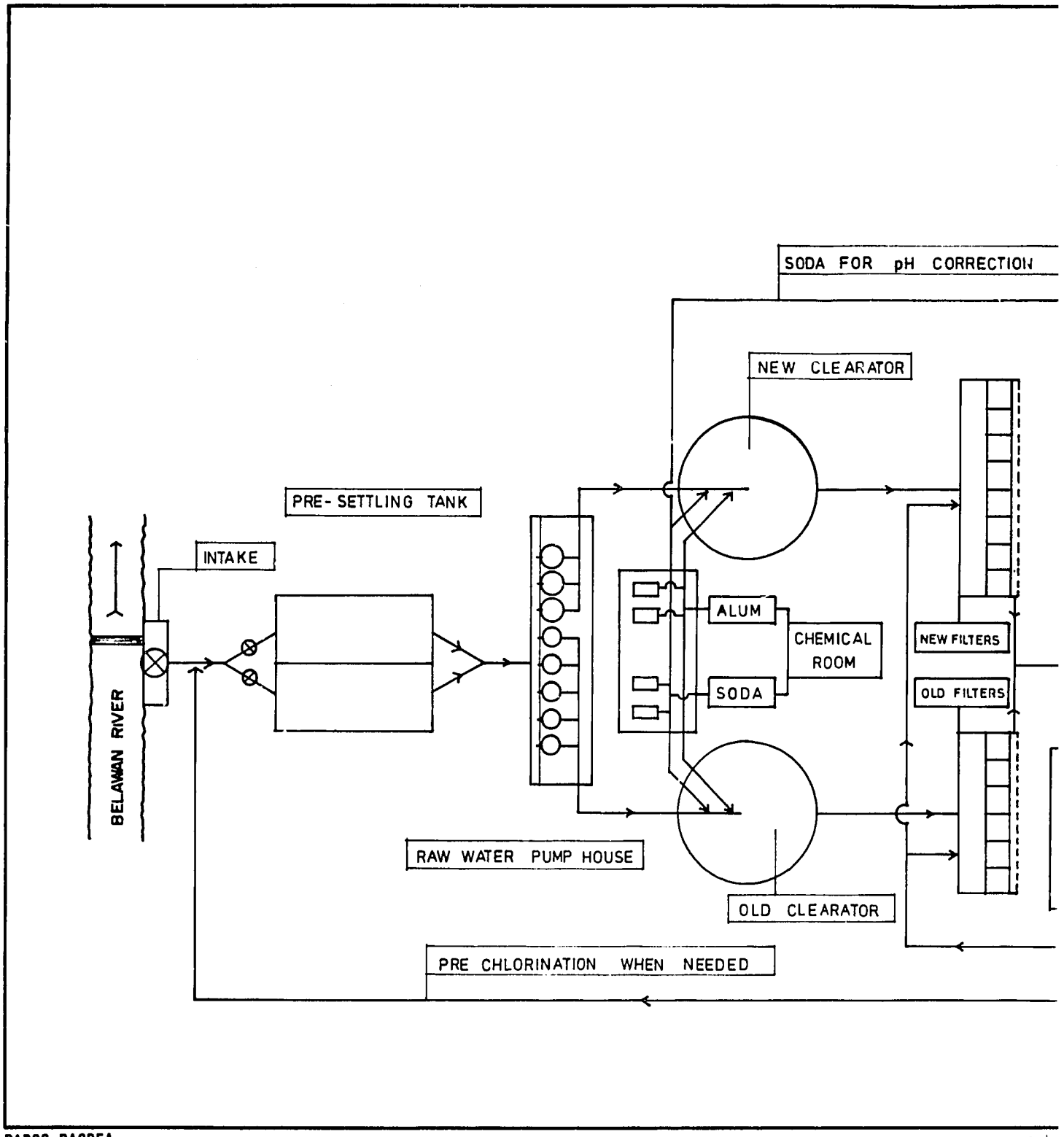

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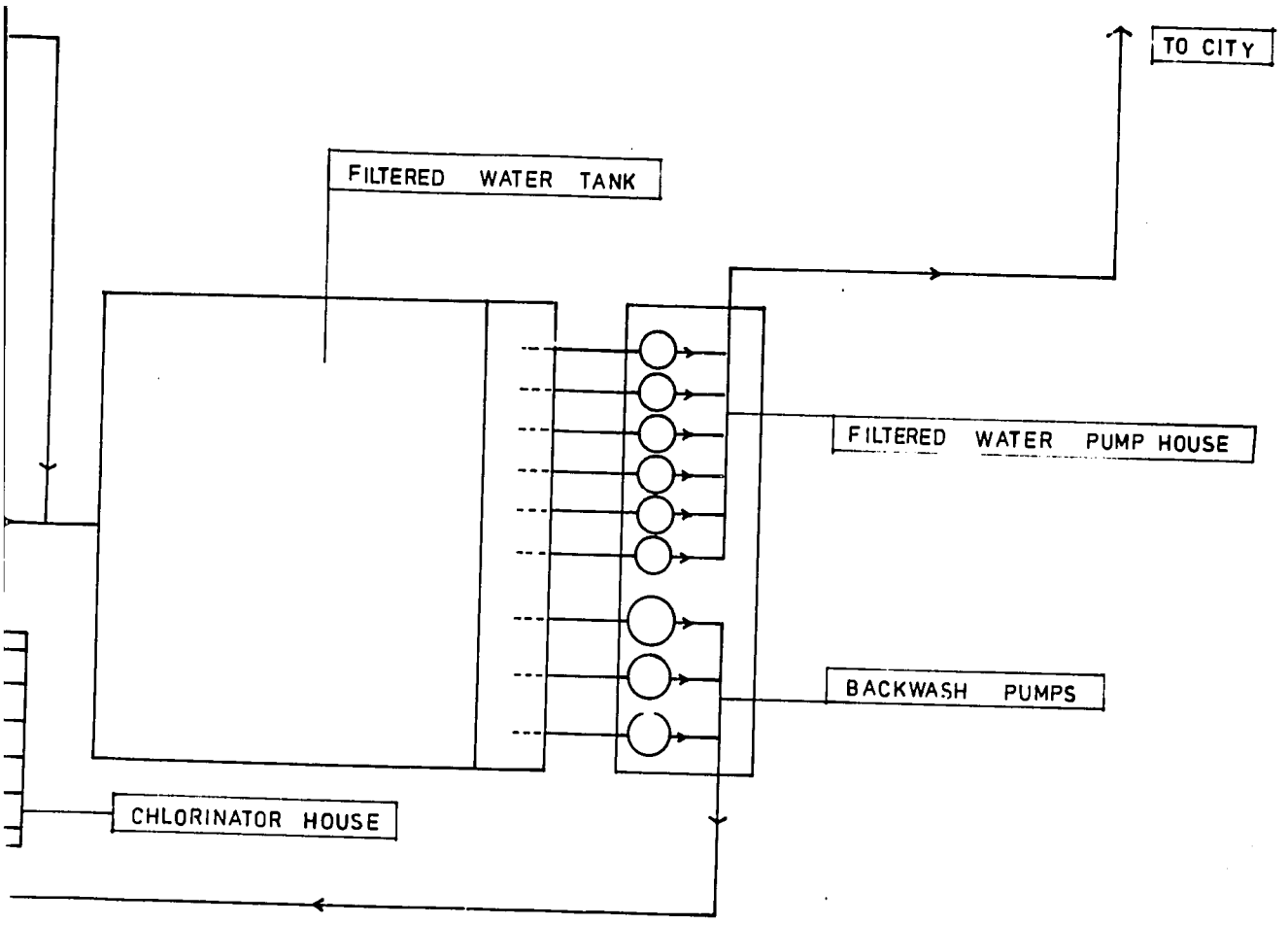
FIGURE 2.3

SUNGGAL WATER TREATMENT PLANT
PROCESS FLOW DIAGRAM



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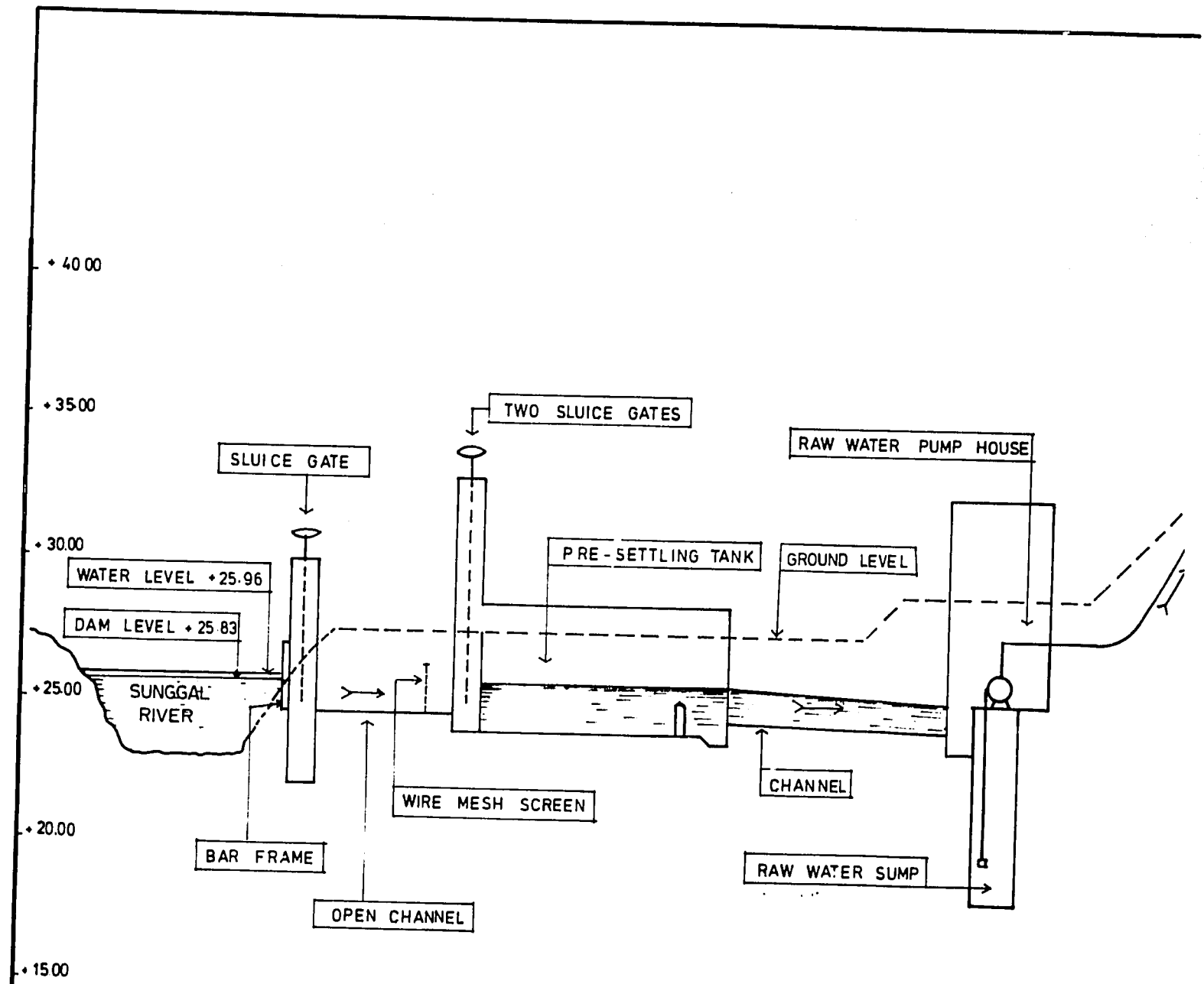

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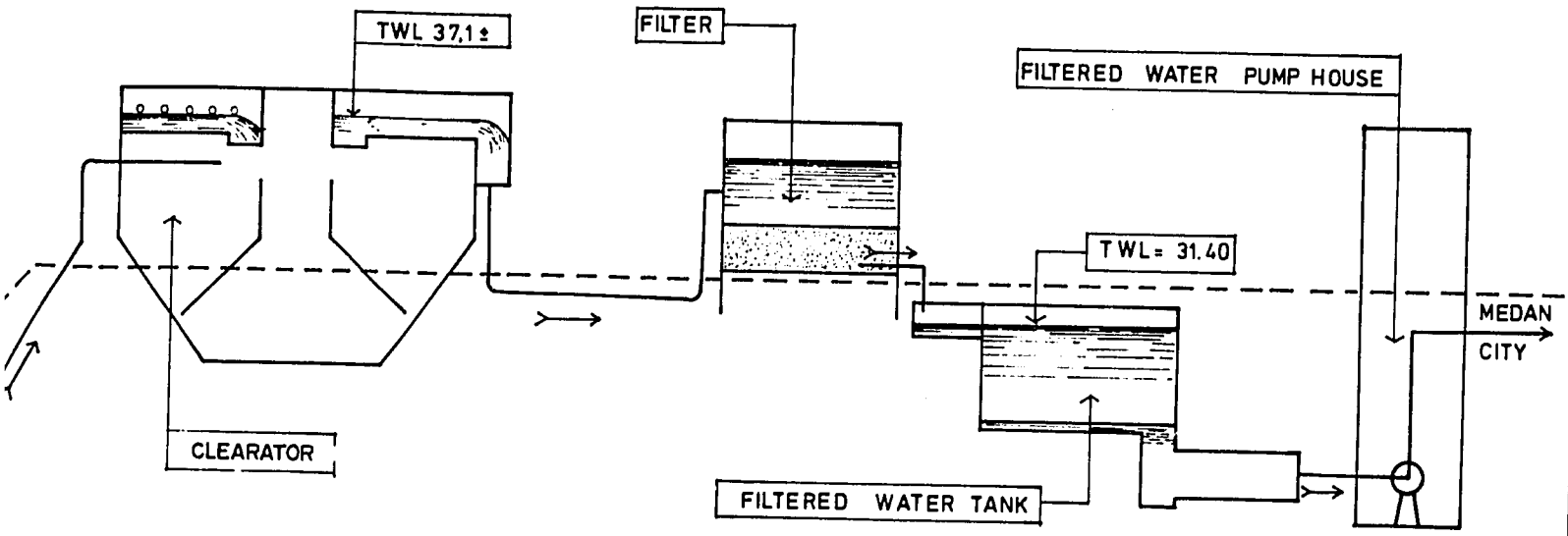
SUNGGAL WATER TREATMENT PLANT HYDRAULIC PROFILE



Based on jar tests, the regular dosage of alum varies from about 17 to 20 mg/l. The theoretical amount of natural alkalinity needed for this dose of alum is about 9 mg/l expressed as $CaCO_3$. In practice however a dose 33 to 50 percent stronger than this theoretical amount has been found to be more effective. Allowing for this, the natural alkalinity needed is approximately 13.5 mg/l as $CaCO_3$. This is invariably available in the raw water. If any auxiliary chemical is added, it should be a weak solution of sulphuric acid to lower the pH rather than Na_2CO_3, which raises the pH, making coagulation less effective.

The pH of the clarified and filtered water will then, of course, be lowered, but this can easily be corrected by the addition of Na_2CO_3 to the filtered water just before the filtered water tank but after chlorination. The above sequence, which can be tested with little expense, is likely to improve coagulation, and if found to be successful, could lead to a reduction in operating costs.

Filters: The filter system at Sunggal consists of:

1. A set of six filter units originally constructed in 1970 which receive clarified water from the old clearator.

2. A set of eight filters commissioned in December 1978 which receive water from the new clearator.

The old filters are of orthodox design. Flow controllers were provided, but have not been operational for many years. A bell-mouth overflow is provided in each unit, and the filters function as a form of declining-rate-of-flow filter. Backwashing is done when the water level builds up due to head losses and is about to overflow. The filter run recommended by the makers is 23.5 hours (with an 0.5 hour allowance for back-washing), but at the moment, filter runs of two to three days appear to be the general practice. No serious harm is done however because very little overflow through the bell-mouths is noticed.

The back wash water is provided with two of the three pumps located in the filtered water pump gallery at a rate of 18.2 cu m/min which works out to 0.57 cu m/min. sq m. Normal backwash rates are generally more than 0.63 cu m/min. sq m. The cross-troughs collecting the rising wash water are suitably placed and the back-washing, in spite of the low rate, appears to be effective enough to provide filter runs longer then recommended.

The new filters, however, are quite different from the old ones and are reported to give constant trouble and a production rate much lower than that of the old filters. There are eight compartments in the new filter gallery but they cannot be regarded as separate units in the normal sense because they are interconnected above the trough level. The new and the old sets of filters are different from each other both in concept and form. Not being based on an orthodox pattern, it is difficult to ascertain all of the causes of the low out-put of the new set, but some of the shortcomings can be identified without difficulty.

The first of these is the inability to backwash the filters efficiently. The normal practice is to place the collecting troughs at

a height above the sand level approximately equal to the rise of the backwash water in one minute; 0.7 m is an average figure. At this height the two most important requirements are satisfied: (1) the particles of sediment, floc, etc., do not have to travel an excessive height to pass into the trough; and (2), the distance is large enough for the expanded sand layer not to be washed away over a period of time. Another usual precaution taken is to place the troughs sufficiently close together to make it unnecessary for a particle of sediment or floc to travel a lateral distance of more than approximately one metre. In the case of the new filters the conditions are quite different. There are no cross-troughs as such, only two being provided for each compartment, one at each end, the distance from lip to lip being 4 metres. Any particle that rises to the surface at the centre has a travel distance of 2 metres to reach a trough. Furthermore the troughs are so placed that the lips are approximately 1.4 metres above the sand level. It is probable that most of the dirt that rises to the surface in the central area of each compartment settles back before it has the opportunity to fall over into a trough.

This problem is further aggravated by the comparatively low backwash rate, which, though it appears to suffice for the old filters, is quite insufficient in this case. Increasing the backwash rate, not to the normal figure 0.63 cu m/min.sq m, but to a higher figure of about 0.69 cu m/min.sq m, in view of the excessive height of the troughs, may help but is unlikely to solve the problem entirely. The filters are already backwashed nearly three times a day. An examination of the records of the various grades of sand used indicate that the smallest size varies from 0.35 to 0.5 mm. This is too fine, and the media should be re-sieved and sizes less than 0.45 mm removed. The sand does not appear to have been either washed or graded when originally placed. For a final solution of this problem, a modification of the trough arrangement and a higher rate of backwash will also be needed.

Each of the eight units is washed three times each day for periods of 7 to 10 or more minutes. Taking a conservative figure of 8 minutes per wash, the total quantity of water used each day (the capacity of each of the two pumps being 9.1 cu m/min) is about 3,500 cu m/d. This is equivalent to the use of filtered water at an average rate of 3,400 cu m/d throughout the day. The output of two new raw water pumps is 26,000 cu m/d, and thus, approximately 13 percent is used for back-washing.

Arrangements are almost complete to provide air scour, and this will probably help, but the extent of improvement is not likely to be appreciable unless the other noted above modifications are made.

Another continuing problem is that there is an overflow of water from two or three filters all the time, the quantity so lost not being separately assessable. Coupled with the excessive amount of water used for back-washing, it is reasonable to assume that the contribution of the new set of filters to the total daily production is appreciably lower than planned when the second phase was implemented.

One other phenomenon has been noticed during the back-washing operations. Immediately after the wash water is admitted from the bottom,

a large number of air bubbles leave the filter. The causes of air binding in filter beds of conventional design can generally be diagnosed, but in view of the unusual construction in this case, the reasons for this phenomenon are not clear. The absence of functioning flow controllers and the consequent high rates of flow through the bed followed by a rapid build-up of head losses could be contributing factors.

Chemical House: The Chemical House is located between the two filter galleries and almost above the filtered water pump house. Facilities are available to conduct jar tests and make chemical analyses of the raw water and residual chlorine tests. There are three Wallace and Tiernan-type chlorinators of which one is not in working order. Additional chlorine safety equipment could be provided without much expense and are recommended. Prechlorination is done before presettling when necessary and the filtered water is chlorinated prior to entry into the filtered water tank, immediately after which the pH is adjusted by adding Na_2CO_3.

Filtered Water Pump House: The filtered Water Pump House has the following pumps:

1. Three backwash pumps, horizontal axis centrifugal type, each having a capacity of 9.1 cu m/min against a 15 m head. Two are used simultaneously to provide 18.2 cu m/min of washwater.

2. Three older, horizontal axis, centrifugal high-lift pumps each having a capacity of 4.55 cu m/min against a 50 m head.

3. Three new and larger horizontal axis, centrifugal high-lift pumps, the specifications of which were not available. From the motor details, the estimated capacity of these pumps is 8.5 to 9 cu m/min against a 50 m head.

As mentioned above, the performance of the five older raw water pumps has deteriorated noticeably. The same is very likely true of the three older pumps referred to above. The raw water pumps have a much greater suction lift than the high lift pumps, which increases the potential for operational problems.

Generator House: When the Sunggal Treatment Plant was commissioned in December 1970, all power requirements were provided by three generators, each having a capacity of 350 kVA. Two of these working together were capable of supplying the full power requirements, with the third available as stand-by.

In December 1978, power was obtained from the city supply and the generator house and equipment are now being maintained in working order for stand-by purposes.

Field Tests: The expansion of the Sunggal Water Treatment Plant, which involved the construction of a second clearator and eight additional filters, was expected to increase the capacity of the plant from 26,000 cu m/d to 52,000 cu m/d. The absence of flow metres at the plant makes it difficult to verify these figures or to determine the capacity of the

clearators and filters from existing records. For this reason two field tests were conducted to determine the total capacity of the plant, as well as to estimate the individual capacities of the old and new clearator and filter units.

Both tests were conducted by pumping raw water into the plant and filtered water out of the plant at a constant rate while temporarily diverting the filtered water from one clearator/filter set to a drain so that only the flow from the other clearator/filter set entered the clearwell. Flow entering the plant was estimated from the rated capacity of the raw water pumps, and the flow through each set of filters was estimated from the rated capacity of the treated water pumps and from the change in water level in the clear well during the test.

Test # 1: The average rates of flow through the old and new filters measured during this test were 24,400 cu m/d and 12,300 cu m/d, respectively. The results of additional flow measurements are shown in Figure 2.5. It was observed during this test that the rates of flow through the new filters decreased very rapidly after backwashing.

Test # 2: The second test was made after an additional transmission line had been placed in service and the plant output had been increased to its rated capacity. All raw water and treated water pumps had been placed in operation, including stand-by un ts. In order to determine the unit flows more accurately, this test was conducted over a five day period beginning on 10 May, 1979. The average rates of flow through the old and new filters measured during this period were 19,900 cu m/d and 26,800 cu m/d, respectively. The result of additional flow measurements are shown in Figure 2.6 and the daily flow measurements are shown in Figure 2.7. The average filtration rates for the old and new filters during this period were 5.6 cu m/sq m.h and 3.9 cu m/sq m.h, respectively. The amount of water used for backwashing the old and new filters was 5.4 percent and 15.8 percent of their total production, respectively.

During this test, it was observed that the effluent quality of the clearators had deteriorated significantly as a result of the increase in flow, which exceeded their design capacity.

2.1.1.3 Springs Transmission Mains - Leakage Survey

A study of the transmission mains from the Sibolangit Spring to Medan was undertaken to ascertain whether there were any serious leakage losses between the sources and the city. The distance between the city and these sources is approximately 37 km and there are about 157 km of pipe used for transmission. The number of pipes varies between three and six in various sections, and the transmission lines are interconnected at several points. Pipe sizes vary between 150 mm and 400 mm, and different sections contain cast iron, ductile iron, steel and asbestos cement pipe.

FLOW CONFIGURATION OF SUNGGAL PLANT DURING TEST NO.1

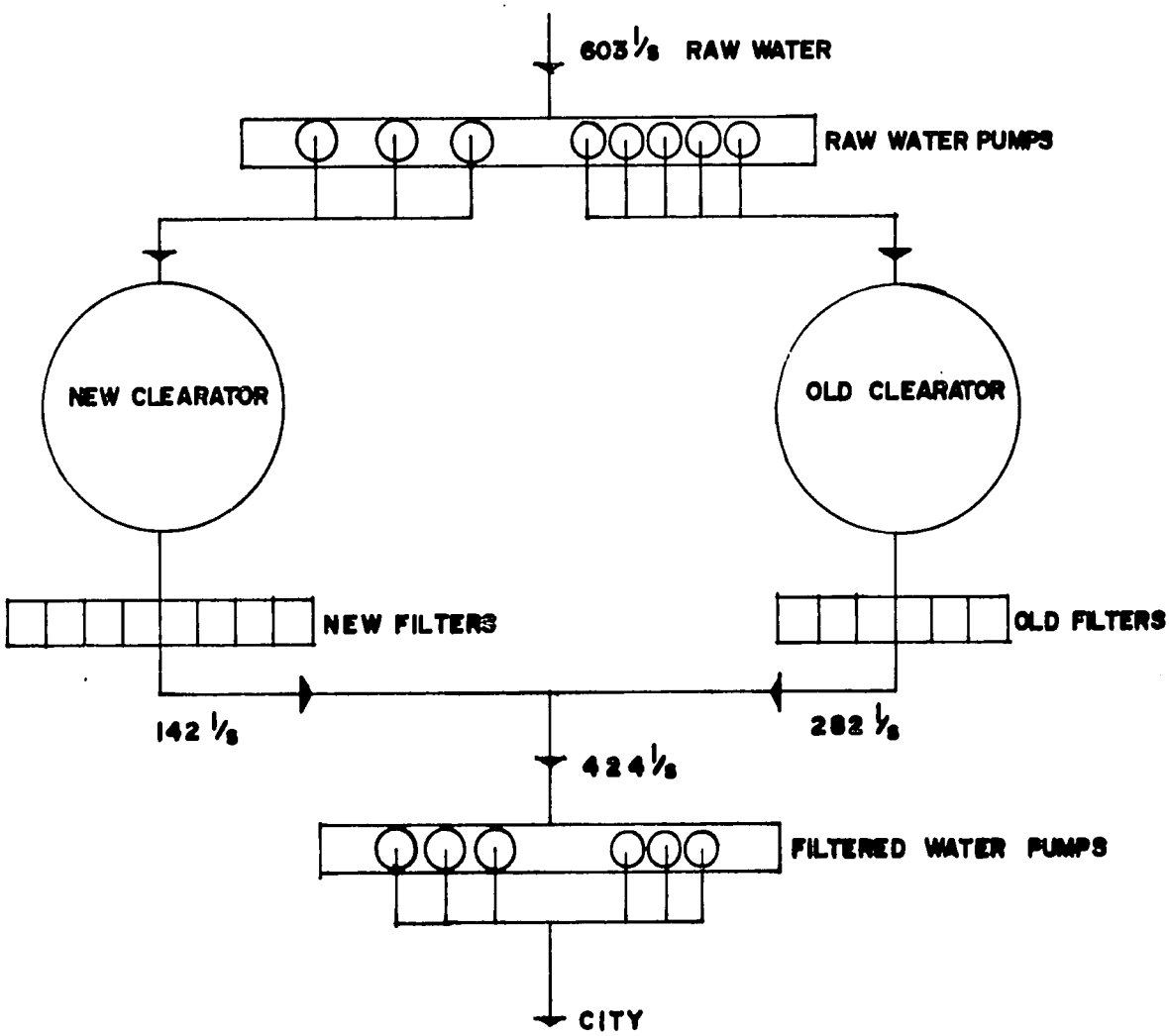
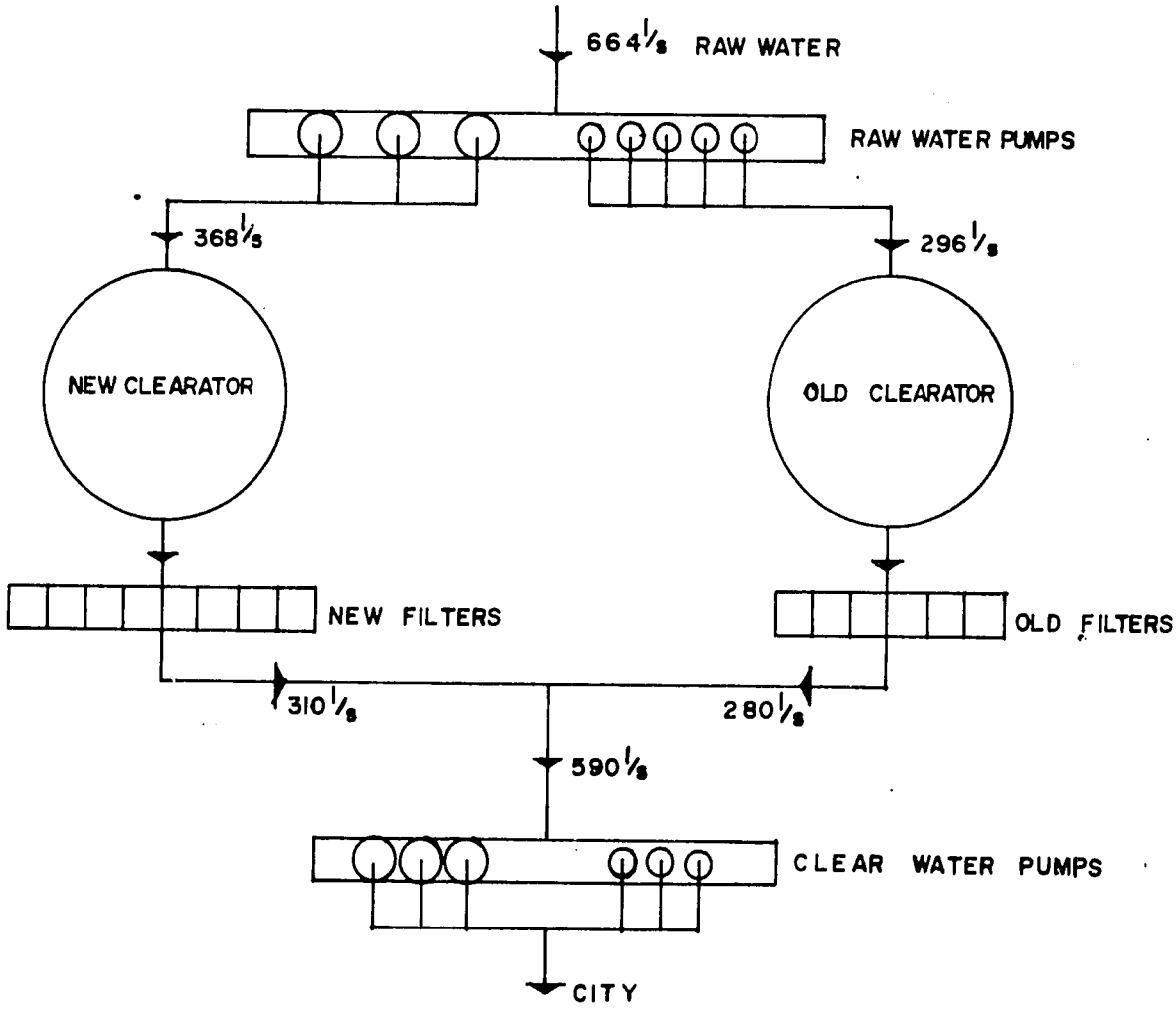
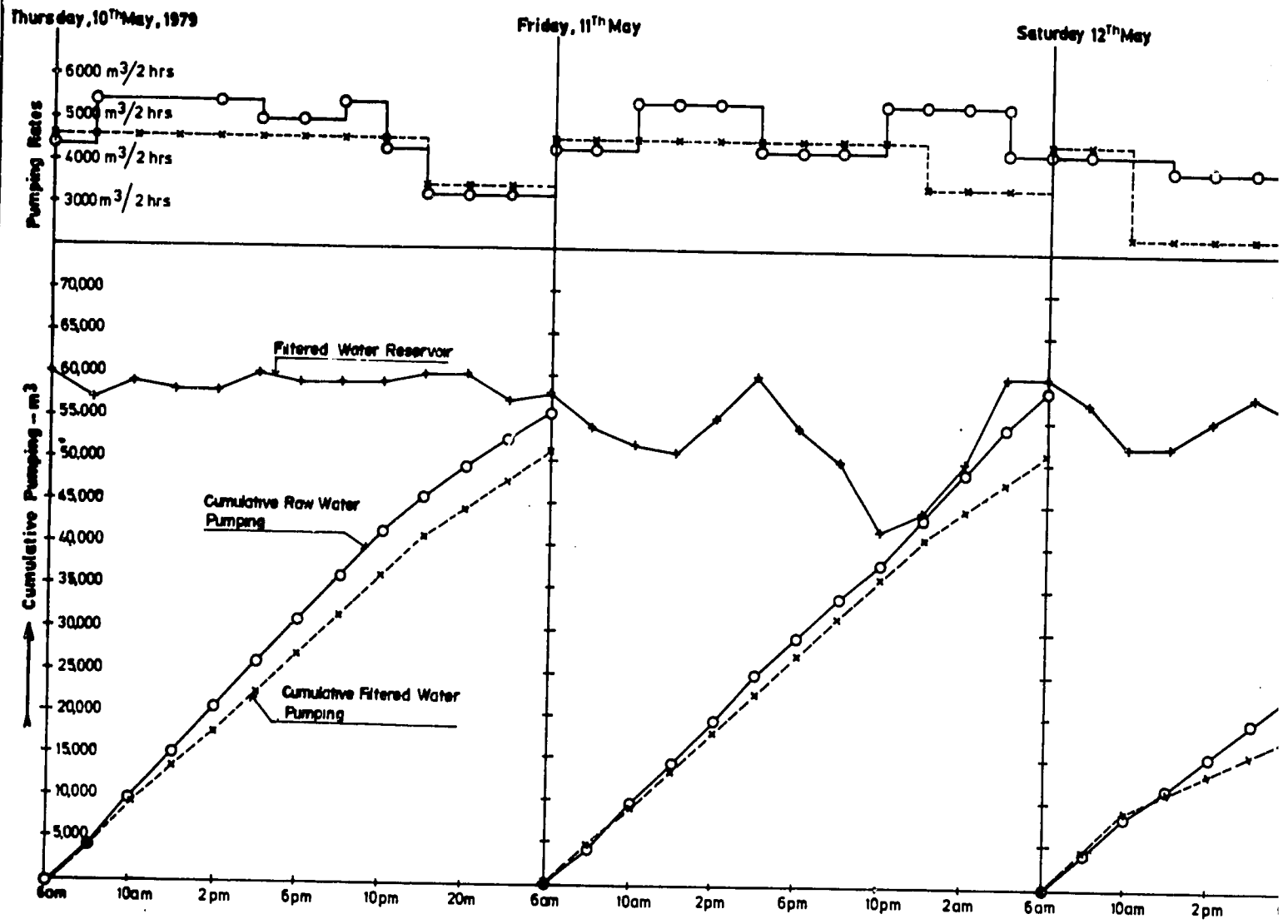


FIGURE 2.6

FLOW CONFIGURATION OF SUNGGAL PLANT DURING TEST NO.2





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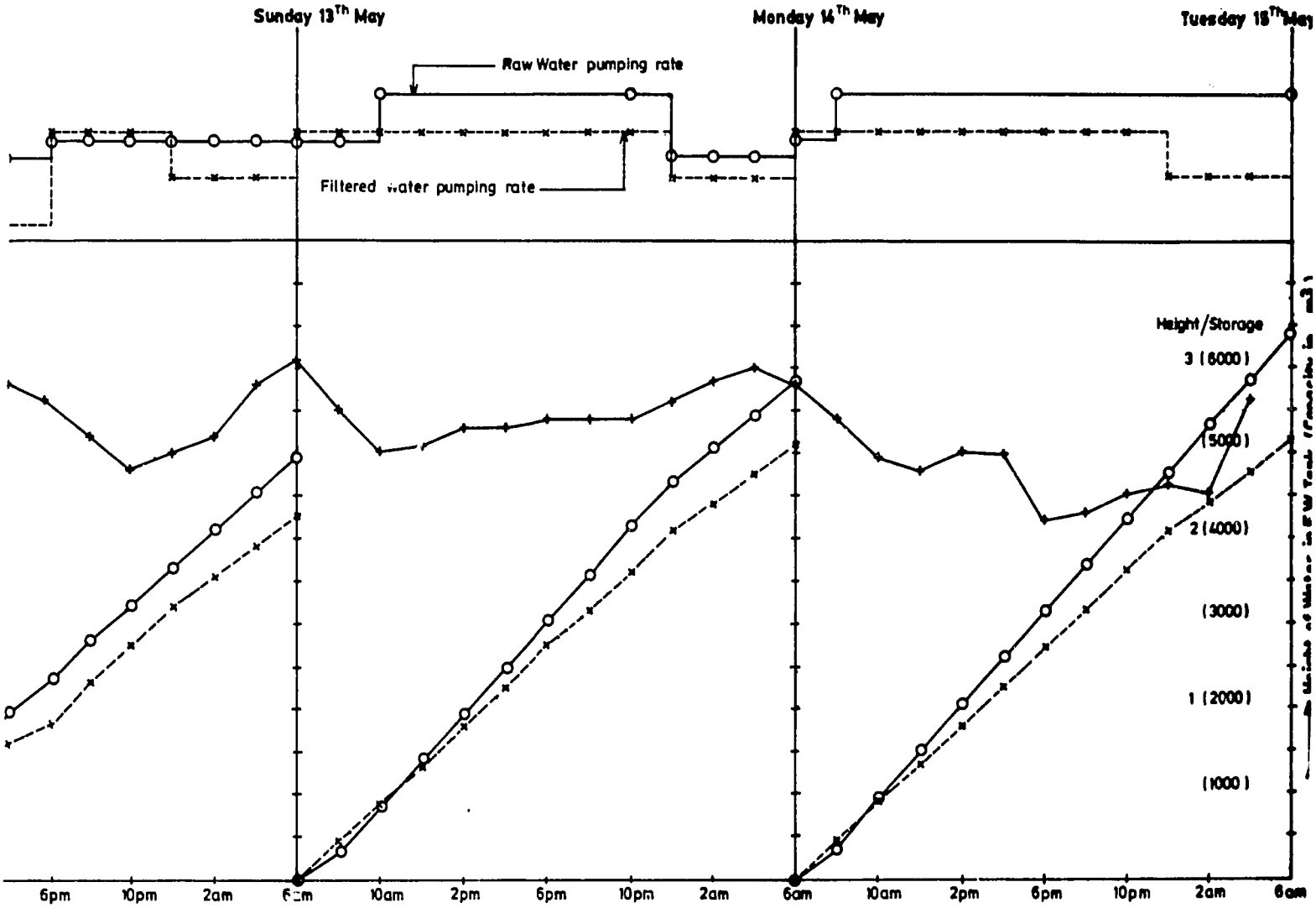


SUNGGAL WATER TREATMENT PLANT

DAILY FLOWS - TEST No. 2

Three pipelines enter the city. They are as follows:

1. At Johor

   a. One 400 mm diameter cast iron line which divides at this point to east and west, serving as distribution mains.

   b. One 375 mm diameter line which proceeds through the Polonia area to the site of the elevated tank and booster station. It acts as a transmission and distribution main.

2. At Deli Tua

   One 325 mm diameter cast iron line entering the city a few kilometres north of Deli Tua and proceeding directly to the elevated tank and booster station site. This line also serves as a distribution main before reaching this site.

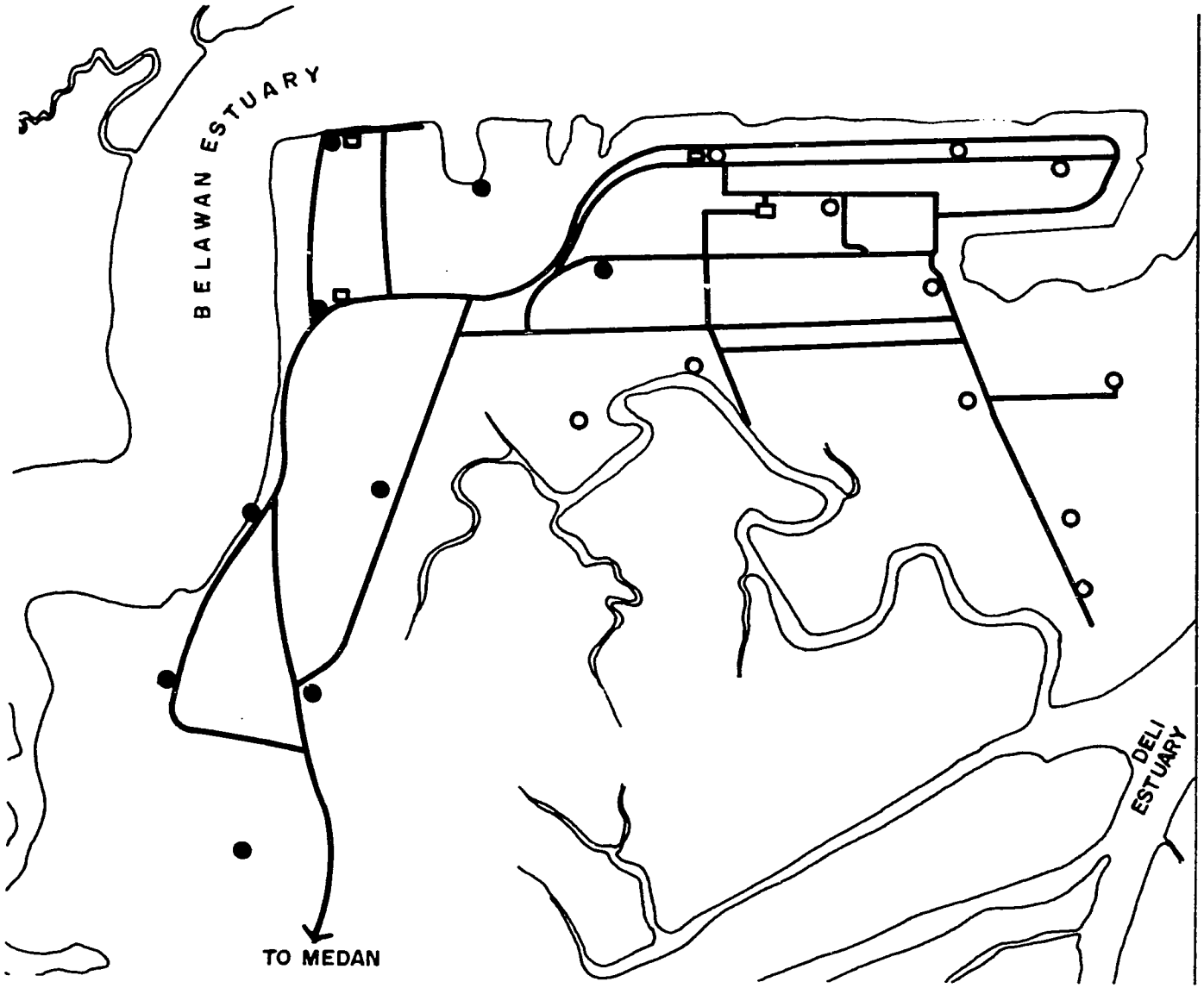
To determine whether there was any serious leakage occurring, the flows at the sources and at the entry to the city had to be measured. There are ten flow meters installed on the transmission mains, three of which are at the points of entry to the distribution system. The other seven are near the spring sources. The metres on the distribution system were installed in 1974, and those near the sources were installed in 1978. One problem encountered in evaluating leakage losses was that these flow meters are frequently out of order. However, all meters were found to be in operation from 10 December, 1978 to 21 January, 1979 and from 22 February, 1979 to 18 March, 1979. The records for these periods indicated that the average flow entering the transmission lines was 48,100 cu m/d, and the average flow entering Medan was 46,300 cu m/d. There are two branch lines at intermediate points to serve Batu and Binjei. The average total flow withdrawn by these two lines was 700 cu m/d. The leakage during the period investigated was therefore 1,100 cu m/d which represents 2.3 percent of the total supply.

2.1.1.4 Wells

The municipal water supply uses groundwater drawn from six wells in Belawan. These wells and three others have recently been transferred to PAM Tirtanadi from the Belawan Port Authority. These six wells produce about 3,000 cu m/d for 1,500 building connections. All but one of the wells are stopped each night between 10:00 pm and 6:00 am. The six producing wells have been recently renovated.

Location and Number: The nine wells transferred from the Belawan Port Authority to Tirtanadi are located in the west rn third of Belawan as shown in Figure 2.8. Of the original nine, three are inactive or abandoned, although the properties are under Tirtanadi's control. Distances between operating wells vary from 400 m to 600 m with a maximum distance of 2,200 m between the northernmost (No.5) and southernmost (No.12) wells. All wells lie within a few metres of sea level, and all sites have been raised with artificial fill.

MAP OF WELLS AND MAJOR DISTRIBUTION FACILITIES FOR BELAWAN



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LEGEND

- ● ACTIVE WELLS, PAM TIRTANADI
- ○ ACTIVE WELLS, PORT OF BELAWAN
- ▭ STORAGE TANKS

Three pipelines enter the city. They are as follows:

1. At Johor

   a. One 400 mm diameter cast iron line which divides at this point to east and west, serving as distribution mains.

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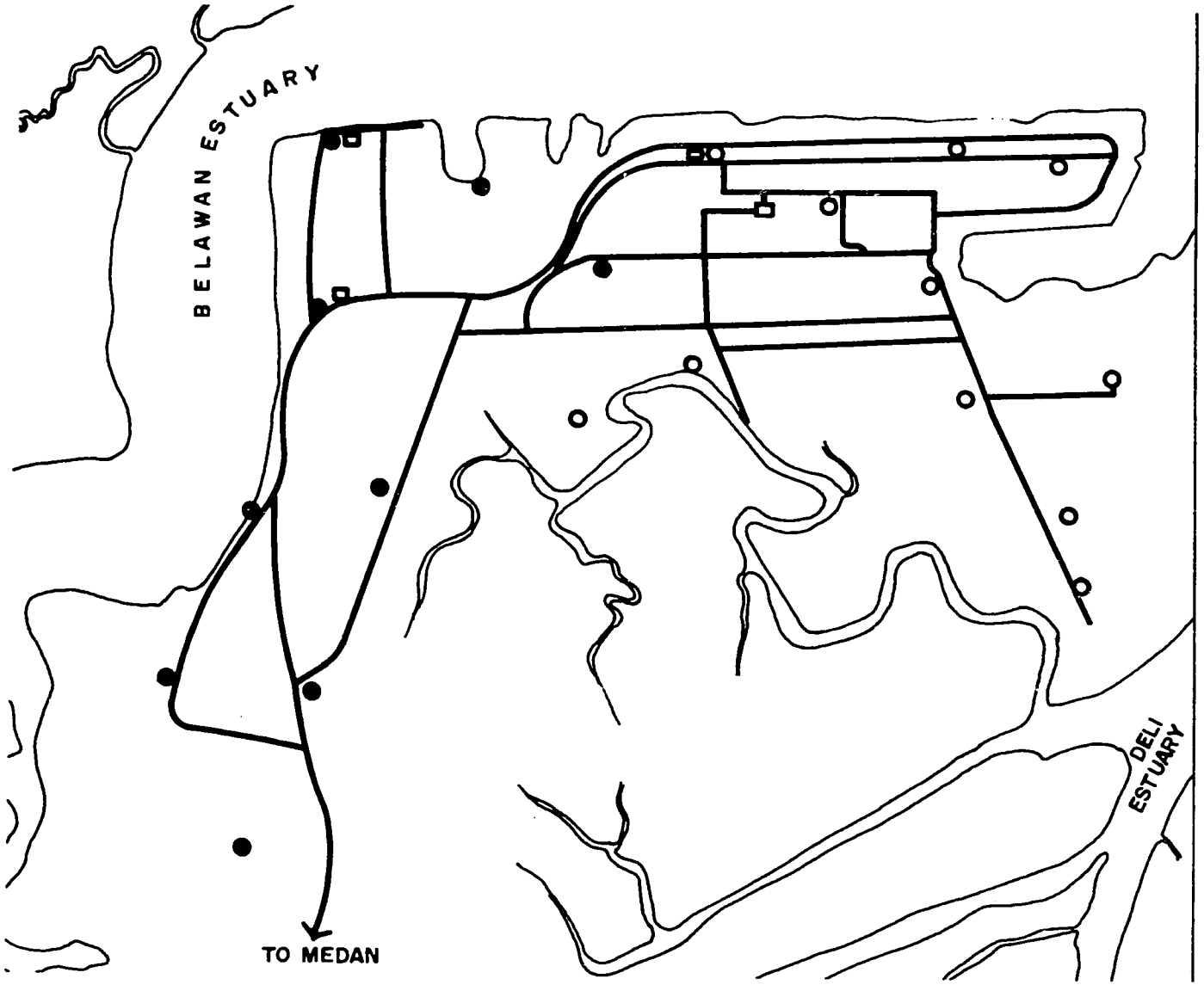
FIGURE 2.8

MAP OF WELLS AND MAJOR DISTRIBUTION FACILITIES FOR BELAWAN



The numbering system applied to the wells is based on that used by the Port Authority and generally indicates the order of their construction (Well No.1 the earliest, No.20 the most recent).

Description of Facilities: Since all of the Tirtanadi wells were constructed before 1972, the basic design of most reflect an older production method using the natural artesian pressure in the intermediate and deep aquifers. Wells No. 4, 5, 6, 9, 11 and 12 have large chambers to receive artesian flows, from which pumps deliver water into the distribution system (see Figure 2.9).

Declining artesian pressure within the aquifers has reduced or stopped flow into the chambers. When Tirtanadi assumed control of the wells in west Belawan, seven wells were cleaned and renovated. As part of the renovation, the wells, except for Nos. 3, 4, and 8, were fitted with submersible pumps and chlorinators, and the chambers are no longer used. These modifications have greatly increased the quantity of water for municipal supply. Wells No. 5, 9, 11, and 12 have been fitted with sand filters in order to reduce turbidity entering the distribution system. Well No.6 pumps directly to the elevated tank on Belawan Road, and Well No.7 pumps small quantities directly into the distribution system.

All six operating wells and Well No.4 have full-time operators stationed at the well sites. Operator housing forms a typical part of all Belawan well facilities operated by Tirtanadi and the Port of Belawan. A summary of the general features of the Tirtanadi Belawan wells, as reported in Tirtanadi records, is presented below.

Well Number	Date Drilled	Depth (m)	Rated Pump Capacity (cu m/d)	Production (cu m/d)
3	1966	114	-	-
4	1950	120	-	-
5	1950	130	680	713
6	1950	145	12	-
7	1952	145	133	136
8	1961	120	-	-
9	1962	130	750	744
11	1971	106	740	942
12	1971	110	820	825

Production, Quality and Operation: Production from the Tirtanadi Belawan Wells is summarized in Table 2.2, and well water quality is summarized in Table 2.3. Water quality at these pumping rates and periods appears suitable for continued potable uses, although the overall quality is slightly poorer than that of the river and spring water above Medan.

Major operational duties involve switching the submersible pumps on and off for each day's operation. Flow meter and electrical power recordings are taken each day, and these are presented by the well operators each week to the Tirtanadi office in Belawan. Any power failures or other irregular operations are also indicated in these weekly

TABLE 2.2

PRODUCTION OF TIRTANADI WELLS IN BELAWAN

Well No.	Production (1000 m^3/mo)																	Mean (m3/d)
	1977		1978												1979			
	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	1.3	1.4	1.5	1.5	1.7	1.7	1.4	1.4	-	-	-	-	-	-	-	-	-	49*
5	15.0	17.9	18.5	18.5	22.9	23.2	22.7	23.2	23.4	22.7	22.2	22.2	24.0	23.0	23.6	20.8	24.2	713
6	0.4	0.4	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11*
7	3.9	3.2	6.7	2.4	5.2	3.3	2.1	2.0	1.4	4.5	4.9	5.5	5.4	5.5	5.5	4.0	5.0	136
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	27.7	28.2	27.5	23.8	26.2	24.2	23.9	21.6	22.1	18.3	23.0	22.1	17.5	19.3	20.1	18.1	20.7	744
11	27.1	28.1	29.9	26.7	30.6	27.2	29.1	27.8	28.7	29.2	27.1	28.2	28.7	29.7	30.6	27.5	30.0	942
12	25.0	32.4	34.6	28.0	29.7	28.5	28.9	27.8	24.7	23.5	20.7	21.1	20.6	20.1	19.6	18.8	21.6	825
Totals	100.4	111.6	118.9	100.9	116.3	108.1	108.1	103.8	100.3	98.2	97.9	99.1	96.2	97.6	99.4	89.2	101.5	3420

* mean production for months operated

A. Passive System With Combined Wet Well

Belawan Wells No. 4, 5, 6 and 9 - 18

B. Pas
Sep
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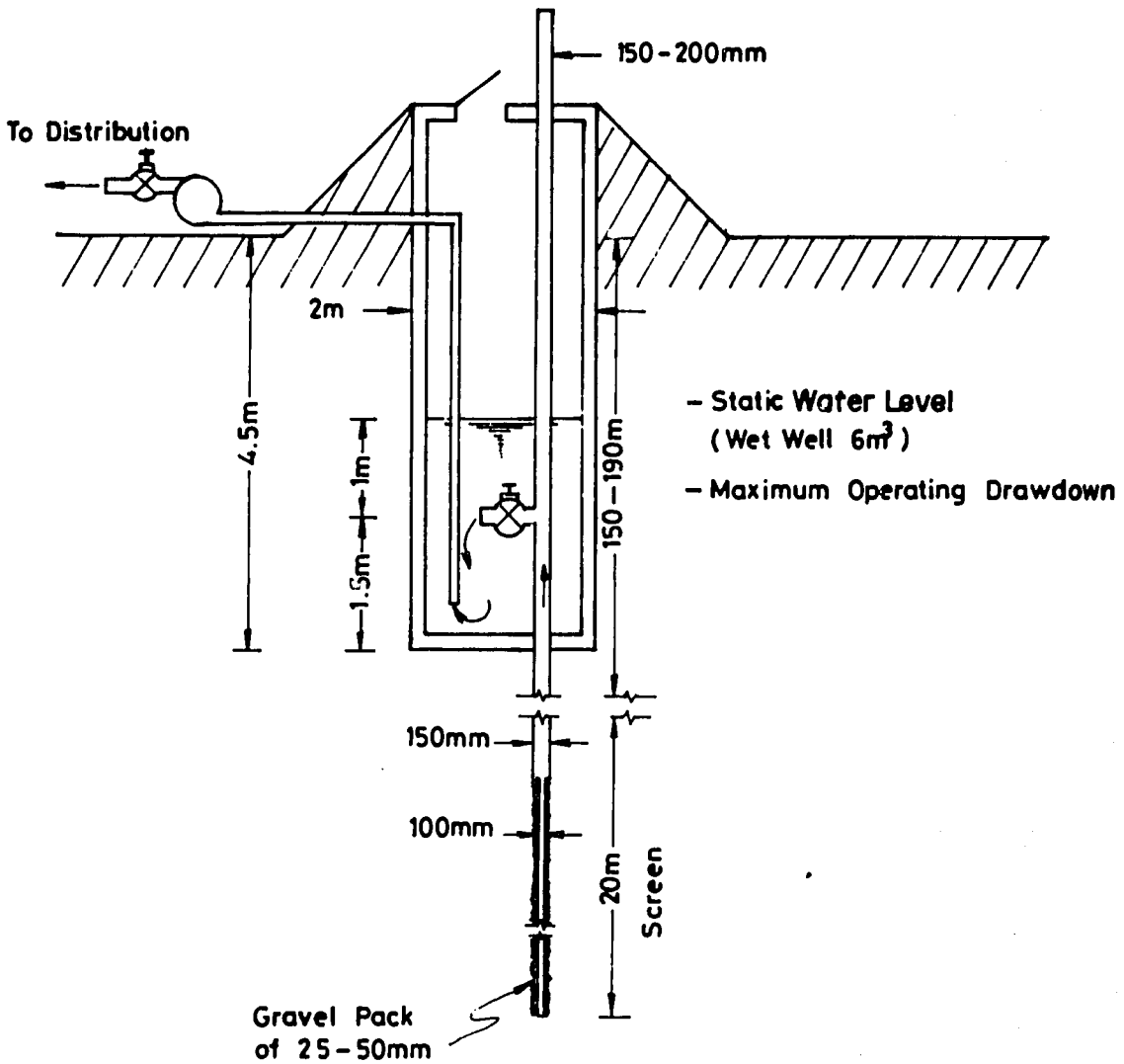

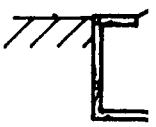

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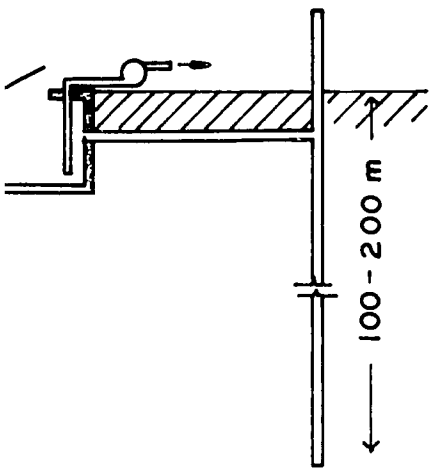
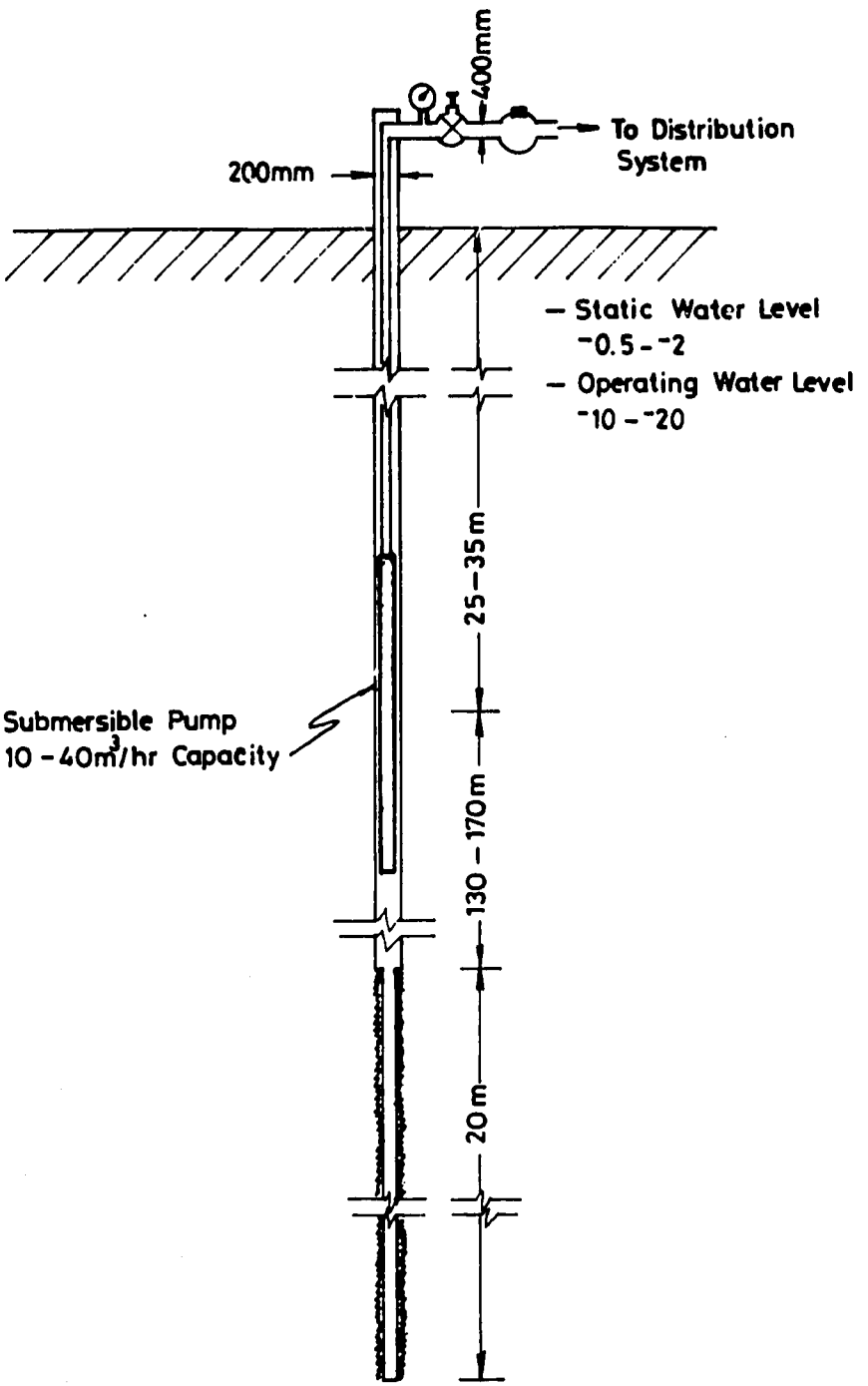


C. Submersible Pump Well System
Belawan Wells 7, 19 and 20



TYPES OF WELLS
USED IN BELAWAN

TABLE 2.3

GROUNDWATER QUALITY - WELLS SUPPLYING
CENTRAL DISTRIBUTION SYSTEM
BELAWAN

Parameter	Unit	Range of Quality Parameter				
		Well No. 5	Well No. 7	Well No. 9	Well No. 11	Well No. 12
Year		1978	1978	1978	1978	1978
Temperature	°C	31 - 33	30.5 - 32.0	27 - 32	29 - 32	30.5 - 32.5
Turbidity	FTU	0.05 - 0.2	0.02- 0.4	0.02 - 2.5	0.02 - 0.2	0.02 - 0.1
pH		7.1 - 7.8	7.3 - 7.8	7.3 - 7.8	7.3 - 7.8	7.1 - 7.8
Total alkalinity	mg/l	98 - 240.5	100 - 246.5	100 - 230	95 - 228	95 - 240.5
Bicarbonate alkalinity	mg/l	97 - 253.8	119 - 244.0	144 - 218.7	140.6 - 229.2	146.4 - 315.0
Carbon dioxide	mg/l	8.6 - 43.7	10.7 - 69.6	18.0 - 63.9	12 - 66.9	14 - 68.6
Hardness	mg/l	23.3 - 57.6	26.9 - 62.7	25.1 - 61.6	31.0 - 67.5	26.9 - 58.2
Calcium	mg/l	3.4 - 13.7	1.2 - 9.21	4.2 - 15.7	4.4 - 13.0	4.0 - 13.2
Magnesium	mg/l	1.3 - 8.7	1.5 - 9.6	1.4 - 9.0	1.7 - 10.0	1.7 - 8.2
Chloride	mg/l	ND - 6.0	ND - 7.9	0.8 - 6.4	1.8 - 15.8	1.9 - 7.2
Conductivity	μ mho/cm	208 - 290	209 - 276	209.5 - 253.5	201 - 261.5	219.5 - 264.5

reports. Water quality samples are taken each month and analysed at the Tirtanadi laboratories.

Evaluation and Recommendations: Tirtanadi operations reflect the standard operating procedures followed by the Port of Belawan and the distribution system limitations. Wells No. 3, 4, and 8 are inactive, although No.3 and 4 could be renovated for future production. Well No.8 appears to be too small for efficient municipal use and should be formally abandoned, but abandonment does require cleaning of the well and proper sealing and covering to prevent possible contamination of the major aquifers. Since residential water demand is high near Well No.8, a new production well on this site could be useful in the future.

Continuous operation of Wells No.9, 11, and 12 could equal the total production of the present intermittant schedule for all six production wells (3,400 cu m/d). If all wells were operated continuously, water could be pumped southward through the existing and proposed transmission pipelines along the Medan-Belawan corridor.

Power is provided by the normal street distribution systems which are subject to numerous power outages, usually resulting from the loss of secondary transformers. In order to better assure uninterrupted pumping, each well should have powerlines from two different secondary and preferably primary transformers or substations.

The four major production wells are fitted with pressurized sand filters in order to reduce turbidity. However, monitoring of turbidity or pressure drop across the filters has not been conducted and no basis of design has been found for the filters. Generally, turbidity in well water should be quite low. Therefore, after appropriate monitoring of water turbidity in the casing of each well and from the distribution system adjacent to the well, the continued use of the pressure filters should be reviewed. Removal of the pressure filters would increase the flow from the wells and the pressure within the distribution system.

Present well monitoring practices include daily readings of flow and electric power meters. A large amount of data regarding efficiency of operations is available, and a simple compilation of the water produced per kilowatt hour would provide an important measure of well and pump efficiency. In addition to these daily records, measurements of water levels in the wells before switching off in the evening and before starting up in the morning should be taken each week to calculate the well capacity (cu m/d.m of drawdown). Comparisons of well capacity and the production and power consumption records would quickly indicate if a well or pump were losing efficiency. This data would also serve as part of a data base for a long-term study of the Belawan aquifers and for selection of new well sites.

Major cost items within the operation and capital improvement program for the Tirtanadi wells include housing and salary for full time, on-site operators at each well. Although this provides great security, the well equipment is generally not subject to vandalism, and enclosure of well facilities should be considered as an adequate alternative. One well inspector could be located full-time at one well and with a

vehicle (e.g. motorbike or pedal bicycle), could easily reach and inspect all wells in less than two hours in the morning and two hours in the evening.

2.1.1.5 Distribution System

Service Area: The existing Medan water system operated by Tirtanadi mainly serves the presently developed residential and commercial areas of the city and Belawan. The service area covers:

1. Kecamatan Medan Kota, Medan Baru, Medan Barat, and Belawan almost fully.

2. Kecamatan Medan Sunggal, Medan Timur, Medan Johor, and Medan Denai partially.

3. A narrow strip along the road leading from Medan to Belawan.

Distribution Network: The existing network can be broadly divided into trunk mains 200 mm or more in diameter and feeder mains 175 mm or less in diameter.

Though not divided into a grid of any definite geometrical pattern, there are about 100 km of major trunk mains 300 mm or more in diameter running along the outer boundary of the service area and other trunk mains within the area (see Figure 2.10). Given below is a summary of the trunk mains in the city of Medan, the lengths given being in metres.

1. Medan

Diameter	Steel	Cast Iron	Ductile Iron	Asbestos Cement	PVC
200 mm	4,300	7,750	4,450	1,440	1,000
225 mm	-	740	-	-	-
250 mm	2,400	18,830	2,455	-	4,540
300 mm	-	2,190	14,540	-	-
325 mm	-	2,100	-	-	-
375 mm	-	4,960	-	-	-
400 mm	4,000	-	2,700	-	-
	10,700	36,570	24,145	1,440	5,540

2. From Medan to Belawan

   13,500 m of 250 mm pipe (up to Labuhan) and
   3,200 m of 200 mm pipe (all cast iron)

3. Belawan

   4,400 of 200 mm pipe (cast iron)

The age and estimated condition of these pipes are summarized below:

Pipe Material	Age	Estimated Hazen Williams "C" Value
Steel	20 - 30 years	80 - 95
Cast Iron	30 - 70 years	65 - 90
Ductile Iron	1 - 10 years	110 - 120
Asbestos Cement	1 - 10 years	120
PVC	1 - 5 years	130

According to Tirtanadi, the practice of scraping the larger mains was carried on regularly until 1977 when it was abandoned due to insufficient pressure to wash the lines. It is assumed that the mains have been maintained at least moderately well and that the reduction in the Hazen-Williams "C" values is due to the normal aging process.

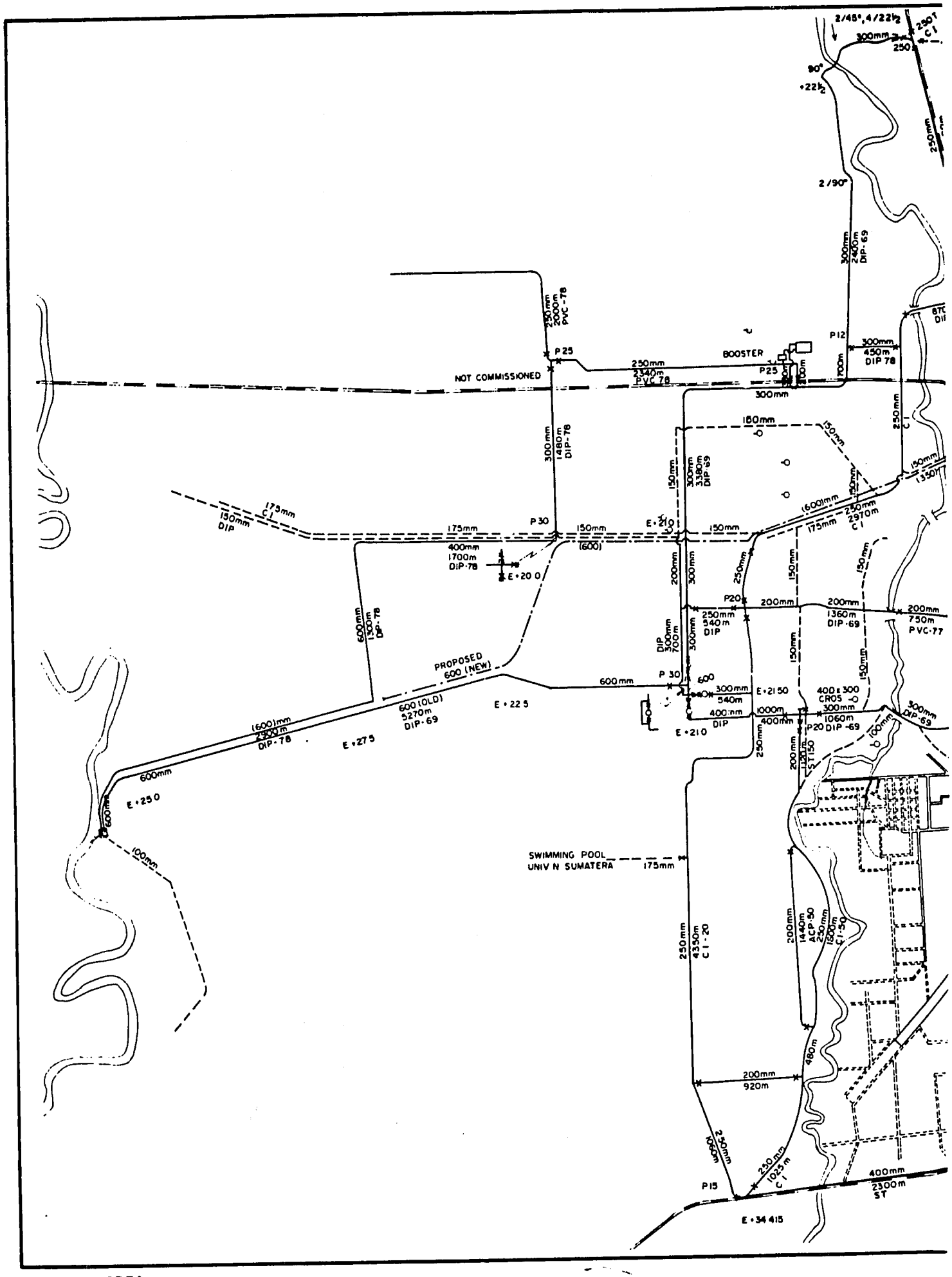
Spring water reaching the booster station and storage tower site is either pumped into the elevated storage tank or allowed to flow by gravity into the ground level storage tanks. Water from the ground tanks can either be pumped into the elevated tank or to the distribution system.

One major problem is that certain sections of the three major transmission lines which supply water to these storage tanks are very old and have gradually deteriorated to the extent that flow through these mains has become markedly restricted. The 375 mm diameter line from Johor to the storage tank site and the 325 mm line from Deli Tua to this site are both cast iron and are 60 and 70 years old, respectively. Water reaching these tanks from the Sunggal treatment plant must flow through a 740 m length of 225 mm diameter cast iron pipe which is nearly 60 years old. The reduction in the capacity of these lines is indicated by the slow rate at which the storage tanks fill at night.

Storage: The absence of adequate storage capacity is one of the major deficiencies of the existing system. Water from both supply sources is brought in at a nearly uniform rate by gravity flow from the springs and by 24 hour pumping from the Sunggal plant. Normal water system storage requirement should be roughly 25 percent of the total daily demand, or about 24,500 cu m. The storage currently provided in the system is as follows:

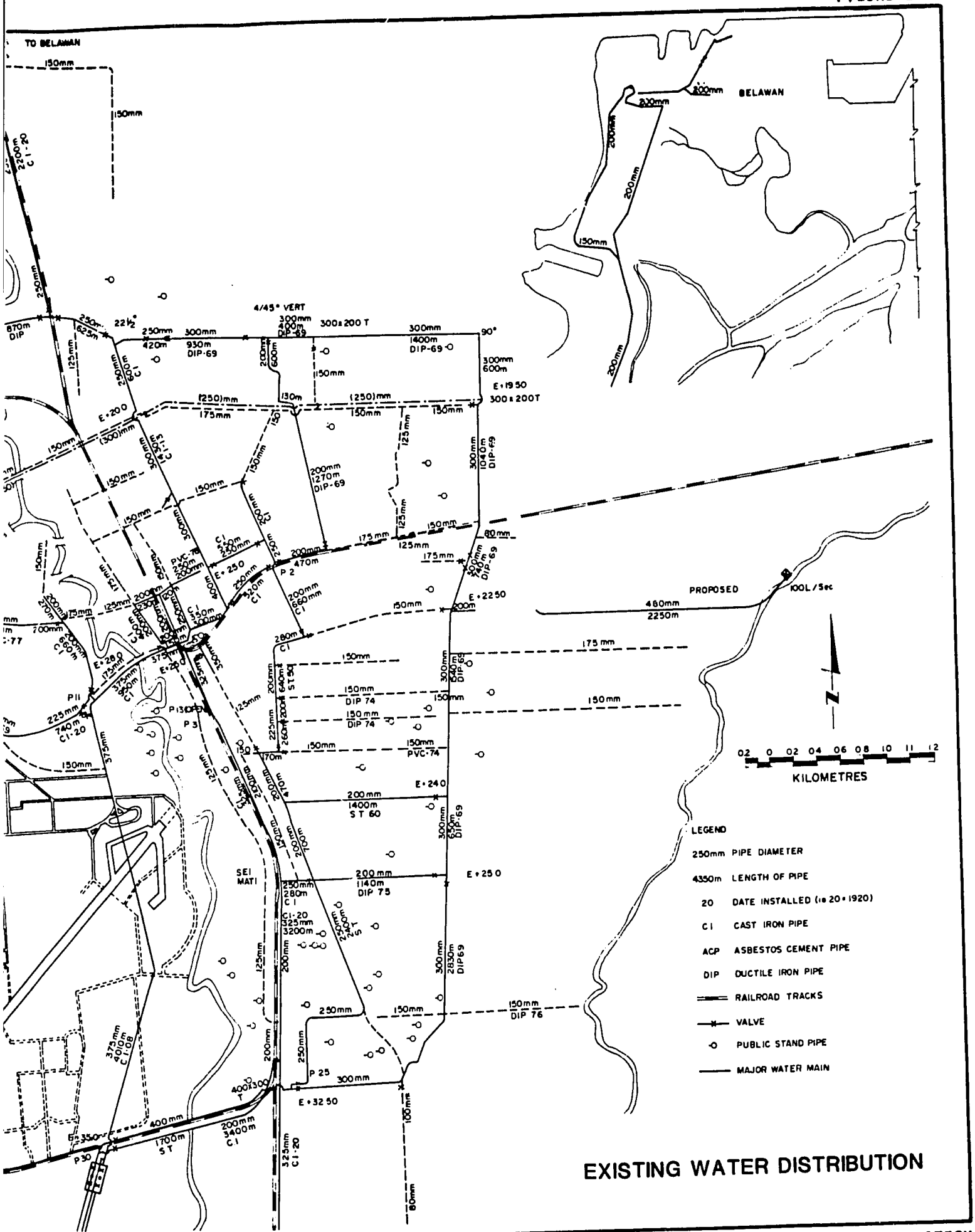
Ground Tanks	3,500 cu m
Elevated Tank	1,200 cu m
Sei Agul Booster	1,400 cu m
	6,100 cu m

This indicates that at least (24,500 cu m - 6,500 cu m) = 18,000 cu m of additional storage capacity is needed. Action should be taken to correct this problem.



PADCO–DACREA

FIGURE 2.10



EXISTING WATER DISTRIBUTION

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Pressure: The system pressures were measured at many locations in Medan during July, 1979. The information obtained is shown in Figure 2.11. In general, the pressures measured in the western and southern areas of the city were adequate throughout the day while the central and northern areas had significantly lower pressures that were often inadequate during peak demand periods.

Present Improvement Programs: The following improvements are being implemented by Tirtanadi in 1979:

1. A 400 mm ductile iron pipeline will be laid from the Ground Tank junction to junction 'D' and a 350 mm asbestos cement line from Junction 'D' to Junction 'B' (see Figure 2.10).

2. Quotations have been called for the supply of 400 mm ductile iron pipes to be laid between Junction 'A' and the Ground Tank junction.

The above improvements will result in more water from Sunggal being brought to the ground tanks and to the eastern part of the city, but the lack of adequate storage will prevent full use of these additional mains. The work is expected to be completed in the latter part of 1980.

Standpipes, Fire Hydrants and Sluice Valves: Almost all trunk mains have been provided with gate valves at the junctions, most of which are kept fully open. One valve, at the south-west corner of the network is kept almost closed, to keep the springs and Sunggal water separate. The reasons for maintaining this separation are not known. Diversion of water to the low-supply areas by manipulation of valves is not done.

Some of the valves which could be inspected showed signs of rusting and disrepair, apparently as a result of long periods of non-use. The major sluice valves at the junction of the supply mains and the distribution network are housed in covered chambers which are usually kept locked. Pressure gauges and meters are generally provided close to these valves. The valves, meters and pressure gauges are maintained in fairly good condition.

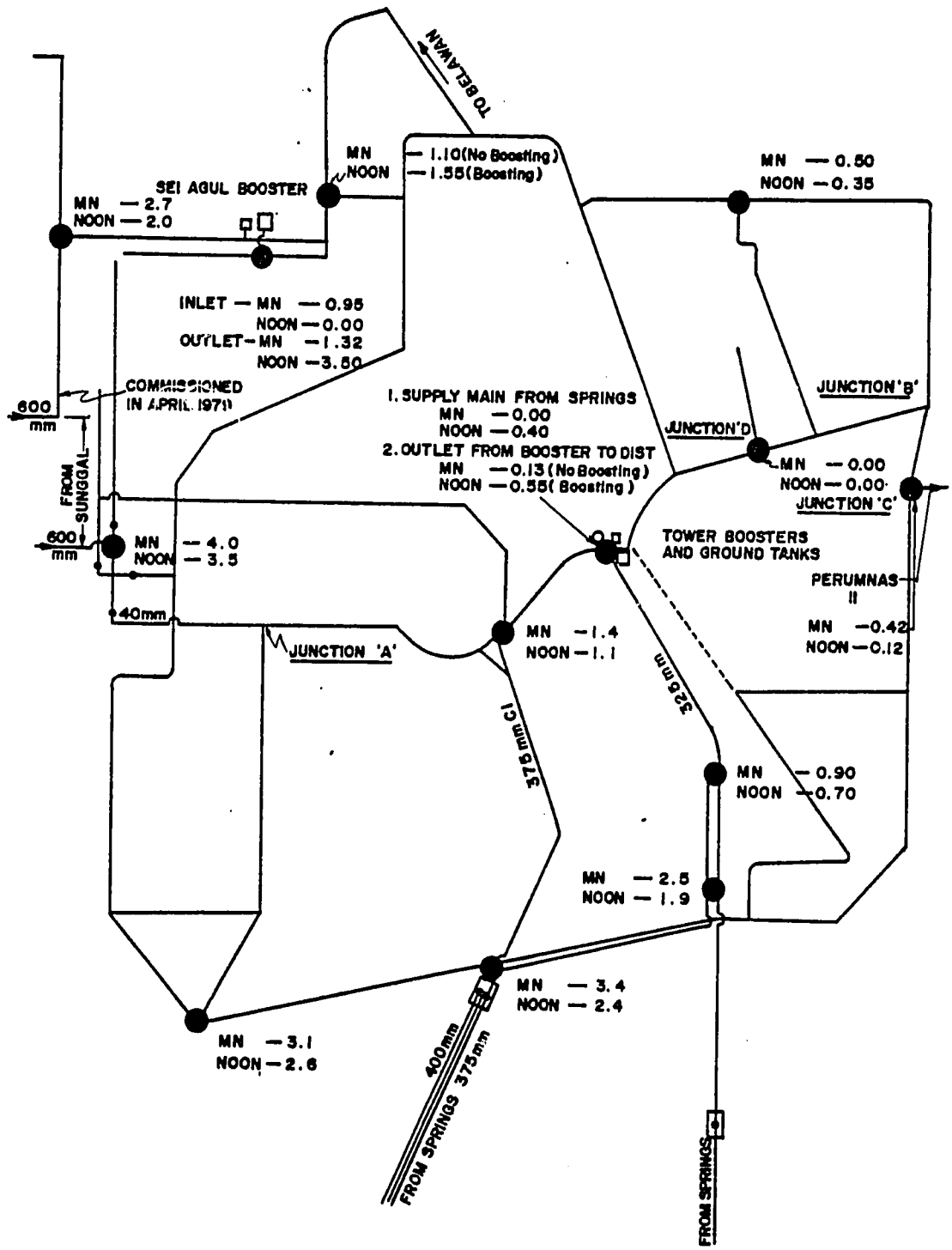
Ninety-three metered standpipes are provided in the city. The water consumed is paid for by the Kepala Lorong (the heads of the subdivisions which kampungs consist of). However, many densely populated, low income residential areas are without standpipes.

According to information obtained from the Fire Department the number of fire hydrants was increased from approximately 1360 in 1974 to more than 3000 in 1978. However, because of inadequate system pressure, only 55 hydrants were in working condition in April 1978.

Water Supply to Belawan: A 250 mm pipeline runs from the northern end of the service area (close to the Sei Agul booster station) towards Belawan. At Labuhan the pipe changes to 200 mm diameter. The total length between Medan and Belawan is approximately 16,500 m. There is a small network of nearly 4,400 m of 200 mm pipes within Belawan.

FIGURE 2.11

SKETCH OF MEDAN DISTRIBUTION SYSTEM SHOWING PRESSURES (KG/CM2) AT NOON AND MIDNIGHT IN MID-JULY 1979



Due to the low pressure in Medan, it is not likely that any appreciable amount of water from Medan reaches Belawan. Most of the water is probably used up by the residents in the narrow strip of developed area on either side of the Medan-Belawan highway.

The Belawan service area has two elevated storage tanks of about 100 cu m capacity each. The system pressures have not been measured but appear to be adequate.

Services and Meters: At the end of 1978, the municipal system had 36,363 service connections. The population served by these is estimated to be approximately 290,000, representing approximately 25 percent of the total study area population. Most service connections are direct screwed - type ferrules except in the case of PVC mains where saddles are sued.

Most of the meters provided were manufactured by Kent Ltd. and are suitably installed and located for making convenient, regular readings and for carrying out repairs. The standard service connection is illustrated in Figure 2.12.

2.1.2 Other Water Supply Systems

2.1.2.1 Belawan Port Authority

The Belawan Port Authority operates a system of wells to supply water to residents, offices and industries within the Port Authority area. There are eight wells currently in operation. Prior to April of 1978, the average total production of these wells was about 6,000 cu m/d. Of this amount, 4,580 cu m/d were used by the Port Authority and 1,420 cu m/d were given to Tirtanadi for municipal supply outside the Port Authority area. After April of 1978, the Port Authority stopped supplying water to Tirtanadi. Since that time, records indicate that the amount of water produced and distributed by the Port Authority has increased to about 6,500 cu m/d.

2.1.2.2 Commercial, Industrial and Institutional

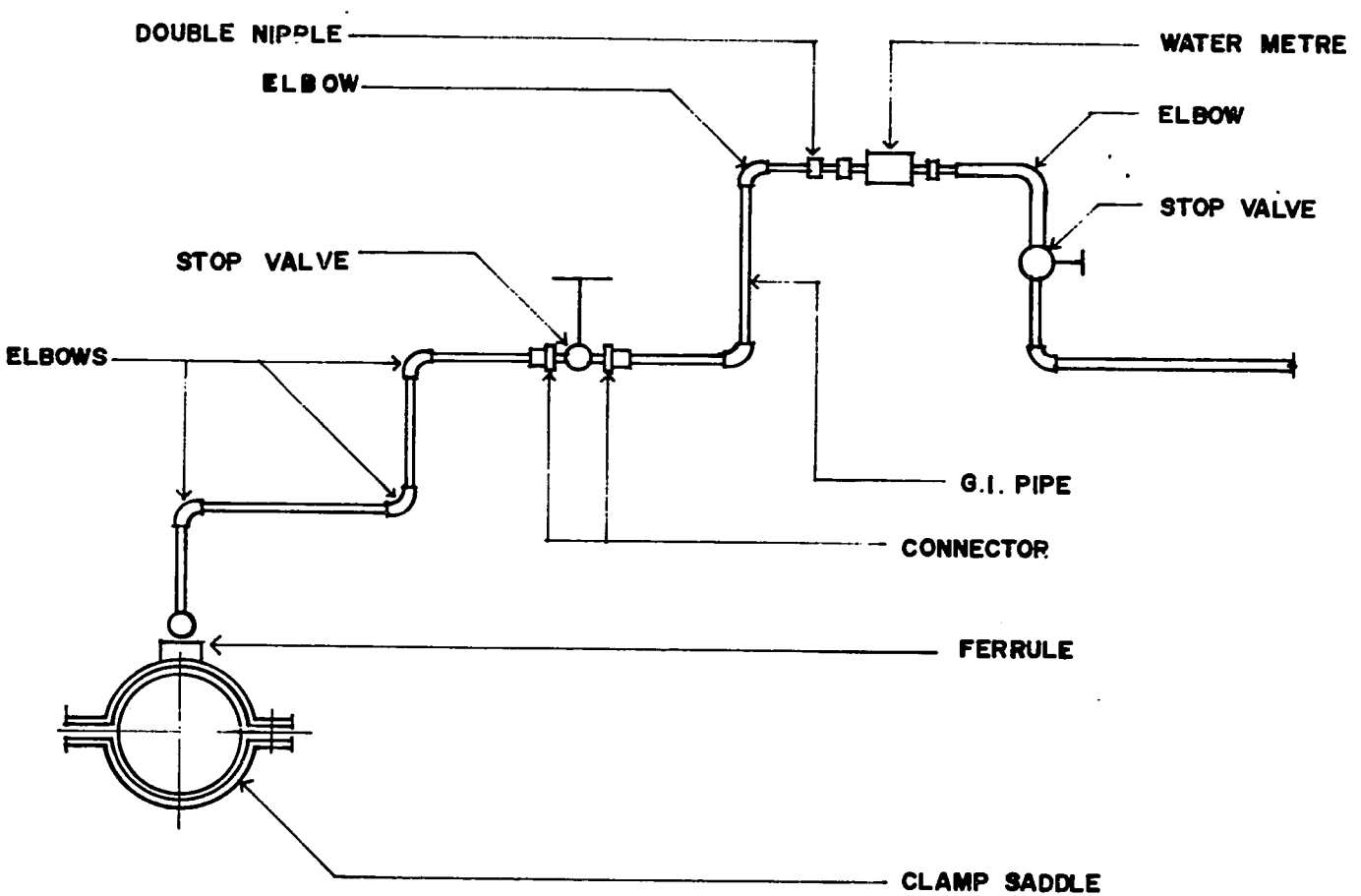
About 59 percent of the total estimated non-residential water requirement are met by Tirtanadi; most of the remaining 41 percent is obtained from private deep wells. About 90 percent of the water required by the government and its affiliated organizations is supplied by the municipal system and the balance from deep wells. In the case of commercial and industrial organizations, 45 percent of the requirements are met by the municipal sytem, the balance being obtained from deep wells. The details of construction, operation, yield, aquifer characteristics, and quality of existing deep wells in the study area are dealt with in Appendix E.

2.1.2.3 Individual Domestic

Out of the total 1978 population of 1,116,000 of the city, approximately 270,000 obtain their daily water needs from the municipal water supply connections. It is estimated that the balance obtain water from shallow wells, standpipes and surface streams as follows:

FIGURE 2.12

EXISTING SERVICE CONNECTION



Predominant Residential type	Source of Supply	Estimated Population
Middle income, Medium density	Shallow well for individual household	696,000
Low income, High density	River, standpipes and public shallow wells	150,000

Shallow Wells can be divided into two broad categories:

1. Individual shallow wells built mainly by middle income residents living in areas of medium density. These reveal a fair degree of attention to good sanitary practice although some degree of contamination is inevitable.

2. Shallow wells built in low-income, high density areas, serving individual or multiple dwellings. Due largely to the construction methods commonly employed for these wells, most of them are polluted.

Data concerning the exact number of households with individual shallow wells or which use public shallow wells is not available. The depth of the ground water level in the different parts of the city varies from one to seven metres. Properly constructed shallow wells are lined with brick and mortar, with the curbed wall rising about a metre above ground. A paved area is provided next to or around the well where laundering, other washing, and bathing is done. Water is drawn with a rope and bucket (one obvious source of possible pollution), and the wastewater drains into a ditch or soakage pit nearby. The water is boiled before drinking in some houses, but not in others.

The installation of a power-driven or hand operated pump and the provision of a well cover would be a major sanitary improvement. This practice has been adopted in the wells of more well-to-do residents.

The second category of well is found mostly in areas where the groundwater depth is shallow. Some wells are curbed, while others are not. Many are located close to drains or ditches carrying polluted wastewater. Drawing of water by buckets introduces contamination, and in a few extreme cases the construction permits surface drainage to flow directly into the wells. Some of the residents used this well water for all their needs, while others obtain their requirements for drinking from public hydrants. Even where public hydrants were used the storage of the standpipe water was far from satisfactory.

In a few parts of the city, persons living in the vicinity of a public standpipe store water in their houses during periods when supply is available and sell it to other users. In one case it was found that a 20-litre container of water was sold for Rp.10.

The danger of using surface water from streams and rivers is obvious, but it is common in the heart of the city to see large numbers of people bathing at one spot and others extracting their water requirements downstream only a few metres away.

2.1.2.4 Government Shallow Well Program

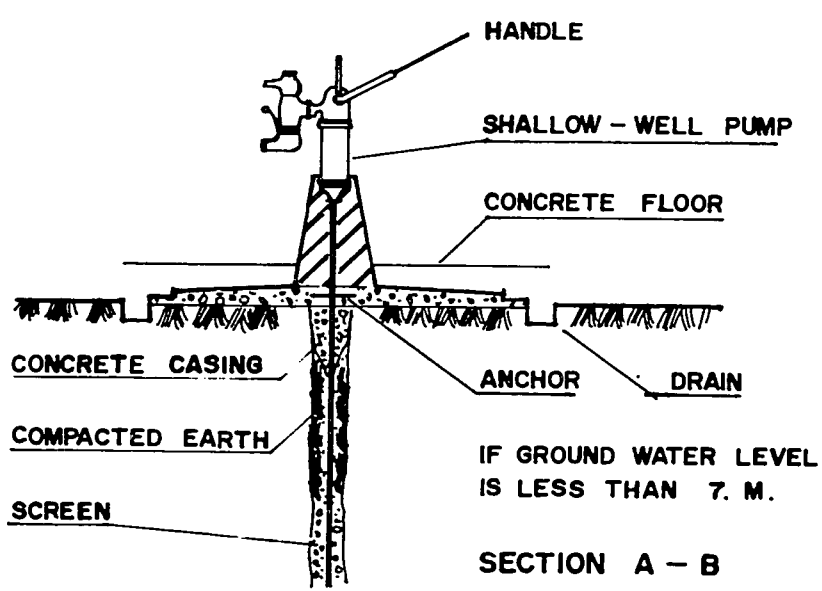
A continuing goal of the Government Repelitas is to provide safe sources of public water supply in areas where it is not yet feasible to provide individual household connections. A shallow well program was carried out during Repelita II by the Public Health Department in order to increase the availability of safe water, particularly in areas where enteric diseases rates are high and piped water supplies are not expected to be available within the next five years.

Wells constructed under this program have 32 mm diameter pipes and are properly cased with the tops sealed to prevent the entry of surface water. A concrete slab and drain are provided to maintain a dry area, free from mud, around the pump. The handpump has a pump shaft fitted with a gasket to prevent contamination and also permit the use of dual outlets. One outlet permits discharge into containers brought by the public and a valve enables the discharge to be transferred to a garden type hose through an outlet provided for this purpose. Details of the type of well being built by the Health Department are shown in Figure 2.13.

Medan, with the low priority allotted to it, has been allocated 60 units for 1979. Each well costs approximately 140,000 Rps. Construction is generally supervised by one of the Health Department officers specially trained for this work.

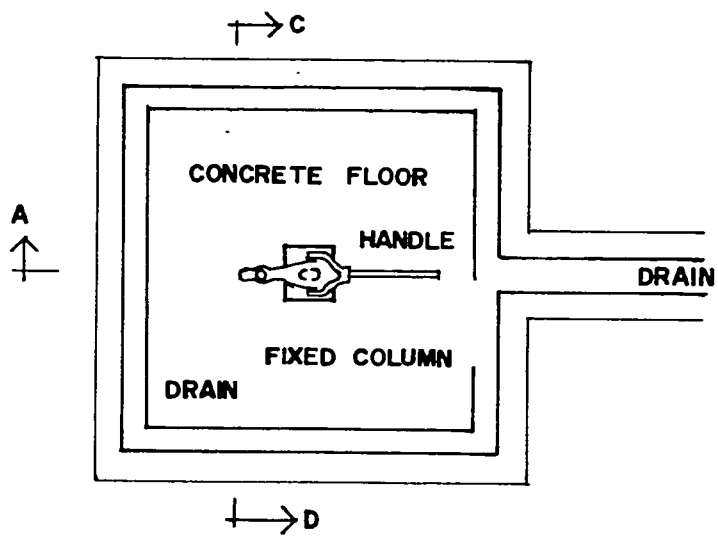
The success of this program has been limited. It has proven difficult to obtain water of acceptable quality from shallow aquifers, and many of the wells which were intended for use by the public are now in private ownership.

HEALTH DEPTMENT SHALLOW WELL DESIGN



IF GROUND WATER LEVEL IS LESS THAN 7. M.

SECTION A – B



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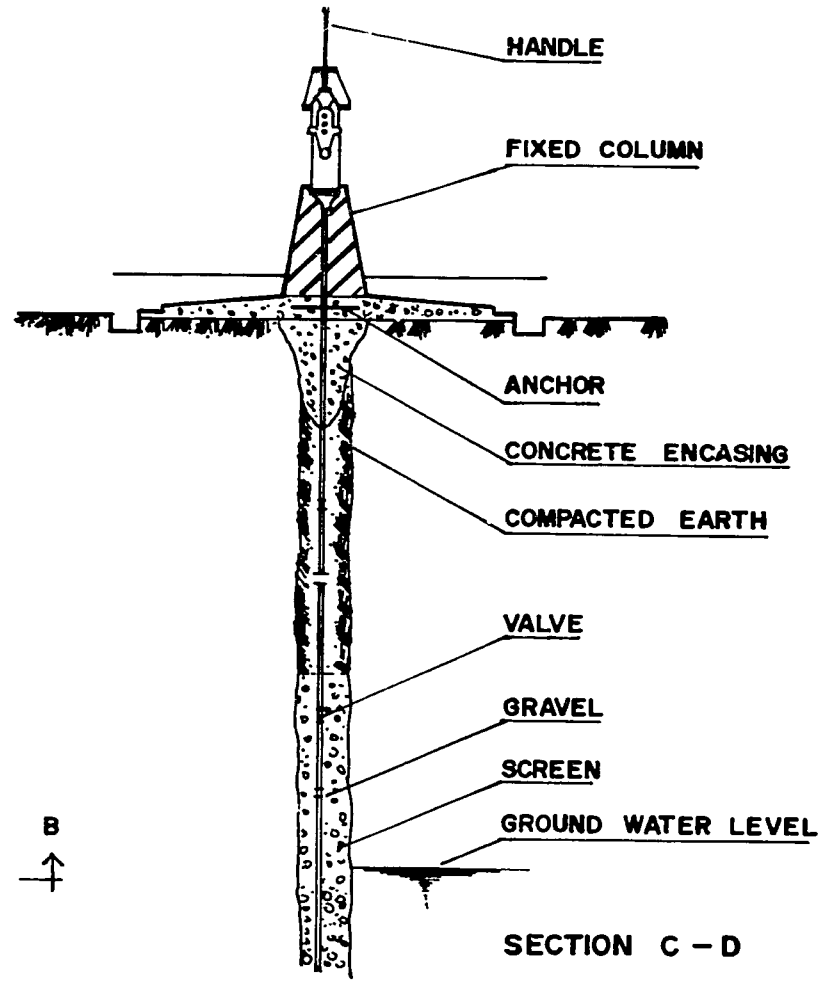

SECTION C – D

FIGURE 2.13

SECTION 3

PROJECTED WATER QUANTITIES

3.1 POPULATION AND LAND USE PROJECTIONS

General estimates of projected population in the study area were developed by Kecamatan in Section 2 of the Long-Term Development Report, which was prepared as part of these investigations. To determine water demand and waste generation patterns, however, it was necessary to assess population distribution on the basis of smaller political units, Kampungs, and further subdivide these into percentages of residential types according to income and population densities. Kecamatan and Kampung boundaries within the study are shown in Figure 3.1.

The existing population distribution by Kampung was obtained from registration records. The numbers and locations of the various residential categories of consumers are necessary to make realistic projections because water use and waste generation are functions of affluence level. The following residential classes were identified by density and income level within each Kampung from 1972 aerial photographs.

High Income - Low density

High Income - Medium density

Medium Income - Low density

Medium Income - Medium density

Medium Income - High density

Low Income - Low density

Low Income - Medium density

Low Income - High density

Projections of the population in different income-density groups within the 1978 built-up areas were basedon the existing income-density distribution. Details of the population distribution by income and density in the 75 Kampungs in the 1978 built-up area are given in Table B.1 of Appendix B. Projections made in areas which are not presently built-up but will be by the year 2000 were based on the following assumed pattern:

Low Income - Low Density - 70 percent

High/Medium Income - Low Density - 30 percent

The population projections by Kecamatan are presented in Table 3.1.

TABLE 3.1

POPULATION DISTRIBUTION BY KECAMATAN

Kecamatan	1978	1980	1985	1990	1995	2000
Medan Kota	232,230	236,900	249,000	261,100	275,000	289,000
Timur	178,790	183,960	193,540	214,000	225,000	236,500
Baru	121,508	126,400	141,080	159,000	178,100	206,640
Barat	132,287	137,600	151,900	175,700	194,800	215,100
Denai	119,416	124,240	138,280	178,000	207,400	249,000
Labuhan	54,031	57,320	63,300	69,900	78,800	87,000
Johor	54,660	56,870	62,800	79,300	95,300	120,200
Tuntungan	17,475	18,180	56,070	66,900	83,860	107,590
Sunggal	94,383	99,200	109,500	143,900	179,600	211,100
Deli	51,456	56,200	62,050	68,500	76,000	86,200
Belawan	60,000	61,200	64,300	67,600	71,000	75,000
Medan II	-	46,800	51,670	57,100	63,000	69,600
Total	1,116,236	1,204,870	1,343,290	1,541,000	1,727,860	1,952,930

The existing and projected land use needs were based on 1972 aerial photographs and 1976 land use maps and are summarized as follows:

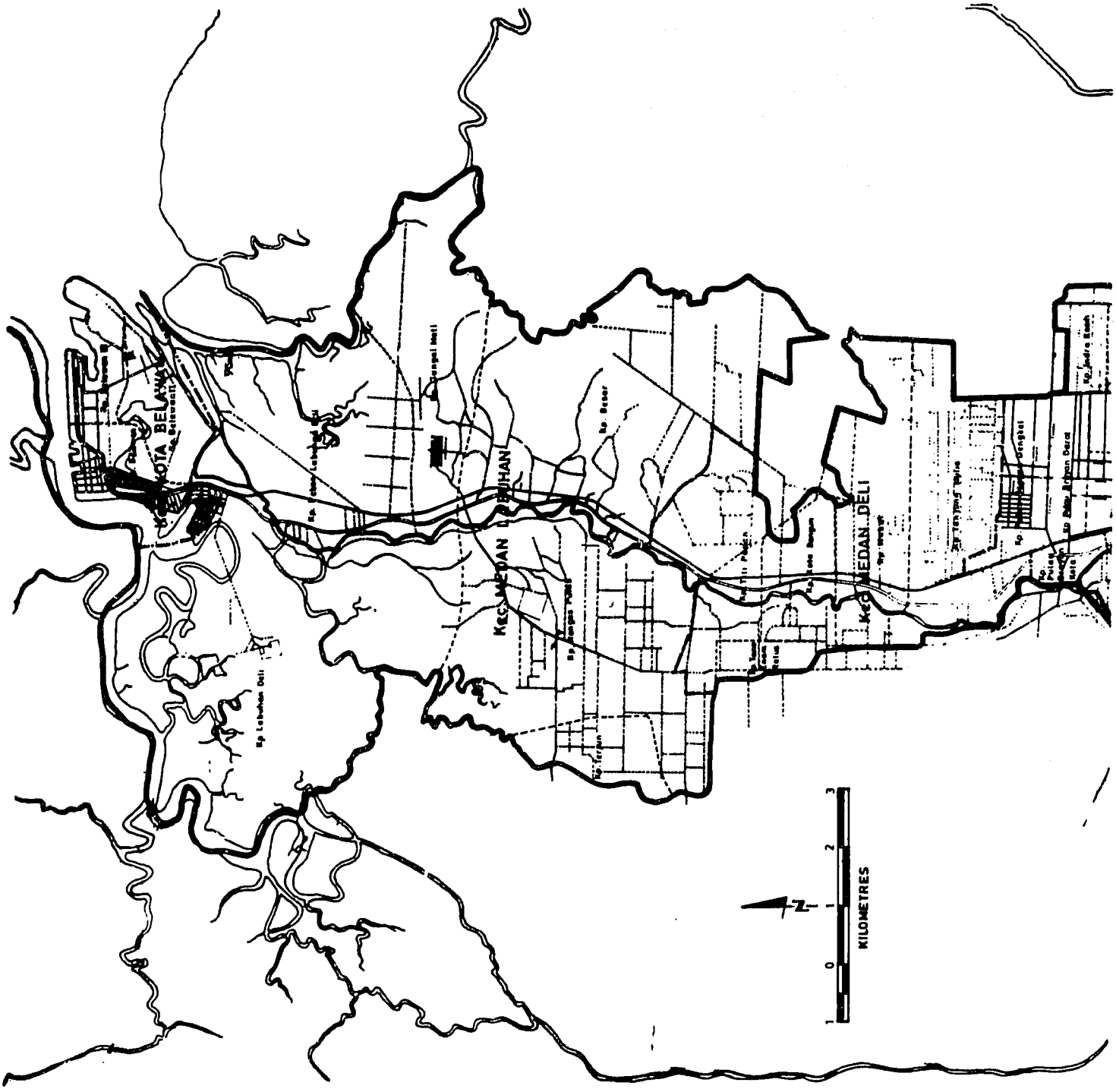

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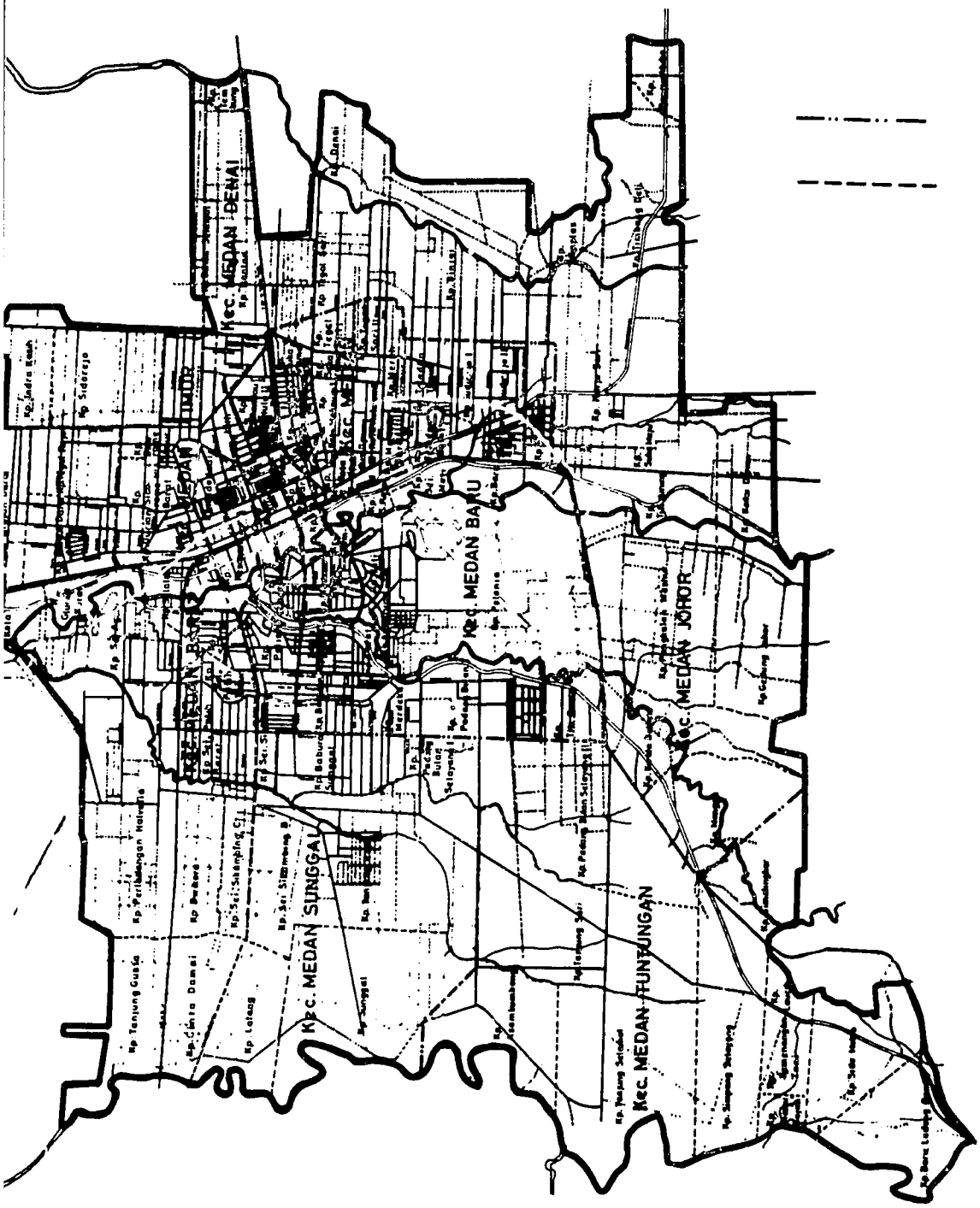
FIGURE 3.1

KAMPUNG BOUNDARIES WITHIN STUDY AREA



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ESTIMATED LAND USE NEEDS (hectares)

Type	1980	1985	1990	1995	2000
Commercial	391	479	654	656	761
Industrial	358	399	440	480	516
Institutional	323	378	437	502	576
Total	1,072	1,256	1,531	1,638	1,853

The detailed demographic and land use projections from which Table 3.1 and the above land use summary were prepared are presented in Table B.1 of Appendix B for each of the 75 Kampungs.

3.2 PRESENT WATER USE

3.2.1 Municipal System (Tirtanadi)

The municipal system presently (1978) supplies water to an estimated service population of 290,000. About 270,000 people receive water through 29,560 metered service connections and an estimated 20,000 obtain water from 93 public standpipes. Commercial, industrial, and institutional customers are also served via an additional 6,900 metered connections. Unaccounted for losses amount to about 25 percent of the water produced. A summary of present municipal water use in the Study Area is presented below:

Category	Estimated Quantity, in cu m/d
Domestic	40,500
Institutional	11,700
Commercial/Industrial	13,900
Unaccounted for losses	21,800
Total	87,900

3.2.2 Non-municipal Deep Wells

A number of commercial, industrial, and institutional water users obtain their supplies from deep wells not connected with the municipal system. The largest of these is the Belawan Port Authority which derives an estimated 4,580 cu m/d from deep wells. Approximately 60 deep wells supply an estimated 5,960 cu m/d to various other non-residential water users.

3.2.3 Non-municipal Domestic Supply

The information available on this category of water use is very scanty and the following figures are therefore necessarily tentative. While about 25 percent of the population obtain their water requirements from the municipal system, the balance obtain water from the only two other sources available to them — shallow wells and surface water from rivers and streams.

Based upon experience elsewhere, it is estimated that consumers with individual shallow wells use about 80 l/c.d. From experience in other similar areas where water must be carried from public sources, the water use for this consumer category is estimated at 35 l/c.d. Using these per capita figures, the estimated amount of water presently being obtained by residential water users from non-municipal sources is as follows:

Consumer Category	Estimated Water Use, cu m/d
Individual households with shallow wells	56,000
Public sources from which water must be carried	5,250

3.2.4 Present Unit Water Use

3.2.4.1 Domestic

An examination of recent Tirtanadi billing records revealed that the average domestic consumption in 1978 was 176 l/c.d. Specific residential areas where high and medium income groups predominated were identified and their unit water use estimated from these records. Residents in the more affluent areas (such as Polonia) use about 265 l/c.d, while use in medium income, high density areas (multi-storey mixed commercial/residential housing in the central business area) was approximately 145 l/c.d.

Based upon an examination of Tirtanadi water records for medium income areas served partially by the municipal system and partially by individual household shallow wells, it was estimated that this type of consumer would use about 100 l/c.d if connected to the municipal system.

It is assumed that domestic users presently obtaining water from public shallow wells or rivers would continue to consume the same amount of water as they do at present (35 l/c.d) if they were able to obtain their supply from public standpipes.

Based upon the above, the estimated present unit water use for all domestic categories is as follows:

Domestic Category	Present Water Use, in l/c.d
High Income - Low density	265
High Income - Medium density	265
Medium Income - Low density	215
Medium Income - Medium density	215
Medium Income - High density	145
Low Income - Low density	145
Low Income - Medium density	100
Low Income - High density	35

3.2.4.2 Commercial, Industrial, and Institutional

Present commercial, industrial and institutional land use within the municipal water system service area was estimated from 1972 aerial photographs and 1976 land use maps to be as follows:

Land Use Type	Area within Tirtanadi Service Area, ha
Commercial and Industrial	311
Institutional	549
Total	860

Estimated commercial, industrial and institutional water use within the Tirtanadi service area is summarized below:

Water Source	Estimated Water Use, in cu m/d
Commercial and Industrial	
Municipal (from 1978 Tirtanadi records)	13,900
Deep Wells	5,960
Shallow Wells and Surface Streams	3,020
Institutional	
Municipal	11,700
Total	34,580

Combining the above information, we obtain an estimate of present commercial, industrial, and institutional water use in the Tirtanadi service area of 40,200 l/ha.d. For purposes of this analysis, a unit rate figure of 41,000 l/ha.d has been adopted.

3.3 PROJECTED WATER USE

3.3.1 Projected Unit Water Use

Allowing for a gradual increase in per capita domestic water use with time to reflect future increase in general affluence levels, the projected unit domestic water use rates in the Study Area were estimated to be as presented in Table 3.2.

TABLE 3.2

PROJECTED UNIT DOMESTIC WATER USE

Residential Type		Unit Water Use, l/c.d				
Income	Density	1978	1980	1985	1990	2000
High	Low	265	265	265	275	300
High	Medium	265	265	265	275	300
Medium	Low	215	215	225	240	260
Medium	Medium	215	215	225	240	260
Medium	High	145	145	160	175	200
Low	Low	145	145	160	175	200
Low	Medium	100	100	115	125	150
Low	High	35	35	35	35	35

The amount of water used by people who must carry their supplies from public standpipes is strongly limited by the amount which can or will be carried and can therefore expected to remain constant at 35 l/c.d.

Unit water use rates for commercial, industrial and institutional activities can be expected to remain essentially unchanged at 41,000 l/ha.d and this figure was therefore adopted for use in making projections of future non-residential water use.

3.3.2 Future Unaccounted for Water

A study of the amount of water entering the city, and the metered amounts distributed by Tirtanadi, as of the end of 1978, revealed an unaccounted for amount of 25 percent. The introduction of new pipes will tend to reduce this figure while the continued use of the old pipes coupled with higher pressures will tend to increase it. Taking all the above factors into consideration, it is estimated that 25 percent of the water brought into the new service area will continue to be unavailable to consumers throughout the study period. This figure includes leakage and illegal use by unauthorized tapping.

3.3.3 Total Projected Water Use

A summary of total projected water use (municipal plus non-municipal) in the study area is presented in Table 3.3. Detailed projections of total water use by consumer category and Kampung are presented in Table B.2 of Appendix B.

TABLE 3.3

SUMMARY OF TOTAL PROJECTED WATER USE

Category	Estimated Total Water Use, cu m/d			
	1980	1985	1990	2000
Domestic	136,510	169,430	214,190	317,870
Commercial, Industrial, Institutional	54,690	62,640	70,675	85,450
Un-accounted for water	63,760	77,330	94,955	134,440
Total	254,960	309,400	379,820	537,760

3.3.4 Projected Municipal Water Use

Conversion of water users from non-municipal sources to municipal supply will of course take place gradually over a considerable period of time as the system is strengthened and expanded. For the purposes of this estimate, it has been assumed that the national Repelita III goal of providing potable water to 60 percent of the urban population by 1985 can be achieved, and that 80 percent will be served by the year 2000. It has also been assumed that commercial, industrial, and institutional users presently relying on their own water systems will gradually convert to municipal supply as that system is improved and becomes more reliable. A summary of the proportion of water needs assumed to be met by the municipal system is presented below:

Category	Served by Municipal System			
	1980	1985	1990	2000
Domestic (percent of population)	25	60	75	80
Commercial, industrial, and institutional (percent of demand)	71	73	76	84

A summary of the projected municipal system water requirements is presented in Table 3.4 Detailed projections of municipal water demand by consumer category and Kampung are given in Table B.3 of Appendix B.

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TABLE 3.4

SUMMARY OF PROJECTED MUNICIPAL WATER USE

Category	Estimated Municipal Water Use, cu.m/d			
	1980	1985	1990	20000
Domestic	48,300	106,900	161,400	254,300
Commercial, Industrial, Institutional	29,500	39,300	46,200	61,700
Unaccounted for water	25,900	48,700	69,300	105,300
Total	103,700	194,900	276,900	421,300

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SECTION 4

PUBLIC HEALTH

4.1 PRESENT CONDITIONS AND PROBLEMS

4.1.1 Health Statistics and Data

In any area, the incidence of enteric diseases is a measure of the general level of sanitation. The available health statistics in Medan confirm the problems that are evident even from a cursory examination of the water supply and sanitation systems.

Table 4.1 presents health data for 1978 obtained from the Medan Health Department, the Provincial Health Department, hospitals and other sources. At best, these statistics are incomplete because there is no comprehensive, uniform system in the city for reporting disease incidence statistics. Many disease cases are unreported or are not treated in established health care facilities. As a consequence, the figures shown in Table 4.1 err on the low side.

Comparisons between kecamatans should be made only very cautiously. For example, Kec. Johor reported no cases of diarrhoeal diseases from the Health Centers in 1978. It is highly improbable that there were no cases; it is more likely that cases of diarrhoeal disease that did occur were not reported for one reason or another.

The data shown in Table 4.1, incomplete as they are, strongly support the fact that many people in Medan are using water from unsafe sources. In 1972-73, there was a major outbreak of cholera in North Sumatra where 22,745 cases were reported. This was an increase of about 50 times the rates reported over the previous three years in the Province. Diarrhoeal diseases (for which Health Centers above reported treating four percent of the population in 1978) are a major contributor to the extremely high Medan infant mortality rate of about 110 per 1000 population.

Typhoid fever is also common in Medan, but it is usually treated in the hospitals and reported only irregularly.

Partial statistics from the Medan Health Centers are available for some other diseases that are related to poor sanitation. These are summarized below:

TABLE 4.1

INCIDENCE OF REPORTED ENTERIC DISEASES IN 1978

Kecamatan	1978 Population	Hepatitis		Cholera		Bacillary Dysentery		Diarrhoeal Diseases	
		Cases	No./1000	Cases	No./1000	Cases	No./1000	Cases	No./1000
Kota	232,230	884	3.8	296	1.3	4,364	18.8	15,118	65.1
Baru	121,508	307	2.5	55	0.5	948	7.8	4,168	34.3
Barat	132,287	271	2.0	139	1.1	1,249	9.4	13,466	101.8
Timur	178,790	300	1.7	113	0.6	841	4.7	4,216	23.6
Sunggal	94,383	63	0.7	84	0.9	497	5.3	1,427	15.1
Tuntungan	17,475	74	4.2	3	0.2	74	4.2	832	47.6
Johor	54,660	-	-	2	-	-	-	-	-
Denai	119,416	37	0.3	97	0.8	213	1.8	350	2.9
Deli	51,456	94	1.8	3	0.1	51	1.0	677	13.2
Labuhan	54,031	-	-	192	3.6	1,952	36.1	84	1.6
Belawan	60,000	-	-	189	3.2	307	5.1	1,930	32.2
TOTAL	1,116,236	2,030		1,173		10,496		42,268	
Average			1.9*		1.1		9.9*		39.8*

* Excluding Kecamatan Johor.

Disease	Reported Incidence (cases per 1000 pop.)
Ascaris	6.0
Hookworm	0.5
Scabies	8.1

These incidence rates are extremely misleading, because only the most severely afflicted cases are seen at the Health Centers. Studies reported by the Child Health Department of the Medan General Hospital (RSUPP) indicated that nearly 100 percent of the children in Medan had round worms at some time of the year. One study showed that 87 percent of the children examined had Ascaris (round worm) and 16 percent had hookworms. A special study in Kec. Tuntungan in 1976-77 showed 80 percent of the population were infected with Ascaris and 22 percent were infected with hookworm. A study in Kec. Deli Tua showed that 90 percent of the children had hookworms. Another study showed that 14 percent of the children were infected with Gardia lamblia.

In 1978 the Medan Health Department reported a total of 2083 cases of malaria from eight of the eleven kecamatans. Two-thirds of the cases were from Kota, Labuhan, and Belawan. Dengue (transmitted by the Aedes aegyptes mosquito which also transmits yellow fever) also occurs in Medan.

4.1.2 Quality of Water Supply

4.1.2.1 Municipal System

The physical and chemical quality of the Belawan River, which supplies water to the Sunggal Filtration Plant, is excellent. The fecal and total coliform bacteria concentrations, however, are quite high. A series of samples taken in 1977 and summarized in Table 4.2 showed fecal coliform concentrations ranging from 23,000 to 210,000 MPN/100 ml. All samples taken greatly exceeded the Medan Health Department standard of 2000 MPN/100 ml for raw water entering a public water supply filtration plant.

The Sunggal Filtration Plant was constructed in two phases. The first phase was put in service in 1970, and its design and operation appear adequate to produce a well filtered water. The second phase, added in 1978, appears to be operating less efficiently. There is some indication that mixing in the flocculator-clarifier is less than optimum, and there are obvious deficiencies in the design of the eight filters put in service in 1978.

The poor filter design results in uneven and inadequate filter back-washing which, in turn, may result in unequal filtration rates through poorly washed sand with a consequent lack of effective filtration. This is a matter of concern, particularly in view of the poor sanitary quality of the raw water.

TABLE 4.2

BACTERIOLOGICAL QUALITY OF BELAWAN RIVER WATER

Date/Sample No.	Total Coliform (MPN/100 ml)	Fecal Coliform (MPN/100 ml)
17 Nov. 77		
1	24,000	4,000
2	24,000	24,000
3	28,000	7,000
4	23,000	9,000
19 Nov. 77		
1	24,000	9,300
2	110,000	2,000
3	23,000	23,000
4	210,000	75,000

Facilities for chlorination at the plant are inadequate from the standpoints of both health and safety. At present, with only one chlorine cylinder connected, chlorination must be interrupted to change cylinders. There is no system (such as a pressure switch or a scale) to indicate when the cylinder is empty. Given this situation, it is likely some filtered water is not chlorinated as it flows to the clearwell.

The chlorine safety equipment is not located in the chlorine handling area. Ventilation of the chlorinator room appears to be adequate. However, there is a potential problem in that a door to the pipe galleries opens into the chlorinator room. In an accident, chlorine gas could flow into and fill the pipe galleries.

The spring water sources provide an excellent quality of water, and the collection facilities are well located and designed. The treatment facilities for two of the spring sources are not accessible by vehicles; this fact could delay necessary maintenance and result in unchlorinated water being sent to the distribution system.

The municipal system obtains some water from wells in Belawan. This portion of the system is discussed in connection with the Port of Belawan system in Section 2.

The major public health problem in Medan results both directly and indirectly from deficiencies in the water distribution system. The most serious problem is caused by the low pressures that occur daily over large areas of the city. When the water pressure drops, contaminated

water can enter the system through leaks, plumbing fixtures, cross connections, and private storage tanks, where the local pressure is greater than the system pressure. These sources of contamination are common in Medan and are discussed in detail in Section 4.1.2.2. This problem, which is most acute in the eastern portion of Medan, is common in rapidly developing areas where it has not been possible to provide additional supplies, pumps, storage tanks, and water mains to provide adequate pressure throughout the day.

One particularly unfortunate aspect of this problem is that many public standpipes can only be used at night or during very brief periods of the day. This forces large numbers of people to seek other sources of supply where the risk of contamination is often much greater.

The City and Port of Belawan obtain water from several wells between 100 and 210 m in depth. Although all the wells now in use were originally constructed and operated by the Port Authority, 9 wells which supplied water to the city have been turned over to Tirtanadi. Six of these wells are currently in operation, two are inactive, and one has been permanently abandoned. Of the eleven wells still being operated by the Port Authority, eight are in production, one is inactive, and two have been permanently abandoned.

The quality of the water obtained from the deep aquifer is quite good. One well was reported abandon because of salt water intrusion, but the quality of water obtained from the others has not deteriorated significantly in the last ten years.

From a public health standpoint, it is very important that wells which draw water from deep aquifers be properly sealed to prevent contamination by water of inferior quality which can leak in from shallower aquifers. The casings of the Belawan wells appear to provide an effective seal since no contamination has been observed. However, the three wells which have been abandoned have not been properly sealed to prevent contamination, and they now form direct channels between the deep aquifers and the contaminated surface aquifer.

Abandoned wells can be properly sealed by many different methods depending on the design of the well and the water quality of the penetrated aquifers. Existing designs make proper abandonment virtually impossible in many cases. Thick concrete sanitary seals, some as deep as 80 m below ground surface, do not allow the casing to be pulled while injecting cement or clay. This procedure should be followed where water quality measurements indicate a potential for degradation of useful aquifers. Well sealing is made more difficult by the poor practice of using deep gravel packs which extend beyond the perforated section of the well. In these wells, the casings should be perforated for the full length of the gravel pack before filling with cement or clay.

The wells operated by Tirtanadi for the City of Belawan are turned off between 11:00 pm and 6:00 am. Since there is virtually no storage in the distribution system, there is little or no water pressure when the wells are not operating. Also, as in the City of Medan, the water pressure frequently drops to low levels (and sometimes zero) during

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certain periods of the day. In order to obtain reliable water supplies with fluctuating pressure, it has become standard practice in Belawan to construct low level storage tanks which are directly connected to the distribution system. Water is obtained from these tanks in most cases by a rope and bucket. These practices are unacceptable from a public health standpoint due to the extremely high risk of contamination. Individual storage tanks can become contaminated by runoff or by the rope and bucket used to remove water, particularly when several families share a storage tank. The distribution system can also become contaminated when water from the storage tanks flows backwards into the system during periods of low pressure. The government currently has no authority to regulate these practices.

The World Health Organization's International Drinking Water Standards contain guidelines for the surveillance of water supplies, and surveys of water supply systems are a high priority recommendation. At present, neither the Water Department nor the Public Health Department are conducting any bacteriological surveys of the water supply sources, treatment systems, storage reservoirs, or distribution system. The WHO standard state that "The importance of a sanitary survey of sources of water cannot be overemphasized. No bacteriological or chemical examination, however careful, can take the place of inspecting conditions of the sources of supply and throughout the distribution systems. It should be emphasized that, when sanitary inspection shows that the water, as distributed, is liable to pollution, it should be condemned irrespective of the results of chemical and bacteriological examination".

The Water Department does take samples daily to determine chlorine residual in the clear well of the Sunggal Treatment Plant and at the point of chlorination for the spring water supply to ensure that a residual of 0.5-0.6 mg/l is achieved in order to maintain 0.3 mg/l residual in the distribution system. In spite of these precautions, repeated tests have found chlorine residuals to be very low or absent in Medan. Adequate levels of chlorine residual are desirable to maintain acceptable water quality in the distribution system, but cannot prevent the severe contamination that can result when connections to private storage tanks and wells are permitted.

4.1.2.2 Other Systems

Because of the inadequacy of the municipal water supply system, many residents of Medan have either constructed individual systems which are connected to the municipal system or have turned to shallow wells as a source of water. Both of these alternatives create serious public health hazards.

The extreme fluctuations in water pressure have forced many commercial and industrial establishments that require uninterrupted water supply to provide their own individual systems which are normally of two types: (1) ground level storage filled from the municipal system from which water is pumped to roof level storage; and (2) wells with pumps connected to roof level storage which are cross-connected with the municipal system. There is no form of control or inspection of these systems, and no records of them are available.

The most serious aspect of these individual systems is the fact that neither the Health Department nor the Water Department require any form of backflow prevention or isolation from the municipal system. Most of these systems are therefore connected directly to it. This can (and probably does) result in the entry of contaminated water into the public system. This can occur whenever the pressure in the private system is higher than in the public system - a situation which occurs every day in some areas.

The key to maintaining good public health in an urban environment is an adequate supply of safe water, and safety lies in the rigid separation of the water and human waste. In Medan, the supply of water for most people is insufficient, and the separation of that supply from human waste is grossly inadequate or nonexistent. This is most clearly illustrated in the case of rivers and shallow wells. The fact that more than 75 percent of the population in Medan must obtain water from these sources is the main cause of the high infant mortality and enteric disease rates.

Most of the shallow wells, which constitute the major source of water for people not connected to the municipal system, draw their water from the upper ten metres of the shallow groundwater. In too many cases the wells are close to drainage ditches carrying wastewaters or to privies and latrines. Most of the shallow wells are not designed, constructed or equipped to keep the water free of contamination from the surface. The relatively few tests that have been made of shallow well water by the Health Department have shown high coliform counts in virtually every sample.

Numerous shallow, open wells are used in place of public standpipes in the more densely developed areas of the city. This is due partly to the fact that water from wells is always available, unlike the uncertainty of public water supply pressure, and partly because the well water is free, whereas persons managing public hydrants commonly collect Rp 20 per pail of water. Some of the "public wells" are extremely unsanitary. One, for instance, within three kilometres of the Project Office is a three metre diameter well with no curbing, and a plank walk-way over part of the well in which the water level is about one metre below grade. The well is within two metres of an unlined drainage ditch and within six metres of a nearby overflowing, grossly unsanitary, semi-public privy.

Even along streets where public water mains are available, few of the very low income families have service connections. One major deterrent to increase service connections for these families is the cost of the connection and meter installation. While the cost depends on several factors, it was reported that a common charge is Rp 200,000 which is usually required in advance and in cash. Some government employees are permitted to pay for service connections over a period of time. Obviously, many poor families do not have the money to pay this charge.

Although it will not be possible to eliminate the use of shallow wells in the near future, some measures can be taken to lessen the risk inherent in their use. Such measures are described and recommended in Section 7, and some measures are being taken now as described in Section 4.3

4.2 CURRENT REGULATIONS

There are certain National and local regulations which are intended to ensure that adequate safeguards of the public health are maintained.

The surveillance of a city water supply system is properly the shared responsibility of the Water and Health Departments. The surveillance should be carried out under authority of National, Provincial and Municipal governments. The National or Provincial health authorities should have the responsibility to see that local authorities carry out their surveillance responsibilities and that applicable laws and regulations are enforced and complied with.

The Indonesian laws include:

1. Act on Public Hygiene, Nr.11, 1962 Gazette Nr.48, 1962

2. Act on Basic Public Health Nr.9, 1960, Gazette Nr.131, 1960.

To assure that the public water supply meets requirements necessary to protect public health, a surveillance program should be planned, executed and continuously carried out to meet the requirement of the Act on Public Hygiene which is intended to assure "Protecting/maintaining/increasing public health which include prevention of diseases which endanger the public". It is common for countries to use the World Health Organization's "International Standards for Drinking Water (1971)" as the basis for their standards, making such modifications as are necessary and acceptable. These standards indicate that microbiological tests should be conducted regularly in a water supply system such as Medan's. The Medan Public Health Department, until 1978-79, did a limited amount of sampling for measuring chlorine concentrations and for testing according to WHO microbiological standards, but are not presently taking and analyzing such samples. The Water Department makes chemical and physical analyses but does no microbiological testing of the supply.

The fact that neither the Water Department nor the Health Department has any authority to regulate private water systems which are connected to the public system — and can cause widespread contamination — indicates that one of these department should begin a program of microbiological sampling immediately to ensure that the objectives of the Act on Public Hygiene are met.

4.3 CURRENT PROGRAMS

The Government of Indonesia, as is common in much of the world, adopts five year development plans for which there are budgetary appropriations. One element of the plans is to provide improved water supply and excrete disposal for families which are not presently and will not in the next several years be provided with public water supplies and sewerage systems. When the first water and sanitation plan was adopted, it was estimated that only five percent of the families in areas to be served by the program had

latrines, and one percent had access to an approved water supply. The goal of Repelita II, which was completed in 1979, was to have 15 percent of the families served by sanitary latrines and 10 percent of the families to have access to a safe water supply.

A future goal is to provide progressively increased numbers of hand pumped wells for drinking water supply. Although the primary emphasis for long term development will be on providing piped water to every home, financing will probably not be available for many years to provide this level of service throughout the scattered housing of Medan. The Medan Public Health Department's policy provides that priorities for shallow well hand pumps will be allocated to areas where enteric disease rates are high and public water supplies are not expected to be available within less than five years. The goal of Repelita II was one pump for each 200 people. Repelita III will reduce this to 100 persons per pump. The goals also include locating pumps so people of villages living along paths will not have to walk more than 200 metres to a pump.

The hand pump wells installed by the Health Department have 1¼ inch pipes, are properly cased, and have sealed tops to exclude surface water. There is a concrete slab and drain to provide a dry, mud-free area around the pump. The hand pump has a gasketed pump rod to exclude contamination and this also enables use of a dual water outlet. One outlet discharges to containers brought by the public. A valve enables changing to a pressure discharge through a connection for a garden-type hose. The total number authorized for Medan for 1979 was 60 wells. Each well costs Rp.140,000.

This program has not been entirely successful due to difficulties in locating acceptable water and lack of public acceptance. In the Labuhan area, for example, four wells were authorized. One was to be installed at a school, but it was not possible to obtain water of acceptable quality at a depth of 20 m. The well was finally installed successfully at a private house, and now, it is a private well. Of the four installed wells, two are acceptable, and two produce so much color (iron) as to be relatively unacceptable. On the other hand, shallow dug wells (2.5 to 3 m deep) produce water which is of good quality, except bacteriologically. Similar experiences were reported in other areas of Medan. People who have become accustomed to using shallow individual wells are reluctant to walk considerable distances to the extremely limited numbers of widely scattered wells which it has been possible to provide, even though the water may be of higher quality than that available from nearer sources.

SECTION 5

DESIGN CRITERIA AND BASIS FOR COST ESTIMATES

5.1 INTRODUCTION

The purpose of this section is to delineate design and cost estimating criteria for the physical facilities required for the water system. The design criteria presented herein represent a combination of accepted international and locally developed design concepts. Within the constraints of acceptable levels of performance and good engineering practise, full consideration was given to the need to minimize costs in the capital-short environment in which the system must operate.

The cost data presented in this section are based upon the best currently available information obtainable from suppliers and contractors and the records of local agencies involved in the construction and maintenance of water supply facilities. Where appropriate, these data have been modified to reflect the estimated impact of changes in design concepts or construction methods as envisioned for the proposed facilities. In the absence of cost information on a given type of facility from local sources, data from similar or, failing that, developed countries were adapted to fit local conditions. All cost figures reflect prices applicable for mid-1979 unless noted otherwise.

Where the alternative evaluation process involved costing of a large number of the same type of facility of varying capacities, cost curves were prepared. If the facilities to be compared were few in number or quite complex in nature, general unit rates for materials and labor were developed for use in estimate preparation. Where appropriate, preliminary screening of alternatives was carried out on the basis of a comparison of average annual costs.

5.2 DESIGN CRITERIA

5.2.1 General Criteria

Though many countries have developed their own sets of standards over a long period of years, other countries are gradually adopting either the World Health Organization's European Standards for Drinking Water or the World Health Organization's International Standard for Drinking Water. The latter have been adopted for the purpose of this investigation. They are applicable under the International Sanitary Regulations for determining acceptability of water available at international airports. They

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are less exacting than, say those stipulated by the American Water Works Association, and have been developed with minimum sophistication and with due consideration to the economic levels of the majority of the countries of the world.

The service life of components of the water supply scheme are assumed to be as follows, unless specifically stated otherwise:

Structure and pipeline - 50 years
Mechanical equipment - 15 years

5.2.2 Wells

Design criteria for well development depend mainly on:

1. Whether the wells are to be developed as well field or as individual wells.

2. Whether treatment is necessary, and if so, its type and extent.

The wells developed in this Master Plan will be on an individual basis for the reasons described below. The requirements for the development of wells for Medan are:

1. The availability of a developable ground-water aquifer

2. The ability to minimize concentration of wells along north-south corridors to avoid interference in view of the ground water flow in the region being from south to north. During the first stage the spacing of wells should be at least 400 metres in a north-south direction and 200 metres in an east-west direction.

3. Availability of land

4. A location close to existing or planned distribution or transmission lines.

5. Nearby storage to avoid the necessity to stop pumping during periods of low demand

6. A comparatively short distance to the major electrical transformers and substations

7. The availability of two electrical power sources from different transformers and preferably from different sub-stations.

Development of individual wells offers the greatest flexibility in meeting the above requirements.

Individual well sites need to be no larger than 200 sq m and should provide a clearance of at least 5 metres around the well casing and unlimited overhead clearance. A site should also have an adequate drain within 100 metres of the site. The site should be fenced or located in an otherwise secure area, and the well and accessory equipment should be protected from direct sunlight.

The dimension of the well's casing screen and pack should be sufficient to permit:

1. flow velocity through the gravel pack of less than 0.03 m/s and through the screen at less than 0.05 m/s.

2. flow velocities through the casing which will maintain adequate operating water levels above the pump intake.

3. continuous production of 1,000 cu m/d or more.

Well production should be maintained at a constant level and be protected from power surges and system back pressure.
The well design should provide for:

1. well depth of at least 200 m

2. well bore diameter of at least 300 mm

3. well casing and screen diameter of at least 200 mm and preferably 250 mm

4. conductor casing of at least 80 m

5. gravel pack of washed, well-rounded and graded gravel throughout the full depth of aquifer with provision for adding gravel

6. perforated screens of corrosion-resistant material from 80 m to within 20 m of the bottom of the well

7. screen perforations with more than 15 percent open area with slots of 1.5 mm width or less

8. a well head foundation at least 0.3 m above ground level

9. support for pump and effluent pipe separate from casing and conductor pipeline

10. meters for total flow and power consumed

11. access ports for water sampling and level monitoring

Pumped water should be discharged directly to the distribution system after disinfection. If the water quality indicates the need for additional treatment, this should be done at the reservoir site to eliminate a further stage of pumping. Wells should be sealed to prevent entry of ground water within the upper 10 m and fully-cased to about 50 m depth.

5.2.3 Water Treatment

Clarification: The two existing clarifiers at Sunggal are of the solids contact (sludge blanket) sludge-circulation type. The quality of the effluent deteriorates slightly in the afternoon but otherwise no serious problems have been encountered. A third clarifier of the same type is scheduled to be constructed shortly and for uniformity, convenient maintenance and operation, the clarifiers built in the future should be of the same type. The surface loading rate should be in the range of 65 to 70 cu m/sq m.d. Under local conditions, with the temperatures comparatively high on most afternoons, a maximum figure of 70 cu m/sq m.d is recommended. The detention period should be between 1.5 and 1.75 hours. Maximum weir loading should be in the range of 175 to 200 cu m/m.d.

Filtration: Rapid filtration through a granular media should be used. The media should be graded sand with an effective size (d_{10}) of 0.8 to 1.2 mm and a maximum uniformity coefficient of 1.5. The filtration rate should be 8 to 10 cu m/sq m.h.

Of the two existing filters, the original one is of comparatively orthodox design where-as the second is not. In the original filters, the rate of flow was designed to be controlled by automatic rate controllers. These ceased to function about two years after their installation, and filters have functioned without them for the last seven or eight years. Rate of flow controllers were not provided in the second set of filters, and the lack of even manual control shows clear evidence of the creation of a negative head leading to air-binding.

The advantages of controlling the rate of flow without rate controllers must be emphasized. This method, which has been tested on plant scale over the past ten years very successfully, is done in one of two ways:

1. Variable Head: A constant filtration rate is maintained by increasing the head on each filter to compensate for the increasing head loss in the filter. Constant rate filtration is achieved without flow controllers and while one filter is washed, the remaining filters share the additional load. A filter unit or box about 1.5 to 1.75 m deeper than the conventional filter compartment is needed. But no automatic equipment is necessary and the number of valves and appurtenances is reduced to a minimum.

2. Variable declining rate: In this method of operation, all of the filters are interconnected hydraulically and operate with the same head over the sand. The maximum rate through each filter is controlled by an orifice plate in its outflow pipe. As the headloss through each filter increases, the rate of flow through that filter decreases. However, because the filters are backwashed at different times, the total flow through the set of filters remains relatively constant.

Of the two, the variable declining rate filters are technically superior and give a better quality effluent. Filter runs are longer

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and very little equipment is needed. In either type, the clear water tank should have a weir at a higher level than the wash water trough level to prevent the occurrence of a negative head. The declining rate arrangement can be adopted in most existing filters having trouble with rate controllers and should be used in the existing plant.

Some structural alterations would be needed, but very little additional equipment. Operation and maintenance will become more labor-intensive. It is therefore recommended that new filters be designed on the declining rate of flow principle and that the existing second set of filters be modified to work on the same principle.

Back-washing should include air-scour; the recommended rates are:

water only	-	35 to 50 m/h
air and water	-	air: 50 m/h water: 7.5 m/h
surface wash	-	water: 5 m/h
water usage	-	3%

Clorination: Both pre-chlorination and post-chlorination should be by use of a solution of gaseous chlorine. As pre-chlorination is done only at certain times, the post-chlorination dosage will vary, but should be sufficient to maintain a minimal residual of 0.1 mg/l in the distribution network.

Fluoridation: This is a very useful feature in a major water supply scheme but its adoption generally depends on the financial position. The minimum dosage necessary to prevent dental caries is 0.5 to 1.0 mg/l, depending on the mean temperature in the area. A careful check has to be kept on the maximum dosage to prevent mottled teeth. With an average annual maximum temperature of 31.2°C in Medan (1976 Medan Statistical Year Book), the recommended dosage should be between 0.6 and 0.8 mg/l. Either sodium flourosilicate (Na_2SiF_6) containing 60 percent available fluoride or 30 percent hydroflourosilic acid containing 23 percent fluoride could be used. The extra cost per metered connection is estimated to be about Rp.140 per year at present chemical costs.

5.2.4 Transmission

The transmission from springs to the city (by gravity) and from Sunggal to the city (24 hours pumping) is at a constant rate. It is recommended that this be continued in future with the addition of adequate storage and boosters within the service area to handle peak demands. Major mains should be sized to carry the average maximum day demand. With the limited fluctuations in local climatic conditions, a maximum day/average day ratio of 1.15 has been adopted.

The pipe material chosen, besides being strong enough to withstand the requisite pressures, should be corrosion-resistant and durable. The choice of pipe material is severely restricted in this project by

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the existing prices and availability of the different types. Asbestos Cement pressure pipes are presently manufactured locally only up to 60 mm diameter but ductile iron and coated steel pipes are two to three times as expensive as ACP pipes of the same size. The distribution network will require pipes of maximum diameters of up to 900 mm. Under these circumstances, it is cheaper to replace all pipes larger than 600 mm diameter by two smaller ACP pipes of equivalent carrying capacity, providing, in addition, the opportunity of staging and thereby reducing the initial capital outlay. Local pipe pricing structure and availability should be reviewed with each new pipe laying project. The requirements for distribution system pipe in the Medan area should be large enough to support a pipe manufacturing operation. It is particularly suggested that steps be taken to encourage the local production of prestressed concrete pipes and appurtenances.

5.2.5 Pumping

Pumps will be driven by electric, constant speed motors. Single stage horizontal or vertical centrifugal pumps will be used where it is possible to maintain a positive head on the pump suction. Where priming would be required for centrifugal units, vertical turbine pumps will be used.

The largest pump in any pump station should be duplicated for standby capacity.

5.2.6 Distribution

The Hazen-Williams formula with suitable 'C' values depending on the age and condition of the pipes has been used in calculating the sizes of distribution pipes.

There are no major differences in elevation in the service area, and hence there is no need for pressure zones. The allowance for fire-protection has been limited to 180 l/s in commercial areas and 45 l/s in other areas. A few selected nodes in the distribution network will be capable of these flows, enabling one major fire to be dealt with at a time. It is assumed that there would be a reduction in pressure in the domestic supplies during the fire-fighting period.

In the case of new pipes, the smallest diameter used in the commercial areas should be 400 mm and 300 mm in other areas. The minimum residual pressure at ground-level for services was taken as 15 metres, which could drop to 5 metres during a fire. A maximum residual pressure of 75 metres was assumed. This is compatible with the maximum allowable pressure of the different makes of pipes likely to be used in the network.

The storage available in the system is negligible, and there is no perceptible "peak" in the pattern of consumption. A consumption pattern is certain to be established when an adequate supply is provided and a factor suitable for Medan can only be obtained by comparison of consumption patterns in other cities with similar social and climatological conditions. A peak factor (ratio of peak hour flow to average flow) of 1.7 has been adopted.

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Another important feature in a distribution network is the provision and location of valves. The ideal arrangement is one that permits the isolation of any single line between two junctions for repairs. This would require a very large number of valves of large and small diameter, with an accompanying high initial capital outlay. The provision of valves should therefore be done in a manner so that a reasonably sized but limited area may be isolated.

Ordinary gate valves should be used for smaller diameter pipes. The use of butterfly valves should be given serious consideration for the larger diameters as these, in addition to performing the function of a gate valve, are less expensive.

The type of pipe that should be used will be in accordance with present practise in the Republic in general and in Medan in particular.

80 mm-200 mm - Asbestos cement pipe or unplasticized PVC pipe

200 mm and larger - Asbestos cement pipe

All joints, including PVC pipe joints, should be of a generally accepted design of the flexible type. High quality rubber rings are an absolute necessity for prevention of leaks at the joints.

The velocities will range between 0.75 m/s in small pipes to approximately 2.5 m/s in the larger pipes.

Pipes should be laid at a depth providing a minimum cover of 1 m. For service pipes this may be reduced to 0.6 m.

5.2.7 Storage and Boosting

The storage provided in a water supply scheme consists generally of three components:

1. Equalizing or operating storage (a function of the peak factor)
2. Fire reserve
3. Emergency reserve

The storage needed for equalizing, with a peak factor of 1.7, is approximately 16 percent of the average daily flow. The flows provided for fire protection and described in the earlier section can be met from the additional storage provided of nine percent of the average daily flow. Emergency storage depends mainly on the vulnerability of the supply to failures in production or transmission. In this case there are two sources and at a later date deep wells and probably another surface water treatment plant. The risk of interruptions due to production failures are minimal and from records available, the water authority has a good record in carrying out repairs fairly speedily. Taking the above factors into account, a total storage amounting to twenty five percent of the daily consumption is considered sufficient. Booster stations should be provided at the 4 major storage reservoirs.

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5.2.8 Service Connection

Service connections provided should be of the following type:

1. Ordinary direct screwed-in type ferrules should be used where-ever the wall thickness permits.

2. Ferrule installation should be aided by the use of saddles where the wall thickness is inadequate to hold a screwed-in ferrule firmly in place.

3. The service pipe from the ferrule connection to the house should be of unplasticized PVC. As the characteristics of these pipes depend on the temperature, the minimum depth of 0.6 metres should be carefully observed and precautions should also be taken to ensure that no pipes are exposed to direct sunlight.

4. All services should be metered, installation of a meter box being optional with the type of service desired.

5.2.9 Public Standpipes

Standpipe coverage in the city is very limited at present. There are only 93 standpipes in the city, many of which deliver water for only part of the day due to low pressures in the distribution network.

Due to the inadequate service provided by existing standpipes the poorest residents are compelled to purchase water either from neighbors having house connections or from persons controlling access to public stand-pipes at a very high unit cost. A common price for water purchased from private connection owners or public standpipes is 5 rupiahs per pail (a pail contains about 10 litres). This amounts to 500 rupiahs per 1,000 litres, an amount considerably more than the 15 rupiah per 1,000 litres currently charged residential water users connected to the Tirtanadi system.

Given the practical difficulties of charging individual standpipe users at rates which would be comparable to unit rates paid by people with standard service connections, public standpipe water may have to be provided at no cost to the individual in the interests of social equity.

This would provide an alternative supply to these people who cannot afford a municipal service connection or an individual shallow well.

The present government policy under the Kampung Improvement Program is to provide on standpipe to serve about 300 persons. At present urban densities this results in about one standpipe per hectare, or a maximum carrying distance of about 60 metres. The results of field surveys carried out under this investigation and by others indicates that this is about the maximum distance that people are willing to carry water. Greater standpipe densities would of course provide a higher level of convenience to users but could also result in larger revenue losses, which would have to be made up by Tirtanadi by some means.

a6

Standpipe service should be viewed as a means whereby government can meet its obligation to provide the minimum of potable water essential for health to the very lowest income segments of the public. Alternatives to standpipe service should be made available at reasonable cost to the rest of the public. Lowering the present high service connection fees and encouraging the use of single service connections by more than one family represent viable methods of accomplishing this. It is therefore recommended that, at least in the initial stages of the standpipe program, the one standpipe per hectare criteria be retained.

Until such time as the pressures in the municipal system become adequate to enable standpipes to function satisfactorily, it is recommended that a tank, fitted with a float-valve and an inexpensive type of cover to prevent pollution be provided at each standpipe. The outlet tap should be one designed to minimize wastage. It is recommended that every standpipe be metered, as a commercially run water authority should be able to at least recover its cost of providing such supplies, perhaps from a government grant.

5.3 BASES FOR COST ESTIMATION

5.3.1 General Bases for Pricing

Current prices of local materials and labor in Medan are summarized in Table 5.1. The unit prices of earthwork and masonry include the costs of labor, materials, equipment, a ten percent contractors overhead and ten percent allowance for contractors profit. No provision is included for supervision and taxes.

TABLE 5.1

GENERAL MATERIALS AND LABOR COSTS

Description	Unit	Unit Cost (Rp.)
Labor		
Unskilled labor	day	700
Skilled labor		
Mason	day	1,200
Carpenter	day	1,400
Assistant to skilled labor	day	800
Foreman	day	1,250
Material (delivered to site)		
Sand for filling	cu m	1,400
Sand for mortar	cu m	1,700
Sand for concrete	cu m	2,000
Gravel for concrete	cu m	2,900
Broken stone	cu m	3,400
Sirtu (sandy stone)	cu m	2,400
Crushed stone	cu m	3,900

TABLE 5.1--Continued

Description	Unit	Unit Cost (Rp.)
Brick	100 pcs	1,850
Portland cement (Cibinong)	40 kg	2,100
Lime	100 kg	3,500
Asphalt	100 kg	9,000
Reinforcement steel	kg	300
Earthworks		
Excavation by hand		
0-1 metre	cu m	500
1-2 metres	cu m	600
Soil transport by hand over maximum distance of 50-100 m	cu m	200
Back filling	cu m	250
Sand filling	cu m	1,500
Loading and unloading of truck using man-power	cu m	250
Trench excavation up to depth of 1.5 m	cu m	550
Filling including compaction (each layer 20 cm)	cu m	1,250
Masonry		
Stone masonry	cu m	19,500
Plastering	sq m	750
Concrete mixed in place 1:3:5	cu m	18,000
concrete mixed in place 1:2:3	cu m	23,000
Reinf. steel including binding and placing	100 kg	45,000
Timber formwork for concrete	cu m	57,000
Housing material		
Paint		
Wall paint	3.5 litres	6,900
Wood paint	1 litre	2,750
Roof		
Cement roof tile	pcs	100
Corrugated asbestos cement 14 x 4 mm x 5 feet	sheet	2,200
Asbestos cement roof 4 mm x [illegible] m x 2 m	sheet	2,360
Floor		
P.C. Tile 20 x 20	pcs	45
P.C. Tile 30 x 30	pcs	160
Glass (transparent)		
t = 3 mm	sq m	3,500
t = 5 mm	sq m	5,750
Wood - depending on quality (1 ton - 1.35 cu m)	ton	40,000 to 115,000

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5.3.1.1 Price Contingencies

No allowance has been made for price escalation arising from inflationary causes. The prices used are current market prices prevalent around mid-1979.

5.3.1.2 Land Acquisition

Most of the water mains will be laid under the public roads, and the cost of land acquisition for these items consequently will be very small. Appreciable areas of land will be needed, however, for the development of treatment plants, storage reservoirs and booster stations for water supply Provision has been made for the above requirements taking into account the locality where the parcels of land are required and the prevalent land prices in such areas.

5.3.1.3 Engineering Services

The cost of engineering services during the design and construction phase is estimated at ten percent of the construction cost of the facilities and has been accordingly included in the estimates.

5.3.1.4 Physical Contingencies

A physical contingency allowance of 15 percent has been added to the estimated costs of all facilities to provide for any unexpected items of work that may be found necessary during construction and also to provide for any inadvertant omissions or other inaccuracies in the cost estimates.

5.3.2 Water Supply System

Construction costs of treatment plants, storage reservoirs, booster-pumping stations, distribution trunk and feeder mains and their appurtenances have all been based on prevalent prices of local materials and labor in Medan and the best available estimates of costs of imported machinery, equipment and materials.

Where components of the system are of varying sizes and capacities, the unit prices are given in the form of costs curves and are described under each individual sub-section.

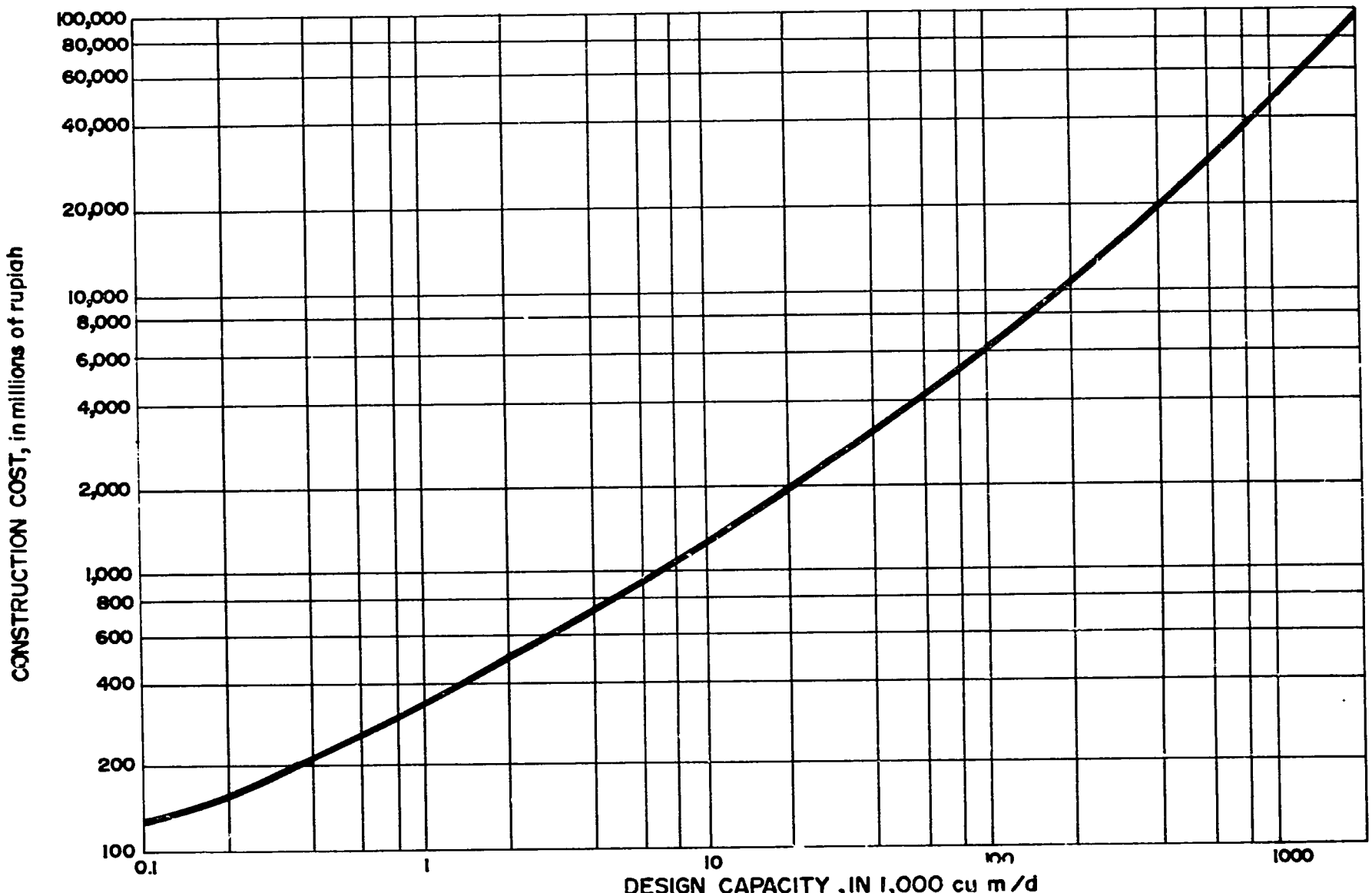
5.3.2.1 Treatment Plants

The present estimated-costs of water treatment plants is given in Figure 5.1 and provides for clarification, filtration, and disinfection. Cost of land, engineering, pumping stations and clear water tanks are additional.

5.3.2.2 Transmission and Major Distribution Mains

The cost of supplying and laying asbestos cement(AC), coated steel (CS) and ductile iron (DI) pipes are given in Figure 5.2, 5.3 and 5.4, respectively. It should be noted that the steel and ductile iron pipes

WATER TREATMENT PLANT CONSTRUCTION COST



NOTE: COSTS INCLUDE TOTAL CONSTRUCTION COST OF TREATMENT PLANT PROVIDING FOR CLARIFICATION, FILTRATION AND DISINFECTION. COST OF LAND, ENGINEERING, PUMPING STATIONS OR FINISHED WATER RESERVOIRS ARE ADDITIONAL

ASBESTOS CEMENT PIPE COST

FOR WATER MAINS

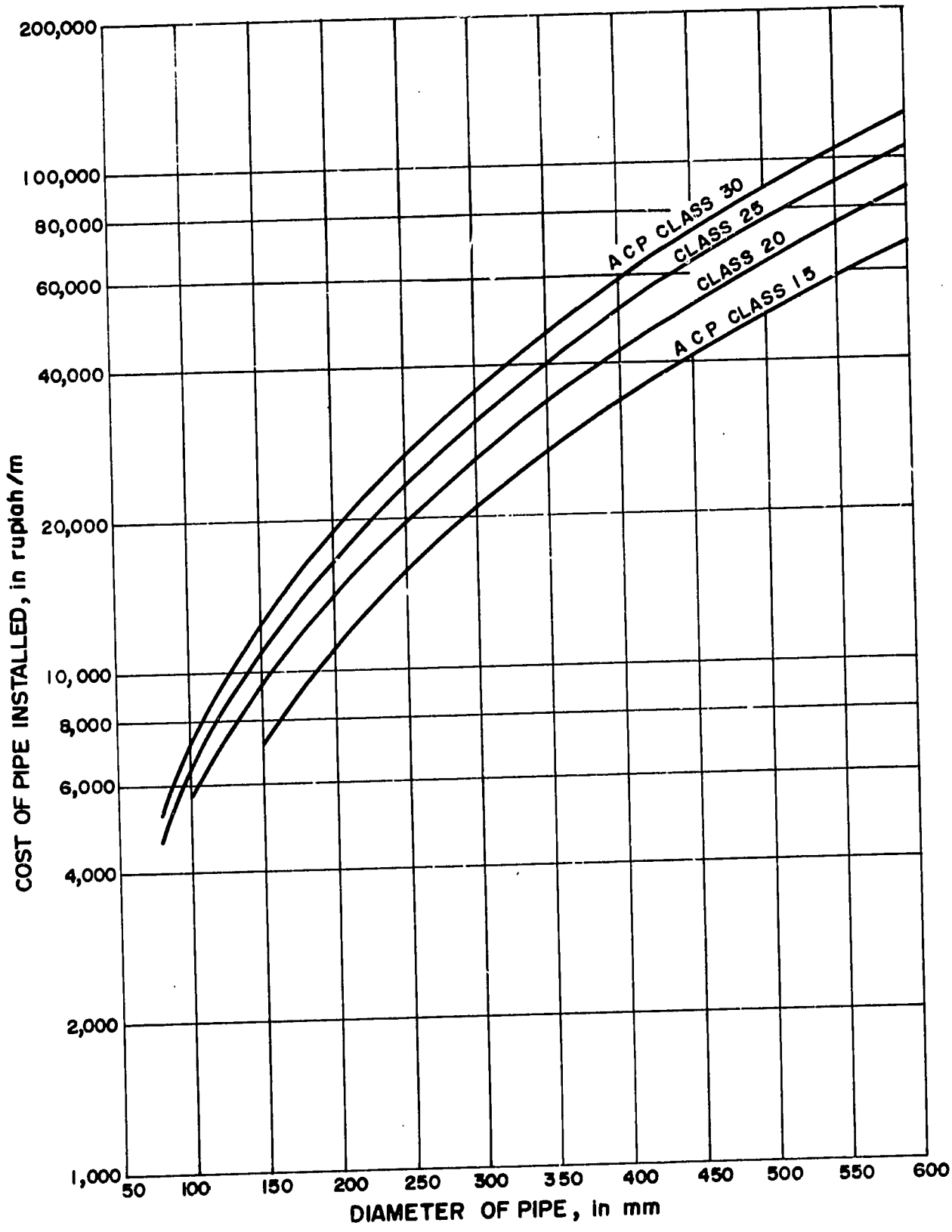
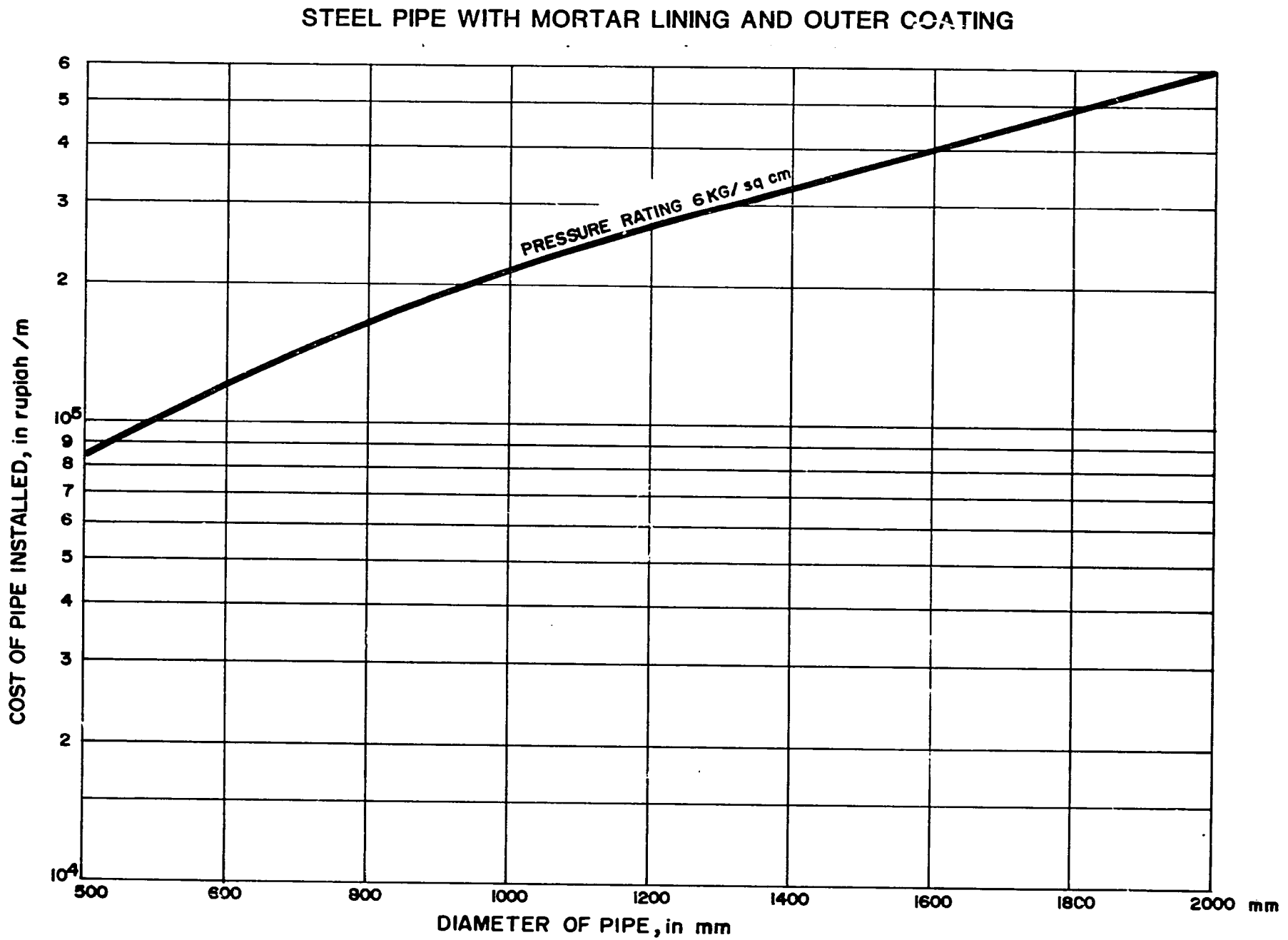


FIGURE 5.3


STEEL PIPE WITH MORTAR LINING AND OUTER COATING
PRESSURE RATING 6 KG/ sq cm
COST OF PIPE INSTALLED, in rupiah /m
6
5
4
3
2
10^5
9
8
7
6
5
4
3
2
10^4
500
600
800
1000
1200
1400
1600
1800
2000 mm
DIAMETER OF PIPE, in mm

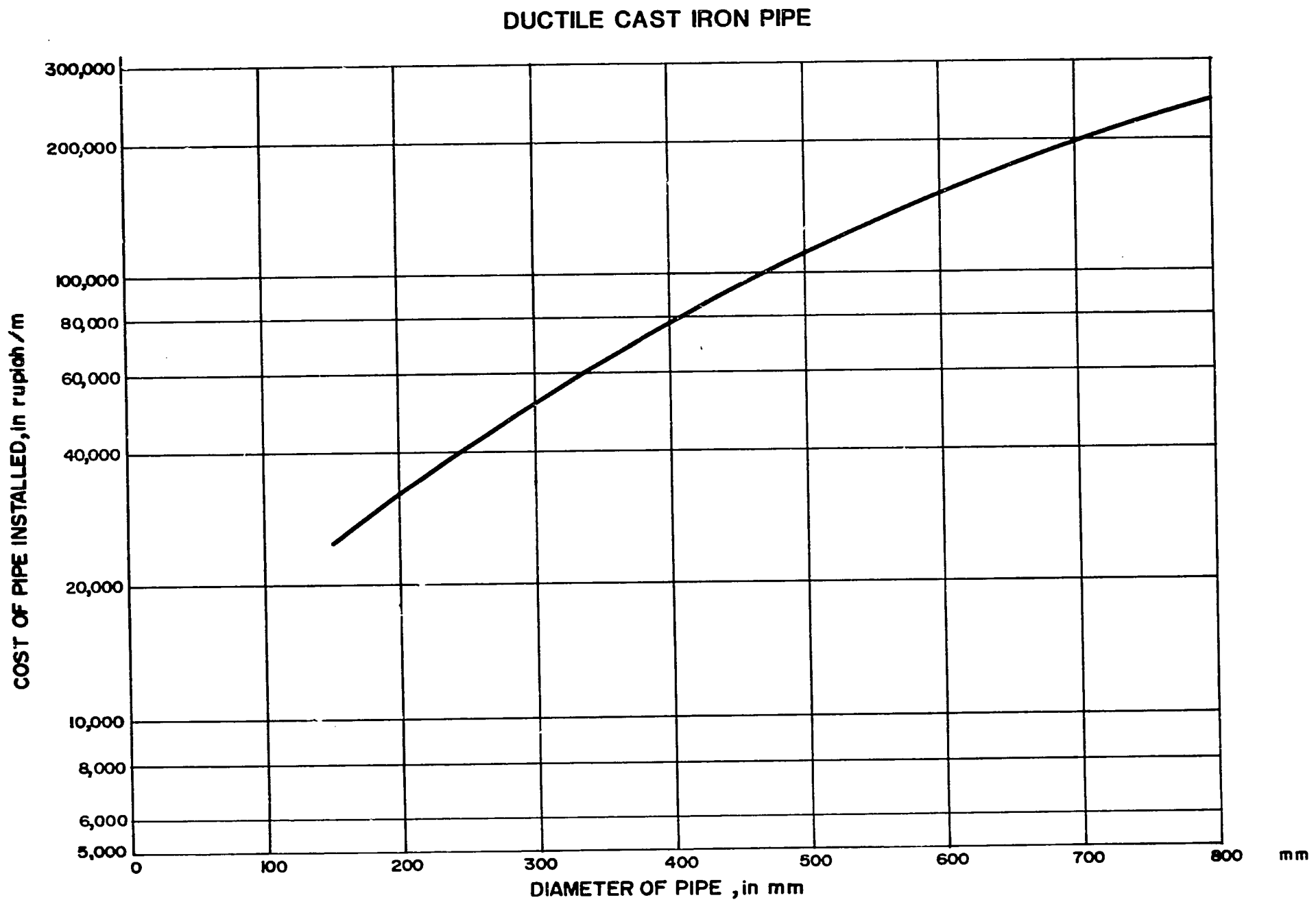

DUCTILE CAST IRON PIPE
COST OF PIPE INSTALLED, in rupiah/m
300,000
200,000
100,000
80,000
60,000
40,000
20,000
10,000
8,000
6,000
5,000
0
100
200
300
400
500
600
700
800
mm
DIAMETER OF PIPE , in mm

FIGURE 5.4

are presently 2 to 3 times as expensive as AC pipes of the same diameter. Where the required diameter of pipe exceeded 600 mm, which is the largest size manufactured locally, two equivalent ACP pipes with the same carrying capacity were selected.

5.3.2.3 Pumping Stations

The costs of pumping stations (high-lift and low-lift at the treatment plants) and booster pumping stations within the service area are shown in Figure 5.5. The costs shown include pumps and drive controls, valves, fittings, pump-house and installation of equipment.

5.3.2.4 Local Distribution

It is the present practice of Tirtanadi to use PVC pipe for local distribution lines where direct service connections are allowed. Although PVC pipe is more expensive than AC for the diameters required for local distribution mains (200 mm or less) it is nonetheless recommended that this practise be continued. Installation of service connections on the AC pipe is considerably more difficult than for PVC. Leakage from improperly installed servive connections on AC pipe is a common occurrence in situations where well equipped, highly skilled workmen are in short supply.

The costs of PVC pipes of diameters less than 200 mm that could be used for feeder mains are given in Table 5.2.

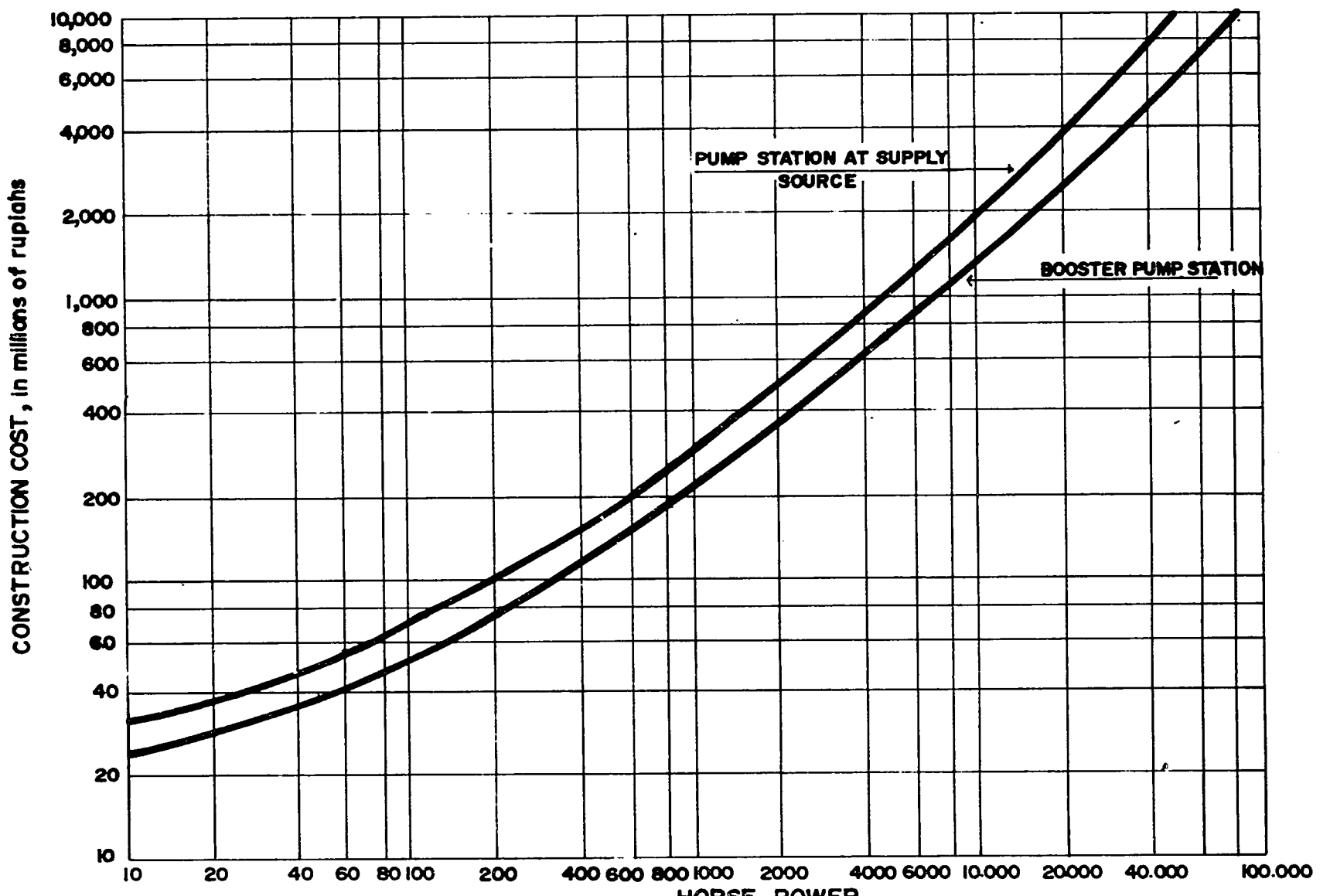
TABLE 5.2

INSTALLED COST OF PVC FEEDER MAINS

Pipe Diameter inches (mm)	Estimated Cost, Rupiah per metre		
	Pipe	Installation	Total
0.50	525	235[a]	760
0.75 (19)	570	245[a]	815
1 (25)	770	260[a]	1,030
1.25 (32)	905	270[a]	1,175
1.50 (38)	1,285	285[a]	1,570
2 (51)	1,885	390[b]	2,275
2.50 (64)	2,395	410[b]	2,805
3 (76)	3 ,340	430[b]	3,770
4 (100)	5,415	1,200[c]	6,615
5 (125)	7,095	1,290[c]	8,385
6 (150)	9,850	1,385[c]	11,235

a No bedding required.
b Sand bedding required.
c Gravel and stone bedding required.

WATER PUMP STATION COSTS



NOTE : COST INCLUDES PUMP AND DRIVE CONTROLS
VALVES, FITTINGS, PUMP HOUSE AND INSTALLATION

FIGURE 5.5

5.3.2.5 Valves

Cost of gate valves for trunk mains (200 mm diameter and larger) and feeder mains (50 mm to 150 mm diameter) are presented in Table 5.3.

TABLE 5.3

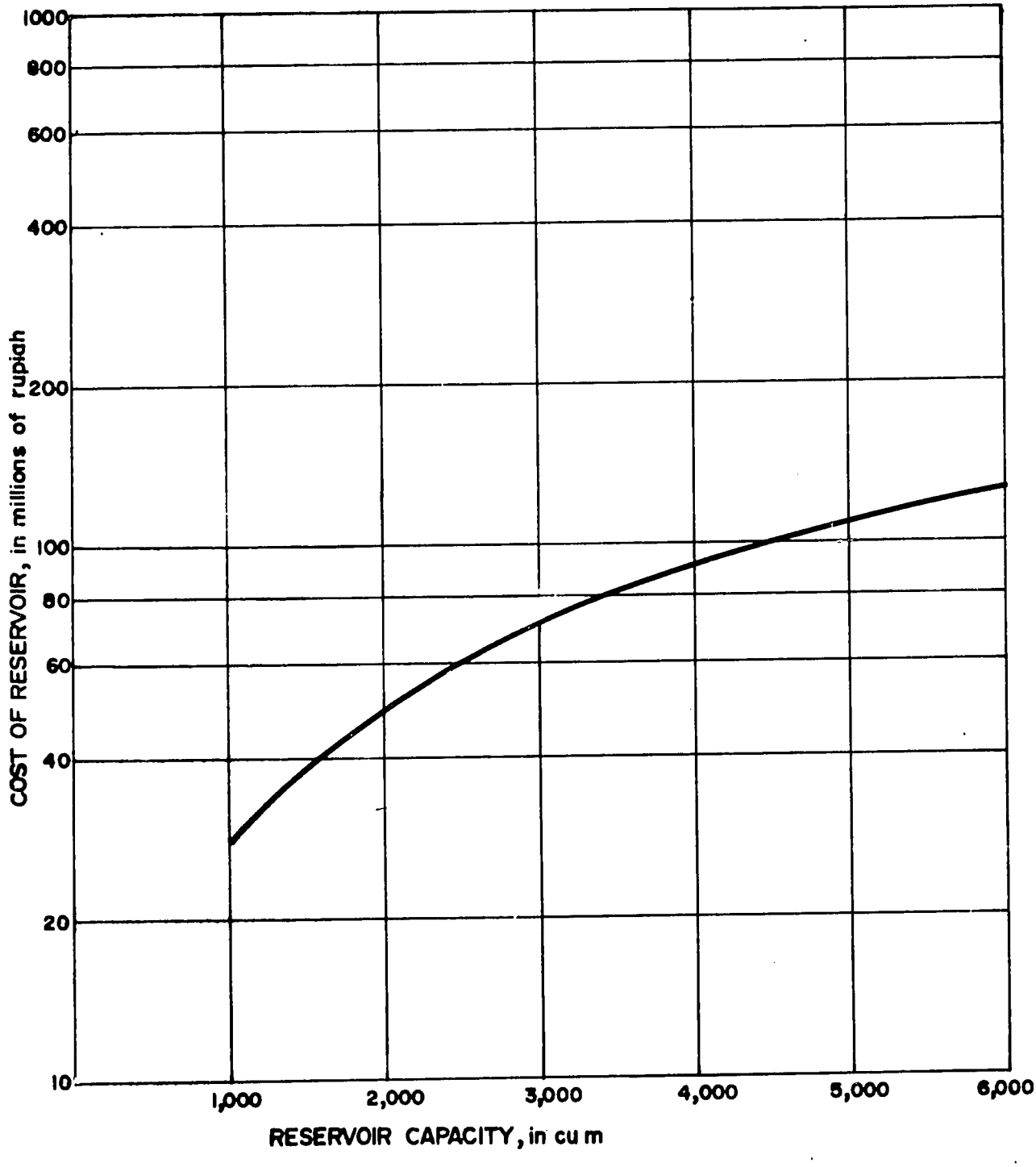
COST OF GATE VALVES FOR WATER DISTRIBUTION SYSTEM

Valve Size (mm)	Valve	Estimated Cost, 1,000's of Rupiah			Total
		Joining	Chamber	Labor	
Feeder Mains					
50	21	13	42	16	92
75	26	20	42	16	104
100	42	30	42	16	130
125	47	39	42	16	144
150	56	45	42	16	159
175	75	49	42	16	182
Trunk Mains					
200	94	56	42	16	208
225	119	83	47	23	272
250	131	97	47	23	298
300	187	123	47	23	380
350	262	147	47	23	479
375	313	159	47	23	542
400	384	170	47	23	624
450	449	266	69	42	826
500	562	327	69	42	1,000
550	749	404	69	42	1,264
600	842	476	69	42	1,429

5.3.2.6 Storage Reservoirs

The costs of ground-level storage reservoirs of different capacities are given in Figure 5.6. The costs shown in this figure are applicable to reservoirs of the more conventional type built out of reinforced concrete. Figure 5.7 gives the costs of a less expensive type of reservoir utilizing earth embankment and a plastic liner instead of reinforced concrete. The earth embankment type of reservoir requires a larger site, but except for areas with very high land costs, the construction cost savings outweight this disadvantage.

COST OF GROUND RESERVOIRS
(REINFORCED CONCRETE TYPE)



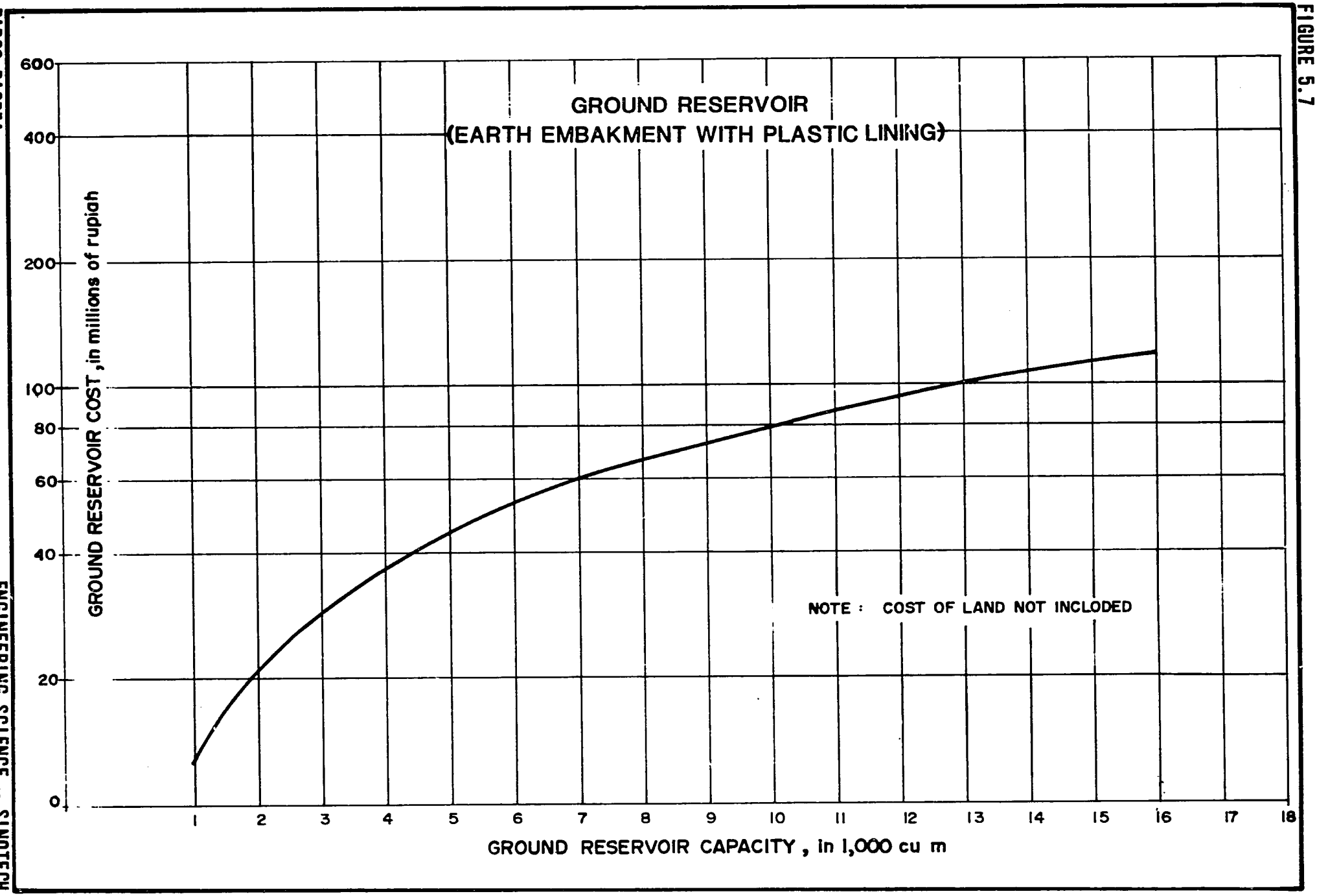

GROUND RESERVOIR
(EARTH EMBAKMENT WITH PLASTIC LINING)
GROUND RESERVOIR COST, in millions of rupiah
600
400
200
100
80
60
40
20
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
GROUND RESERVOIR CAPACITY, in 1,000 cu m
NOTE : COST OF LAND NOT INCLODED

FIGURE 5.7

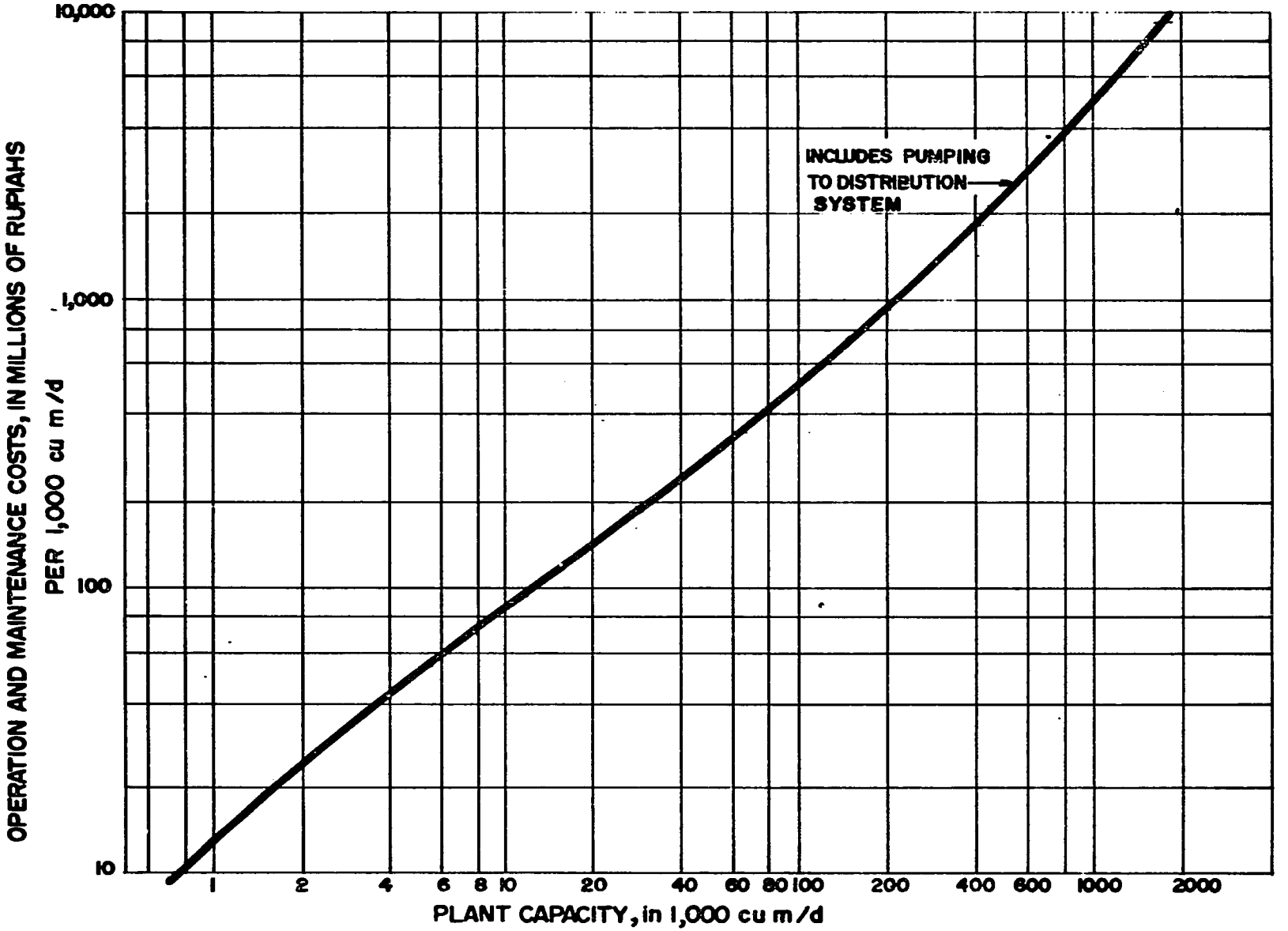
5.3.2.7 Operation and Maintenance

The costs of maintenance of engineering structures, pipe lines, etc. have been estimated at one and a half percent of the capital costs except in the case of moving machinery and equipment where a two percent allowance has been made. In the case of booster pumping stations, the maintenance costs have been worked out on the above basis and the operational costs added to it, the cost of electricity being rated at the prevalent price of 21.5 Rupiahs per kilowatt-hour.

The costs of operation and maintenance of treatment plants of varying capacities are shown in Figure 5.8 and includes labor, chemicals, equipment maintenance, power, gasolene, operation and maintenance of vehicles and other items of miscellaneous expenditure.

FIGURE 5.8

OPERATION AND MAINTENANCE COSTS FOR WATER TREATMENT PLANTS



NOTE : COST INCLUDES LABOUR, CHEMICALS, EQUIPMENT, POWER, GAS, VEHICLES AND MISCELANEOUS

10c

SECTION 6

ALTERNATIVE WATER SUPPLY MANAGEMENT SYSTEMS

6.1 INTRODUCTION

Selection of an optimal water supply management system must consider the projected water demands in the study service area, the various water sources available, and the differences in transmission, distribution, and storage costs associated with alternative sources of water. The primary purpose of this section is the evaluation of existing and potential new water sources and the identification of optimal distribution systems for alternative sources. From this evaluation and identification, a recommended water supply management system was developed and is presented in Section 7.

In addition, methods and programs for conversion of private supply systems to the municipal system are identified and evaluated. Improvements to the widespread shallow wells are an important part of these programs.

The total present supply of about 100,000 cu.m/d must be increased to meet a projected average day demand of 195,000 cu.m in 1985 and 421,000 cu m in 2000. The deficits between existing supply sources and projected demands require development of new sources with production of 91,000 cu m/d between 1980 and 1985 and of about 226,000 cu m/d between 1985 and the year 2000. An average of 15,900 cu.m/d of new source production must be provided each year between 1980 and 2000. This annual production increase is nearly equal to two thirds of the most recent expansion of the Sungal Water Plant; five years' increase would be more than the production from all remaining planned expansions of the Sunggal Plant.

6.2 ALTERNATIVE WATER SOURCES

Three alternative water sources are available to Medan, (1) springs, (2) river waters, and (3) groundwater.

The municipal water system uses each of these sources. PAM Tirtanadi collects 46,000 cu m/d water from the springs at Sibolangit, 52,000 cu m/d from the Belawan River, and 3,000 cu m/d from wells in Belawan (Figure 6.1).

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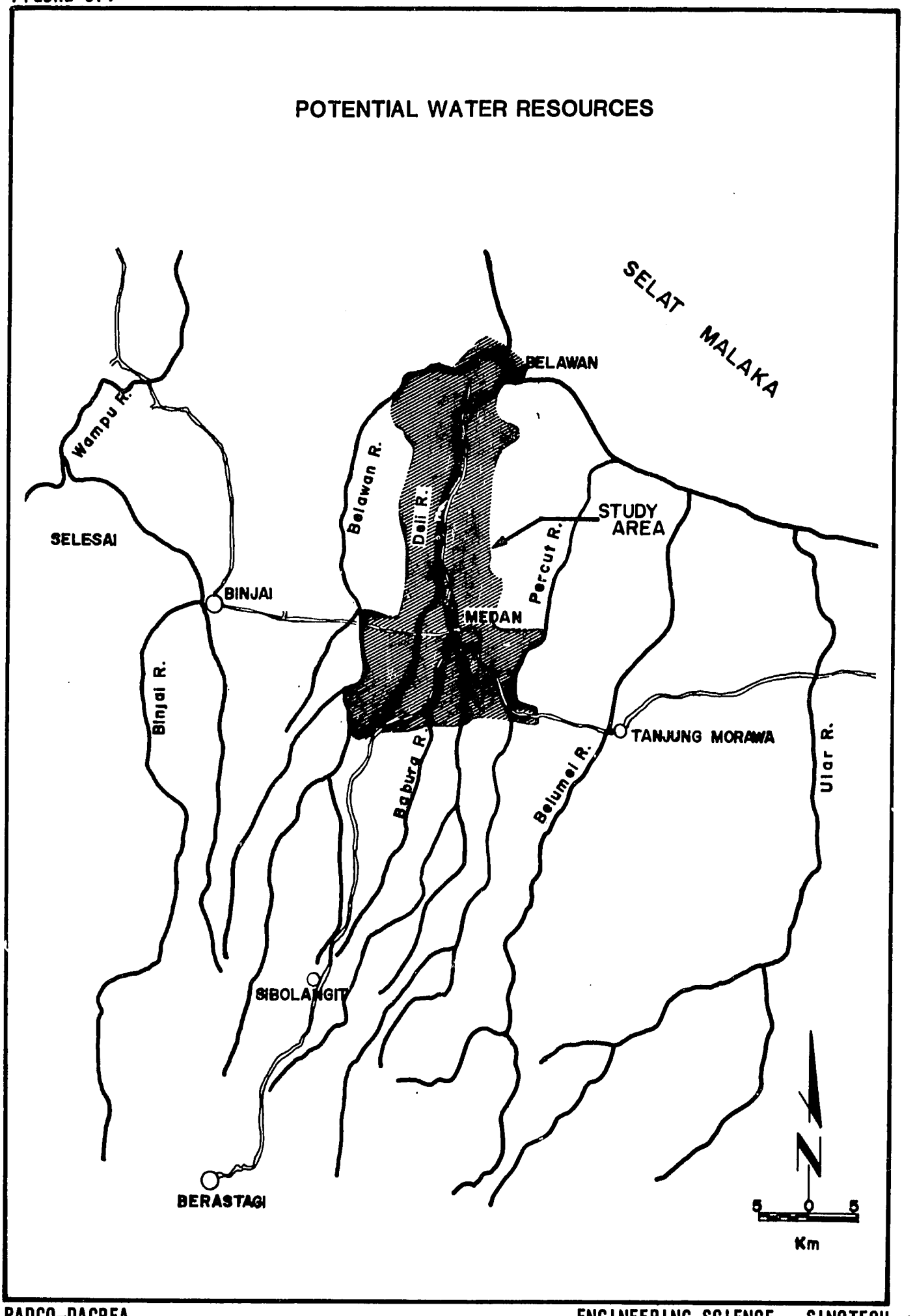
FIGURE 6.1


POTENTIAL WATER RESOURCES
SELAT MALAKA
BELAWAN
Wampu R.
Belawan R.
Deli R.
STUDY AREA
Percut R.
SELESAI
BINJAI
MEDAN
Binjai R.
TANJUNG MORAWA
Ular R.
Babura R.
Belumai R.
SIBOLANGIT
BERASTAGI
N
5 0 5
Km

These sources supply 46 percent, 52 percent, and 3 percent, respectively, of the present municipal system production.

Potential spring sources are located at Sibolangit, at Rumah Galuh and Tuntungan, and at Kampung Bantan and Tanjung Marihan.

Seven major rivers lie within practical transmission distances:

Local - Belawan

- Deli and its tributary, Babura

- Percut

Regional - Binjei

- Wampu

- Belumai

- Ular

Groundwater sources are found throughout the region, although suitable municipal supply must be drawn from depths of 100 to 200 m.

Each major source category has been evaluated and important sources and their yields have been estimated. Estimated production, required facilities, and costs for each source are evaluated within each supply category. A summary comparison is presented for important sources from each category.

6.2.1 Springs

Four major springs or groups of springs lie within 40 km south of Medan (see Figure 6.1). The flows of these and other springs in northern North Sumatra have been estimated by the Geological Survey of Indonesia (published as a map and list, 1978). The Sibolangit Springs (four groups of springs) have the highest estimated flow of about 76,000 cu m/d, while the next larger springs range from 8,000 to 17,000 cu m/d (see Table 6.1). A discussion of the hydrogeologic aspects of the Sibolangit Springs is presented in Appendix C.

Some flow from these springs not used by Tirtanadi has been used historically by local landowners, and considerable negotiations may be necessary before more springs can be collected and downstream flows reduced.

6.2.1.1 Sibolangit Springs

Existing municipal springs have been monitored for many years, and the general water quality is presented in Table 6.2. The generally high quality of the spring water does not require extensive treatment. Some aeration, pH adjustment, and disinfection for the long transmission to Medan appear to be the only needs.

TABLE 6.1

PRODUCTION OF OTHER POTENTIAL SPRING SOURCES

Spring Number	Name of Spring	Estimated Production (cu m./d)	River Basin	Distance from Medan Service Area (km/direction)		Elevation
24	Rumah Galuh	17,300	Binjei	26	SW	300
26	Tuntungan	8,600	Belawan	9	SW	90
41	Tanjung Marihan	10,800	Belumai	16	SSE	140
42	Kampung Bantan	13,000	Belumai	16	SSE	140

SOURCE: The Rumah Galuh and Tuntungan springs and the Tanjung Marihan and Kampung Bantan springs could be developed together. Names ans spring numbers from Geological Survey of Indonesia (1978).

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TABLE 6.2

SURFACE WATER AND GROUNDWATER QUALITY

Parameter	Units	Rivers Belawan	Rivers Deli	Rivers Percut	Springs	Belawan Wells[b]
Temperature	C°	25 - 28	25 - 28	25 - 26	23 - 24[c]	27 - 33
Color	Pt/Co Scale	0.2 - 40[a]	-	-	-	-
Turbidity	FTU	-	-	-	0.01 - 0.15[c]	0.02 - 2.5
pH	-	6.9 - 7.9	6.7 - 6.9	6.7 - 6.9	6.1 - 7.2	7.1 - 7.8
Alkalinity	mg/1	23 - 97[a]	-	-	60 - 130	95 - 247
Carbon dioxide	mg/1	4 - 42[a]	-	-	8 - 42	9 - 70
Calcium	mg/1	4 - 23[a]	-	-	14 - 29	1 - 16
Magnesium	mg/1	3 - 6[a]	-	-	5 - 11	1 - 10
Iron	mg/1	0.2 - 0.8	0.4 - 1.5	0.3 - 2.8	0.02 - 0.03	-
Mangenese	mg/1	0 - Tr	0	0	ND	-
Hardness	mg CaC03/1	16 - 74[a]	27 - 46	39 - 45	37 - 100	23 - 68
Arsenic	mg/1	0	0	0	ND	-
Chromium	mg/1	0	0	0	-	-
Copper	mg/1	TR - 0.2	TR - 0.1	0.1 - 0.4	ND	-
Cyanide	mg/1	0	0	0	-	-
Fluoride	mg/1	0 - TR	TR - 0.3	0 - 0.1	-	-
Mercury	mg/1	0	0	0	-	-
Sulphur	mg/1	0	0	0	-	-
Chloride	mg/1	0 - 11[a]	2 - 7	4 - 5	8 - 17	0 - 16
Conductivity	umho/cm	60 - 188[a]	115 - 135	110 - 168	198 - 270[c]	201 - 290
Total Residue	mg/1	82 - 95	109 - 125	102 - 129	203 - 227	-

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TABLE 6.2 — Continued

Parameter	Units	Rivers			Springs	Belawan Wells[b]
		Belawan	Deli	Percut		
Ammonia nitrogen	mg N/l	0 - 1	TR - 0.2	0.1 - 0.3	ND	-
Nitrite nitrogen	mg N/l	0	0	0	-	-
Nitrate nitrogen	mg N/l	0.1 - 0.3	0.1 - 0.2	0.1 - 0.3	ND	-
BOD_5	mg/l	3 - 9	5 - 17	4 - 8	-	-
Coliform bacteria:						
Total	MPN/100 ml	23,000-210,000	30,000-240,000	43,000 1,100,000	-	-
Fecal	MPN/100 ml	4,000-93,000	700-93,000	3,600-15,000	-	-

a. Range of values measured at Sunggal WTP intake during 1978
b. Various analyses in 1978 from Wells V, VII, IX, XI, and XII
c. Lau Kaban only

Note: Tr = trace; N.D. = not detected

Presence of a large municipal collection complex at the Sibolangit Springs provides many advantages for increased collection of more spring water from existing facilities and the expansion with new facilities to unutilized springs on the south and west of existing facilities (see Figure 2.1). Figure 6.2 shows the major disadvantage of this source: the 26 km of transmission distance to the closest point of distribution in the Medan network. Although this distance is substantial, rights of way have been established for existing pipelines, and a new pipeline would require little land negotiations. Futhermore, the long transmission distance is all downhill and at grades sufficient to maintain gravity flow.

Facilities for expanded spring production would include:

- Local collectors and collection pipelines,
- Two treatment facilities for aeration, pH adjustment, and disinfection,
- A 26 km long, 500 mm diameter pipeline, laid along the existing right-of-way.

Some expanded production may require only simple modifications of existing collection facilities. Collections of new springs in the area would require new collectors and long pipelines for conveying water to treatment facilities. New treatment and transmission facilities could be merged with existing facilities to reduce costs for housing, roads, and local pipelines.

6.2.1.2 Rumah Galuh and Tuntungan

The springs at Rumah Galuh (Langkat Regency) and at Tuntungan lie 17 km apart, but the Tuntungan springs are on the transmission route from Rumah Galuh to the Medan distribution system. Flows from these springs have been estimated by the Geological Survey of Indonesia at 17,300 and 8,600 cu m/d, respectively. Most of the flow from these springs pass into the Binjei and the Belawan river, respectively.

Water quality of the Rumah Galuh and Tuntungan springs has not been measured, although the similarity of elevation and geological setting between Rumah Galuh and Sibolangit suggests that the water quality should be similar. Treatment would probably be similar to that at Sibolangit, i.e., aeration, pH adjustment, and disinfection.

As shown in Figure 6.2 the transmission distance for the combined Rumah Galuh/Tuntungan system would be equal to that from Sibolangit to Medan. Although about one-half of the alignment would follow existing roads and trails, much of the right-of-way would be new and require extensive easement negotiations and new excavations. The route profile (shown on Figure 6.3) indicates that transmission between Rumah Galuh and Tuntungan would be under gravity flow. However, injection of the Tuntungan flow into the pipeline would require pumping to maintain pressure head. To avoid high pumping costs, a smaller transmission pipeline with greater head loss (e.g. 5 to 10 m/1000 m of pipeline) would allow gravity flow from Tuntungan to Medan while requiring minimal injection pumping of the 8,600 cu m/d.

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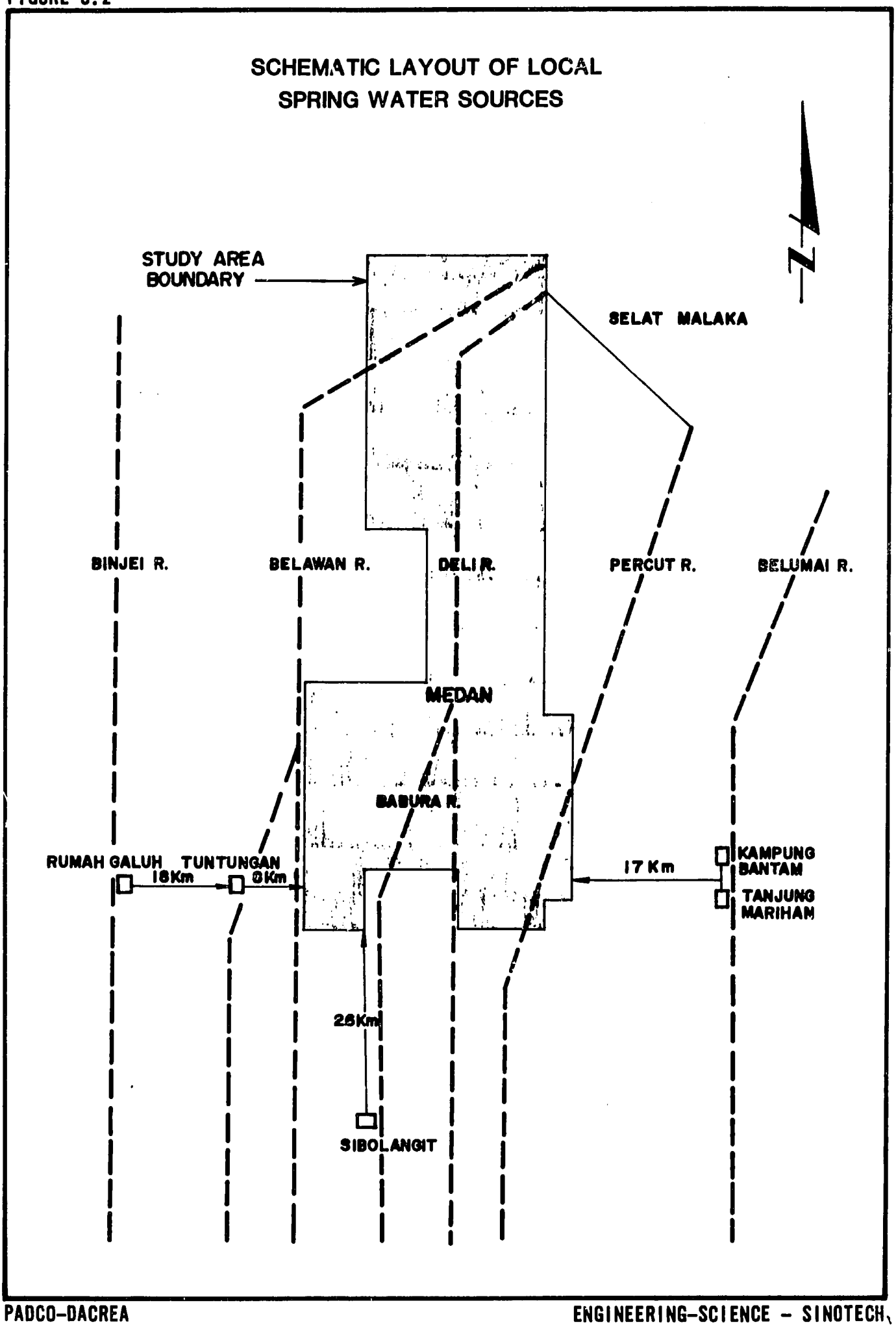
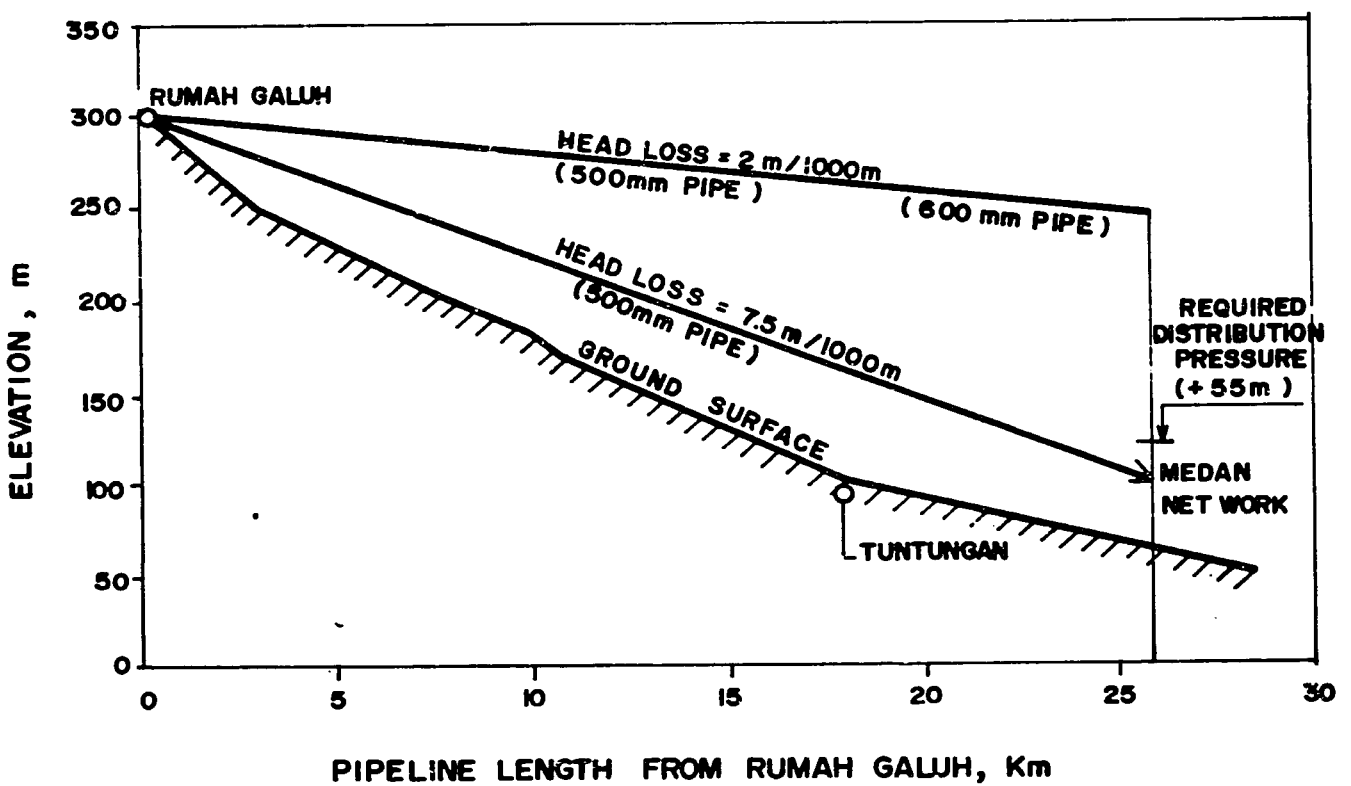
FIGURE 6.2


SCHEMATIC LAYOUT OF LOCAL
SPRING WATER SOURCES
N
STUDY AREA
BOUNDARY
SELAT MALAKA
BINJEI R.
BELAWAN R.
DELI R.
PERCUT R.
BELUMAI R.
MEDAN
BABURA R.
RUMAH GALUH
18Km
TUNTUNGAN
8Km
17 Km
KAMPUNG
BANTAM
TANJUNG
MARIHAM
26Km
SIBOLANGIT

ELEVATION AND HYDRAULIC PROFILES FOR PIPELINES BETWEEN TANJUNG MARIHAN/KAMPUNG BANTAM AND MEDAN



The major facilities would include:

- Local collectors and collection pipelines,
- One major treatment facility for aeration, pH adjustment and disinfection either at Rumah Galuh or Tuntungan,
- Connection to the transmission main and possible pumping station at Tuntungan,
- Two pipelines: a 500 mm or smaller diameter for 17,000 m and a 600 mm for 9,000 m.

The isolated location of the springs at Rumah Galuh and Tuntungan would require additional facilities for personnel.

6.2.1.3 Tanjung Marihan and Kampung Bantan

The springs at Tanjung Marihan and Kampung Bantan would have the shortest transmission distance to the Medan distribution system (Figure 6.2). Flows of 11,000 and 14,000 cu m/d from the two springs have been estimated by the Geological Survey of Indonesia. Most of these flows discharge without use to the Belumai River. Existing local uses are small.

The water quality of the springs has not been monitored but visual inspection indicated no apparent problems (e.g. iron staining, algal growths, etc.). Water quality is expected to resemble that of the Sibolangit springs and would require only aeration, pH adjustment, and disinfection.

Both springs lie within a one-kilometre distance of each other and near existing all-weather roads connecting to Medan and Deli Tua. Although the springs are at 140 m elevation (compared to 300 to 400 m elevation at Sibolangit and Rumah Galuh) the hydraulic profile (Figure 6.4) indicates sufficient slope to allow gravity flow to Medan. Some low lift pumping may be necessary at the spring sites to balance pressures between the springs and to avoid deep excavation.

The following facilities would be required:

- Local collectors and collection pipelines,
- One treatment facility at Kampung Bantan for aeration, pH adjustment, and disinfection, and
- A 16 km long, 600 mm diameter pipeline, laid along existing roads.

Since the springs are located near existing roads, substantial on-site personnel facilities would not be required. Daily inspection and maintenance would be required using locally hired staff or staff transported from Medan.

ELEVATION AND HYDRAULIC PROFILES FOR PIPELINES BETWEEN RUMAH GALUH, TUNTUNGAN AND MEDAN

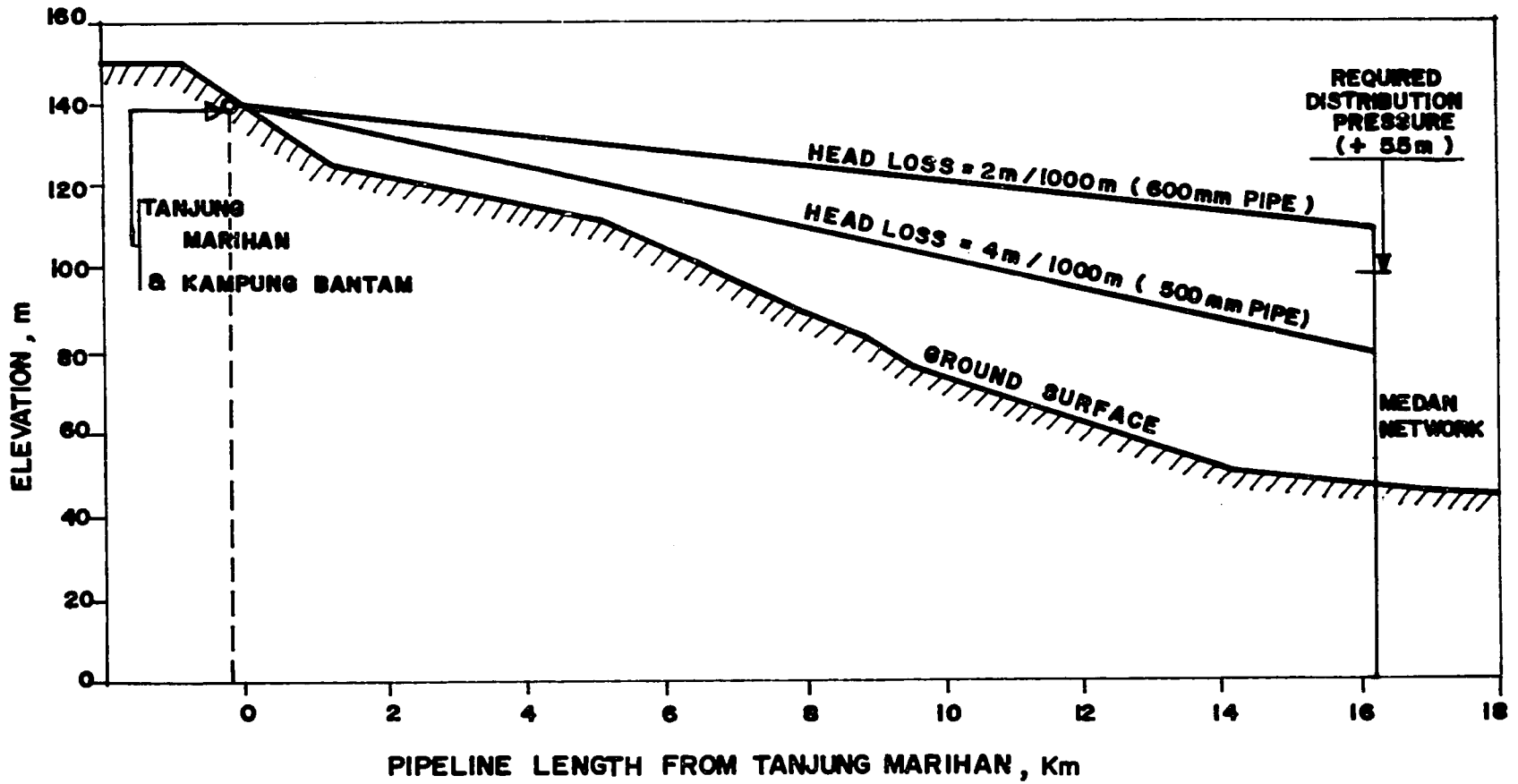


FIGURE 6.4

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6.2.1.4 Costs

Estimated capital costs are presented in Table 6.3. A range of costs has been presented for the Sibolangit Springs development, since a large range of flows could be collected. Furthermore, some individual springs could be collected with less capital cost than others. The range of costs given is expected to cover most combinations. Much higher costs would arise in local collection and treatment of springs at Sibolangit, because of the widely scattered nature of the individual springs. Most local collection pipelines are carrying high flows, and additional flows would require new local pipelines.

Unit capital costs vary from a high of Rp. 115,000 to 138,000 per cu m/d at Rumah Galuh/Tuntungan and at Sibolangit down to a low of Rp. 91,000 at Tanjung Marihan/Kampung Bantan.

Total annual and unit annual costs (Table 6.4) follow similar trends to those of capital costs. Major operation and maintenance costs arise in transmission pumping in the Rumah Galuh/Tuntungan spring system, while lower pumping costs would be required in the Tanjung Marihan/Kampung Bantan system. If additional springs could be found near the known springs or along transmission routes, unit costs could be decreased substantially, while total capital costs would remain relatively constant.

Present cost estimates presume that the existing inventory of springs represents the total spring resources in the area. The occurrence of more than 10 separate springs within a radius of 10 km at Sibolangit would suggest that the geological structure of the area must create other springs. Further exploration for springs should be concentrated in the upper Belawan, Babura, Deli, and Percut basins. Effective monitoring of low stream flows, review of aerial photos and interviews with local residents could locate potential sources between 400 and 600 m elevation. Combining new spring flows with those of the Sibolangit Springs could substantially reduce unit costs for gravity flow water supply to Medan.

6.2.2. Surface Water Sources

Northern Sumatra contains many rivers which flow northwards from the central mountainous axis of the island to the Straits of Malacca. These rivers are fed by heavy rainfalls especially in the mountains. The water quality of these rivers reflect the volcanic soils, the forests, and the human land uses through which the rivers pass. Several rivers have been assessed for part of the future water supply system for Medan. Rivers in and near Medan appear to be sufficient to supply Medan throughout the study period and well beyond the year 2000.

6.2.2.1 River Hydrology

A. General

Seven major rivers (Figure 6.1) have been identified as possible surface water sources:

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TABLE 6.3

ESTIMATED CAPITAL COSTS FOR ALTERNATIVE SPRING SOURCES

Springs and New Facilities	Estimated Capital Costs (Millions of Rupiahs)
Sibolangit (Expansion)	
Collection and Treatment	1,300
Pipeline (in place) 500 mm diameter - steel 26,000 m, @ Rp.93,000/m	2,420
Accessories	70
Engineering	144
Contingency	216
TOTAL CAPITAL COSTS	4,150
Rumah Galuh/Tuntungan (New)	
Collection and Treatment	193
Pipeline (in place) 500 mm diameter - steel 17,000 m, @Rp.93,000/m	1,580
600 mm diameter - steel 9,000 m, @Rp.116,000/m	1,040
Accessories and Pump Station (100 HP)	100
Engineering	30.8
Contingency	46.2
TOTAL CAPITAL COSTS	2,990
Tanjung Marihan/Kampung Bantan (New)	
Collection and Treatment	178
Pipeline (in place) 600 mm diameter - steel 16,000 m, @Rp.116,000/m	1,860
Accessories and Pump Station (50 HP)	80
Engineering	28.8
Contingency	43.2
TOTAL CAPITAL COSTS	2,190

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TABLE 6.4

COMPARISON OF ANNUAL COSTS AND UNIT COSTS FOR ALTERNATIVE SPRING SOURCES

Costs (Millions of Rp)	Alternative Sources		
	Sibolangit	Galuh/Tuntungan	Marihan/Bantan
Annual Capital*	428	303	223
Annual Operacions and Mantenance	99	32	10
Annual Power	-	14	7.0
TOTAL ANNUAL COST	527	349	240
Production (Millions of cu m/yr)	11.0	9.0	8.0
Unit Annual Costs (Rp/cu m)	47.9	38.8	30.0

* Facility lives: 50 years for pipelines and 30 years for collection, treatment, accessories facilities and pump stations. Interest rates of 10 percent.

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1. Local Rivers - Belawan
   - Deli
   - Percut

2. Regional Rivers - Wampu
   - Binjei
   - Belumai
   - Ular

These rivers lie within 40 km of Medan and are expected to have low flows of more than 43,000 cu m/d (0.5 cu m/s). Other streams within 40 km were expected to have flows of less than 43,000 cu m/d, these streams have basins of less than 75 sq km and are located below 150 m elevation. A discussion of the hydrology of existing and potential surface water sources is presented in Appendix D.

Several industries and irrigation projects use the rivers in the Medan region as their water sources. Their existing and projected requirements have not been established and have not been formally recognized as water rights. About 60 percent of the low flows has been assumed to be available for withdrawal by Tirtanadi.

Conservative estimates of low flows in local rivers and the flows available for withdrawal by Tirtanadi indicate that the projected production from local rivers and the existing spring and well sources may only meet the average day demands in the year 2000 of 421,000 cu m/d and a few years more. Without adequate flow data and the inventories of future water requirements by other users, production from the local rivers would have to be augmented beyond the study period when necessary by:

- Flow control reservoirs on the local rivers (Section 6.2.2.3),
- Treated water or diverted raw water from regional rivers - Wampu, Binjei, Belumai, and Ular rivers (Section 6.2.2.5), and
- Local groundwater (Section 6.2.3).

Flow measurements have been made on six of the major rivers. However, there are major deficiencies in the flow data for local rivers. No measurement of flows in the Percut River has been made, and flows on the Belawan and Deli Rivers have been measured only since 1972. The water level gages were moved in 1978 when it was realized that the river cross-sections at the gages were unstable. As a consequence, the data collected between 1972 and 1978 are extremely suspect. Nevertheless, these are the only data available, except for a number of instantaneous discharge measurements taken at various times between 1972 and 1979.

For the purpose of developing the Master Plan it has been assumed that:

1. There were no systematic changes in the cross-sections, i.e., the section areas fluctuated about some mean value.
2. The changes in cross-sections had a relatively less important effect on the low flow measurements.

With these assumptions in mind the data have been analyzed to estimate the probable low flows in the rivers and the yields from the catchment areas. It must be kept in mind that these estimates and the conclusions drawn from them may be substantially in error.

B. Belawan River

The Belawan River is the only present source of treated surface water for the Medan service area. The Sunggal Water Treatment Plant is located on the western perimeter of Medan (see Figure 6.1 and Section 2.3.2.1). The plant produces about 52,000 cu m/d (0.6 cu m/sec) of treated water. Current plans call for expansion of the plant to 78,000 cu m/d in the near future and, ultimately, to 130,000 cu m/d (1.5 cu m/sec).

Flows in the Belawan River have been adequate for the 10 year initial phase production of about 30,000 cu m/d. Flows were measured at Asam Kumbang immediately upstream of the Sunggal Plant for about seven years between 1972 and 1978 (the gaging station was moved to nearby site and a second gage was added near the mouth of the river, 20 km downstream). The average daily flows for three years and a series of instantaneous discharges for seven years are the only basis for flow estimates.

Lowest annual flows and discharges are listed below:

Lowest Average Daily Flows		Smallest Instantaneous Discharge Measured	
1972	3.9 cu m/s	1972	4.5 cu m/s
1973	2.5	1973	5.2
1974	4.7	1974	6.5
		1975	4.0
		1976	4.0
		1977	1.7
		1978	4.5
		(1979	3.1, record incomplete)

Analysis of these flows is shown on Figure 6.5 (as well as the analyses of Deli River measurements to be discussed below).

Projected low flows from probability analysis are about 215,000 cu m/d for a one percent recurrence and 250,000 cu m/d for a five percent recurrence. The planned production from the Sunggal Plant (130,000 cu m/d) represents 50 to 60 percent of these low flows.

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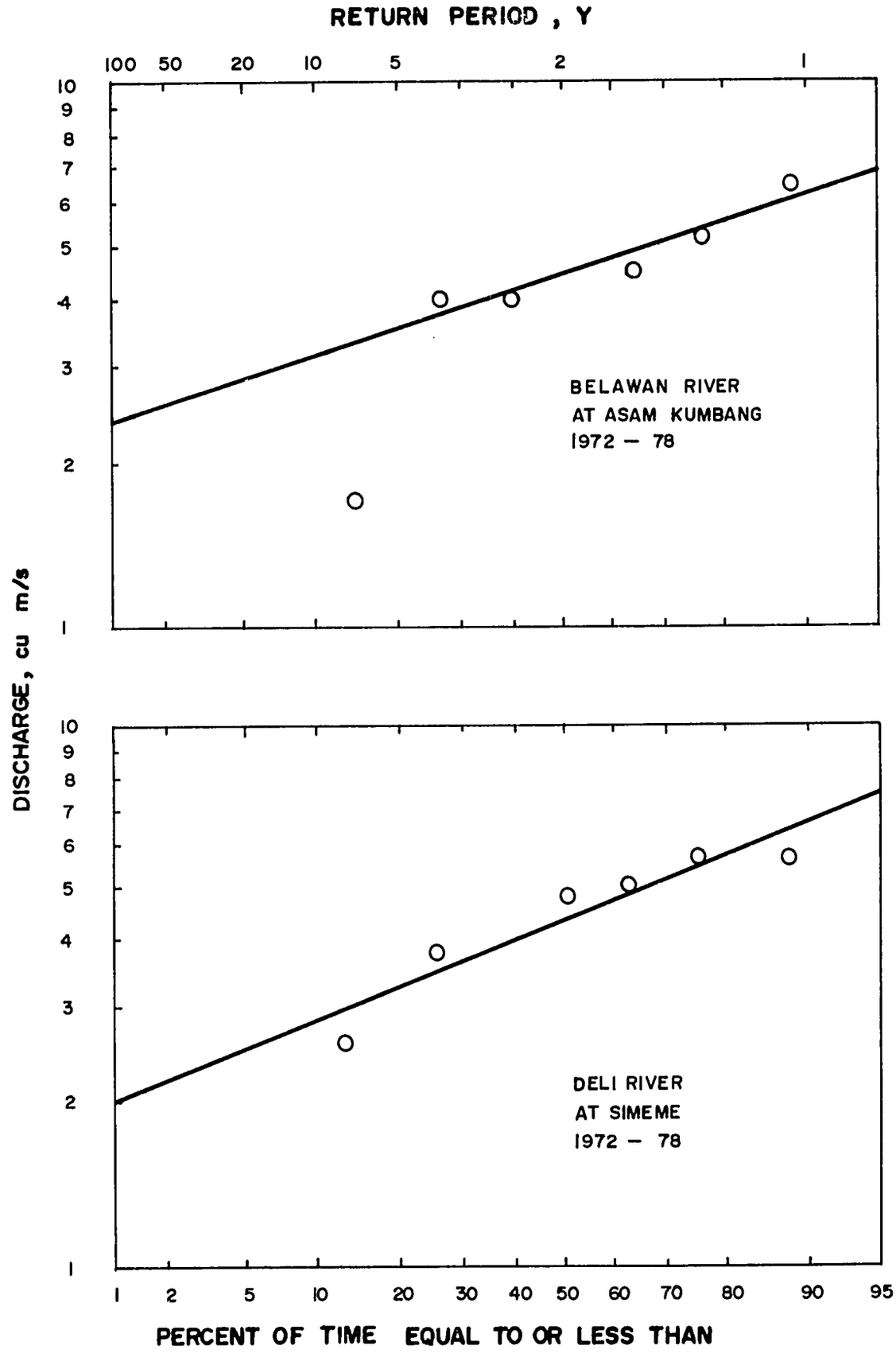
FREQUENCY-DISCHARGE FOR LOW FLOWS ON THE BELAWAN AND DELI RIVERS



The catchment area above the station is about 243 sq km and the averaged low flow yield would be about 885 cu.m/sq km.d.

C. Deli and Percut River

Flows in the Deli River were measured for seven years at Simeme, near or within 5 km upstream of candidate plant sites on the Deli River. This gaging station was relocated to a nearby site. No flow has been measured in the Percut River or the Babura branch of the Deli River.

A similar analysis of low flow data was made for the Deli River at Simeme. The data are shown below and on Figure 6.5.

Lowest Average Daily flows		Smallest Instantaneous Discharge Measured	
1972	2.4 cu.m/s	1972	5.7 cu m/s
1973	4.8	1973	5.7
1974	4.8	1974	5.0
		1975	3.8
		1976	4.0
		1977	2.6
		1978	4.8
		(1979	3.8 record incompl te)

The estimated one percent and five percent low flows at the Deli gage station are 2.0 cu m/s (175,000 cu m/d) and 2.5 cu m/s (215,000 cu m/d), respectively.

There are no low flow discharge data for the downstream portions of the Deli River, the Babura sub-basin, or the Percut River. Estimates of their one and five percent low flows were made, based on the assumptions that rainfall and groundwater conditions in their catchments are similar to those of the Belawan River and the upper Deli River. Their estimated low flow yields vary from 700 to 880 cu m/sq km.d and are extrapolated from those of the Belawan and Deli catchment after removing spring flows. The estimated low flows for all local basins above Medan are presented in Table 6.5.

The accumulative one percent low flows of 460,000 cu m/d may be available for production with 205,000 cu m/d from the main Deli, 750,000 cu m/d from the Babura Branch, and 150,000 cu m/d from the Percut. Because of numerous assumptions in these estimates, a conservative production estimate should be used for possible withdrawals from these streams until

TABLE 6.5

ESTIMATED LOW FLOWS AND AREAL YIELDS FOR LOCAL RIVERS ABOVE MEDAN

River	Catchment Area[a] (sq km)	Estimated Low Flows One Percent (cu m/d)	Five Percent (cu m/d)	Areal Yields For One Percent Low Flow (cu m/d.sq km)
BELAWAN	243	215,000	250,000	885
DELI				
Babura Branch	106	75,000[c]	110,000	705[b]
Batuan-Deli Tua-Medan	43	30,000[c]	45,000	700[b]
Deli above Deli Tua	164	175,000	215,000	1,070
PERCUT	173	150,000	230,000	870[b]

a Catchment areas for rivers above Asam Kumbang, Simeme and the Medan urban area.
b Assumed values based on Belawan and Deli River data.
c Estimated from assumed areal yields and catchment area, see Appendix D for additional discussions.

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flow measurements have been improved. A one percent low flow and 60 percent production of this low flow have been assumed for planning maximum production from a water plant using these sources and production would be as follows:

1. Deli Basin, only: 205,000 cu m/d flow, 120,000 cu m/d production,

2. Babura Branch : 75,000 cu m/d flow, 45,000 cu m/d production, and

3. Percut River : 150,000 cu m/d flow, 85,000 cu m/d production.

This would allow an initial 120,000 cu m/d production from the Deli River in stages (about the same as the total production of the Sunggal Plant) and eventually a total production of about 160,000 cu m/d with a diversion from the Babura or the Percut.

D. Regional Rivers

The four regional rivers could also provide water to Medan. Because of the remote location of the larger, more distant Wampu and Ular rivers, the smaller, closer Binjei or Belumai rivers may be developed when necessary as the initial sources and then expanded by addition of either the Wampu or Ular sources.

The estimated one percent low flows for these rivers at the gage stations are as follows:

Binjei	6.5	cu m/s or more
Wampu	50.0	cu m/s
Belawan	3.2	cu m/s
Ular	23.0	cu m/s

The estimates were derived from analyses of the lowest instantaneous discharges measured at gage stations on the four rivers (see Appendix D for detailed discussions). As indicated in Figure 6.1, the Namu Ukur gage lies about 10 km south and upstream of Binjei and does not measure flows on the Menthrin River. The one percent low flow at the gage would be about 570,000 cu m/d, while using the same low flow yield rate for the entire middle and upper subbasins above Binjei would provide Binjei about 820,000 cu m/d flow. The limited duration of monitoring, three years, suggests that such an estimate may have low reliability. A reliable production of 200,000 cu m/d has been projected. About 70 percent of the one percent low flow in the Belumai River would be needed to meet a production level of 200,000 cu m/d. If this alternative was recommended, the planning criteria would have to be increased from 60 up to 70 percent. The flows of both the Wampu and Ular would be adequate to supply the total Medan water demand.

E. Summary

The four local basins above Medan have an estimated one percent low flow of about 650,000 cu m/d. (Water supply facilities are often planned on the basis of five percent flows which would be about 850,000 cu m/d above Medan). The smaller, one percent flow was assumed as a conservative target due to the quality of available data. Further monitoring could alter this planning guide. Production of about 60 percent of the one percent flows, 390,000 cu m/d, was assumed to be available to Tirtanadi for municipal supply.

The existing springs and wells supply about 50,000 cu m/d, and the existing and projected local river surface water would produce a total of 390,000 cu m/d. Therefore, 100 percent of the total year 2,000 demand of 421,000 cu m/d could be met.

6.2.2.2 Surface Water Quality

Water quality of the three major local rivers is quite similar and has been periodically analysed by the City of Medan public health laboratory. The Tirtanadi laboratory has analysed water samples from the Belawan River intake for the Sunggal Water Plant. Engineering-Science collected and analysed a series of river, spring, and well water samples in July 1979. The results of these river water analyses are presented in Table 6.6.

Analyses were made in 1977 for a series of two to six samples from each major river. These analyses showed a number of trends in water quality at different sites on the same river, between the different rivers, and some daily variations. During the three-day sampling period, pH and chlorides were slightly higher in the Belawan River and iron, BOD, conductivity and total residue were lower than in the Deli or Percut Rivers. Chemical differences between the Belawan and the other two rivers were paralleled by bacteriological differences. Coliform counts were larger in the Deli and Percut rivers than in the Belawan River.

These difference generally reflect the greater urban drainage reaching the Deli and the Percut river when compared to the Belawan River. Six samples were taken south and north of the Medan City Hall along the Deli River which yielded the following results:

	South		North	
Dissolved Oxygen decline from	6.7	to	4.8	mg/l
Biological Oxygen Demand increase from	5.2	to	17	
Temperature increase from	26	to	28°C	
Ammonium increase from	a trace	to	0.2	mg/l
Clorides increase from	4.6	to	6.9	mg/l
Iron increase from	0.4	to	1.5	mg/l, and
Total Coliform increase from	46,000	to	240,000	mpn

These changes would be consistent with increasing discharge of urban surface drainage into the river from south to north.

TABLE 6.6

WATER QUALITY OF THE BELAWAN, DELI, AND PERCUT RIVER

Analyses	Belawan River				Deli River			Percut River		
	Sunggal Range 1979	Sunggal Samples 1979	Medan Range 17 Oct 77	Medan Range 10 Oct 77	Deli Tua 18 Oct 77	Titi Papan 18 Oct 77	Deli Tua[c] 1979	Hari Sajo 1979[a]	Medan II 1979[a]	Medan[c] II 1979[a]
pH	7.3- 7.0	7.2[E]-7.8	6.9- 7.1	7.0- 7.2	6.9	6.7	-	6.9	6.9	6.7
Alkalinity	23 -97	80	-	-	-	-	45	-	-	6.7
Hardness Total	16 -74	42	30 -31	34 -38	42	47	64	39	41	-
Conductivity	60 -45	143	-	-	-	-	172	110-115	168-124	199
Turbidity FTU	0.2-40	2	-	-	-	-	-	-	-	-
Total Residue	-	-	82 -85	90 -95	114	122	180	102-107	129-109	168
Carbon Dioxide	4.1-42	28	-	-	-	-	10	-	-	14
Dissolved Oxygen	-	26[E]	5.5- 5.9	6.7- 6.8	6.6	4.9	-	5.6-6.6	5.6-6.7	-
Calcium	7.6-23	12	-	-	-	-	16	-	-	-
Magnesium	2.8- 6.5	3.4	-	-	-	-	6.1	-	-	-
Chlorides	N.D-10.8	5.2	0.7- 0.9	1.0- 1.3	4.6	6.3	14	3.8-4.1	5.3	-

TABLE 6.6 — Continued

Analyses	Belawan River				Deli River			Percut River		
	Sunggal Range 1979	Sunggal Samples 1979	Medan Range 17 Oct 77	Medan Range 10 Oct 77	Deli Tua 18 Oct 77	Titi Papan 18 Oct 77	Deli Tua[c] 1979	Hari Sajo 1979[a]	Medan II 1979[a]	Medan[c] II 1979[a]
Sulphate	-	-	2.6	2.6	10.0	5.2	26	7.7	5.2-10	19
Fluoride	-	-	tr	0	t	0.3	0.1	0.1	0.0	0.1
Ammonium	-	-	0.1.0	t- 0.1	0.1	0.2	-	0.0	0.1	-
Nitrate	-	-	0.2-0.3	0.2	0.2	0.2	-	0.2-0.3	0.2	-
Biological Oxygen Demand	-	-	3.5- 4.8	5.0- 9.0	5.2	12	-	5.0	4.5-7.9	-
Iron	-	1.2[E]	0.5- 0.9	0.2- 0.6	0.4	1.5	0.4	-	-	1.1
Manganese	-	-	0	0-t	0	0	0.02	-	-	-
Copper	-	-	t- 0.2	t- 0.1	0.1	0.1	-	-	-	-

a Range of values between 17-X-66 and 19-X77.
b All analyses in values of mg/l, except for pH, and turbidity.
c ND = not detected, t = trace
Analyses of samples taken by Engineering-Science July, 1979.

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Samples were also taken at six sites on the Belawan and Percut Rivers on two different days. The daily variation equalled or exceeded geographical differences among the Deli River samples. Daily differences in water from the Percut River included iron decreases from 1.9-2.8 down to 0.3 mg/l. Even greater differences exist between a smaller number of tests made for raw water quality at the Sunggal Plant on the Belawan River. Turbidity varied from 0.2 to 40 FTU, alkalinity from 23 to 97 mg/l, hardness ranged from 16 to 74 mg/l, Calcium from 4.4 to 23 mg/l, and Chloride from not detected to 10.8 mg/l. The daily and annual variations could reflect changes in local and upper basin rainfalls, in irrigation discharges, and in urban drainage discharges.

The available water quality data do suggest some trends exist which are consistent with trends in other urban areas. The daily and seasonal variations, however, reduce the reliability of decisions between use of alternative water sources based on the available data. Local data and conditions in other urban areas would support giving priority to using water from:

1. Belawan River.

2. Deli River at or above Deli Tua, and

3. Percut River above the Tanjung Morawa - Siantar Road Bridge.

Some individual samples and field analyses showed high levels of iron at the Sunggal Plant on the Belawan River (1.2 mg/l), at a potential diversion site on the Babura River (1.6 to 1.7 mg/l), on the Deli River in Medan (1.1 to 1.5 mg/l) and at Deli Tua (0.8 mg/l), and on the Percut River in Medan (1.2 to 2.8 mg/l). Iron contents may be highly variable (Percut samples had 0.3-2.8 mg/l), but the consistently high values in many rivers, the discharge of runoff from iron-rich volcanic deposits, and its presence in both deep and shallow groundwaters should be taken into account when locating new production facilities. The plant sites above Deli Tua and for the Percut diversion reflect the concern for withdrawing raw water with the least amount of iron and other urban pollutants. Furthermore, clarification and filtration can reduce the iron content in the treated water delivered to the users.

6.2.2.3 Alternative Surface Water Sources

Four alternative local water sources and two regional systems have been analyzed. They include the following:

- Further expansion of the Sunggal Water Plant on the Belawan River.

- Construction of a new plant near Deli Tua on the Deli River with diversions from the Percut and Babura rivers.

- Separate new plants on the Percut and Babura rivers, and

- Low flow control reservoirs on the Belawan, Deli, and Percut rivers.

Most emphasis has been placed on the first two sources, since they have some measured flow data and are the most immediate water sources. Smaller new plants on local rivers could only be developed after flows have been measured for many years. Long transmission distances for regional systems will increase their costs over those of local sources, but these sources would meet future demands even beyond 2000.

A. Sunggal Water Plant

The first stage of the Sunggal Water Plant was constructed on the Belawan River (see Figure 6.1 and 6.5) in 1968 and was planned to be expanded upto 130,000 cu m/d. Existing production is about 50,000 cu m/d. Planned expansion would follow existing designs with some modifications. The existing river diversion, stilling basins, and land are sufficient for the planned facility expansion for 80,000 to 120,000 cu m/d, but a new stilling basin, new clarifiers, filters, pumps, and other accessory facilities will be required.

The estimated cost for expansion has been estimated by comparing costs of a new plant of 50,000 cu m/d capacity with those of a completed plant with a capacity of 130,000 cu m/d. These costs are estimated below:

Capital Costs		Operation and Maintenance
Existing Plant	: Rp. 5,690 million	Rp. 3.3 million
Completed Plant	: Rp.12,300 million	Rp. 7.0 million
Incremental Cost	: Rp. 6,610 million	Rp. 3.7 million

The total incremental capital cost of about Rp. 6.61 billion equals an annual capital cost of Rp. 701 million with an annual operation and maintenance cost of Rp. 370 million. These costs equal a total incremental annual cost of Rp. 1.07 billion for the daily production increase of 0.9 cu m/s or 78,000 cu m/d with a derived unit annual cost of Rp. 37.7/ cu m. This plant lies on the western perimeter of Medan and requires more than six 400 to 600 mm pipeline across much of the city (e.g. a new 400 and 350 mm pipeline of about 10 km). These pipelines are discussed in Section 6.3.

B. Deli Tua Water Plant

The water treatment plant would be located along the main channel of the Deli River between the joining of the Petani and Saimaimai branches, 2.0 km upstream of the town of Deli Tua, and the joining of the Batuan Branch near Titi Kuning (Figure 6.6). The precise location of the plant would depend upon land availability and costs, river water quality and soil conditions. The plant would draw water directly from the Deli River and by diversions and pipelines from the Percut and Babura Rivers. Additional analyses would be required to minimize pumping and pipeline costs for the plant and the two diversions. More northern sites would receive pollutants in drainage from the Deli Tua urban area and would require longer raw water pipelines from the Percut diversion, but a

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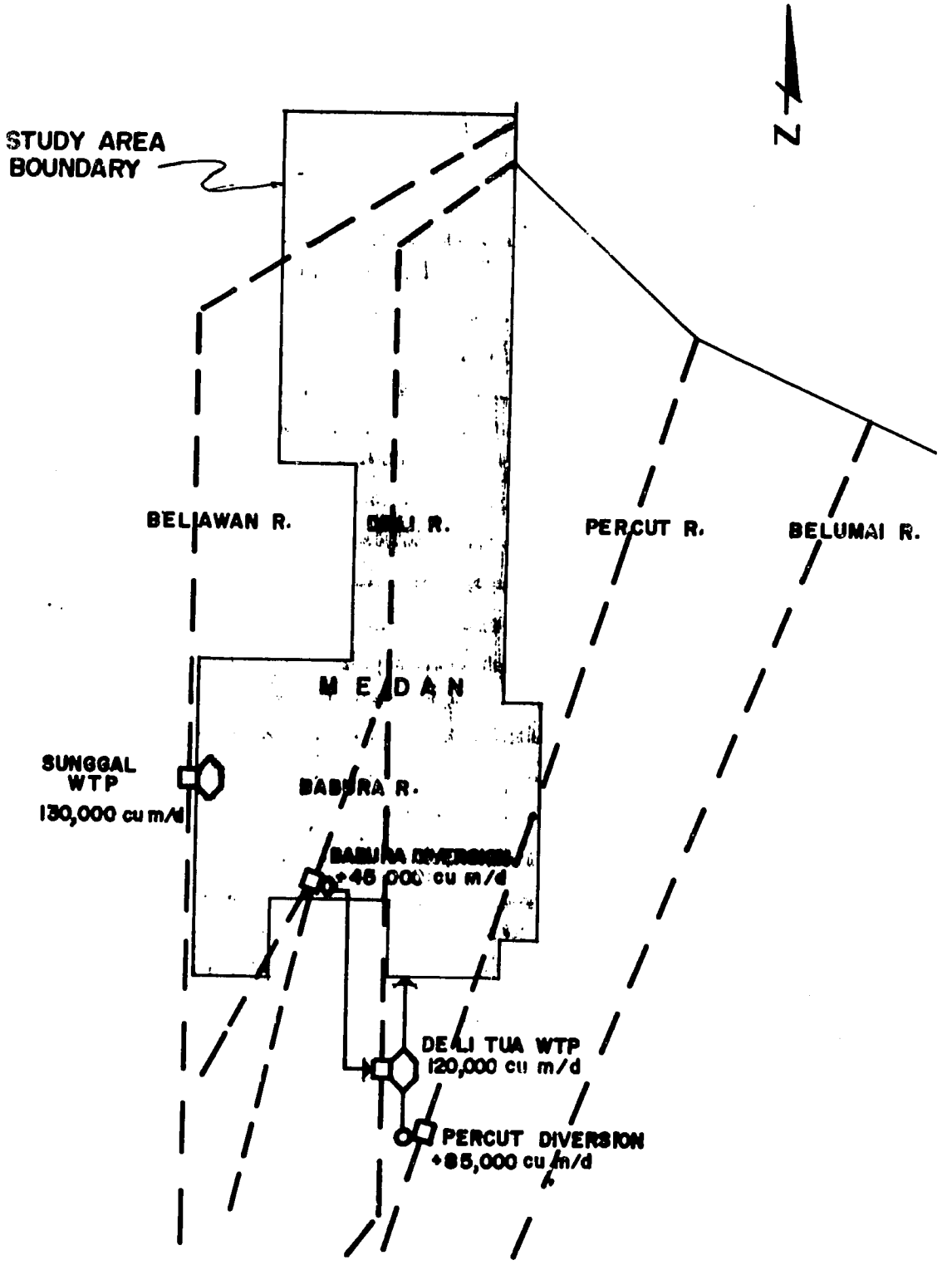
FIGURE 6.6

SCHEMATIC LAYOUT OF LOCAL SURFACE WATER SOURCES



northern site would reduce pipeline and pumping costs for the Babura diversion.

Plant facilities would closely resemble those at the Sunggal Plant on the Belawan River. A small weir and control gate would regulate water levels and raw water inflow to stilling basins. Raw water pumps would lift water to the clarifier, then the water would flow through the filters to the treated water reservoir and effluent pump station.

Diversions on the Percut and Babura would consist of simple weirs, level control gates, stilling basins and raw water pumping stations. Pipelines would carry raw water directly to the Deli Tua Plant, although this raw water could be discharged into the Deli River channel and then recollected at the Deli raw water intake. This would reduce pipeline costs for the Percut diversion but would also reduce the quality of water reaching the Deli Plant.

The Babura weir may be somewhat smaller and pump station larger than those at the Percut diversion. The pipeline from the Babura diversion would join the existing Sibolangit Springs transmission corridor for about 6 kilometers of the Babura pipelines' total nine kilometer length. Depending upon rights-of-way acquisitions, the pipeline may be located along a route which would lessen the elevation changes and perhaps reduce the total length.

Cost estimates for the Deli Tua Plant and the Percut and Babura diversions are presented in Table 6.7. These costs reflect a production capacity of 250,000 cu m/d, transmission pipelines between diversions, and a plant site, 2.0 km south of Deli Tua. Table 6.8 presents costs for four different combinations of the Deli Tua facilities. Facilities for the Deli River only (1), those for the Deli and Percut rivers (2A), those for the Deli and Babura rivers (2B), and those for all three rivers. Production of the total amount of 250,000 cu m/d, however, will not be necessary during the study period up to the year 2000.

As indicated in the unit costs of both tables, the Babura diversion is more costly than the Percut diversion. The higher unit costs for the Babura diversion reflect the 65 percent greater costs for the Babura pipeline and the smaller production. If the Deli Tua Plant was located directly east of the Babura diversion (Site D2 in the Appendix D), the pipeline costs could be two-thirds less and pumping costs would be about 50 percent less. Such a plant location would require a doubling of the Percut pipeline or discharge directly to the Deli River. Discharge to the river would allow a pipeline reduction of about 50 percent.

To maintain higher water quality, a pipeline could carry raw water from a raw water intake on the Deli River near Deli Tua to the northern plant site at Titi Kuning, but costs for pipelines and pumping would increase unit costs. The Deli Tua site is recommended because of its probable better water quality, greater availability of large land parcels at lower prices, and fewer disruptions to nearby residents compared to the Titi Kuning sites.

TABLE 6.7

ESTIMATED COSTS OF DELI TUA PLANT AND DIVERSIONS

Element	Costs (Millions of Rupiahs)				
	Total Capital	Annual Capital*	Annual Operations and Maintenance**	Total Annual	Unit Costs (Rp/cu m)
Deli Tua Plant	22,800	2,420	1,150	3,570	39.1
Weir	110	11.7	1.1	12.8	0.2
Pump Station	100	13.1	97.7	110.8	1.2
Pipeline 1,500 mm diameter; 6,000 m	2,280	230	11.4	241.4	2.6
Sub Total	25,290	2,674.8	1,260.2	3,945.0	43.1
Percut Diversion					
Weir	55	5.8	0.6	6.4	0.1
Pump Station 720 HP	230	30.2	113	143.2	1.5
Pipeline 900 mm diameter; 5,500 m	1,100	111	5.5	116.5	1.3
Sub Total	1,385	147.0	119.1	266.1	2.9
Babura Diversion					
Weir	55	5.8	0.6	6.4	0.1
Pump Station 500 HP	186	24.5	79.5	104	1.1
Pipeline 900 mm diamter; 9,000 m	1,800	182	9.0	191	2.1
Sub Total	2,041	212.3	89.1	301.4	3.3
TOTALS	28,711	3,034.1	1,468.4	4,512.5	49.3

* Annual cost based on amortization of capital cost at 10 percent interest over 30 years for treatment facilities, over 15 years for pump-stations, and over 50 years for structures and pipelines.

**Including power costs.

Plant Capacity, Deli Tua: 250,000 cu m/d; 91.25 million cu m/year

TABLE 6.8

COMPARISONS OF STAGED COSTS FOR THE DELI TUA SYSTEM

Stage	Costs (Millions of Rupiahs)				Unit Costs (Rp/cu m)
	Total Capital	Annual Capital	Annual O and M	Total Annual	
1	13,900	1,470	685	2,155	49.3
2A	13,900	1,470	685	2,155	
	8,500	895	475	1,370	
	22,400	2,365	1,160	3,525	47.2
2B	13,900	1,470	685	2,155	
	6,290	665	310	975	
	20,190	2,135	995	3,130	52.1
3	13,900	1,470	685	2,155	
	8,500	895	475	1,370	
	6,290	665	310	975	
	28,690	3,030	1,470	4,500	49.3

1 Deli Tua Plant with pipeline, production of 120,000 cu m/d.
2A Deli Tua Plant and Percut diversion, production of 205,000 cu m/d.
2B Deli Tua Plant and Babura diversion, production of 165,000 cu m/d.
3 Complete Deli Tua system, production of 250,000 cu m/d.

Comparison of staged costs in Table 6.8 indicates that the more costly Babura diversion should be added last. This would provide additional monitoring of the Babura and Percut flows in order to thoroughly review their benefits and costs. If the flows and production could not be increased or costs on either the Babura or Percut rivers could not be reduced, other local water sources (e.g. flow control reservoirs) and regional surface water sources should again be reviewed and compared.

Surface storage can provide a source of water for the existing Sunggal Plant on the Belawan River or the Deli Tua Plant on the Deli River. The storage reservoir would act only to retain some of the river flow during the rainy seasons so that the stored water would be available during an exceptionally dry period (February-March). The proper design and location of storage reservoirs require the same type, amount, and duration stream flow monitoring as needed for optimal determination of treatment plant capacity.

As a guide for planning purposes, two types of surface reservoirs have been considered: system-wide low flow storage and low flood storage for individual plants. Both types of reservoirs provide virtually no flood control capability, although they could be augmented to provide for flood control. An overall supply reservoir would collect and hold 14 days supply at about average consumption for the entire service area. Such a reservoir would have to hold and release the equivalent of about 6,500,000 cu m of water for treatment and supply to Medan. Such a supply would have to be located on a river where one treatment plant would provide the total supply to Medan, i.e. the Belawan River and Sunggal water treatment plant. A reservoir for overall system supply would hold:

1.	Active storage	:	6.5 M cu m
2.	Safety factor 50 percent	:	3.3 M cu m
3.	Dead storage	:	2.0 M cu m
4.	Evaporation and percolation	:	2.2 M cu m
	Total		14.0 M cu m

A large reservoir would require very detailed and prolonged studies of the hydrology, geology, and topography in order to establish technical and economic feasibility. Because of the magnitude of the commitment, required monitoring would either extend well past the time when additional water was needed in Medan or the reservoir would have to be located and constructed with a poor data base. General review of existing topographic maps does not indicate that any apparent sites for a reservoir of 3.0 sq km exist in the upper Belawan River sub-basin.

Reservoirs for supply to the individual Sunggal and Deli Tua plants would be smaller and would only store that additional volume needed to meet the design capacity of the plant. As an example and potential alternative to the Deli Tua system described in Section 6.2.2.3, a reservoir alternative has been developed to replace the diversionson the Babura and Percut rivers. General requirements are listed below:

1. Annual costs less than Rp. 550 million or Total Capital Costs less than Rp. 5,400 million (similar to that of the other diversions)

2. Operating depth of reservoir, 4 m

3. 4 day supply x 130,000 cu m/d = 1.8 M cu m
   Safety factor (50 percent) = 0.9 M cu m
   Dead storage (20 percent) = 0.3 M cu m
   Evaporation/percolation = 1.0 M cu m

   Total Storage = 4.0 M cu m

4. Minimal Surface Area of Reservoir
   4.0 M cu m/4 = 1,000,000 sq m or 100 hectares (1.0 sq km) and

5. Dam site of less than 500 m across the river.

Unfortunately, aerial photos and topographical maps are inadequate to establish the location of such a site. If such a site could be located, a generalized dam, control weir, and spillway may cost the following:

1.	Earth-filled Masonry dam	= Rp. 1,290 M
2.	Weir	= Rp. 151 M
3.	Spillway	= Rp. 390 M
4.	Accessories and other Structures	= Rp. 174 M
5.	Total land (100 ha x Rp. 1000/sq m	= Rp. 1,000 M
6.	Contingencies and Engineering	= Rp. 795 M
	Total capital costs (1-6)	= Rp. 3,800 M
	Annual capital costs	= Rp. 383 M
	Operation and maintenance (1.0%)	= Rp. 38 M
	Total Annual Costs	= Rp. 421 M
	Unit costs (130,000 cu m/d)	= Rp. 8.9 cu m

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The above discussion of structures and land requirements and costs indicates that a small surface reservoir may be a viable alternative to diversions and long transmission pipelines. Treatment plant costs would remain the same, and overall unit costs and total costs would be quite similar to diversion alternatives. Further data, more detailed maps, and analyses would be required for designs for selection of either the diversions and interbasin transfers or the small reservoirs.

D. Medium-Sized Water Plants

Previous plans by Tirtanadi proposed small water treatment plants on both the Deli and Percut rivers, downstream of Medan. Table 6.9 indicates the unit construction costs for small, medium, and large scale water plants. A small plant with 10,000 cu m/d capacity will have a unit cost twice as much as a plant of 80,000 cu m/d. The economy of scale for increasing size of facility can be seen. However, unit cost differences between plants of 150,000 cu m/d and plants of 250,000 cu m/d are quite small, less than five percent.

The Deli Tua Plant without diversions would have unit costs of about Rp. 59,000/cu m for 120,000 cu m/d, Rp. 55,000/cu m for 205,000 cu m/d, and 54,000/cu m for 250,000 cu m/d with maximum unit difference of only Rp.5,000/cu m (less than five percent). If medium and large scale plants must be augmented by diversions or reservoirs, the overall costs may exceed the costs of tw or three separate facilities with the same combined production.

Following the first five years of monitoring, flow and cost evaluations should be reassessed to properly project the stages of the Deli Tua Plant and the diversions. If the monitoring of the Percut River indicates that 85,000 cu m/d could be withdrawn from the Percut River, further evaluation should be made of adding a third moderate-sized water plant on the Percut River and perhaps a fourth plant on the Babura River, if necessary. Because of the smaller flows on the Babura River, longer monitoring would be required to confirm the reliability of the flow.

The simple cost comparison below indicates the potential cost savings of the medium-sized plants compared to a larger plant with long pipelines between the plant and city and the plant and diversions.

A. Three Plants (Millions of Rupiahs)

		Capital	Annual
Deli Tua Plant	(120,000 cu m/d)	13,000	2,060
Percut Plant	(85,000 cu m/d)	7,500	1,200
Babura Plant	(45,000 cu m/d)	4,300	720
Total Costs		24,800	3,980

Unit Cost/(Rp.cu m) = 43.6

TABLE 6.9

COMPARISON OF PLANT PRODUCTION, CAPITAL COSTS AND UNIT CAPITAL COSTS

Plant Production (cu m/d)	Capital Costs* (Million of Rupiah)	Unit Capital Costs
10,000	1,230	123,000
20,000	1,900	95,000
26,000	2,200	84,600
40,000	3,000	75,000
50,000	3,500	70,000
60,000	4,000	66,700
80,000	5,000	62,500
100,000	6,000	60,000
150,000	8,400	56,000
200,000	11,000	55,000
250,000	13,700	54,800

* Capital costs excluding land, pump stations, reservoirs, engineering, and contingencies.

B. One Plant

	(Millions of Rupiahs)	
	Capital	Annual
Deli Tua System (250,000 cu m/d)	28,700	4,500

Unit Annual Costs (Rp./cu m) = 49.3

Flow data are not available for the Percut or the Baburc, however, and the medium sized plants would be dependent upon somewhat more variable flows from single, small streams compared to the combined flows from three different streams. If thorough monitoring were undertaken immediately, a new water plant on the Percut River at Harjo Sari could be completed by 1990 to 1995.

The ten year period for flow monitoring, design and construction of a new plant would be insufficient to supply adequate assurance of production.

E. Regional Plants and Diversions

Four regional river sources have been identified as potential water sources for Medan (See Figure 6.7). The assumed 60 percent production from the one percent low flows in the local rivers would have to be augmented in order to meet regional water requirements beyond the year 2000. If surface water sources were required to meet this demand, the regional rivers could be used to supply the additional needs. Regional sources and their integration with local cources and the Medan distribution network are discussed in Appendix D. The regional facilities are briefly summarized below with estimated costs.

One large river (Wampu and Ular) and one smaller river (Binjei and Belumai) lie with within 26 km of the Medan service area (figure 6.7). Larger rivers (Ular and Wampu) lie further away (26 km) from Medan than the smaller Belumai and Binjei rivers. The Belumai River lies 7.5 km east of the Percut River and 5.5 km east of the future distribution system, while the Binjei River is 13 km west of the Belawan River and the distribution system.

Both the Binjei and Wampu rivers could supply water to the Medan distribution network along the Binjei - Medan Road or at the Sunggal Water Plant. Low flows (one-percent) at Binjei are estimated at more than 400,000 cu m/d for the main branch of the Binjei River and its eastern branch, the Mencirim River. An estimated 200,000 cu m/d water production would be produced at a plant located on the main or western branch of the Binjei River, while 80,000 cu m/d may be diverted from the Mencirim River to the water plant, 3.0 km west of the Mencirim.

SCHEMATIC LAYOUT OF REGIONAL SURFACE WATER SOURCES

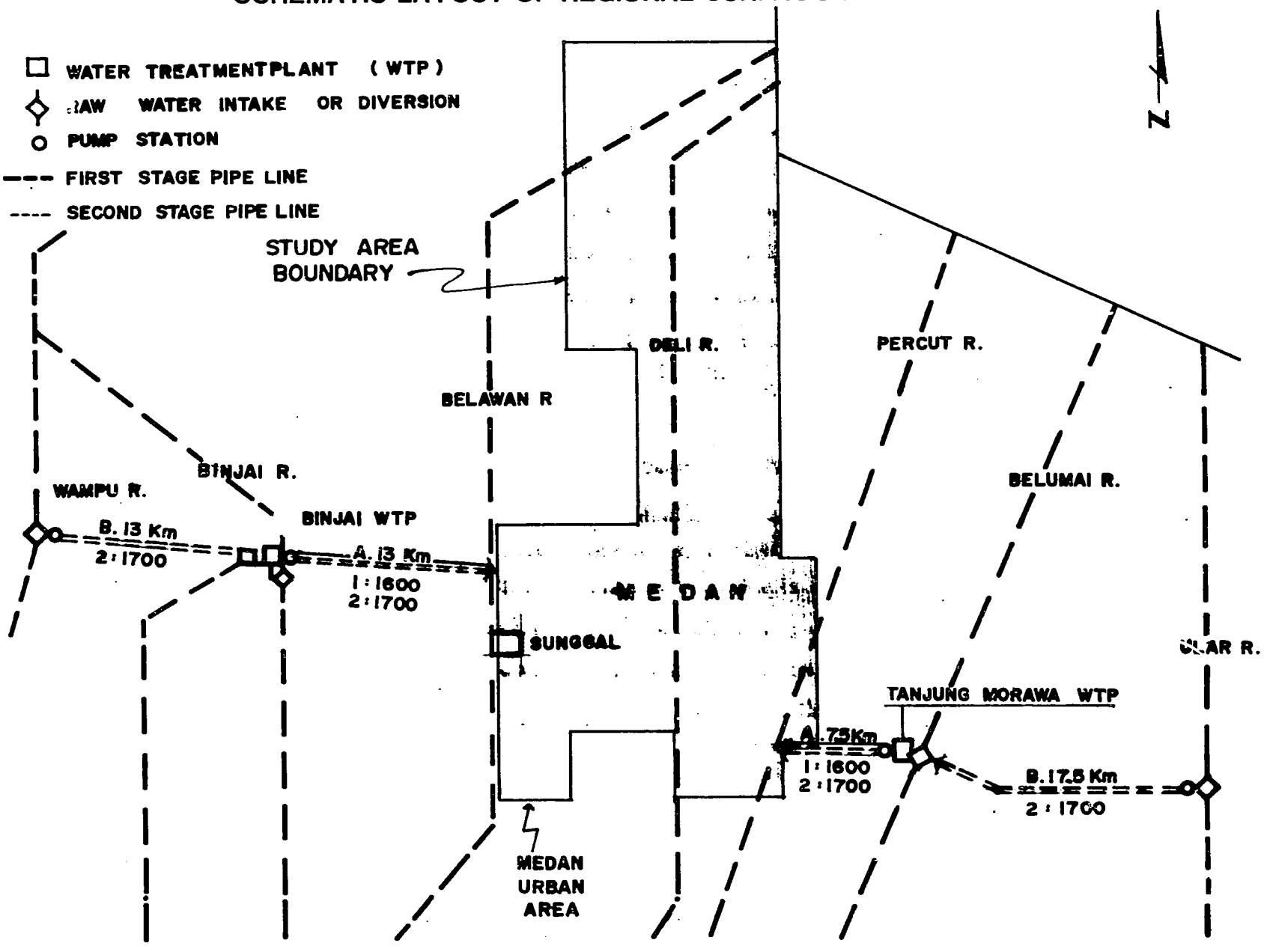

FIGURE 6.7

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The Wampu River has an estimated one-percent low flow of about 4,300,000 cu m/d (50 cu m/s) and could easily supply 500,000 cu m/d. A raw water intake and stilling basin could be located on the east (right) bank of the Wampu River, near Seleseh (Figure 6.1). A raw water pumping station would then send water to the Binjei Water Treatment Plant, 13 km to the east. The Wampu raw water would be treated at the Binjei Plant. Treatment at the Binjei Plant would provide a greater cost saving due to the larger scale plant and would reduce the costs of electrical power, on-site housing, and transportation to a more remote Wampu River site.

Treated water from the Binjei Plant could supply the total water demand for Binjei, the Binjei-Medan transportation corridor, and Medan. Thereby, the costs of direct service and long distance transmission could be distributed over a large population. The raw and treated water transmission system would require about 26 km of large diameter pipelines. Estimated total flows would require two 1,700 mm diameter pipelines for 13 km between the Wampu and Binjei and three 1,700 mm pipelines between Binjei and Medan (see Table 6.10).

The Belumei and Ular rivers appear to be capable of providing about 200,000 cu m/d and 500,000 cu m/d, as in the western rivers. One percent low flows, up to 280,000 cu m/d, could be expected in the Belumai River near Tanjung Morawa, about 7.5 km southeast of the Percut River in Medan. The more distant, but larger Ular River lies 25 km southeast of Medan and has an expected one percent low flow of about 2,000,000 cu m/d near Baungar.

The eastern regional production system (Figure 6.7) would resemble that of the western rivers. A treatment plant would be located west of Tanjung Morawa and would be connected by a 7.5 km pipeline to the main Medan network (Node 71). In the second stage, a raw water intake, pump station, and 17.5 km transmission pipeline would be added between the Ular River and the Morawa Plant.

Costs

Costs for treatment facilities and transmission facilities have been estimated and are presented in Table 6.11. Although costs of the complete eastern and western systems are similar, the first stage development at Tanjung Morawa would be less expensive due to the shorter 7.5 km transmission system compared to the 13 km transmission system needed for the first stage development at Binjei.

F. Gravity Flow Surface Water Sources

Three sites were assessed for use as surface water treatment plant sites which could use gravity flow to, through and from the plant. Sites on the Deli, Binjei, and Belumai rivers would have to lie within 16 km of Medan and be at or above 130 m elevation. Additional spring flows from the major springs discussed in Section 6.2.1 could be included in a total 120,000 cu m/d of plant and spring production.

TABLE 6.10

TRANSMISSION REQUIREMENTS FOR THE BINJEI (WESTERN) AND TANJUNG MORAWA (EASTERN) WATER PLANTS

		Production Capacity (cu m/d)	No.	Pipeline Diameter (mm)	Pipeline Distance (m)	Total Length (m)	Pump Size (HP)
Western							
- First	- Binjei River	200,000	1	1,600	13,000	13,000	3,000
- Second	- Binjei River	-200,000	1	1,600	13,000	13,000	3,000
	- Wampu River						
	Raw Water	500,000	2	1,700	13,000	26,00	1,400
	Treated Water	500,000	2	1,700	13,000	26,000	7,400
Eastern							
- First	Belumai River	200,000	1	1,600	7,500	7,500	2,800
- Second	- Belumai River	200,000	1	1,600	7,500	7,500	2,800
	- Ular River	-	-	-	-	-	-
	- Raw Water	500,000	2	1,700	17,500	35,000	2,000
	- Treated Water	500,000	2	1,700	7,500	15,000	6,900

TABLE 6.11

COSTS FOR THE BINJEI (WESTERN) AND TANJUNG MORAWA (EASTERN) REGIONAL WATER SOURCES

Project Facilities	Costs (Millions of Rupiah)				Unit Cost (Rp/cu m)
	Total Capital	Annual Capital	Annual Operations	Total Annual	
Western					
- First Stage					
Binjei WTP	21,400	2,250	1,130	3,380	46.3
Diversion	220	23.4	2.2	25.6	0.4
Pump Station	700	93.9	431	524.9	7.2
Pipeline	5,270	532	26.4	558.4	7.6
Total	27,590	2,899.3	1,589.6	4,488.9	61.5
- Incremental costs of the Second Stage (500,000 cu m/d)	84,325	8,904.7	3,266.7	12,141.4	66.3
- Total System					
Binjei WTP	80,400	8,530	3,000	11,500	45.0
Diversions	165	34	3.3	37.3	0.1
Pump Stations	2,650	350	1,710	2,060	8.1
Pipelines	28,700	2,890	143	3,033	11.9
Total	111,915	11,804	4,856.3	16,630.3	65.1
Eastern					
- First Stage					
Morawa WTP	21,400	2,250	1,130	3,380	46.3
Diversion	110	17.7	1.1	18.8	0.2

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TABLE 6.11 — Continued

Sources	Costs (Millions of Rupiahs)				Unit Costs
	Total Capital	Annual Capital	Annual Operations	Total Annual	
Pump Station	650	85	399	484	6.6
Pipeline	3,038	306	15.2	321.2	4.4
Total	25,198	2,658.7	1,545.3	4,204.0	57.5
- Incremental costs of the Second Stage (500,000 cu.m/d)	82,500	8,750	3,250	12,000	65.8
- Total Cost					
Morawa WTP	80,400	8,530	3,000	11,530	45.0
Diversion	220	23.4	2.2	25.6	0.1
Pump Stations	2,250	300	1,678	1,978	7.7
Pipelines	25,500	2,580	128	2,708	10.6
TOTAL	108,370	11,433.4	4,808.2	16,241.6	63.4

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Review of maps and available data indicated the following ranking of priority for further investigation:

1. Sibolangit/Deli River

2. Rumah Galuh/Binjei River, and,

3. Tanjung Marihan/Belumai River.

Considerable flow monitoring and detailed topographic surveys would be required for such alternative systems. These surveys are identical to those for further studies needed to establish the reliability of additional spring production and transmission and of low-flow control reservoirs. Although the alternatives cannot be recommended for inclusion within future water supply systems, further investigation should be undertaken because of potential cost savings and reduction of reliance on pumping and power supplies.

6.2.2.4 Comparisons of Surface Water Sources

A variety of local and regional surface water sources have been considered which differ in their total production, their environmental and water quality effects, their flow and production reliabilities, their schedules of planning-design-construction, and their capital and total costs. Some sources are combinations of water plants and diversions or reservoirs and must be compared as systems, while the Sunggal Plant expansion can be compared as a single unit to combination systems.

In the comparisons of alternative surface water sources, local sources have been viewed as essential components in the year 2000 supply plan. Therefore rather than comparing and selecting one alternative source, all sources are compared as to when each source will be developed. Only if future demands would require more water than available in local sources would either the eastern or western regional facilities be selected. This selecting would be required by the high cost of installing both systems.

In order to rate the various surface sources for possible implementation, they are compared below for production adequacy, effects, reliability and data adequacy, scheduling, and costs. Production from the various rivers has been estimated based on their estimated low flows, and they are ranked below:

1. Western Regional Rivers - more than 700,000 cu m/d

2. Eastern Regional Rivers - 700,000 cu m/d

3. Belawan River - 130,000 cu m/d

4. Deli River - 120,000 cu m/d

5. Percut River - 85,000 cu m/d, and

6. Babura Branch - 45,000 cu m/d.

Both the western and eastern regional systems would be adequate to meet all water demands for many years beyond the year 2000. Local rivers have to be combined to meet the year 2000 demands.

Environmental and water quality effects from use of the various sources reflect the percentage of total flow which is withdrawn from the source and the downstream needs for the water, and the above ranking also corresponds to the trend of potential adverse effects. Use of regional sources would have less adverse effect than use of large, local sources, and the use of large local rivers may have less effect than use of small, local streams.

The ranking for data adequacy and the resulting reliability of projections for low flows and production follows that shown above: the larger regional rivers have more reliable flow measurements and errors of the same absolute flows will have less effect upon projected production. The large local sources have flow measurements of questionable reliability, and the small, local sources have no flow measurements.

Major changes in the above ranking result from comparisons of (1) the compatibility of planning-design-construction schedules with projected water demand growth and (2) the capital, annual and unit costs for alternative systems. The very large size of the regional production requires that many large facilities be constructed during the early development stages, while the long pipelines further increase the cost and lengthen the design and construction periods. To effectively use these expensive initial facilities, large production facilities (e.g. 50,000 to 70,000 cu m/d) would be added incremently at more widely spaced intervals. Smaller facilities on local rivers require less effort for pipeline and pump station design and construction, and smaller production increments can be coordinated more easily with the growth of demand. Existing designs, land acquisitions, and plans for the Sunggal Plant allows its expansion to be carried out before any other surface facility could be developed. These factors result in the following ranking of compatibility and flexibility:

1. Belawan River (Sunggal)

2. Babura - Percut Rivers

3. Deli River

4. Eastern Regional Rivers

5. Western Regional Rivers

Comparisons of costs for various sources generally follow the same trend as in ranking of schedule/demand compatibility (Table 6.12).

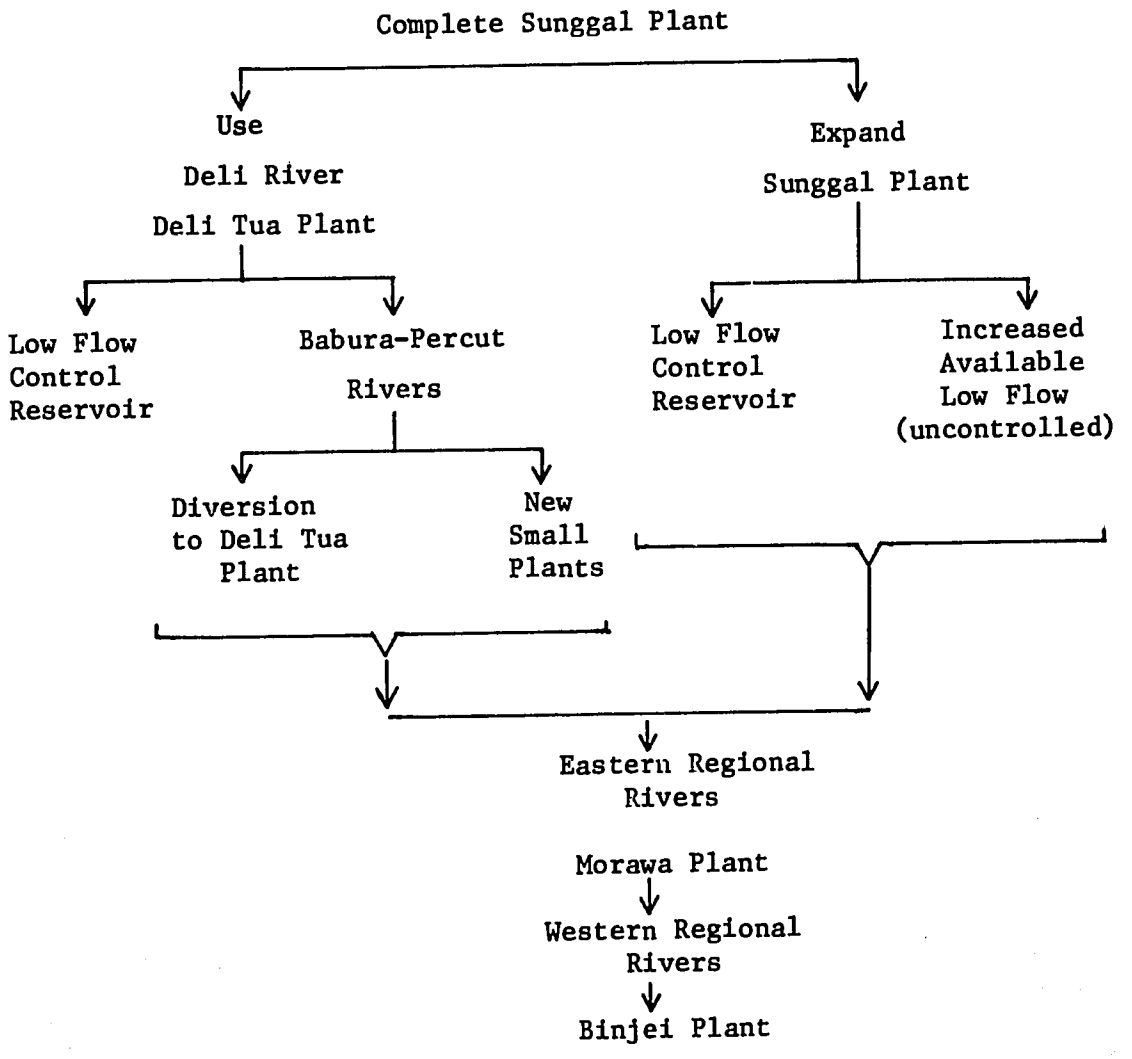
TABLE 6.12

COST COMPARISON OF ALTERNATIVE SOURCES

Sources	Costs (Millions of Rupiahs)				Unit Costs
	Total Capital	Annual Capital	Annual O & M	Total Annual	
Sunggal Plant (Incremental Costs)	6,610	700	370	1,070	37.7
Deli Tua Plant	28,700	3,030	1,470	4,500	49.3
System (Staged Costs)					
(1 - 120,000)					(49.3)
(2A - 205,000)					(47.2)
(2B - 165,000)					(52.1)
(C - 250,000)					(49.3)
with reservoirs	30,090	3,160	1,310	4,470	49.0
Medium-Sized Plants	24,800	2,530	1,320	3,850	43.6
Regional Systems					
Western					
Stage 1	27,600	2,900	1,590	4,490	61.5
Stage 2	112,000	11,800	4,860	16,660	65.1
Eastern					
Stage 1	25,200	2,650	1,550	4,200	57.5
Stage 2	108,000	11,400	4,800	16,200	63.4

General comparison of the various factors of the alternative sources shows a conflict between the schedule, cost, and implementibility ranking, and the ranking for production reliability and data adequacy. The conflict reflects the poor data regarding flows in local rivers and their long-term safe yields. As flow data are gathered, local source reliability can approach that of the regional sources, although the total available local flows are not expected to equal those of the Wampu, Ular, or Binjei rivers. Improved reliability of data, flow projections, and production will also reduce the potential for adverse environmental and water quality effects. Therefore, the overall evaluation should be made by a simple comparison of cost.

In order to reflect this evaluation with improved data for local streams and the ranking of source costs, the following sequence of source selection could be used:



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This sequence would allow collection of adequate data before selection of the next phase of source development. Depending upon further analyses, local rivers and existing spring production may be able to supply the total average daily demands of Medan to the year 2000 (about 421,000 cu m/d). Therefore, the recommended surface water sources should include the Sunggal Plant and a plant on the Deli River (e.g. Deli Tua Plant or Titikuning Plant) with further development of both plants or either plant in conjunction with increased available river flows, diversions from other local rivers, and low flow control reservoirs. If year 2000 average day demands of 421,000 cu.m exceed the safe yields indicated after 10 years of data collection and analyses, regional sources could then be developed for production.

6.2.3 Groundwater

Groundwater data (see Appendices A and E) are limited and, in some cases, questionable. This data and results of the Groundwater Program indicate that a substantial reservoir of groundwater underlies Medan. The total aquifer storage capacity may be between 70,000 and 125,000 cu m/ha, and the transmissivity may be between 300 and 600 sq m/m.d. At present the groundwater flow may have a velocity of 4 to 8 m/d. If these estimates are confirmed by long-term monitoring, the groundwater represents a significant water resource that could satisfy a large portion of the study areas water demand.

This potential was the major justification for the well exploration program described in Appendices A and E.2. The following discussion of groundwater as a water supply source are based on the (1) implementation of the well exploration program and (2) the confirming results of that program support a major groundwater development program.

6.2.3.1 Groundwater Facilities

Groundwater resources and geohydrology are discussed in Appendix E.1. Estimates of aquifer capacity and potential well production based on limited data indicate that the aquifers beneath Medan and Belawan may provide more than 200,000 cu m/d for more than 25 years. Long-term production, especially at the higher values, will depend upon a better understanding of the aquifers, the movement of groundwater within them, and the sources and rates of recharge. The recommended Drilling Program (see Section 7.1.1.4 and Appendix E.2) has provided the data for immediate groundwater development up to 100,000 cu m/d. Long-term development of 200 to 300,000 cu m/d production will require monitoring data from the exploratory and other production wells for the next five years.

Alternative groundwater programs consist of various levels of production with a number of wells. Some alternatives within these alternatives levels of production can be developed for:

- Well spacing and locations
- Well design and construction
- Aquifer depletion and recharge.

These alternatives, however, depend upon the basic development potential of the aquifer - the safe yield, both for the region and for specific sites. Since the regional safe yield cannot be adequately defined with available data, the groundwater alternatives have a common first stage of exploration, and monitoring. This stage will provide the data needed to define the long-term potential of the aquifer. Therefore, the alternative programs for groundwater production differ only after the first stage.

The first stage is assumed to reach a total groundwater production of 60,000 cu m/d. The alternative programs for the second stage involve total production of 105,000 or 200,000 cu m/d. These goals could be reached with many different combinations of the number, the spacing, and the designs of wells all of which vary throughout the region. Based upon existing data and analyses, several guidelines have been developed which can provide estimates needed for planning.

The alternative levels of production are most closely related to the condition of the aquifer. Alternative production levels can be accompanied by depletion of stored water in addition to the recharge, by balance of production and natural recharge with little depletion, or by inducement of greater recharge with greater production and artifical recharge.

A. Well Systems

The existing well production in Medan and in Belawan (24-240 cu m/d per metre of drawdown) indicates that the very close spacing of wells leads to interference between the wells and reduces their efficiencies. The initial well system for Medan should be developed with individual wells which will be widely spaced (1000 m intervals or one well per 100 ha). Later, additional wells can be located in more dense systems up to one well for 10 hectares) where aquifers have sufficient proven capacity. More dense well systems would not be placed in a single, small area (i.e. a well field with 5-10 wells/ha).

Multiple wells in a well field require more land area and longer, larger transmission pipelines, while individual wells, however, require more accessories and somewhat more operating effort. The larger land requirements for well fields requires continuous ownership of large amounts of land which are not usable for any other structural uses. Percels of one hectare within an urban area are virtually impossible to locate, and this restricts well fields to zones on the urban edge. Such restrictions, as in treatment plants, require longer transmission pipelines to supply demands in the center of the urban service area.

B. Wells

Observations of the drilling and development practices and analysis of the local well designs indicate that several alternatives to existing designs could increase production and extend the service life of the wells. New drilling and development procedures have been outlined in the Recommended Drilling Program in Section 7.1.1.4 and Appendix E.2. Designs modifications are also presented in that program and as design criteria in Section 5.2.2.

The large number of wells in the well system will require additional changes in operating procedures and personnel facilities at the wells. Existing operations include a full-time operator for each well, who is housed on site with his family. Such operations were required in the past because of poor transportation, use of diesel driven pumps and more complicated pumping systems. However, existing submersible electric pumps are simple and easily controlled systems, and transportation is more adequate than in the past.

C. Production and Distribution

As indicated above, each well should be developed as a discrete production source at intervals of about 1,000 m initially and later at closer spacings where aquifer capacity permits. Although the planned production goal for wells has been conservatively set at 1,000 cu m/d, higher production has been achieved with properly constructed wells using existing designs. Recommended design changes should improve production, service life and allow higher well production if the aquifer can sustain the withdrawal rate.

The immediate distribution of 60 wells (1980-1985) would be in the eastern and northern service areas at 1,000 m intervals along the existing 300 mm pipelines. By 1985, a maximum of 60 wells would be located in a 60 square kilometre area in eastern and northern Medan. During the following 10 years up to 1993 an additional 90 to 140 wells may be placed, primarily in the western section of the Medan urban area and in the Medan-Belawan corridor along the Deli River.

D. Special Problems

Environmental problems associated with large scale, long-term groundwater production are well known and include: decline in water quality, subsidence of overlying land surface, and compaction of the aquifer with reduced future storage capacity. Other effects include higher power consumption and declining production for wells and therefore increasing annual unit costs over the service life of the well. The recommended programs for groundwater development recognizes these potential problems and has been phased so that the data from each phase or each year can be used to reevaluate the groundwater production capacity and determine the next phase production goals. This staged strategy will allow effective groundwater production with minimal adverse environmental and operating effects.

In a dense urban area, concerns often focus on finding an appropriate site. Assuming an area of 1.0 sq km has a production potential of at least 1,000 cu m/d. the site selection within that area should reflect the minimum costs of land and construction. Because of the relatively small land requirements (less than 200 sq m) for the well, pump, and accessories, a well may be located on numerous sites. Wells may be constructed in parks, parking lots, median dividers and traffic circles, factory storage yards, school yards, and similar open spaces. The major restriction involves the retention of an open area of a 10 m radius around the well for initial construction and periodic cleaning and renovation. Where public views are important, the protective structures can be designed to conform to or improve their surroundings and in some cases may be placed underground to avoid any surface disruption. Large-scale governmental housing projects, including those of Tirtanadi, could easily incorporate a production well within their general open space layouts and even in certain types of buildings.

Major problems in Medan's groundwater development have been the poor design ,construction, and development of wells. Well construction has not been continuously inspected to insure the conformance of construction to designs, and improper design elements may lead to declining production or water quality. For the municipal well program, a training element is included in the Recommended Drilling Program that would provide the Tirtanadi staff with adequate experience to permit proper inspection of future wells and thereby insure both proper design and construction.

E. Artifical Recharge

Available data do not provide any indication of recharge areas, although they would be expected to be located in the mountains to the south of the study area. Some natural recharge may occur in the natural riverbeds near Deli Tua and Tuntungan. Following the initial production period and during the second drilling phase, data would indicate the probable infiltration areas. At that time, further consideration could be given to artifically recharging the groundwater with unallocated streamflow. Recharge could be incorporated with low-flow control reservoirs on the Belawan or Deli Rivers.

6.2.3.2. Well Water Quality

Available groundwater quality data are highly variable and may reflect a combination of geographical and stratigraphic variations of chemical concentration in the groundwater aquifers and variations of well design and production. In general, all well water analyses indicate that the groundwater quality is similar to that of the rivers with two major exceptions, iron and CO_2 content.

The ranges of pH, alkalinity and total hardness in groundwater include those values found in surface waters although the highest groundwater alkalinity values may be more than twice those of surface water (i.e. 240 mg/l compared to 97 mg/l in surface water). Iron concentrations of 2.5 mg/l have been found in several wells, and the high content is a common complaint among drillers and well operators because of taste, odor, and color. Geographical variation in iron content appears to be

as great as the daily variations found in surface waters. Wells of similar depths may differ in iron content by 2.0 mg/l, while some shallow wells have less iron than some deep wells.

Carbon dioxide content of groundwater is commonly higher than surface waters. Although high carbon dioxide content is related to the corrosiveness of the water, groundwater in Medan commonly has a high pH and alkalinity which tend to reduce the corrosiveness of the well water.

Water quality should not differ between the lower production and thehigher production levels. Both production levels assume adequate safe yields to maintain water quality. Wells in both alternative systems would be concentrated in the Medan region in order to eliminate potential problems of water quality degradation in the coastal zone.

6.2.3.3 Alternatives and Costs

Alternative groundwater developments involve levels of production rather than the design of facilities. The two alternatives for the short-term first phase should reflect the results of the Recommended Drilling Program. If this program indicates moderate potential, about 60 wells would be drilled during the first phase with an initial total production of 60,000 cu.m/d of groundwater. If the program indicates a very low or indeterminate potential, additional wells may be drilled for special uses and for short-term supplements, until other sources become available.

Alternatives for the 1985-2000 period presuppose positive results from the Recommended Drilling Program and the first phase production program. If first phase production indicates a yield of 200,000 cu m/d can be sustained, then Alternative 1 with an additional 140 wells would beimplemented. If monitoring indicates unacceptable water quality or a lower long-term yield, then Alternative 2 would be implemented and only 40 additional wells would be drilled.

Capital and operating costs of wells do not show the same economy of scale trends usually present in costs for treatment plants. Since well fields will not be employed, capital costs are directly proportional to the number of wells. Similarly, power and other costs for operations are based upon individual wells, their production levels, and required operating pressures. Personnel costs represent the only operating cost which may vary with the number of wells in operation. Staff requirements for well operations would be about one operator for four to five wells with one supervising operator for every 50 wells. Therefore, the first phases upto 1985 would need a total of 12 technicians and two supervisors. The maximum total staff needed in 1995 would be about 50 technicians and foursupervisors (Alternative 1).

The total capital and operating costs are presented in Table 6.13. Changes in service life from 15 to 30 years reduces annual capital costs by 30 percent. Increasing individual well production from 1,000 up to 2,000 cu m/d can reduce by one half the annual capital costs and the unit capital costs.

TABLE 6.13

COSTS OF SINGLE WELL AND ALTERNATIVE GROUNDWATER DEVELOPMENT PLANS

Wells and Production	Costs (x millions of Rupiah)				Unit Costs (Rp/cu m)
	Total Capital	Annual Capital	Annual Operation, with Power	Total Annual	
One Well 1,000 cu m/d	44.3	5.8	5.0	10.8	30
60 Wells 60,000 cu m/d	2,658	350	300	650	30
100 Wells 100,000 cu m/d	4,430	580	500	1,080	30
200 Wells 200,000 cu m/d	8,860	1,160	1,000	2,160	30

6.2.4 Comparison of Water Sources and Alternative Combinations

Comparison of unit costs for various alternative sources indicates that the order of new source development should follow the sequence shown below:

	Unit Costs, Rp/cu m
Wells	30
Sunggal Water Plant Expansion	37
Springs	27 - 48
Deli Tua Water Plant, with or without Diversions or Reservoirs	48
Regional Water Plants	60+

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The unit costs were estimated based upon the costs per individual well producing 1,000 cu m/d. Operating staff and unit capital costs would be significantly reduced with increasing production, while the power and other materials costs would increase slightly for higher production. Capital costs include costs for installation, land, engineering, and contingency. Annual capital costs are calculated using a 15 year service life and interest of 10 percent. Annual operating and maintenance costs assume general cost of five percent of total capital costs plus power costs for a 20 HP submersible pump at a rate of Rp. 21.5/kWh. Groundwater represents the cheapest, but least understood of potential sources. In Sections 6.2.3, two alternative levels of production were developed: (1) 100,000 cu m/d and (2) 200,000 cu m/d. These levels, in turn, determine the remaining year 2000 supply requirements from other sources.

The Sunggal Water Plant expansions have followed a planned schedule, and new construction for the next stage will begin in late 1979 or early 1980. This commitment and the relatively low costs of the expansion support the completion of the Sunggal Plant. Completion would add about 80,000 cu m/d to the water supply. This Sunggal production, existing production, and well production would supply a total of 280,000 to 380,000 cu m/d with a remaining year 2000 requirement of 141,000 to 41,000 cu m/d from other sources.

The third stage of water source development must reflect improved and expanded data collection, analyses, user inventory, and water allocations (see Section 10.3.4 and 10.4) conducted during the initial development of groundwater sources and the Sunggal Water Plant from 1980 to 1993. If the estimated springs flows are available to Tirtanadi, total production from the three spring system would be about 80,000 cu m/d. This production could supply the growth in demand for about three years.

Because of the questionable availability of the spring flows and requirement for additional water sources, the fourth major source Deli River may eventually be required to meet demands to the year 2000. The following sources, production, and sequence show the range of potential production capacities for a water plant on the Deli River:

Sources	Additional Production (cu. m/d)	
1. Existing	100,000	100,000
2. New Wells	100,000	200,000
3. Sunggal Plant Expansion	80,000	80,000
4. Springs	0	0
Sub Total (1 - 4)	280,000	380,000
5. Required Addition Source on Deli River	141,000	41,000
Total Year 2000	421,000	421,000

Two major alternative combinations of sources have been formed from the above comparisons and development sequences:

1. Large Groundwater Production with a medium-sized Deli Tua Plant

2. Moderate Groundwater Production with a large Deli Tua Plant.

Existing production would be continued, the Sunggal Plant would be completed, and no additonal spring production would be collected. These alternative source combinations have been further developed below and are used for comparing alternative distribution systems (see Section 6.3).

6.3 DISTRIBUTION SYSTEM ALTERNATIVES

6.3.1 Analysis Methodology

Distribution system alternatives generally arise from possible alternative sources, different peak factors could be employed in the design, different levels of service that could, within reasonable limits, be provided in the service area and of course the different types of networks that could be adopted depending on the existing and projected system of main and secondary roads in the city and its suburbs.

6.3.1.1 Peaking Factors

Most town and cities with adequate water supply systems have fairly well established peaking patterns. The more developed and affluent the areas, the larger are the peaking factors. Peaking factors decrease with increasing system size. No established pattern exists in Medan mainly due to the fact that the supply is inadequate.

The situation will naturally alter after the establishment of an adequate supply. Finances permitting, the peak factors should provide for fire flow. A reasonable allowance has been provided for fire fighting, but when such situations do occur, the domestic and industrial supplies are likely to be affected adversely.

A peaking factor of 1.7 (peak hour flow/average daily flow) has been selected after a study of cities elsewhere with similar sociological and climatological conditions.

6.3.1.2 Network Analysis

Only one pressure zone is required in Medan. The layout of the road network permits a trunk main of reasonably large size to be located on the periphery of the existing service area. Within and outside this ring, the network has been divided into closed loops except in a very few instances where dead-ends were unavoidable.

It was not possible to calibrate the mathematical model of the existing system properly because of the inadequate supply and the consequent inability to make sufficient field measurements of pressures under

actual operating conditions. For example, operations at the tower, ground level reservoirs and two boosters stations at the Jalan Singamangaraja site are changed many times a day without adherence to any strict patterns, in order to provide the most equitable distribution possible. Pressures were taken at noon and midnight at different point in the city, but due to the above reasons, they could not be considered to represent normal, consistent working pressures for analytical purposes.

A number of computer analyses were made for the 1985 and 2000 requirements, respectively, for each of two alternative source inputs (see Section 6.2.5.2). The existing network with suitable adjustments for the Hazen-Williams roughness coefficient according to the ages of the respective components was taken into account in each case and the new pipe provided has been assumed to work in parallel with the existing mains, though, of course, the contribution of the latter in many instances is only minimal. The computer analyses were made by ascertaining the nodal demands and correcting the flow in each loop until a head loss balance was achieved. The network analysis model is described in Appendices F.1 and F.2. The alternative network layouts are illustrated in Figures 6.8 and 6.9.

6.3.2 Effects of Source Alternatives on Distribution System Design & Costs

The alternative source configurations selected have a large impact on the alternative distribution systems considered. The source alternatives are summarized below. The supply configurations selected for the distribution system alternatives represent extremes in minimum and maximum development of groundwater resources. The difference in distribution system costs for Alternatives 1 and 2 therefore gives a measure of the additional distribution costs associated with development of surface water versus groundwater sources.

SUPPLY ALTERNATIVES THROUGH 1985

Source	Distribution Alternative No. 1 (cu m/d)	Distribution Alternative No. 2 (cu m./d)
Sibolangit Springs	46,000	46,000
Sunggal Water Plant	78,000	78,000
Deli Tua Water Plant	67,000	-
Wells: Belawan	4,000	4,000
Medan	-	67,000
Total	195,000	195,000

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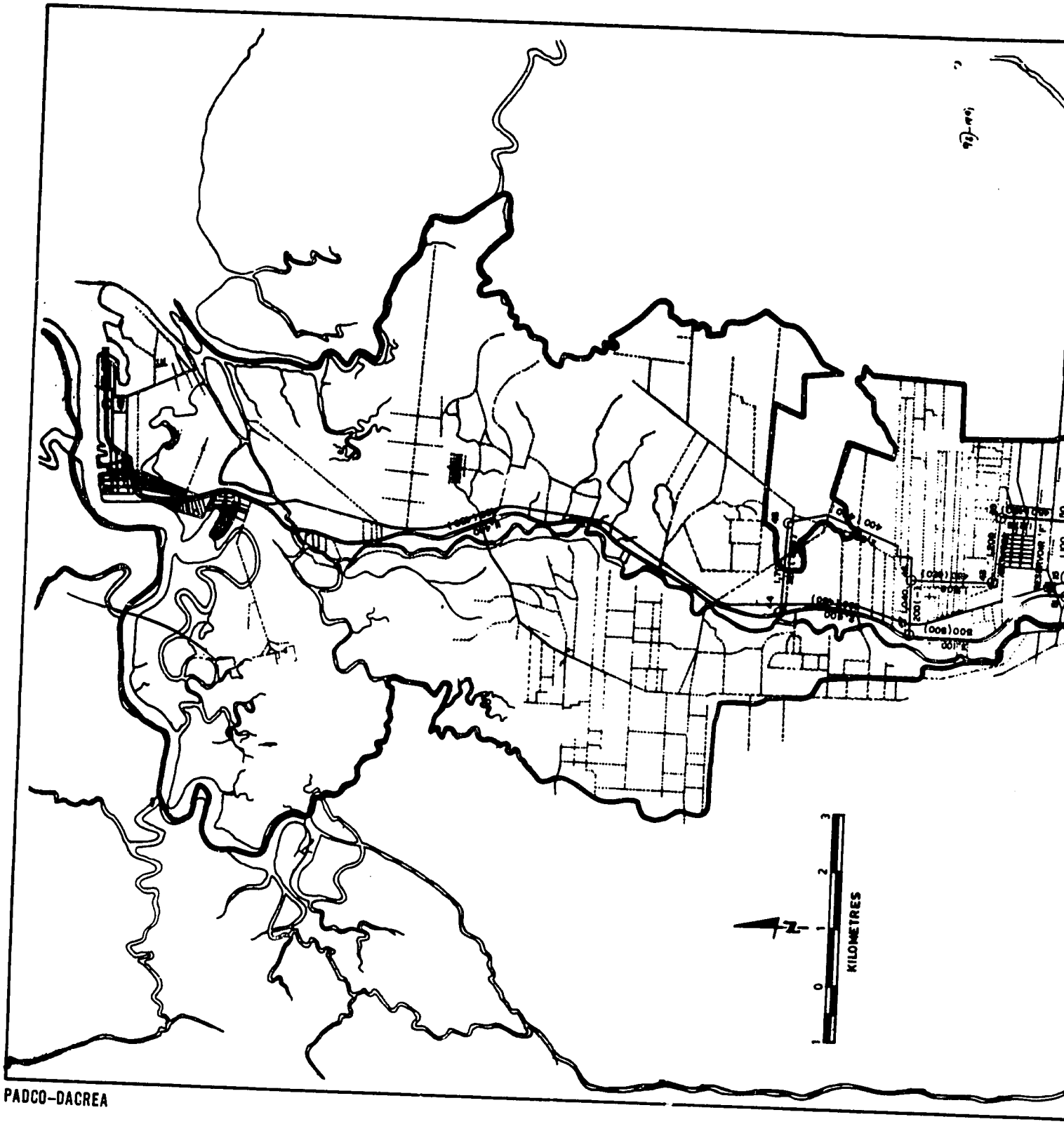

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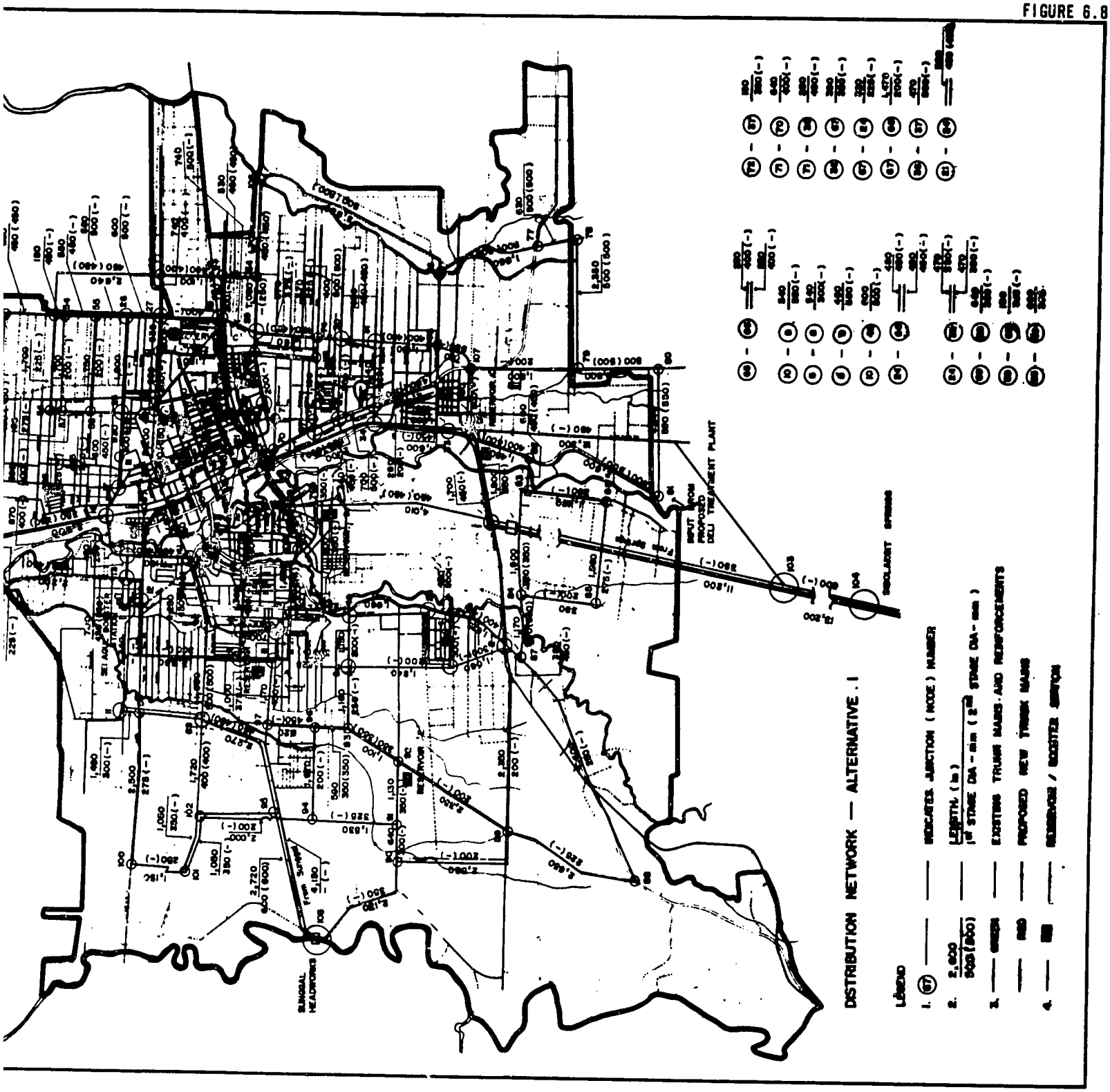
FIGURE 6.8



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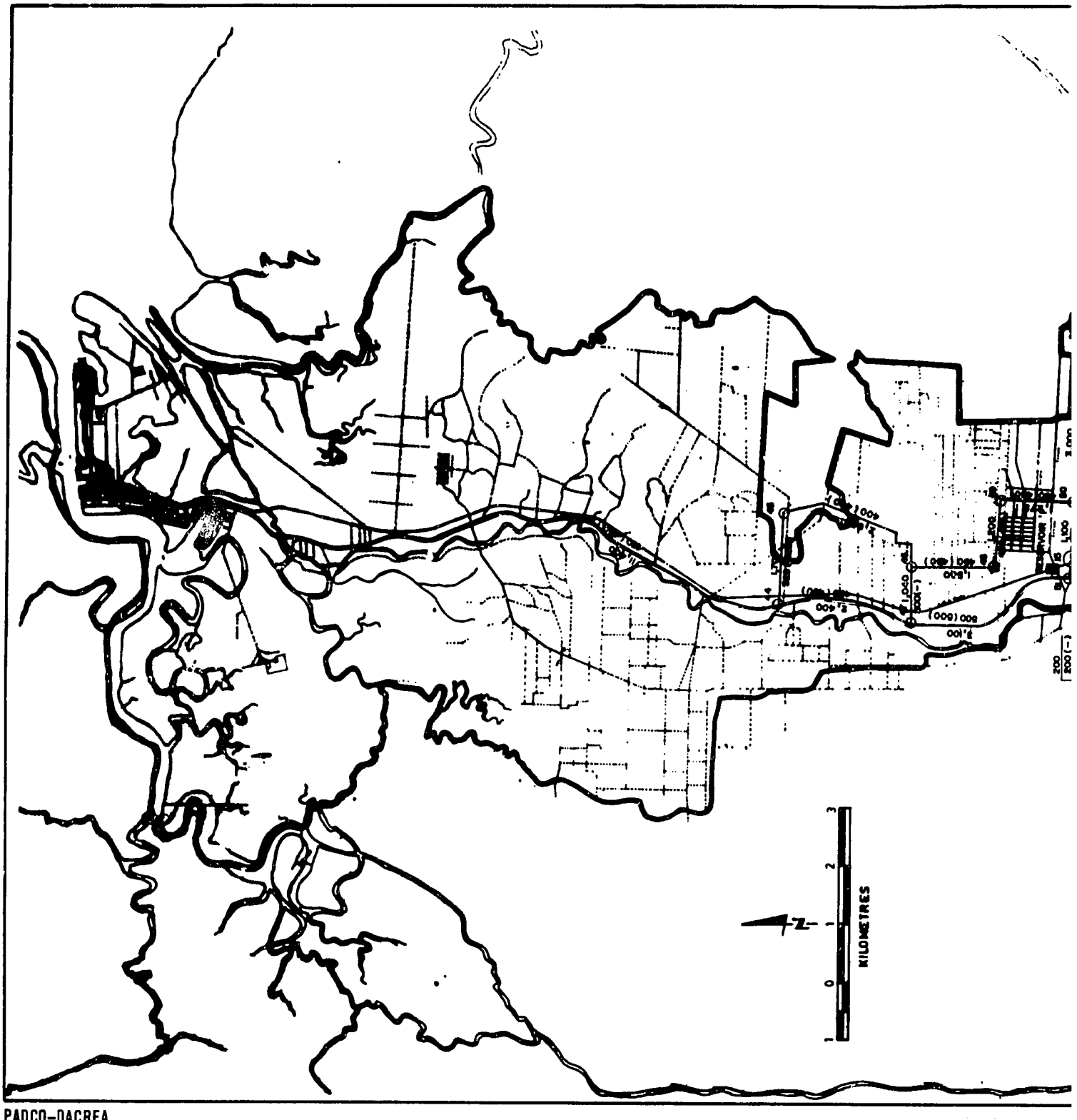

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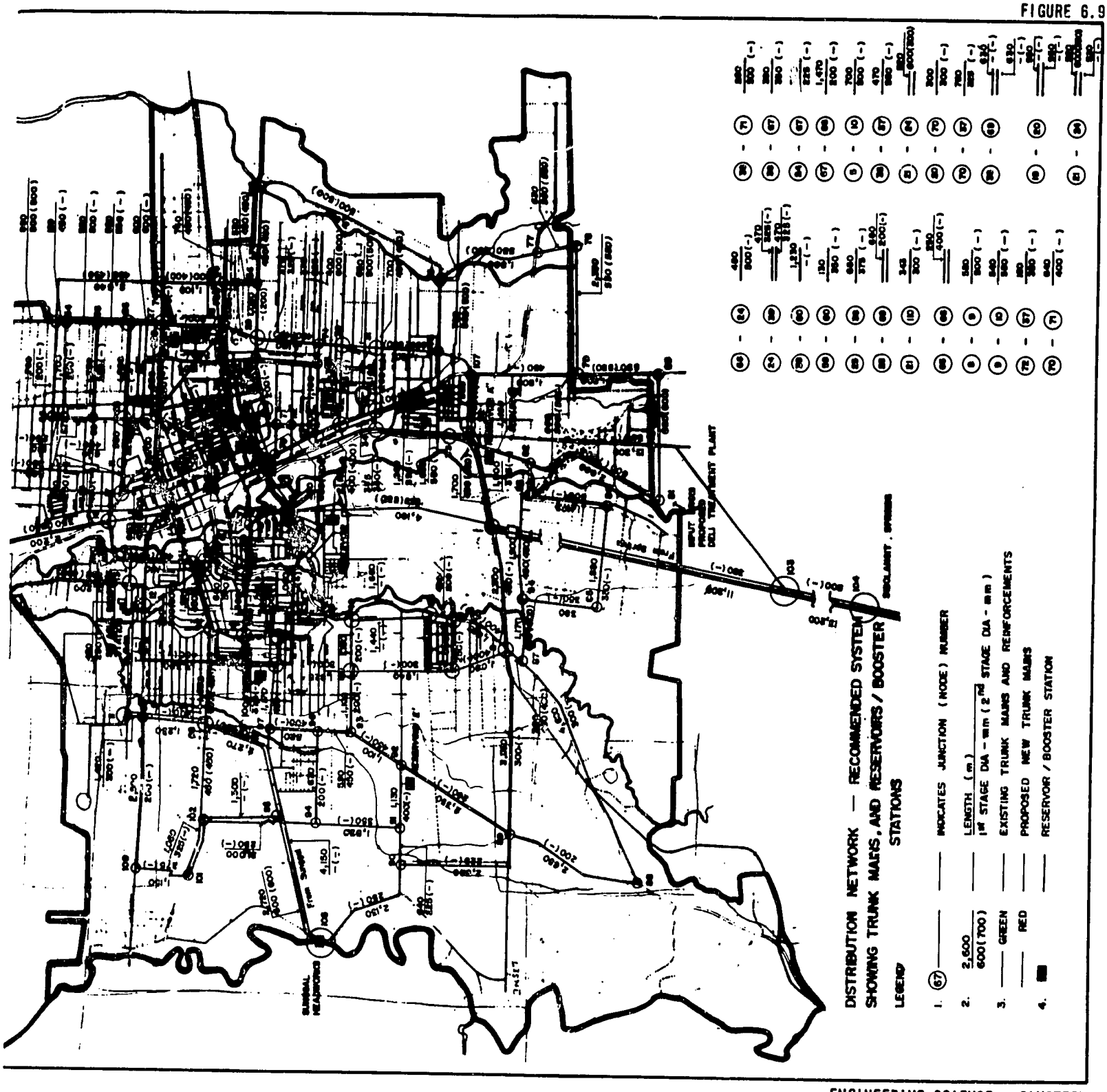
FIGURE 6.9



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SUPPLY ALTERNATIVES THROUGH 2000

Source	Distribution Alternative No.1 (cu m/d)	Distribution Alternative No.2 (cu m/d)
Sibolangit Springs	46,000	46,000
Sunggal Treatment Plant	130,000	130,000
Deli Tua Water Plant	141,000	41,000
Wells: Belawan	4,000	4,000
Medan	100,000	200,000
Total	421,000	421,000

Given below (Table 6.14) is a summary of the two distribution system Alternatives No. 1 and 2 for the year 2000. The costs are given at mid-1979 prices. The differences in the total pipeline lengths of Stages I and II in the two alternatives are due to different staging decisions.

6.4 EVALUATION OF ALTERNATIVE WATER SUPPLY MANAGEMENT SYSTEMS

Water supply management system Alternative W1 assumes that only a limited amount of groundwater will be developable through the year 2000 (100,000 cu m/d). Alternative W2 assumes that the results of the recommended groundwater exploration program will indicate a larger groundwater potential (200,000 cu m/d).

Alternatives can be compared on the basis of

1. Costs
2. Reliability
3. Implementability and flexibility
4. Environment Effects

As discussed below, general consideration of these categories have led to the recommendation of Alternative W1.

6.4.1 Costs

As discussed above (see Section 6.2.4 for a comparison of alternative source of supply costs and Section 6.3.2 for an analysis of alternative distribution system costs), maximizing development of groundwater (supply alternative 2) minimizes both supply and distribution system costs.

TABLE 6.14

COMPARISON OF ALTERNATIVE DISTRIBUTION SYSTEMS

	Alternative No. 1				Alternative No. 2			
Diameter (mm)	Stage I Lengths (m)	Stage I Costs (million of Rp.)	Stage II Lengths (m)	Stage II Costs (million of Rp.)	Stage I Lengths (m)	Stage I Costs (million of Rp.)	Stage II Lengths (m)	Stage II Costs (million of Rp.)
200	32,490	357			27,240	300	1,030	11
225	6,390	83			7,340	95	-	-
250	9,520	143	1,030	15	8,750	131	-	-
275	4,560	82	-	-	1,150	21	-	-
300	15,555	311	-	-	17,750	355	360	7
325	4,225	95	1,700	38	3,880	87	1,700	38
350	19,480	487	11,260	282	10,465	262	2,720	68
375	1,660	46	-	-	4,210	118	-	-
400	15,515	496	9,630	308	23,340	747	10,395	333
450	57,855	2,256	49,225	1,920	48,555	1,894	43,005	1,677
500	23,830	1,120	17,970	845	22,690	1,066	14,850	680

TABLE 6.14 — Continued

	Alternative No. 1				Alternative No. 2			
Diameter (mm)	Stage I Lenghts (m)	Stage I Costs (million of Rp.)	Stage II Lengths (m)	Stage II Costs (million of Rp.)	Stage I Lengths (m)	Stage I Costs (million of Rp.)	Stage II Lengths (m)	Stage II Costs (million of Rp.)
550	4,630	264	2,230	127	14,150	807	11,500	656
600	-	-	-	-	11,750	787	5,350	358
700	-	-		-	-	-	2,600	244
TOTALS	195,710	5,740	93,045	3,535	201,270	6,670	93,510	4,072

Alternative No. 1

Stage I (1980-85) - 5,740 Million Rp.
Stage II (1990-2000) - 3,535 Million Rp.
9,275

Cost of valves and any special fittings not included.

Alternative No. 2

Stage I (1980-85) - 6,670 Million Rp.
Stage II (1990-2000) - 4,073 Million Rp.
10,743

Cost of bends, tees, etc. included.

6.4.2 Reliability

Reliability for the Medan water supply system relates to two elements:

1. Projection of sources availability
2. Operation of the water supply system.

6.4.2.1 Sources Availability

The reliability of projections of sources is low because of the short-term records and poor quality of the data. Many alternative sources were excluded from consideration in this study because of the substantial amount of data needed to estimate production with reasonable accuracy. Only the Belawan and Deli rivers and groundwater were expected to have sufficient water supplies which could be estimated with an acceptable degree of reliability. Development of Alternatives W1 and W2 assumed moderate reliability either for groundwater or for the Deli River flows.

6.4.2.2 System Operation

Groundwater sources would provide greater system reliability compared to the concentration of surface water production at two large water plants at the perimeter of the service area. If power failure or pipeline rupture interrupts service, groundwater sources would be less affected than the effects from the loss of one 600 to 1000 mm pipeline or one major raw water pump. Some increase in the probability of pump and power failures occurs with their high number, although the significance and duration would be small compared to rupture of one major surface water pipeline.

Surface water sources require major raw water pipelines and more pumps at the raw water diversions. This increases the probability and severity of failures within the Deli Tua System. The larger diameter pipelines, however, will increase the capacity of the system to redirect flow from the Sunggal Plant and the presence of a number of wells would lessen the significance for loss of production. The smaller pipelines required with a larger proportion of the supply coming from wells allows for less redistribution of flows to compensate for loss of a well or a major pipeline from either the Sunggal or Deli Tua Plant.

6.4.3 Implementibility

Although either surface or groundwater sources can implement production in accordance with the projected demand, larger surface water treatment plants are less flexible to meet even higher growth of demands and for meeting major geographical shifts of demand growth (e.g. from the southwest to northeast).

Geological information suggests that groundwater storage may not be sufficient in some areas, and therefore, wells are not completely flexible. Drilling of 100 wells in 15 years would require one or two drilling rigs for the entire peirod. Only three suitable rigs were available on Sumatra in 1979. With sufficient planning, additional rigs could

be imported. The relatively high technological and coordination requirements for drilling, development, and operation of a large number of wells will require considerable changes in training of staff. The slower rate of drilling which could be used if less groundwater were developed would reduced the training requirements and allow Tirtanadi staff to become familiar and better trained in use and operation of both drilling rigs and production wells.

6.4.4 Environmental Effects

Environmental evaluation of alternative water supply systems involve two major categories of effects: construction and operational effects. Construction effects are usually more apparent and may appear to be very significant, but they are usually short-term (one to two years). Operational effects usually become evident over time and may build up gradually until they become significant.

Environmental assessment of these alternative facilities involves potential water quality and production problems that might arise from extracting more water from either source than can be replenished by the aquifer or channel flow. Down-stream or other aquifer users might be adversely affected.

Overdrafting or excessive withdrawal from the Deli River or from the Percut and Babura rivers could reduce or eliminate flow downstream from the diversion. This, however, would only occur when the total flow fell below the planned diversion rate. Such effects could occur within one month and be gone within a few days or a week.

Overdrafting or mining the groundwater aquifers usually takes longer to occur than overdrafting of surface water sources but last much longer once they begin even if overdrafting stops or flow in increased. The operational effects of decisions to overdraft either the surface or the ground waters would be similar, but the effects of mining the groundwater would be more significant then those in surface waters.

6.4.5 Summary

Alternative W1 assumes a moderate reliability for groundwater projections and moderate levels of flexibility for implementation. Environmental effects or potential effects are similar in both alternatives. Alternative W1 is recommended for implementation to provide a more conservative basis for the Master Plan. However, the groundwater exploration program has indicated that moderate groundwater resources are available and supports seleccion of Alternative W2.

The importance of groundwater reliability appears at this time to be equal or more important than the costs. Alternative W1 can be easily adapted to both lower and higher groundwater production levels when feasiblity is demonstrated by the recommended groundwater exploration and the initial well production program.

SECTION 7

RECOMMENDED WATER SUPPLY MANAGEMENT SYSTEM

7.1 DESCRIPTION OF RECOMMENDED SYSTEM

7.1.1 Water Supply Improvement

7.1.1.1 Spring Supply

Supply: In this recommended plan, the present production of 46,000 cu m/d from the springs at Sibolangit would not be changed during the study period. Evaluation of the known springs in the Sibolangit area indicates that about 40 percent is not collected. During the next 20 years, additional negotations with existing water users may allow larger production from the springs. If such additional flow is collected, larger capacity collection and transmissions systems would be required.

Improvement: Several pipelines within the spring collection system are more than 50 years old, and eventually replacement of some old pipelines with larger diameter pipe would increase flows and pressure at the junction of the local pipelines and the transmission system to Medan.

Local collector and transmission pipelines at Sibolangit are near or at maximum flows. Pipeline breaks can disrupt and stop production from any of the four groups of springs, therefore, all pipelines for the Rumah Sumbul and Lau Bengklewang springs should be examined and evaluated for replacement during the 1980-2000 period. Replacements should provide for at least 25 percent emergency capacity for each group of springs.

Low pH and high CO_2 content of the springs water have required aeration and lime treatment in order to reduce the water's corrosion potential. Apparant excessive lime treatments have caused calcium carbonate deposition on some pipeline walls. More frequent analyses of CO_2, pH, temperature, bicarbonate, sulphate, and dissolved solids should be conducted. Comparisons of analyses from the aerators, junctions chambers, and air relief valves would allow accurate adjustments of the bicarbonate and pH levels in order to both reduce incrustation and control corrosion.

Costs: No additional cost is projected for the maintenance of existing facilities at the Sibolangit springs. Replacement of pipelines cannot be projected at this time.

7.1.1.2 Surface Water Supplies

Sunggal Plant: The existing raw water diversion and pre-settling facilities are sufficient for an extraction of 78,000 cu m/d. Additions and improvements will however be needed when the second stage of augmentation is undertaken to increase the output to 130,000 cu m/d.

The plant produced 52,000 cu m/d in 1978-1979, but the following improvements are necessary. The original clarifier and filter, built according to conventional principles and design, function well. The second clarifier is comparatively satisfactory, but the second set of filters is not. The performance of the raw water pumps has also deteriorated and, as a result of these two problems, all the pumps in the raw water pumping station have to be operated at one time to provide the required flow. The addition of at least one more pumping set as standby is necessary, so that at least one pump can be taken out of service. The situation in the filtered water pump house is similar and the addition of a stand-by set is needed.

The improvements necessary to ensure more efficient performance of the second set of filters are as follows:

1. There are not effluent rate of flow controllers at present, and provision of these at this stage is not feasible. Instead it is recommended that once the third set of filters is commissioned, the second set be structurally altered to make the filters operate on a variable head basis (See Section 5.2.1.3). The main structural alteration to enable this is the provision of a channel of suitable dimensions capable of carrying more water from the second clarifier to these filters. The wash-water troughs have to be demolished and new troughs installed, sized and spaced according to orthodox design requirements.

2. The filter media in all filters should be regraded to obtain an effective size of at least 0.5 mm and a maximum uniformity coefficient of 1.5. The effective size, coefficient of uniformity and depth of media are directly related to the rate of filtration and back wash rate and these values should be determined from pilot plant tests.

3. The back-wash rate should be increased, the exact rate depending on the success of the air scour now being installed.

4. It is also recommended that a modified method of transporting the filter effluent to the clear-water tank be provided, ensuring that no negative head or "air binding' will occur. A simple arrangement is to provide a weir set a few centimetres above the level of filter media, over which the filter effluent has to flow before reaching the channel leading to the clear water tank. This will ensure a positive head in the filter media at all times.

5. The addition of soda ash before coagulation and flocculation should be studied critically. Jar tests should be run with varying dosages of soda ash (including none added) and alum to determine the optimum dosages. This should be done regularly to take care of changes in raw water quality. If, as seems likely, best coagulation occurs with no addition of soda ash, pH adjustment can be done on the finished water.

The first stage of augmentation, to 78,000 cu m/d, is due to commence shortly. However only construction of the third clarifier has yet been definitely decided on. It must be stressed that the third set of filters is essential if 78,000 cu m/d is to be produced. From the experience Tirtanadi has had with the first set of filters, where all of the effluent rate of flow controllers failed, and with the second set where no controllers have been provided at all, it is strongly recommended that the third and future sets of filters be of the declining rate of flow type. These can be designed to function with the least amount of sophiscated imported equipment, but still provide an effluent of equal or better quality than the effluent flow control types. The emphasis will shift from automation to manual control based mainly on visual observations.

The clarifiers should, in the new augmentation phases, be of the sludge - blanket upflow type which are functioning satisfactorily in the present plant. Uniformity in operation will be helpful but special attention should be focused on desludging during the hotter hours in the early afternoon at which time the performance of sludge blanket clarifiers tends to deteriorate.

Additional clear water storage and a new clear water pump house will be needed as the capacity of the existing facilities cannot be increased. Sufficient land space is available for both.

The total cost of upgrading the Sunggal Plant from its present 52,000 cu m/d capacity is estimated at Rp. 4,280 million. The first stage, which should also contain some of the facilities needed for the second stage, will cost approximately Rp. 200 million and the latter, Rp. 2,280 million.

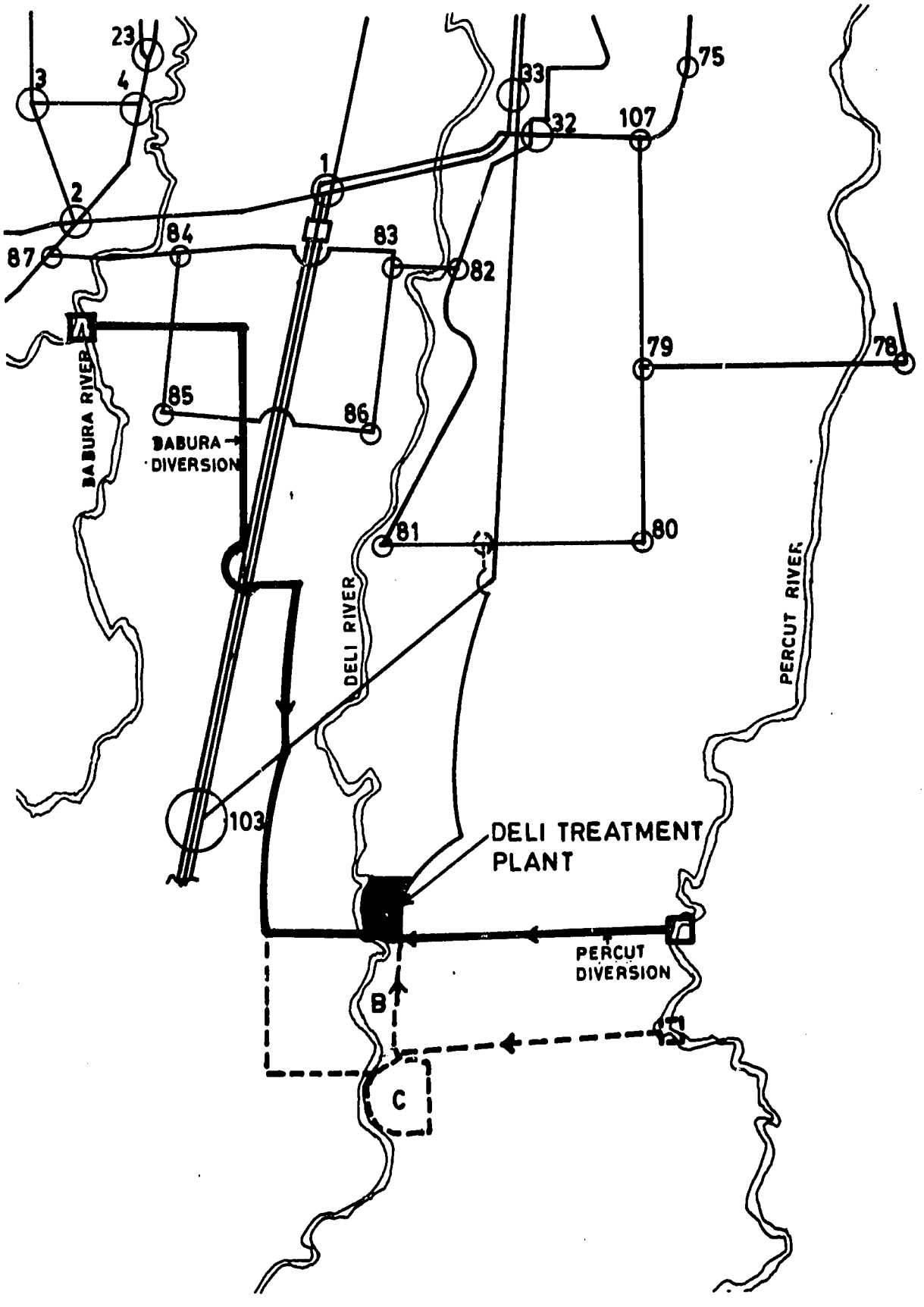
Deli Tua Plant: This plant would supply 141,000 cu m/d to the system by 2000. The initial construction, drawing water only from the Deli River, would have a capacity of 35,000 cu m/d available by 1987. Diversions from the Percut or Babura Rivers and expansion of the Deli Tua Plant would provide the additional supply needed to meet the 2000 demand.

Figure 7.1 shows the locations and routes for the plant, diversions and pipelines.

Several alternative plant sites south of Deli Tua and along the east or west side of the river would have sufficient area (10 to 15 ha) for a plant of 141,000 cu m/d. Three candidate sites will be evaluated more fully. Sites A, B and C along the existing paved road from Deli Tua to the Deli River have at least 10 to 30 ha, and are upstream of

FIGURE 7.1

DELI TUA WATER PLANT FACILITIES AND CONNECTION WITH MEDAN DISTRIBUTION NETWORK



Deli Tua and the small stream to the east which collects most urban runoff from Deli Tua.

The Deli Tua Plant would contain the same element as described for the Sunggal Water Plant: weir and sluice gate, presedimentation basin, raw water pumps and chemical feed facilities, clarifiers, filters, filtered water reservoirs, and a treated water pump station. Major electrical power lines lie within 2 km and both an electrical substation and diesel back up generators would be required.

The treated water would be transmitted first to Deli Tua, 600 m to the northeast of the plant. From Deli Tua, the transmission pipeline route would follow the existing spring water pipeline right of away for about 4.0 km along the old railroad right-of way. The new pipeline would connect with the future distribution network between Nodes 80 and 81 in Titi Kuning. Water supply service could be provided throughout the south-central, Medan-Deli Tua development corridor.

The Percut diversion would have a weir across the Percut River similar to that on the Deli River. Sluice gates would regulate water levels across the weir and entering the pre-settling tank. Water would be withdrawn from the tank and pumped by four 180 to 200 HP pumps across the divide between the Percut and Deli River to the Deli Tua Water Plant. Total land requirements would be less than one hectare depending upon the inundation of the regulating pool behind the weir.

The pump station would be supplied with electrical power from the major distribution power lines along the old railroad right of way, 1.0 km to the west or by diesel generator on the site.

The layout of the Babura diversion would be similar to the Percut diversion except that Babura pumps and pipelines would be smaller than those at the Percut River. The pipeline would follow the edge of the year 2000 urban area for about 4.0 km in Medan Johor. At the study area boundary the pipeline would join the existing main pipeline right-of way from Sibolangit. After about 3.0 km, the pipeline would turn east for 1.0 km and cross the Deli River at the Deli River diversion. The Babura raw water would then be combined with that of the Deli and Percut.

A number of option for the best future development of this system will have to be considered when more river discharge and other data are available. The final design of the Percut station pumps may also include facilities to boost spring water from the Marihan/Bantam springs to the railroad pipeline corridor. Further analyses may also indicate the desirability of pumping settled river water from the Belumai River, 4.0 km to the east, through the Percut Diversion to the Deli Tua Plant. The First Stage groundwater program may indicate a large yield, and a smaller Deli Tua Plant could be installed with Percut or Babura diversions.

The Deli River alone (120,000 cu m/d) together with the Sunggal Plant and wells would be sufficient to meet demands through 1997/98. By 1995, decisions would have been made to either use a low-flow control reservoir on the Deli River, use more water from the Deli River and Percut River low flows, use raw water diverted from the Babura or the Belumai Rivers, or develop additional groundwater.

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7.1.1.3 Transmission Pipelines

The existing transmission pipelines from the Sibolangit springs carry water to Johor and Deli Tua. These pipelines range in age from 70 years to 10 years, and some may be replaced during the next 20 years. New replacement pipes should be of large diameters in order to reduce pressure losses and to allow for emergency re-routing of flows in the case if pipeline ruptures. Is spring production can be expanded, new or replacement pipelines should be sized to provide for higher flows and emergency capacity.

New transmission pipelines and their costs are discussed as part of the Deli Tua Water Plant system. The Deli Tua pipeline system could also serve the expansion of Sibolangit and the Marihan springs. Only 21 km of new transmission pipeline would be required to join the Sibolangit Springs with the Deli Tua transmission pipelines. A 14 km spring water transmission pipeline from the Marihan springs could follow the Percut raw water diversion system and connect with the Deli Tua treated water pipeline. Any additional costs for the collection and transmission of spring waters would be balanced by reduction in costs of treating river water at the Deli Tua Plant.

The two existing 600 mm diameter transmission mains from Sunggal to the periphery of the present service area are adequate for a supply of 52,000 cu m/d. From the point of entry at the periphery to the ground tanks and tower at Jalan Singamangaraja, the existing pipelines are inadequately sized and are more than 60 years old, resulting in little or no water from Sunggal reaching the latter site. Tirtanadi is however taking remedial measures by laying a 400 mm ductile iron transmission main which will make a radical improvement. Their intention is to use the existing lines as distribution mains, and the new main for transmission only.

The laying of the two new mains given in Stage I of the distribution system improvements should be done without delay.

When the Sunggal Supply is increased to 78,000 cu m/d, a third 600 mm transmission main, approximately 2700 metres long, will be necessary. The new main will cost about Rp. 182 million and will be essential if the additional supply is to be utilized effectively. The exact length and route of the transmission main from Deli Tua Plant to the trunk main network will depend on the location of the plant. Its estimated cost is Rp. 2,280 million.

7.1.1.4 Well Supplies

Deep wells will be the cheapest, most flexible source of municipal water supply for Medan. The well supply takes on even greater importance when considering total use of the estimated production from other local sources. If wells are not developed, about 100,000 cu m/d would have to be collected from more distant and more expensive regional sources. The 100,000 cu m/d groundwater availability figure must be recognized as being only an estimate based upon limited data. The results of the

recommended groundwater exploration have indicated that the estimate can be achieved although long-term monitoring is required. The lower costs of groundwater calls for development of as much groundwater as possible, under any longer or short range water resources management plan.

Well Exploration Program: The well exploration program was recommended for 1979 but was completed in 1980. The program is described in Appendices A and E.2. The program clearly indicated the potential groundwater supply is equal to or greater than that estimated and has provided general guidance for First Stage well locations and schedules.

Facilities: The recommended plan would require construction of 100 deep wells which would produce a total of about 100,000 cu m/d. A standard production well design is recommended which should reduce the costs of facilities at each site.

Wells should have large diameter bores, casings, and screens. Each well should be fitted with water-level switches for the submersible pump, flow meters, pressure gages, and electric meters. Valves would allow on-site discharge for sampling of the flow to the distribution system. Each well should be provided with a dual electrical supply where possible.

The land area required for each well will be about 200 sq m. This area will permit construction of the well and periodic renovation. The building will be only 25 sq m and would have wide doors and removable roof panels for renovation and pump removal.

The discharge pipeline of the pump would be connected to local street distribution pipelines of 100 to 200 mm diameter. A fire hydrant may also be located on the street side of the site and could be connected to the well discharge pipe or to the street distribution pipeline.

Locations: Most of the recommended 100 wells would be on sites separated by about 1,000 m from each other (See Appendix A.5). At this spacing, about 35 wells would be distributed across Medan east of the Deli River. Most remaining wells would be distributed in the Belawan corridor (15) and in the Sunggal-Medan Baru area (30). The final 20 wells would be located within the high demand areas of the northern urban area that may prove to have sufficient groundwater capacity to supply more than one well per square kilometer.

Schedule of Construction: The recommended schedule would require completion of 60 wells before 1984 with about 15 wells completed each year. After completion of the Sunggal Plant expansion, the remaining 40 wells would be completed between 1984 and 1989. This second phase of wells would be coordinated with the production from the Sunggal Plant and first increment of the Deli Tua Plant.

Costs: Costs and facilities for a typical recommended production well are described in Table 7.1. Capital and annual costs for the first stage (60 wells) and second stage (40 wells) are described in Table 7.2.

No cost saving has been assumed for the 100 wells, although some could be expected with a 10 year drilling program. The total unit cost would be Rp. 29.6/cu m for each well.

TABLE 7.1

ESTIMATED CONSTRUCTION COSTS FOR SINGLE PRODUCTION WELL

Facilities	Cost (Millions of Rupiahs)
Drilling and Development	22
includes:	
drilling bore of 300 mm diameter casing and screens for 250 mm diameter gravel packing and development testing and well logging.	
Pump	4
20 HP Submersible pump pipe, electrical cable, water level control switches.	
Accessories	3.5
Chlorinator, flow metre, pressure gages, valves electrical switch and fuse panel, and powerlines.	
Structure	3.0
25 sq m with building of removable roof security door and fencing.	
Total Construction Costs	32.5

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TABLE 7.2

COMPARISON OF CAPITAL AND ANNUAL COSTS OF A SINGLE WELL AND THE RECOMMENDED FIRST AND SECOND PHASE WELLS

	Costs (Millions of Rupiahs)			
	Single Well	First Stage (60 Wells)	Second Stage (40)	Total
Capital	32.5	1,950	1,300	3,250
Land Costs	2.5	150	100	250
Engineering	3.5	210	140	350
Contingency	5.8	348	232	580
Total	44.3	2,658	1,772	4,430
Annual Capital	5.8	348	232	580
Annual Operations and Maintenance	2.2	132	88	220
Power	2.8	168	112	280
Total Annual	10.8	648	432	1,080

7.1.2 Distribution System Improvements

7.1.2.1 Pipeline Network

The existing supply is satisfactory in the North-East sector of Medan. The 400 mm main being laid by Tirtanadi, and the new mains recommended in the previous section on transmission mains will improve the existing situation. It is recommended that the highest priority be alotted to the laying of the new Stage I trunk distribution mains in this section of the city.

Table 7.3 summarizes the lengths of each size main recommended for Stage I and II of the project. Details are given in Figure 6.8. The existing mains have been taken into account in computing the sizes of the new mains. The trunk mains recommended for Stage I will generally be adequate until 1990 by which time work on Stage II should be underway. The complete layout of the recommended distribution system is shown in Figure 6.8.

TABLE 7.3

SUMMARY OF RECOMMENDED DISTRIBUTION PIPELINE IMPROVEMENTS

Diameter (mm)	Stage I Lengths (m)	Stage II Lengths (m)	Total Length (m)
200	27,450	1,030	28,480
225	7,340	-	7,340
250	7,030	-	7,030
275	1,150	-	1,150
300	17,388	-	17,388
325	4,350	1,700	6,050
350	9,805	2,200	12,005
375	4,210	-	4,210
400	21,177	10,395	31,572
450	48,555	42,955	91,510
500	22,690	15,500	38,190
550	14,150	11,500	25,650
600	12,330	5,350	17,680
700	-	2,600	2,600
Total	197,625	93,230	290,855

The total length of new mains will be 291 km of which 198 km will be needed in Stage I and 93 km in Stage II (see Table 7.3). Gate valves have been provided in the estimates on the basis of one valve between two junctions, enabling a repair on any line to be carried out by closing the line affected and one more. According to statistic obtained from the Fire Department, nearly 3,700 fire hydrants have been installed in the existing service area of which, however, very few are in working order due to lack of sufficient pressure. Provision has been made for 1500 new hydrants, mainly in the new service area. Flow meters should be installed on each separate transmission main leaving the treatment plants and on each outlet distribution main from the booster pumping stations. Meters have been installed on the transmission mains from the springs but some are defective and should be repaired.

The total cost of the distribution system improvements is Rp.10,742 million, Stage I improvements costing Rp. 6,670 million and Stage II Rp. 4,072 million. This includes the cost of gate valves and hydrants but no feeder mains of diameters less than 200 mm.

It is estimated that about 870 km of feeder mains of average diameter 80 mm will be needed to provide 80 percent of the projected 2000 population with reasonable access to the municipal system. The cost of supplying and laying these mains, (including valves) is estimated at Rp. 3,470 million. It will be done progressively; the Stage I cost are estimated at Rp. 1000 million and the Stage II cost at Rp.2,470 million.

7.1.2.2 Storage and Booster Stations

The available storage is quite inadequate, but the insufficiency is not felt directly due to the demand far outstripping the supply and the limited amount reaching the Jalan Singamangaraja reservoirs and tower. The situation will change radically when the new transmission mains are provided and additional storage should be given priority. Land space is not likely be available at or near the Singamangaraja site, and it is therefore recommended that of the four new reservoirs provided in the new system in Stage I, the one at East Medan be constructed first together with a booster station of the recommended capacity.

Three more reservoirs, each of capacity 12,000 cu m should be completed during Stage I, if the 282,000 cu m/d from Sunggal and the additional amount from the well program are to be utilized effectively. The booster stations should each have a peak pumping capacity, during Stage I, of 850 cu m/hour, the pressures being boosted in each case by 40 metres. Three pumps are to be provided, two working together having the peak capacity and the third being a stand-by. The periods of peak-hour pumping will be determined by pressure readings transmitted electrically to a recorder at the booster station either from a small capacity tower or a pressure gauge located at a critical point in the area served by each reservoir. The pumps will operate at constant speed and be controlled manually.

In the second stage, the capacity of the four reservoirs constructed in Stage I will be doubled and an additional pumping set of the

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same capacity will be added. The new peak pumping rate will be 1285 cu m/hour. Two new additional reservoirs, each of 6000 cu m capacity, will be provided, one in the southwestern sector of the service area and the other close to the industrial estate in the north. Boosting to Belawan will be done mainly by the booster station at the northern reservoir site. The peak pumping capacities of the booster station at the two additional reservoirs will be the same as those at the other four. The existing booster station at Sei Agul and Jalan Singamangaraja will continue to function, but at the same peak capacities as the other stations. The recommended storage and booster pumping capacities are given in Table 7.4.

TABLE 7.4

RECOMMENDED STORAGE AND BOOSTER PUMPING

Reservoir Location (Reference Figure 6.9)	Reservoir Capacity cu m	Booster Station Peak Pumping Rate cu m/h	Reservoir Capacity cu m	Booster Station Peak Pumping Rate cu m/h
"A"	12,000	850	24,000	1285
"B"	12,000	850	24,000	1285
"C"	12,000	850	24,000	1285
"D"	12,000	850	24,000	1285
"E"	-	-	6,000	1285
"F"	-	-	6,000	1285
Sei Agul (existing)	1,400 (estimated)	540	no change	1285
Jl. S.M.Raja (Ground tanks)	3,900	540	no change	1285
Jl. S.M.Raja (Elevated Tank)	1,200	present	no change	present rate

The locations of the reservoir and booster pumping stations are shown in Figure 6.9. Pumping to the existing tower at Jalan Singamangaraja is done only for a few hours each day due to the insufficient supply, but in the new scheme pumping will be done whenever the level indicates the necessity for it.

The cost of reservoirs in Stage I will be 960 million rupiah and in Stage II 1,200 million rupiah. The corresponding figures for the booster pumping stations are 510 million rupiahs and 240 million rupiahs, respectively.

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7.1.3 Public Standpipes and Water Services

7.1.3.1 Standpipes

Public standpipes have been provided in the system on the basis of one per 300 residents in selected low income areas. The 1985 projected population in the service area is 1,150,000. Since the increase in the number of house connections is likely to be slow at the start, sufficient standpipes should be provided to serve 20 percent of the above population. The total required in Stage I is assessed at 700 and the cost estimates allow for 250 in 1980/89 and 150 each year through 1983/84. As access to the municipal system through metered connections increases, the annual rate of provision of standpipes is expected to decrease,

The total number of standpipes needed by 2000 is estimated at 1000, costing approximately Rp. 84 million in Stage I and 36 million rupiahs in Stage II. There are less than 100 standpipes in the city at present, about half of which are not in working condition due mainly to damage or insufficient pressure.

7.1.3.2 Water Service Connections

In 1978, there were approximately 36,000 service connections. In 2000, 125,000 individual and multiple service connections are estimated to be required to achieved the targets set for domestic and non-domestic service from the municipal system. The total cost is estimated at 4,900 million rupiahs, 1,500 million rupiahs being for Stage I and 3,400 for Stage II.

7.1.4 Shallow Well Improvement Program

Approximately 846,000 persons presently obtain their water requirements from non-municipal sources. Of these about 696,000 belong to the middle income, medium density group and the remaining 150,000 to the low income, high density group. Almost all of them obtain their water needs from shallow wells which are mostly polluted, or from surface sources which are invariably polluted.

Assuming that about 100,000 of those in the low income, high density areas obtain water from public standpipes and surface sources, the estimated number of persons using shallow wells is about 750,000. Of the middle income group, a major part, particularly those living outside the busier sections of the presently built up area, have individual wells. Probably there are about 500,000 in this category. The balance of 200,000 have wells shared by two or more families. The number of wells, on this basis, used by the middle income group is about 75,000.

In the case of the 50,000 people in the low income, high density group using wells, each well is probably used, on an average, by about five families. The total number of wells used by this group is therefore estimated at 50,000/8 x 5 or 1250 wells.

The present program strategy is to increase the access to safe water from 25 percent of the population in 1980 to 60 percent in 1985 and

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80 percent in the year 2000. Even if 80 percent coverage is achieved, therefore, an appreciable fraction of the population will still use shallow wells for many more years. A simple and inexpensive, but effective and continuing program to improve such wells to aesthetically acceptable and safe sanitary standards is needed.

A few of the multiple dwelling wells in the congested areas are not capable of being meaningfully improved because it will be a practical impossibility to eliminate the source of underground and surface pollution. Assuming that about 40 percent of the wells will continue to be used for a reasonable period, a shallow well improvement program will have to cover about 30,000 wells on a phased schedule. To derive the fullest benefit from such a program, there should also be a parallel and continuing maintenance program.

The initial cost of improvements, if done under the supervision and advice of a trained officer, should be around Rp.5,000 per well. A phased program of well improvement expenditures is given below.

Year	Number of Wells Improved	Initial Cost (Million of Rp.)
1980/81	2000	10
1981/82	4000	20
1982/83	4000	20
1983/84	2000	10
1984/89	8000	40
1989/2000	10000	50
Total	30000	150

7.1.5 Summary of Capital Costs and implementation Schedule

A summary of costs of the recommended water system, phased annually, is given in Table 7.5. An implementation schedule based on these figure is given in Figure 7.2, which takes into account appropriate provision for loan negotiations, design, tenders and construction.

7.2 OPERATION AND MAINTENANCE

7.2.1 Operations

The operations division of the future water supply system will have five units:

1. Spring Supply

2. Surface Water Plants

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TABLE 7.5

ESTIMATED CAPITAL COSTS FOR WATER SUPPLY MANAGEMENT SYSTEM Rp.(millions)
CONSTANT 1979 PRICES

Item	REPELITA III							Total
	1979/80	1980/81	1981/82	1982/83	1983/84	1984/89	1989/2000	1979/2000
Sunggal Treatment Plant								
Stage I	(200)	(900)	900	-	-	-	-	900 (1,100)
Stage II	-	-	700	700	880	-	-	2,280
Deli Treatment Plant	-	-	-	-	-	8,437	13,093	21,530
Well Program	(150)	(350)	500	500	450	430	870	2,750 (500)
Transmission pipelines	-	(100)	82	-	-	2,462	-	2,544 (100)
Service Reservoirs	-	(240)	400	320	-	-	1,200	1,920 (240)
Booster Pumping Stations	-	(126)	134	250	-	-	240	624 (126)
Major distribution mains	-	(210)	1,650	2,100	1,455	-	3,445	8,650 (210)
Minor distribution mains	-	-	300	300	400	1,000	1,470	3,470
Service connections	-	(300)	400	400	400	2,000	1,400	4,600 (300)
Public standpipes	-	(20)	10	10	20	30	30	100 (20)
Shallow well improvements	-	(10)	20	20	10	40	50	140 (10)
Base Totals	(350)	(2,256)	5,096	4,600	3,615	14,399	21,798	49,508 (2,606)
Engineering	(35)	(226)	509	460	362	1,440	2,180	4,951 (261)
Land	(200)	(100)	200	-	-	-	-	200 (300)
Physical contingency	(88)	(387)	871	759	597	2,375	3,596	8,198 (475)
Totals	(673)	(2,969)	6,676	5,819	4,574	18,214	27,574	62,857 (3,642)

Note: ( ) indicates immediate action program expenditures.

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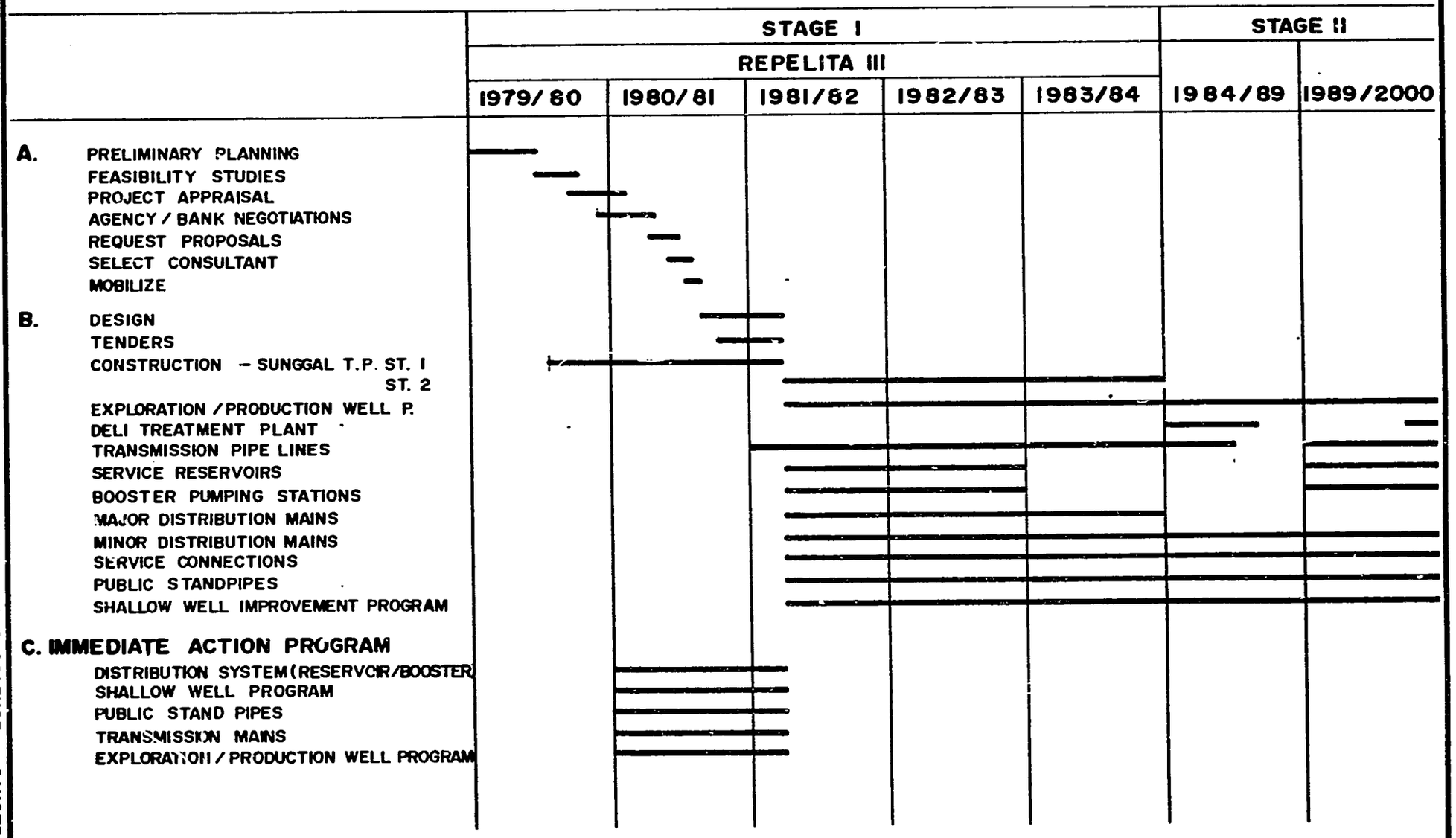
FIGURE 7.2

WATER SUPPLY PHASED IMPLEMENTATION PROGRAM



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3. Well Supply

4. Transmission Systems

5. Distribution System.

Although the first three operating units will be independent, the transmission unit will be closely linked to the spring supply and surface water plant units by transmission facilities for the Sibolangit springs, the Sunggal Plant and the Deli Tua Plant and its diversions. The transmission systems unit will also interact with the distribution system unit and may assume operating responsibility for some of the larger diameter pipelines within the distribution system (e.g. 600 mm pipelines from the Sunggal and Deli Tua Plants and the pipeline connecting Medan and Belawan.

7.2.1.1 Springs

The isolated location of the Sibolangit springs requires separate operating units for the spring collectors, treatment facilities, and both local collector and transmission pipelines. At the junction of the local transmission pipelines downstream of Sembahe, the transmission system unit would be given operational responsibility. Spring operations would include:

- Daily inspection of each spring collector, recording of flow level and overflow.
- Daily inspection of all local collector and transmission pipelines and junction chambers, and immediate, temporary patching of leaks.
- Daily record of water levels of incoming water at each treatment facility and discharge to local transmission pipelines.
- Daily recording of water temperature, dissolved solids, and alkalinity and calculation or graph determination of required dosage of lime for pH balancing. Hourly adjustments of lime and chlorination treatment to flow and chemical characteristics of the spring flows.
- Daily inspection of all roads and buildings for repairs and daily cleaning of grounds and building. Weekly trimming and clearing of vegetation from general area of all collectors, pipelines, roads and building areas.
- Display of daily flows, water quality, and materials usage at each treatment works, daily communication of daily discharge to transmission system.
- Immediate communication to Medan of any disruption of flow lasting more than 30 minutes and affecting more than 50 percent of the discharge from the treatment works.

7.2.1.2 Surface Water Plants

Extraction, treatment and pumping of surface water will be done at two points in the scheme - the existing plant at Sunggal and the proposed plant at Deli Tua.

The unit operations adopted at the Sunggal and Deli Tua Plants are extraction and pre-settlement, pre-chlorination and addition of soda ash, pumping of the pre-settled water to the clarifiers, clarification, filtration, post chlorination, pH correction and pumping of treated water to the city. The following routine procedures are recommended for efficient operation of the plant:

- Check the operation of sluice gate at the entrance of the diversion channel and the two sluice gates at entrances to the two halves of the pre-settling tank daily to ensure sufficient flow of raw water to the raw water pump house. Check the level of debris and silt in the pre-settling tank weekly. Check the quality of the effluent from this tank daily and if any deterioration is noted, particularly an increase in the amount of algae, inform the quality control officers for adjustment of the pre-chlorination dose. Examine the raw water channel between the pre-settling tank and raw water pump-house for blockage.

- Check raw water tank under raw water pump house floor once a week for excessive silt which can clog the foot valve. Check raw water pumps for working load, record voltages and amperages each hour, as is now being done, check general condition of pumps and motors, shaft seals, discharge pressure and temperatures of motor bearings every hour.

- Check on flow of raw water to each clacifier hourly. Dissolve coagulant, and coagulant aid such as Kaolin clay if turbidity is low, (the dosages should be determined from daily jar tests), for each shift separately. If clay is added for stabilitation of flow it should precede addition of alum. If a polymer is used, it should follow the addition of the coagulant. Keep a close watch on the quality of the water reaching the overflow weirs, particularly during the afternoon. Sludge circulation is necessary, but should be controlled during these hours. Check on the turbidity of clarifier effluent. Check on the functioning of the scraper and agitator. Turbidity of effluent should be kept under 10 units. Keep close contact with monitoring unit and operate dosing equipment accordingly.

- Operational procedures for the filters will depend on the design of the filters. The original set is of conventional design, but the rate of flow controllers are non-functional. After each wash, the flow should be controlled by throttling effluent gate valves to avoid an excessively rapid rate of filtration. Present practice of backwashing filters in the original set only once in 72 hours should be checked for economy. After the flow meters are repaired, conduct tests over a reasonable

period varying the length of filter run and the total daily output. The turbidities of clarifier and filter effluents should be recorded for any meaningful interpretation of results. A graphical recording of results will indicate optimum length of filter run. The duration of the tests should be at least one month.

- If the second set of filters is converted to a constant flow rate (variable head) type without effluent rate controllers the operation is simpler. The same test should be carried out for optimum length of filter run. Backwashing should be done carefully with air-scour and surface wash.
  If, as recommended, the future sets of filters are of the declining rate of flow type, the operation is similar. Examine filter media for cracks and formation of mud-balls. Record time of each backwash.

- The Wallace and Tiernan - type chlotinators provide a chlorine solution from chlorine gas cylinders. The rate of application should be done in consultation with the monitoring staff for post-chlorination. Check safety equipment daily.

- Check level of water in clear water tanks every half hour. Check, at least once per shift, whether all valves are open. Make same checks recommended for raw water pumps. Record flow of water through each transmission main leaving treatment plant. Check accumulation of silt in clear water tank periodically and in any case clean the tank, one half at a time, once every six months.

The operating staff should maintain complete records of performance of the unit processes. These should be a source of regular and reliable information to the Manager of the Plant from which he should not only be able to ascertain what is already wrong with any section of the plant, but should be able to take action to correct developing problem which the records may indicate are likely to occur.

The operation of the Deli Tua Plant should be carried out on a similar basis.

The Deli Tua Plant eventually may receive water from two diversions, one on the Babura and one on the Percut River. Since the weirs, settling tanks, pumps stations and pipelines will serve the Deli Tua Plant, operations of the two diversion must be under the authority of the Deli Tua Plant engineer. Staff at each diversion will have direct contact with the control engineer of the Deli Tua Plant. Operations will include the following:

- Hourly inspection and adjustment of water levels in the settling tank and of the pump.

- Hourly recording of water levels, pump discharges and power consumption. If diesel engines are used to power the pumps, periodic inspection and adjustment of engines and fuel supplies.

- Periodic inspection and removal of debris from intake screens.

- Daily inspection and maintenance of site appearance, sluice gates, and pipeline to the Deli Tua Plant.

7.2.1.3 Well Supply

Operation of 100 wells will require a mobile staff of well operators and supervisors who will operate as unit closely associated with the distribution system unit. Operation will include:

- Thrice daily inspection and adjustment of wells, pumps, valves, and chlorinators

- Daily recording of well production, discharge pressure, power consumption, and water levels and any power outages (a simple electric clock would indicate the daily loss of power). Values should be placed on charts for visual inspection of well

- Daily inspection of security locks, doors, fences and gates

- Deliver weekly records of well operations and performance to well supervisor and include any repairs or replacements needed.

7.2.1.4 Transmission System

Operation of the transmission system largely involve the weekly inspection of the pipeline route for leaks, nearby construction activities, and air relief valves, the daily inspection and adjustment of flow regulating valves, and the monitoring and recording of flows and pressures at meters along the pipelines. The performance of the transmission system and especially any emergency or maintenance disruption of flow must be directly and quickly communicated to the staffs of the Sibolangit springs and the Deli Tua Plant in order for them to adjust their discharge to the transmission system.

Each month and at the end of the operating year, the performance of the transmission pipelines should be evaluated to determine long term changes in pressure losses and flow reduction. Any repairs or preventive maintenance which opens the pipelines should be coordinated with inspection of the pipe wall for corrosion and deposition. This data would be correlated with changing pipeline performance.

7.2.1.5 Distribution System

The major components of a distribution system are:

1. Pipelines and valves

2. Storage and booster pump station

3, Metering.

Pipelines and Valves: The operation of this component, unlike most other components of the system can usually be done on a one-shift basis, with stand-by gangs available on a 24-hour basis for emergencies.

Operational procedures generally consist of:

- Monitor valves to accommodate system demands for any unusual conditions that may arise
- Operate each system valve at least one in six months
- Check all pipeline appurtenances on a routine basis.

Storage and Booster Pumping Stations

The operational procedures necessary are:

- Check positions of inlet valve at beginning of each shift
- Check and record water levels every hour
- Check on pressure recorder for pressure transmitted from tower, and check pressure gauges
- Check pumps
- Check for overflowing or any unusual changes in level at beginning and end of each shift
- Check chlorine residual once per shift and maintain a record of same

Meters

The following operational procedures are recommended:

- Daily and weekly recording of meters at outlet of each pumping station and any other meters in the system
- Replace automatic recorder charts. If these are non-functional, record readings manually and have recorders repaired
- Check the valve immediately before and after each meter
- Regularly calibrate the meters
- Report any unusual flow patterns to reservoir manager

For operational and maintenance purposes, it is recommended that the system be divided into four zones with headquarters at the four major reservoir — booster station sites.

7.2.2 Maintenance and Repairs

Regular maintenance will be the responsibility of the operating units, while the maintenance group will be in charge of regular and preventive maintenance and the repair of facilities. Staff will be divided among the maintenance and workshop units.

7.2.2.1 Routine Maintenance and Minor Repairs

Regular maintenance and minor repairs of all pumping and other equipment in the system should generally be done by the operating staff. It will be the responsibility of the officer-in-charge of the particular unit to ensure that all machinery and equipment in his division are kept in good running condition. In the event his staff is unable to carry out a repair, it should be made by the central workshop.

The maintenance of buildings should be done at regular intervals, and no efforts should be spared to keep the entire premises neat and attractive. It should always be kept in mind that water-works sites in general and treatment plants in particular are often visited by groups of students for educational purposes and by other officials and people. It is important that a good image of the water authority be projected during such visits and a feeling of confidence in the authority be created which may be needed on occasions when the authority encounters operational problems and has to curtail or suspend the supply for a short time.

Springs

- Clean debris and deposits from spring collector and collection basins
- Lubricate valves and paint or coat exposed metals
- Service chemical mixing equipment and dosing pumps
- Clean and renovate aerators
- Test and flush local collector and transmission pipelines and repair leaks

Treatment Plants

- Service all pumps, motors and other electrical equipment and clean panels, wiring, terminals etc., in accordance with manufacturers instructions. Repair any leaks through valve gland packings
- Service chemical mixing equipment and the dosing pumps according to makers' instructions. Service sludge scraper, agitator and motor of clarifier at specific intervals. Check, and if necessary, clean piping from chemical mixing room to clarifier

- Keep hand-railing, walkways clean

- Clean walls of filters, walk-ways, keep hand-railing clean. Check influent and effluent valves for proper functioning

- Maintain plant grounds and buildings. Make repairs and paint as required.

Distribution System

- Repair leaks, install new pipes and appurtances on routine basis or when required

- Test and flush lines, and disinfect same, on a regular schedule

- Maintain accurate valve location records

- Maintain pumps, motors, and auxilliary equipment according to maker's instructions. Follow recommendations for Treatment Plant pump stations

- Preventive maintenance unit should maintain all system meters, excluding service connection meters.

- Maintain reservoir and booster station sites in clean and attractive condition.

Wells

Repairs and maintenance of wells is somewhat similar to that of any pumping station plus those features unique to the well. Thrice daily inspection of wells will indicate any immediate problems with equipment on the surface, chlorinator, valves, meters, and electric panels.

Unless a total failure occurs in the pump, the performance of the submersible pump can only be judged on the basis of its efficiency as determined from the ratio of water production to power consumption in relationship to well water levels and system pressures. Each well house should have records of daily measurements of flow and energy consumption charted for indications of declining efficiency. The values can be compared quickly to water depth in the well and distribution pressure. If the efficiency drops rapidly, the pump may have to be pulled and inspected. If efficiency declines slowly, the pump may be undergoing normal wear or sediment has begun clogging the screens and reducing inflow. Individual well performance should be compared to that of surrounding wells, and if disproportionately poorer, the pump may have to be pulled.

Either as an ongoing maintenance program or based upon performance evaluation, the submersible pump and effluent pipe should be pulled from the well casing annually. In an annual maintenance program, a new or

renovated pump would replace the previous pump and operation would continue on normal schedule. While the pump is removed, the level of the gravel pack between the well casing and the conductor pipe should be inspected and replenished if needed.

If the pump is removed for more than 24 hours and performance evaluation indicates that the screen may be clogged, the well should be cleaned by air lifting sediment from the well casing and by surging the well. Swabbing of the casing and screen may also be done, if equipment is available.

The above discussion of well and pump maintenance also implies a maintenance division within Tirtanadi which will be capable of repairing and inspecting well pumps. At present, submersible pumps of 20 to 45 HP are available and would provide required heads and capacities. Maintenance and repairs would be simpler if only one or two makes of pumps were used. At least seven makes are available locally on a three to six months order.

Annual purchases of 20 pumps plus two stand-by replacements would allow sufficient time for importation. Dealers should provide a local training program for the repair and maintenance staff. With five years experience with 20 to 60 operating pumps, maintenance schedules and parts inventories could be developed for an orderly maintenance system through the year 2000. This theme is further discussed under preventive maintenance.

Well-cleaning requires mobile equipment which would be a part of the drilling division of Tirtanadi. High pressure air compressors would be required for development of newly drilled wells. A drilling schedule of one well every three weeks would allow the air compressor to be rotated between well screen cleaning after the total number of wells reaches 60 (1985). Similarly, a truck or trailer mounted hoist could be designed and operated for both well development and well cleaning. Such a hoist would allow better use of the drilling rig for drilling only. The hoist would be scheduled for three days well development every two weeks, and during the remaining work days it could be used for cleaning wells on a regular well maintenance program. As with the air compressor for cleaning, such a hoist would become part of the maintenance and drilling divisions only after 1985, when the second phase of more than 60 wells may be implemented.

Transmission Systems

- Check and service valves, pressure gauges, flow meters and air relief systems
- Annually test sections of the transmission systems for pressure losses

7.2.2.2 Preventive Maintenance

This is an aspect of vital importance which, unfortunately, is rarely given sufficient emphasis by many water authorities. An effi-

cient program of preventive maintenance is useful anywhere, but particularly in countries which have to first import almost all the machinery and equipment needed for a water system and later must follow it up by importing the spares needed for maintenance and repairs. The latter aspect is often particularly frustrating to the maintenance and workshop staff because it is not uncommon to find frequently needed and important spare parts unavailable, while the stores have large quantities of relatively unneeded items. The situation becomes worse if such a situation finally leads to a break-down in any part of the system.

A well planned an efficiently implemented preventive maintenance program will not only help to avoid such situations but will also prevent the waste of scarce foreign resources by ill-planned over-stocking. It is therefore recommended that while day-to-day maintenance and minor repairs of the various prices of machinery and equipment to be done by the operating staff themselves, a separate Preventive Maintenance Unit directly responsible to the Chief Engineer (Operation and Maintenance) be established. It should be headed by an electrical/mechanical engineer and should consist of a group of experienced and well trained employees possessing a detailed knowledge of the equipment in the system.

When the unit is established it should prepare a catalog card for each and every item of machinery and electrical equipment large or small, in every site or division of the organization. A glance at any such card should enable one to know the make, age, technical specifications, date of last servicing, the due date for the next inspection of the item, etc. The unit should, after a few months of operation, establish a strict schedule indicating its program of visits and inspections of the various sites, thus enabling the officer-in-charge to be ready and thereby be able to give the inspectors all possible assistance. Thereafter, the unit should be in a unique position to advise the stores-manager when and in what quantities spares should be ordered.

7.2.2.3 Repairs

The establishment of a central workshop is essential. It should be capable of handling any feasible repair that may become necessary anywhere in the system. To avoid duplication of senior staff, it is recommended that, at least to start with, the central workshop be in charge of the engineer heading the Preventive Maintenance Unit.

The central workshop should preferably have separate sub-divisions for repairs of:

- Mechanical equipment and machinery
- Electrical equipment and machinery
- Water works appurtances and equipment
- Water meters, both large and small

The central workshop should be adequately staffed and be provided with sufficient vehicles and equipment to transport equipment to the workshop.

7.2.3 Water Quality Monitoring and Control

Operation of any large water supply system requires a large system of sampling, analysing, and assessing the water quality of the sources, the discharges to the distribution system, and the water delivered to the users. Raw water quality determines the treatment requirements necessary to maintain acceptable potable water standards and those levels of treatment processes which will make most efficient use of facilities and materials. Treated water quality analysis verifies the treatment operation and may indicate potentials for corrosion or incrustation in the transmission and distribution systems. Delivered water quality must be completely acceptable for municipal water supply for human use without additional individual treatment (e.g. boiling and filtering).

7.2.3.1 Springs and Surface Waters

Existing monthly and twice-monthly water quality analyses at the Sibolangit springs and Sunggal Water Plant should be continued and extended to the Deli Tua Plant and its diversions. Recommended additions to the existing programs include the following:

- Monthly tests for all parameters required by Potable Water Supply Regulation of the Department of Public Health (1975)
- On site daily analyses of the springs by operating staff for pH, temperature, total dissolved solids, alkalinity, acidity and carbon dioxide (CO_2)
- Daily analyses at the Sunggal and Deli Tua system raw water intakes for turbidity and the above parameters
- Semi-annual analyses of alkyl benzene sulphonates (ABS), phenolic substances, chemical oxygen demand (COD), carbon chloroform extract (CCE), and grease oils

7.2.3.2 Ground water

Periodic complete water quality analyses for the large number of wells included in the recommended ground water program would exceed the practical limits of the existing laboratory. Frequent well monitoring should consist of an abbreviated list of important parameters: pH, temperature, total dissolved solids, hardness, alkalinity, carbon dioxide calcium and magnesium, iron, chlorides and coliforms. These parameters would be analysed each quarter for all wells.

Once a year, a complete chemical analysis should be conducted for selected wells. The analyses should be identical to those conducted for surface water sources.

7.2.3.3 Distribution System

The World Health Organization's International Standards for Drinking Water have been adopted for this scheme. The tests to determine

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the absence or presence within permissible limits of compounds affecting the potability of the water, components hazardous to health, and substances and chemical indications of pollution are generally made at the source.

The most important test carried out on water obtainable from the distribution system is the bacteriological test. Sufficient chlorine should be added after filtration to ensure a residual of 0.8 to 1.0 mg/l in the far end of the clear water tank at the treatment plant and a coliform count of any 100 ml sample taken from any transmission main close to the treatment plant should be zero.

Bacterial contamination, however, can and does sometimes occur after the water leaves the treatment station. It is unlikely to occur when the pipelines are full and under pressure, but the danger is greatest when the pressures are very low or zero which would be the case after a pipe burst. In such situations infiltration of water from the ground into the pipe through the cracks or through defective joints can pollute the water in the network. Only vigilance and regular tests can guard the consumers against this danger.

The number of samples collected and tested per month depends on the magnitude of the system and the population served. It is strongly recommended that not less than 300 samples collected from representative points throughout the service area according to accepted principles of sampling be tested each month. This number should be increased progressively to 375 or more per month in the year 2000.

An additional requirement is the test for residual chlorine that should be carried out at each storage reservoir in the system at least once during each shift, and from each tap in the system when it is sampled for bacteriological quality. The residual chlorine at the reservoir or in any sample of water collected from any tap in the system should not be less than 0.1 mg/l.

It is recognized that the number of bacteriological tests per month recommended represents a major effort considering the almost total lack of testing at the present. However, it is extremely important that this recommendation be implemented. The frequency of tests recommended above is not excessive; similar standards have been followed by water utilities in developed countries for many years. In Medan, such standards can only be considered a bare minimum in view of: (1) the prevailing sanitary conditions; (2) the extremely high incidence of enteric diseases; (3) the larger number of uncontrolled cross-connections in the system; and, (4), the present impossibility of maintaining adequate system pressures. Any one of these conditions would, by itself, be reason for increasing the frequency of bacteriological testing above that recommended.

A test for viral contamination has been devised lately, but it is not recommended for adoption in the system at this stage.

7.2.3.4 Laboratory Requirements

An adequate laboratory is essential for quality control and also for carrying out tests that have to be made for proper treatment of surface and ground waters. It should preferably be equipped to carry out the following examinations:

1. Complete physical, chemical and bacteriological analyses of water.

2. Tests for process control:

   a. jar test for coagulant dosages

   b. raw water algal characteristics

   c. Chlorine demand

The emphasis should be on the common testing facilities for efficient treatment. Radiological tests, for example, require expensive equipment and often can be done through other organizations better equipped to do them.

Other features that should be given consideration include:

1. Laboratory space, furniture and layout; and

2. Heating, air-conditioning, ventilation and lighting. It is often important to have strict control over one or more of these characteristics for specific tests.

7.3 SAFE YIELDS AND ALLOCATIONS

The entire recommended plan for development of local water sources requires a major monitoring program of both surface and ground water sources. Based upon its results, the safe yields of the rivers and the local aquifers can be more accurately projected. These general safe yield estimates should be based upon the projected yields of the river subbasins and local groundwater yields. From the results of these safe yield analyses, a reasonable and implementable allocation of available water sources can be made, and thus, water rights could be established for all basin and aquifer users. Part of this allocation requires that private water production be measured.

7.3.1 Monitoring and Analyses

The major limitation for water supply planning in Medan has been the absence of long-term, reliable data. PAM Tirtanadi and the Department of Irrigation have primary responsibility for supplying water. Therefore the two agencies should develop a flow monitoring program to accurately measure low flows in the Belawan, Babura, Deli, and Percut rivers.

Although the Hydrological Design Unit of North Sumatra has responsibility for the gages on the Deli and Belawan rivers, Tirtanadi should begin accurate measurement of water levels of the raw water intake of Sunggal Plant and corresponding production levels. The weir at the Sunggal Plant provides the most stable cross-section of the Belawan River which is daily and hourly inspected.

The surface water monitoring will require ten or more years of recordings before reasonably accurate projections of low flows can be made. Initial development of the Deli River source will require construction and production based upon preliminary estimates from a five year record, but the Percut and Babura rivers would have more reliable projections.

Tirtanadi assume responsibility for further monitoring of the Deli River at or near sites near Deli Tua and of points on the Babura and Percut Rivers near the diversion sites. Tirtanadi should further expand the program by adding two additional low flow stations on the major tributaries of both the Belawan and Deli Rivers. The additional sites would indicate potential areas for future low flow control reservoirs and for surveys for unknown springs.

Tirtanadi should establish one or two gage stations at or near the confluence of the Bekala and main Babura rivers in Kampung Kwala Gekala. The stations would provide data for design of the Babura diversion. One station on the Percut near Haryo Sari (Siantar road) should be operated by Tirtanadi to obtain data necessary to estimate the feasibility of either a third medium-sized water plant or a diversion seven kilometers further upstream.

Groundwater monitoring by Tirtanadi should begin immediately. All existing municipal and major public and institutional wells in Medan and Belawan should be monitored for pumping and static water levels. To thoroughly document the coastal aquifer, water levels in Tirtanadi wells should be measured three times daily, before pumping in morning, at midday, and before stopping the pumps in the evening. Tidal water levels, exact time of pump stoppages, and daily production should be recorded. At weekly intervals, pumping and static water levels should be taken in all Port of Belawan Wells, and at least 20 wells of 90 m or greater depth in Medan. Flow meters should be installed on all wells used for monitoring water levels. When the wells of the Recommended Drilling Program have been completed, these wells should be included in the monitoring program.

This groundwater monitoring effort should be included within the normal operations of all Tirtanadi and Port of Belawan wells and would require some additional staff time only for weekly monitoring of Medan wells and analyzing the recovered data. No extra facilities would require construction, and only 20 meters would be installed. Because of the less variable state of the groundwater aquifers compared to surface water sources, the recommend monitoring of groundwater and especially of the new wells drilled for Tirtanadi under the Recommended Drilling Program and in 1980/81 could determine the most productive sites for the remaining 40 well of the First Stage program (1981/82-1983/84). In the period from 1980 to 1986, monitoring and well testing would accurately establish the available ground water production.

7.3.2 User Inventory

An important element of the analyses of safe yields and allocation of surface and subsurface water is an inventory of existing and planned uses, production, and water quality requirements of individual well and surface water users. The water allocation should reflect the existing uses. Tirtanadi, the Department of Irrigation, and the Hydrologic Design Unit for North Sumatra could coordinate an inventory of all formal river and groundwater users.

After initial inventory efforts, public announcements should invite unlisted users to inform the agencies of their water use and requirements so that allocations could be considered. Following the collection of a user inventory, all subsequent new uses or expansion should be subject to the availability of estimated supplies. Any uses which exceed the safe yields of low flows in the rivers should be limited to production only from above average flows or should be considered as interruptible uses during times of low flows in the rivers.

Few private wells have meters, and part of the inventory will require installation of meters on large production wells at major institutions and at commercial buildings. From the inventory of users and the monitoring of their use (averaged over a year), allocations may be made based on their known use.

7.3.3 Water Rights and Allocations

Existing water rights are poorly developed and not coordinated. Once initial safe yields have been established and compared to user requirements, allocations could be established. If users' demands exceed supplies, priorities for future allocations or re-allocations would have to be made or historic water rights would have to be defined.

7.3.3.1 Water Rights

Historically, questions of water rights in and around Medan have been resolved by informal discussions and compromise. No formal rights or allocations have been made, because no legal instruments exist for such allocations, and no severe shortages or conflicts have arisen.

The National Directorate of Water Research, Department of Irrigation, the Directorate of Public Works, and the Department of Mining have regulations regarding individual aspects of water supplies, water quality, water well drilling, and well pumping. In addition, the Provincial Government and municipal governments may also regulate directly or indirectly the use of water sources. Public Health regulations can be exercised against public or institutional water users. Therefore, administrative regulations or mechanisms exist that can be adopted to regulate water use. In Jakarta, the local municipal government and the water company worked together to regulate, monitor, and allocate pumping from the local aquifers when the number of users and the total use threatened the long-term yield of the aquifers.

In Medan, water rights have not been a major problem. Near the Sibolangit springs, Tirtanadi and local residents have informally allocated spring flow but no regional formal allotments have been made. Apparently, Tirtanadi has accepted no further collection of spring flows above 46,000 cu m/d. The remaining 30,000 cu m/d is allocated for potable, irrigation and recreational users or for water quality maintenance. This informal allocation of 70 to 80,000 cu m/d flow, however, was made based on local uses rather than on total basin use. Since 80,000 cu m/d of flow represents nearly 40 percent of the recorded low flow of Deli River near Deli Tua, the significance of such local informal allocation becomes great relative to the allocations within the entire basin.

Irrigation projects have been and are being developed on both the Deli and Belawan rivers. The significance of these projects and their water demands will increase as large individual surface water users increase withdrawals. The municipal water supplies will eventually compete with both irrigation and private users near Medan and those users in the upper and lower subbasins of the Belawan, Deli, and Percut rivers. Therefore, informal agreements will eventually be strained by competing uses. Unfortunately, little or no data are available to define the low flows by subbasins and then support basin-wide allocations of projected low flows.

Existing and future water plants have been located upstream of significant urban drainage in order to assure potable water quality and reduce costs for additional treatment of urban pollutants. Therefore, for municipal water supplies, the allocation of a volume of projected low flows is only part of the water rights issue. Water quality, inter basin transfers, and return wastewater flows must be taken into consideration. All of these factors can be regulated to various degrees by existing rules for public health, irrigation, and provincial/municipal agencies. The dispersed authorities will create coordination difficulties for effective control when withdrawals approach the safe yield of the sources.

The Directorate General of Public Works (3 April 1979) has indicated in the Urban Water Supply Program-Repelita III that drinking water should have greatest priority when competitive interests arise over a water source. Furthermore, the DGPW stated the need for regulations, especially for groundwater, to be improved and that in a metropolitan area such as Medan only one water organization should operate to insure orderly development of the safe yield of all water sources.

Groundwater rights control in Medan and Deli Regency are virtually absent. Several agencies have been involved in regulating drilling contractors and production but enforcement has not been adequate in Sumatra. Ground water production in Jakarta has been more closely regulated and both the drilling and production require permits and are monitored. In Medan, the deficient municipal water supply has forced many large water users and wealthy residents to construct private wells without any regulation or control. Until the municipal supply becomes more adequate, little effective regulation can be enforced. Without established and enforceable water rights, private wells cannot be regulated, but the

private well operators have no rights established for their continued production.

The recommended well designs and operations can effectively dominate the groundwater production within a 100 m radius, and therefore the initial well development should have little effect upon existing private wells. As the municipal water supply becomes adequate, many private well operators may not replace poor wells when they decline in production or quality. Where possible, existing private wells may be replaced by Tirtanadi with the private users supplying the land and receiving well water at a reduced rate while excess production would flow into the municipal supply.

If the municipal well program is expanded during the 1985-1995 period, the authority of Tirtanadi over groundwater production should be firmly established based upon its predominance during the 1980-1985 period. This authority should be integrated with and recognized by other government agencies and companies first, and then expanded to individual private operators.

7.3.3.2 Surface Water Allocations

Allocation of surface water reflects two elements: the amount of water and the beneficial human uses and natural requirements, or the damage that may result from inadequate supplies. Monitoring and user inventories will only establish the supply and demands. During some years and seasons, all users may withdraw their maximum needs. However, during dry periods, surface water flow may be insufficient to supply all users with their total needs. At such time, priorities will be required to allocate the available supplies, or formal water rights will assign a specific quantity based upon historic use. Priorities commonly follow the order given below:

1. Municipal water supplies

2. Water dependant industries and institutions

3. Agricultural irrigation

4. General industries

5. Recreation, wastewater assimilation, and fisheries.

Since potable water supplies should be given highest priority, PAM Tirtanadi should be given necessary regulatory responsibility to insure adequate, safe water supply for Medan. Similarly, Tirtanadi should have primary responsibility for coordinating and funding the monitoring of surface water sources.

Allocations must be coordinated to the flow levels within the rivers. The higher flows during the fall and spring rainy periods would be available for general uses, especially for agricultural irrigation. During a major low flow event, gradual curtailment or stoppage of some

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uses would be required in the basin, in order to insure adequate potable supplies. Although agricultural irrigation and general industrial users would be first curtailed, the duration may be varied depending upon the stage of plant growth. If flows continued to decline, water-dependant industries would be required to reduce withdrawal. Similarly, major non-potable and non-water dependant uses with the municipal system would be curtailed (e.g. offices, non-essential institution, and swimming pools).

Enforcement of water curtailments on non-municipal water users requires both Tirtanadi's monitoring of their use and coordinated enforcement powers for Tirtanadi and the city and provincial governments. Without enforcement powers, the regulations, allocations, and monitoring are useless. All three must be developed together with the other concerned agencies. If enforcement powers cannot be gained, the location of Tirtanadi Water Plants and diversion would practically dominate the use of water by downstream users.

7.3.3.3 Groundwater Allocation

Allocation of groundwater represents a somewhat easier task than the allocation of surface waters, although the degree of monitoring and enforcement are more important. The groundwater resources represents the most valuable water resource within the region and therefore its regulation should reflect the greatest benefits for the Medan population. Furthermore, the groundwater aquifers are more sensitive to production and misuse. Once damage occurs in any one location recovery is difficult.

Regulation of drilling represents the major focal point in the regulation of groundwater use. Existing permit and reporting requirements for well designs, water quality and production testing should be enforced through the regulations of the Department of Mining, and new wells within the Medan groundwater basin should be approved by both the Department of Mining and Tirtanadi.

The recommended drilling program and the monitoring of existing and recommended first phase production wells for Tirtanadi would provide sufficient data to estimate the safe yield from the deep aquifers. The existing and updated inventory of existing well production would provide an estimate of use of the available safe yield. If the safe yield had not been exceeded, existing uses could be continued unimpeded.

As Tirtanadi increased production, the safe yield level would be approached, and other uses may have to be re-evaluated. Since many privately drilled wells do not last more than ten years, regulation on the drilling of new wells would gradually curtail unapproved pumping from the deep aquifers. Then, new wells could be evaluated as to their beneficial uses and potential interference with the requirements for the municapalwater supplies. Wells to be used for beneficial and water dependant public institutions or projects (e.g. hospitals, schools, and housing) would be given priority, while general industrial use by a private company would be reviewed as to the applicants' alternatives sources, and their needs for human consumption.

Through the existing drilling permit requirements, if enforced, the Department of Mining and Tirtanadi could regulate production from groundwater sources. Specification in the permit could determine the depth, diameter, and amounts of screens and gravel packs and the size and power of the pump. These factors would establish the maximum production from the well. Specifications for all wells would require flow meters which could be installed and monitored by Tirtanadi.

In some groundwater-dependant areas, the water agency has authority over the groundwater reservoir and pumping. All wells are drilled for the water agency, and no privately controlled well is permitted. However, if an approved user has a very high potable water demand and wishes to insure adequate supply from the groundwater, the user could provide land for a well and be allowed to receive water from the well, and unused water could enter the general municipal distribution system. The private user would be charged for the delivered water at a rate which reflects the cost of long-term lease of the well and on-going maintenance of the well.

7.4 ENVIRONMENTAL ASSESSMENT

An assessment of the environmental impact of the proposed Water Supply Master Plan Program has been undertaken along with a similar analysis for other sectors included in the overall MUDS program. This is contained in Appendix G.

SECTION 8

ORGANIZATION AND FINANCE

8.1 EXISTING WATER SUPPLY ORGANIZATION

In the past several years the direction of P.A.M. Tirtanadi as a local enterprise has been changed several times. Tirtanadi's organisational structure has ranged from direction being provided by a single Board of Directors for all Regional Companies of North Sumatra to P.A.M. Tirtanadi's present temporary Board of Directors.

In November 1977 the staff of P.A.M. Tirtanadi prepared a development plan which included suggested regulations to govern its operations, a planned organization stucture with job descriptions, and short term plans for the development of water supply facilities.

In the development plan it is proposed that the existing organization stucture be modified to conform generally with organizational guidelines prepared by the federal Directorate of Sanitary Engineering. The current and proposed organization charts are shown in Figure 8.1 and 8.2 respectively.

The present temporary Boards of Directors was appointed by the Provincial Government. Under the organizational plan put forward by Tirtanadi, overall direction would be provided by a Board of Supervisors formed and chaired by the Governor of North Sumatra. The Secretary of the Board would be from Regional Government and membership would consist of representatives of Regional Government, the Department of Public Works, the Bank of Indonesia, the Department of Health and others as required.

Day to day operations of P.A.M. Tirtanadi would be provided by a Board of Directors consisting of a General Director assisted by two other Directors. It has been proposed that the Directors also be appointed by the Governor. The duties of the Directors and other staff positions are described by the proposed organization and job descriptions. The relationship between the Board of Supervisors, the Board of Directors, and Government is further defined by the proposed new regulation under which P.A.M.

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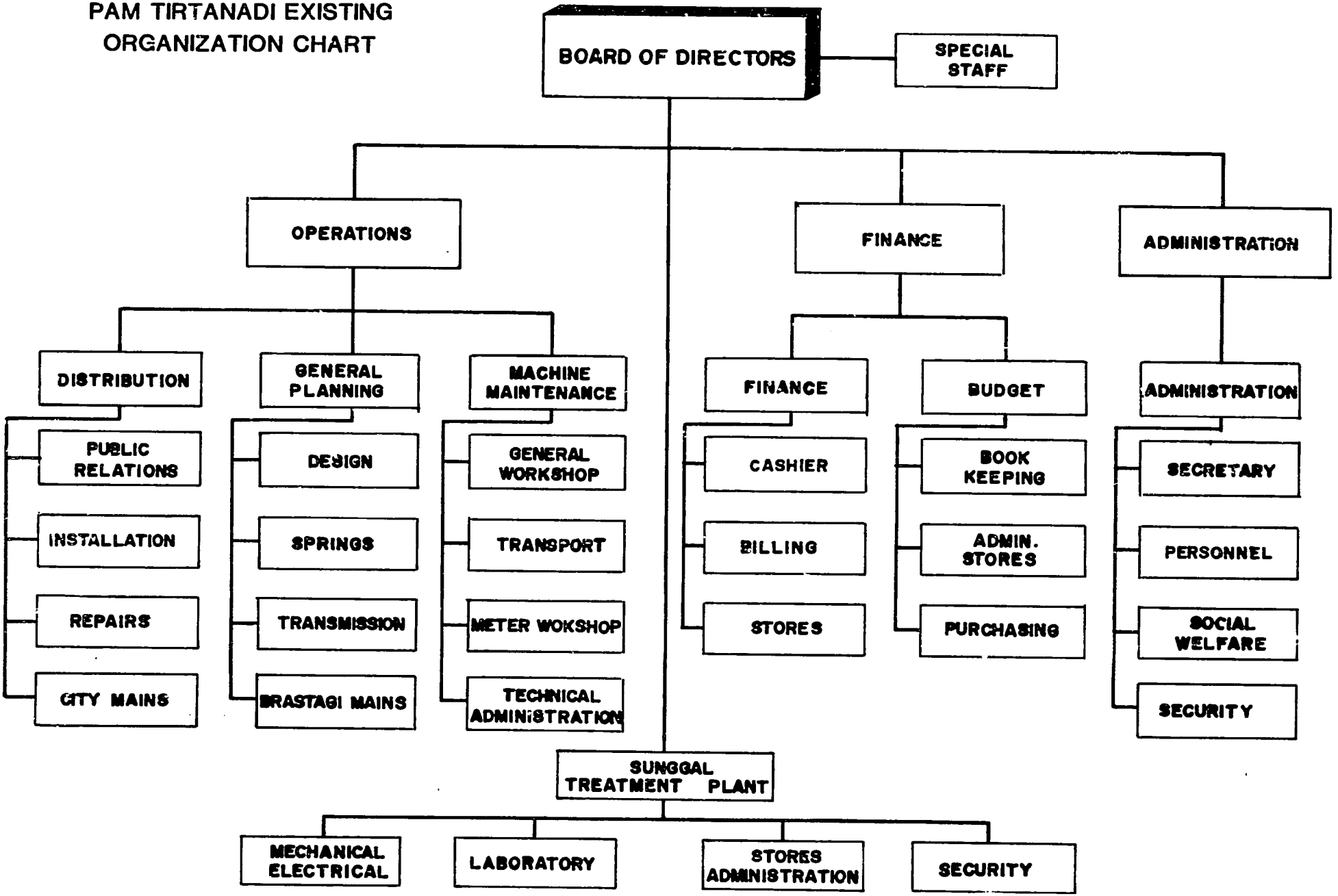
PAM TIRTANADI EXISTING ORGANIZATION CHART



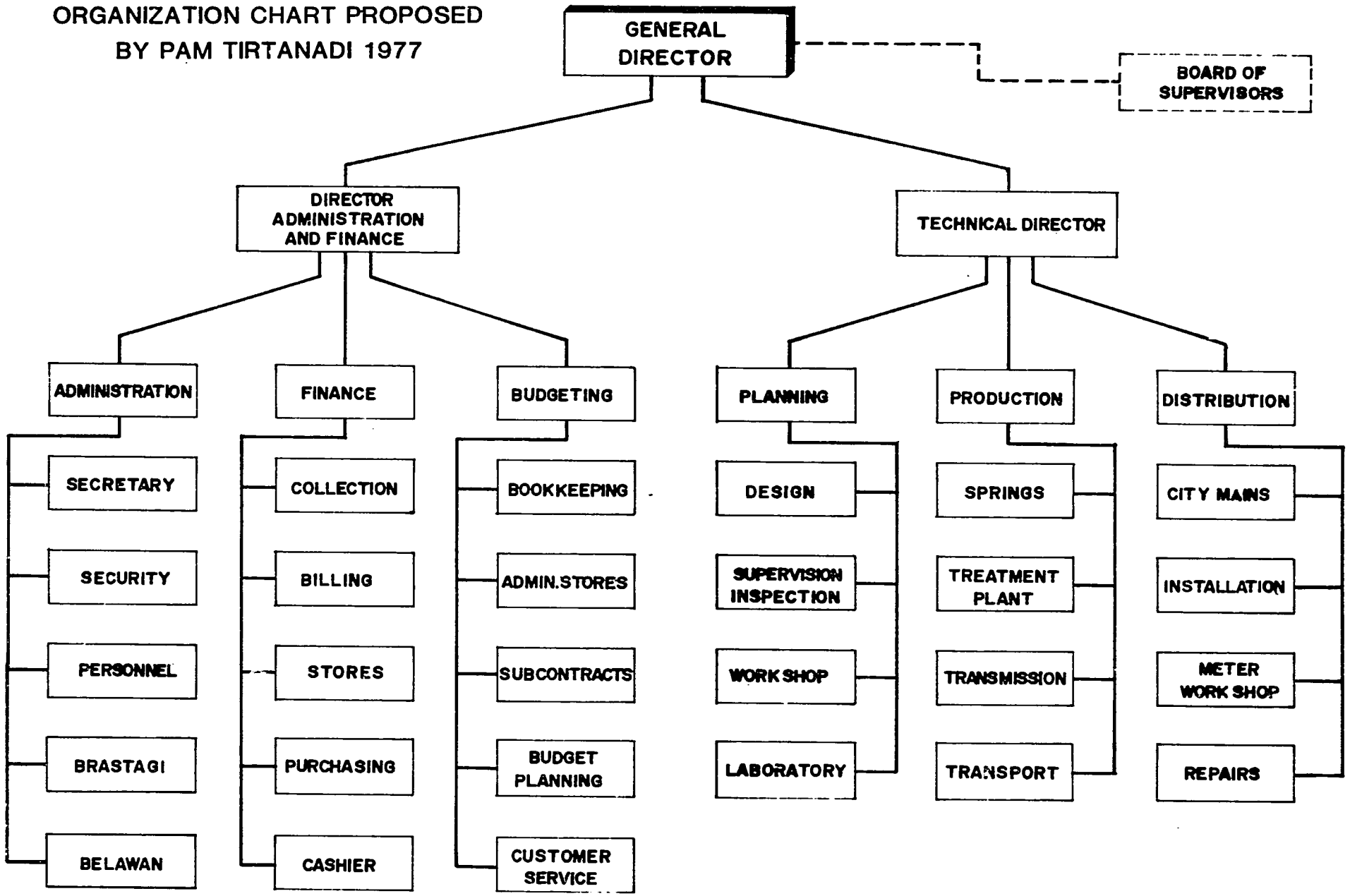

ORGANIZATION CHART PROPOSED
BY PAM TIRTANADI 1977
GENERAL DIRECTOR
BOARD OF SUPERVISORS
DIRECTOR ADMINISTRATION AND FINANCE
TECHNICAL DIRECTOR
ADMINISTRATION
SECRETARY
SECURITY
PERSONNEL
BRASTAGI
BELAWAN
FINANCE
COLLECTION
BILLING
STORES
PURCHASING
CASHIER
BUDGETING
BOOKKEEPING
ADMIN.STORES
SUBCONTRACTS
BUDGET PLANNING
CUSTOMER SERVICE
PLANNING
DESIGN
SUPERVISION INSPECTION
WORK SHOP
LABORATORY
PRODUCTION
SPRINGS
TREATMENT PLANT
TRANSMISSION
TRANSPORT
DISTRIBUTION
CITY MAINS
INSTALLATION
METER WORK SHOP
REPAIRS

FIGURE 8.2

Tirtanadi would operate. However, the relationship among these groups requires additional definition to ensure that areas of responsibility and accountability are clear.

Until recently major water supply projects have been planned by the Directorate of Sanitary Engineering. The completed works have then been turned over to P.A.M. Tirtanadi for operation and maintenance.

Recently the planning and development of new water supplies has been decentralized to the Provincial level. All additions to the distribution system and the recently completed additions to the Sunggal Water Treatment Plant have been planned by P.A.M. Tirtanadi by a small design group within the operational structure of the organization and constructed by force account or contract.

Problems resulting from organizational deficiencies occur in the areas of formulation and implementation of board policy matters such as planning of service extensions; planning and executing work programs necessary to provide the physical facilities needed to meet service objectives, ability to alter company structure to provide better operation, rate structure changes, and the ability to define the status of employees and to provide work incentives comparable to the private sector.

Organizational changes necessary to overcome these fundamental problems are described in Section 8.2.

8.2 RECOMMENDED ORGANIZATIONAL MODIFICATIONS

If PAM Tirtanadi is to operate effectively as an independent self supporting local enterprise it is essential that the objectives, strategies and goals of the organization be clearly defined and that the body responsible (Board of Directors) for the attainment of corporate objectives be provided with the authority to act independently within broad guidelines established by government.

The activities of the enterprise must be closely monitored and controlled by the Board and excecutive responsibilities must be defined explicitly. The chief executive of the organization should preferably be appointed by the Board of Directors from among its members. He would be assisted in his duties by a staff of specialists in the areas of public relations, law, planning and programming, coordination with development programs, management and staff development and auditing. He would delegate key operational responsibilities in each of the areas of administration and finance, engineering design and construction, operations and maintenance, and system monitoring.

Implementation of the capital works programs for the development of new water sources and strengthening the distribution system will be the essence of PAM Tirtanadi's activities over the next several years and direct executive control of this function must be assured.

Figure 8.3 illustrates the organizational modifications proposed for PAM Tirtanadi. Below the manager level more flexibility exists for a gradual transition from the existing situation. The final form of the organization structure must be based on a detailed inventory of existing functions and personnel needs. Now that the future program is more clearly defined it is recommended that an intensive management study of PAM Tirtanadi's operations be initiated to prepare it for the tasks that lie ahead.

8.3 EXISTING FINANCE SYSTEM

8.3.1 Income and Expenditure

P.A.M. Tirtanadi operates a commercial accounting system, working on a accrual basis and producing income and expenditure accounts. A standard format balance sheet is also prepared.

Annual income and expenditure statements for the years 1976, 1977, and 1978 are shown in Table 8.1. Some caution is needed when interpreting these figures. Included in revenues is part (30 percent) of a substantial surplus earned on making new connections, where the charge heavily exceeds actual cost. This is discussed in more detail below. Also, funds made available by Perumnas (the agency responsible for low cost housing development) for investment in water services to new housing projects appear under revenue in 1978.

The fact remains, however, that even after the inclusion of these non-operating surpluses and contributions in the revenue statement, a deficit is recorded in two out of the three years. This reflects the low growth in water revenues which results from limited water supply (and thus limited potential for additional sales) and low tariff rates. At the same time, operation and maintenance costs have shown a sharp increase, particularly between 1977 and 1978.

Higher operating costs will also be feature of the current year, following the 50 percent devaluation of the rupiah in November, 1978. The budget for 1978 is now being reviewed and was not available at the time of writing. Discussions with the Director and financial management of P.A.M. Tirtanadi indicated that a further operating deficit is likely this year.

PROPOSED ORGANIZATION CHART
PAM TIRTANADI

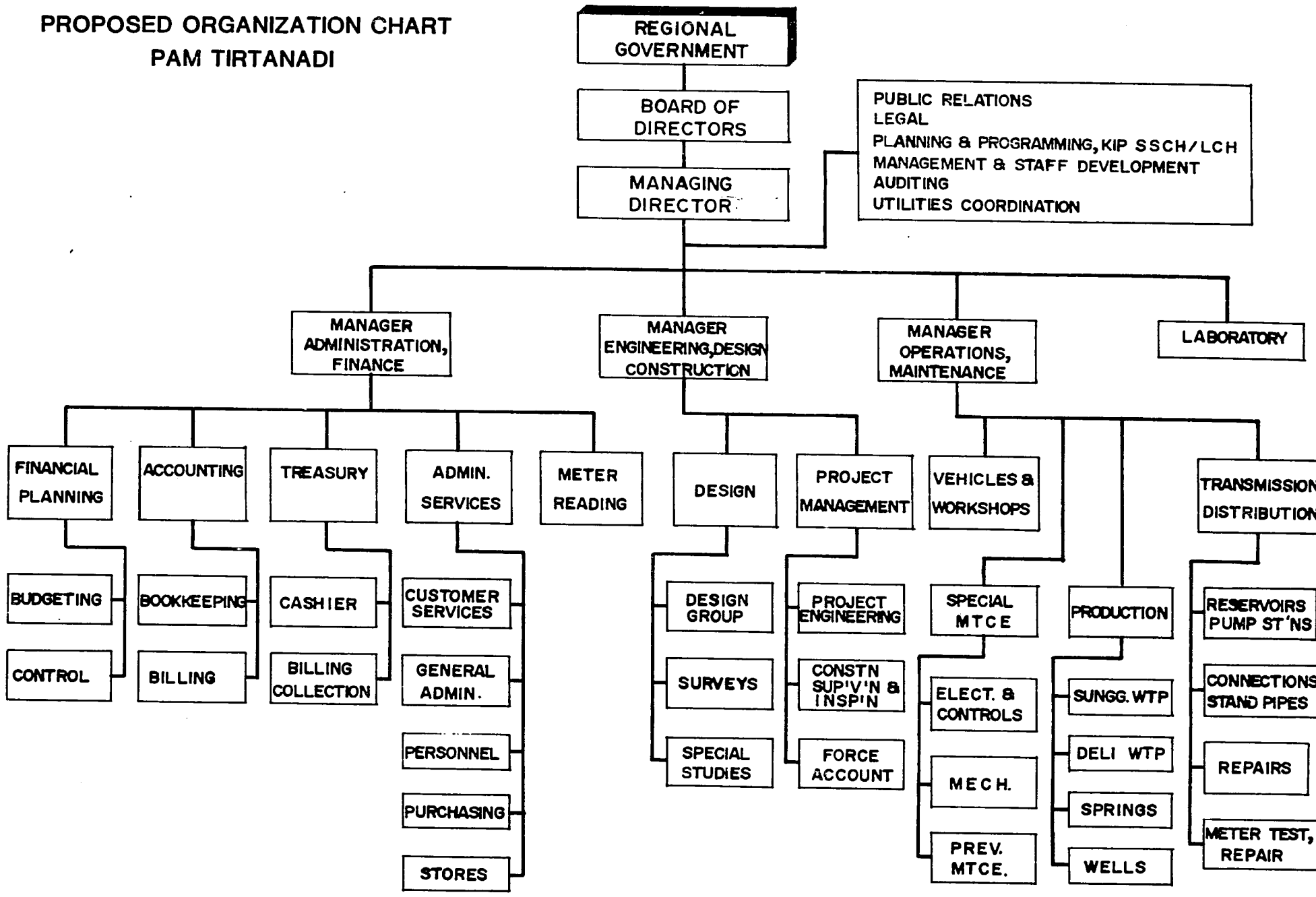


TABLE 8.1

P.A.M. TIRTANADI - WATER SUPPLY
INCOME AND EXPENDITURE (RP MILLION 1976-1978)

	1976	1977	1978
Income			
Water sales (incl. meter rent)	721	758	780
Excess connection charges	182	93	121
Connection/reconnection fees		111	148
Perumnas	-	-	312
Other	18	-	-
Total	921	962	1,361
Expenditure			
Operating and maintenance	779	704	1,194
Depreciation	132	141	154
Total	911	845	1,348
Less contribution to Governor's Office	40	40	40
Surplus/(deficit)	(30)	77	(27)

Source: P.A.M. Tirtanadi

Only by augmenting supply and increasing tariffs can this outcome be avoided. Both these objectives are now being pursued.

Salient features of income and expenditures are discussed further in the following paragraphs.

8.3.1.1 Tariff Rates

The existing tariff rate schedule was introduced in 1973. These rates are summarized by consumer category in Table 8.2, along with actual comsumption and revenue for Medan city in 1978.

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TABLE 8.2

TARIFF RATES AND REVENUE 1978 BY CONSUMER CATEGORY

Consumer Category	Rate Rp/cu m	Consumption		Revenue	
		cu m ('000)	%	Rp Million	%
Domestic	15	10,347	45	155	22
	30	2,916	13	87	12
Commercial/ Industrial	100	1,487	7	149	21
	80	2,543	11	203	29
Government Offices	30	1,025	5	31	4
Social/ Religious	5	447	2	2	-
	15	478	2	7	1
Schools	20	877	4	18	3
Army	20	2,385	10	48	7
Public Taps	15	255	1	4	1
Total		22,760	100	704*	100

* This is lower than water sales total in Table 8.1 as meter rents and revenue from Belawan and Brastagi are excluded.

The industrial and commercial sector generates 50% of the revenue while consuming only 18% of the water. Conversely, domestic consumption is just under 60%, providing just over one fifth of total revenue. This proportionately lower domestic contribution reflects the very low average rate obtained for domestic consumption. Two rates apply: an initial allocation of 4.5 cu m per person per month is charged at the very low rate of Rp. 15 per cu m; consumption above this allowance is charged at the still very modest rate of Rp. 30/cu m. As on average only 22% of domestic consumption is at the higher rate this implies that each person only consumes a further 1.0 cu m above the cheap allowance allocation. This seems highly unlikely and suggests, as could be expected, that considerable overstatement occurs of the number of people dependent on private domestic connections.

The rates for all other consuming categories, apart from industry and commerce, are also at very low levels, ranging from Rp. 5 to Rp. 30 per cu m. Public taps are charged at the minimum domestic rate of Rp. 15 per cu m but total consumption is extremely low (1%) due to the small number (approximately 100) which have so far been installed.

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P.A.M. Tirtanadi is well aware of the need to increase tariff rates and has put forward proposals to the provincial government for both restructuring the tariff schedule and higher rates. Under these proposals the existing structure would be rationalized into three consumer categories: domestic, commercial, and industrial. The industrial rate would increase from Rp. 100 per cu m to Rp. 150 and all domestic consumption would be charged at Rp. 25, with no cheaper band as at present. These rates were put forward before devaluation (and the consequent high increase in costs) and now need reviewing. At present, tariff increases have to be approved by both the provincial legislative assembly and the Governor. According to P.A.M. Tirtanadi, under revised operating regulations now awaiting central government approval, only the consent of the Governor will be required. This should facilitate the processing of increased rate proposals in future.

8.3.1.2 Meter Charges

At the end of 1978, there were approximately 35,000 metered connections, of which 29,000 were domestic and 7,000 industrial or commercial. Monthly meter charges vary from Rp. 50 for a 3/8" meter to Rp. 750 for a 1½" meter. This is, in effect, a nominal service charge and it would be difficult to justify a higher charge as the property owner pays heavily in excess of actual cost for the meter and its installation. Meter revenue in 1978 was Rp. 34 million.

8.3.1.3 Connection Charges

As P.A.M. Tirtanadi has been unable to effect rate increases, it has sought to generate additional revenue through high connection charges. This is done with conspicuous success. Table 8.3 shows the actual cost of making a typical domestic connection compared with the amount charged. This yields a 'surplus' of Rp. 163,000 or, put another way, actual cost is 22 percent of the actual charge.

TABLE 8.3

TYPICAL DOMESTIC CONNECTION COSTS AND CHARGES
Rp ('000)

	Actual Charge	Actual Cost	Surplus
Distribution	60.0	-	60.0
Meter and pipes	117.5	23.4	94.1
Internal pipes	30.5	21.5	9.0
Total	208.0	44.9	163.1

Source: P.A.M. Tirtanadi

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The disadvantage of making excessive charges for connections is that private piped supplies are priced beyond the means of the majority. In fact, this is not a major problem when there is a paucity of supply, as at present; P.A.M. Tirtanadi claims that the demand for connections, even at current charges, exceeds what pressure in the system enables it to satisfy. This policy will clearly need to be revised, however, when water supply is augmented.

8.3.1.4 Operating Expenses

The major items appearing in the expenditure statement are wages, rehabilitation costs and depreciation, accounting in total for 71 percent of charged expenses.

P.A.M. Tirtanadi is required to contribute Rp. 40 million per annum to the Governor's office as well as 4 percent of revenue as a management fee to the provincial holding company. The 4 percent contribution does appear in the expenditure statement, but it is understood that the Rp. 40 million is included, although not shown as a separate item. This can be considered as a charge in lieu of interest (albeit at a low rate) as investment funds provided by the provincial government in the past have been in the form of grants.

8.3.2 Sources of Finance

Major investments in water supply and water treatment have been financed by the provincial government through grants. Investments in distribution and other works have been made largely through the surplus earned on service connection charges.

There is a complete absence of debt finance in P.A.M. Tirtanadi's capital structure. This is due to the reluctance of banks to lend to the organization given its current status rather than Tirtanadi's deliberate avoidance of this potential source of funds. However, this position should change in the next few months if, and when, the central government ratifies the revised organizational structure for the utility which has already been approved by the provincial government. The Director of Tirtanadi is confident that bank loans will be forthcoming once it has approved Perda status (that is, formal authority from the provincial and central governments).

Meanwhile, Tirtanadi is entirely dependent upon internal cash generation for its routine development finance. In recent years, this has yielded between Rp.300 and Rp.400 million, as shown in Table 8.4. This has been insufficient to undertake major capital works.

8.4 TARIFF AND FUNDING ALTERNATIVES

8.4.1 General

In this sub-section the financial implications of the proposed capital investment programme are considered. It is assumed that the existing institutional arrangements, as discussed above, will continue

in the future but that the status of PAM Tirtanadi will be enhanced when the new regulations concerning its organisation and structure are approved by the provincial government.

TABLE 8.4

TIRTANADI CASH GENERATION 1977-1979
(RP MILLION)

	1977	1978	1979 (Estimate)
Operating surplus	77	(27)	(40)
40% of excess connection charge	82	233	276
Depreciation	141	154	164
Total Cash	300	360	400

Source: P.A.M. Tirtanadi and MUDS estimates.

In considering future methods of charging for water, the general principle followed is one of charging customers in accordance with usage but suitably modified in accordance with the social/equity objectives of Repelita III.

In respect of funding, it is assumed that the capital investment programme will be financed by a mixture of foreign and local (Indonesian) credit. No attempt has been made at this stage to anticipate the terms on which foreign funds might be made available to the Government of Indonesia. Similarly, the terms on which funds could be made available to P.A.M. Tirtanadi, and from which sources, have not been assumed. Rather, the approach is to consider the tariff requirements resulting from postulated funding packages and then to assess these against local income levels. Also taken into account is the objective contained in the terms of reference which is "to improve the financial status of the enterprise to enable it to finance at least a reasonable part of future investments of water supply development from its own resources, thereby reducing the need for Government equity capital, grants or subsidies".

8.4.2 Estimated tariff requirements 1980/81 - 1988/89

The average unit tariff rate required to cover specified costs under different patterns of funding are shown in Tables 8.5 - 8.10. Tables 8.5 - 8.7 are shown in constant 1979 prices; Tables 8.8 - 8.10 are in current prices, assuming 10% compound inflation.

The assumptions used in arriving at these unit rates are as follows:

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TABLE 8.5

WATER SUPPLY - ESTIMATED TARIFF REQUIREMENTS 1980/81 - 88/89

Assumptions: a) Constant 1979 prices
b) 100% loan
c) Debt Service A: 15 yrs repayment at 10% Debt Service B: 20 yrs repayment at 8%

	Unit	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
Production	M cu m/yr	39.4	51.1	53.3	55.1	74.0	79.6	85.2	90.8	96.
Consumption	M cu m/yr	29.6	38.3	40.0	41.2	55.5	59.7	63.9	68.1	72.
Recurrent Costs	Rp x 10^6	1602	1690	2000	2212	2541	2630	2720	2809	2899
Depreciation	"	186	319	529	717	860	924	988	1052	1116
Debt service - A	"	-	523	523	523	3254	3460	3666	3872	4078
Debt service - B	"	-	410	410	410	2551	2712	2873	3034	3195
CASH APPROACH										
Debt Service A										
Revenue required to cover recurrent costs & D.S.	Rp x 10^6	1602	2213	2523	2735	5795	6090	6386	6681	6977
Unit charge req'd	Rp/cu m	54	58	63	66	104	102	100	98	97
Debt Service B										
Revenue required to cover recurrent costs & D.S.	Rp x 10^6	1602	2100	2410	2622	5092	5342	5593	5843	6094
Unit charge req'd	Rp/cu m	54	55	60	64	92	89	87	86	84
RATE OF RETURN APPROACH										
Debt Service A										
Revenue required to cover recurrent costs & D.S. & depreciation	Rp x 10^6	1788	2532	3052	3452	6655	7014	7374	7733	8093
Unit charge req'd	Rp/cu m	60	66	76	84	120	117	115	114	112
Debt Service B										
Revenue required to cover recurrent costs & D.S. & depreciation	Rp x 10^6	1788	2419	2939	3339	5952	6266	6581	6895	7210
Unit charge req'd	Rp/cu m	60	63	73	81	107	105	103	101	100

TABLE 8.6

WATER SUPPLY - ESTIMATED TARIFF REQUIREMENTS 1980/81 - 88/89

Assumptions: a) Constant 1979 prices
b) 75 % loan
c) Debt Service A: 15 yrs repayment at 10% Debt Service B: 20 yrs repayment at 8%

	Unit	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
Production	M cu m/yr	39.4	51.1	53.3	55.1	74.0	79.6	85.2	90.8	96.4
Consumption	M cu m/yr	29.6	38.3	40.0	41.2	55.5	59.7	63.9	68.1	72.3
Recurrent Costs	Rp x 10^6	1602	1690	2000	2212	2541	2630	2720	2809	2899
Depreciation	"	186	319	529	717	860	924	988	1052	1116
Debt service - A	"	-	392	392	392	2441	2596	2751	2905	3060
Debt service - B	"	-	307	307	307	1914	2034	2155	2276	2396
CASH APPROACH										
Debt Service A										
Revenue required to cover recurrent costs & D.S.	Rp x 10^6	1602	2082	2392	2604	4982	5226	5471	5714	5959
Unit charge req'd	Rp/cu m	54	54	60	63	90	88	86	84	82
Debt Service B										
Revenue required to cover recurrent costs & D.S.	Rp x 10^6	1602	1997	2307	2519	4455	4664	4875	5085	5295
Unit charge req'd	Rp/cu m	54	52	58	61	80	78	76	75	73
RATE OF RETURN APPROACH										
Debt Service A										
Revenue required to cover recurrent costs & D.S. & depreciation	Rp x 10^6	1788	2401	2921	3321	5842	6150	6459	6766	7075
Unit charge req'd	Rp/cu m	60	63	73	81	105	103	101	99	98
Debt Service B										
Revenue required to cover recurrent costs & D.S. & depreciation	Rp x 10^6	1788	2316	2836	3236	5315	5588	5860	6137	6411
Unit charge req'd	Rp/cu m	60	60	71	79	96	94	92	90	89

TABLE 8.7

WATER SUPPLY - ESTIMATED TARIFF REQUIREMENTS 1980/81 - 88/89

Assumptions: a) Constant 1979 prices
b) 50 % loan
c) Debt Service A: 15 yrs repayment at 10% Debt Service B: 20 yrs repayment at 8%

	Unit	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
Production	M cu m/yr	39.4	51.1	53.3	55.1	74.0	79.6	85.2	90.8	96.4
Consumption	M cu m/yr	29.6	38.3	40.0	41.2	55.5	59.7	63.9	68.1	72.3
Recurrent Costs	Rp x 10^6	1602	1690	2000	2212	2541	2630	2720	2809	2899
Depreciation	"	186	319	529	717	860	924	988	1052	1116
Debt service - A	"	-	262	262	262	1628	1730	1834	1936	2039
Debt service - B	"	-	205	205	205	1275	1356	1437	1518	1598
CASH APPROACH										
Debt Service A										
Revenue required to cover recurrent costs & D.S.	Rp x 10^6	1602	1952	2262	2474	4169	4360	4554	4745	4938
Unit charge req'd	Rp/cu m	54	51	57	60	75	73	71	70	68
Debt Service B										
Revenue required to cover recurrent costs & D.S.	Rp x 10^6	1602	1895	2205	2417	3816	3986	4157	4327	4497
Unit charge req'd	Rp/cu m	54	49	55	59	69	67	65	64	62
RATE OF RETURN APPROACH										
Debt Service A										
Revenue required to cover recurrent costs & D.S. & depreciation	Rp x 10^6	1788	2271	2791	3191	5029	5284	5542	5797	6054
Unit charge req'd	Rp/cu m	60	59	70	77	91	89	87	85	84
Debt Service B										
Revenue required to cover recurrent costs & D.S. & depreciation	Rp x 10^6	1788	2214	2734	3134	4676	4910	5145	5379	5613
Unit charge req'd	Rp/cu m	60	58	68	76	84	82	81	79	78

TABLE 8.8

WATER SUPPLY - ESTIMATED TARIFF REQUIREMENTS 1980/81 - 88/89

Assumptions: a) 10% compound inflation
b) 100% loan
c) Debt Service A: 15 yrs repayment at 10% Debt Service B: 20 yrs repayment at 8%

	Unit	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
Production	M cu m/yr	39.4	51.1	53.3	55.1	74.0	79.6	85.2	90.8	96.4
Consumption	M cu m/yr	29.6	38.3	40.0	41.2	55.5	59.7	63.9	68.1	72.3
Recurrent Costs	Rp x 10^6	1762	2045	2660	3223	4091	4655	5304	5899	6958
Depreciation	"	186	319	550	770	967	1060	1163	1276	1403
Debt service - A	"	-	523	523	523	3822	4142	4501	4897	5342
Debt service - B	"	-	410	410	410	2996	3246	3526	3836	4176
CASH APPROACH										
Debt Service A										
Revenue required to cover recurrent costs & D.S.	Rp x 10^6	1762	2568	3183	3746	7913	8797	9805	10796	12300
Unit charge req'd	Rp/cu m	60	67	80	91	143	147	153	159	170
Debt Service B										
Revenue required to cover recurrent costs & D.S.	Rp x 10^6	1762	2455	3070	3633	7087	7901	8830	9735	11134
Unit charge req'd	Rp/cu m	60	64	77	88	128	132	138	143	154
RATE OF RETURN APPROACH										
Debt Service A										
Revenue required to cover recurrent costs & D.S. & depreciation	Rp x 10^6	1948	2887	3733	4516	8880	9857	10968	12072	13703
Unit charge req'd	Rp/cu m	66	75	93	110	160	165	172	177	190
Debt Service B										
Revenue required to cover recurrent costs & D.S. & depreciation	Rp x 10^6	1948	2774	3620	4403	8054	8961	9993	11011	12537
Unit charge req'd	Rp/cu m	66	72	91	107	145	150	156	162	173

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TABLE 8.9

WATER SUPPLY - ESTIMATED TARIFF REQUIREMENTS 1980/81 - 88/89

Assumptions: a) 10% compound inflation
b) 75 % loan
c) Debt Service A: 15 yrs repayment at 10% Debt Service B: 20 yrs repayment at 8%

	Unit	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
Production	M cu m/yr	39.4	51.1	53.3	55.1	74.0	79.6	85.2	90.8	96.4
Consumption	M cu m/yr	29.6	38.3	40.0	41.2	55.5	59.7	63.9	68.1	72.3
Recurrent Costs	Rp x 10^6	1762	2045	2660	3223	4091	4655	5304	5899	6958
Depreciation	"	186	319	550	770	967	1060	1163	1276	1403
Debt service - A	"	-	392	392	392	2867	3107	3376	3673	4002
Debt service - B	"	-	307	307	307	2247	2436	2646	2878	3134
CASH APPROACH										
Debt Service A										
Revenue required to cover recurrent costs & D.S.	Rp x 10^6	1762	2437	3052	3615	6958	7762	8680	9572	10960
Unit charge req'd	Rp/cu m	60	64	76	88	125	130	136	141	152
Debt Service B										
Revenue required to cover recurrent costs & D.S.	Rp x 10^6	1762	2352	2967	3530	6338	7091	7950	8777	10092
Unit charge req'd	Rp/cu m	60	61	74	86	114	119	124	129	140
RATE OF RETURN APPROACH										
Debt Service A										
Revenue required to cover recurrent costs & D.S. & depreciation	Rp x 10^6	1948	2756	3602	4385	7925	8822	9843	10848	12363
Unit charge req'd	Rp/cu m	66	72	90	106	143	148	154	159	171
Debt Service B										
Revenue required to cover recurrent costs & D.S. & depreciation	Rp x 10^6	1948	2671	3517	4300	7305	8151	9113	10053	11495
Unit charge req'd	Rp/cu m	66	70	88	104	132	137	143	148	159

TABLE 8.10

WATER SUPPLY - ESTIMATED TARIFF REQUIREMENTS 1980/81 - 88/89

Assumptions: a) 10% compound inflation
b) 50 % loan
c) Debt Service A: 15 yrs repayment at 10% Debt Service B: 20 yrs repayment at 8%

	Unit	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89
Production	M cu m/yr	39.4	51.1	53.3	55.1	74.0	79.6	85.2	90.8	96.4
Consumption	M cu m/yr	29.6	38.3	40.0	41.2	55.5	59.7	63.9	68.1	72.3
Recurrent Costs	Rp x 10^6	1762	2045	2660	3223	4091	4655	5304	5899	6958
Depreciation	"	186	319	550	770	967	1060	1163	1276	1403
Debt service - A	"	-	262	262	262	1911	2071	2250	2449	2673
Debt service - B	"	-	205	205	205	1498	1623	1763	1918	2088
CASH APPROACH										
Debt Service A										
Revenue required to cover recurrent costs & D.S.	Rp x 10^6	1762	2307	2922	3485	6002	6726	7554	8348	9631
Unit charge req'd	Rp/cu m	60	60	73	85	108	113	118	123	133
Debt Service B										
Revenue required to cover recurrent costs & D.S.	Rp x 10^6	1762	2250	2865	3428	5589	6278	7067	7817	9046
Unit charge req'd	Rp/cu m	60	59	72	83	101	105	111	115	125
RATE OF RETURN APPROACH										
Debt Service A										
Revenue required to cover recurrent costs & D.S. & depreciation	Rp x 10^6	1948	2626	3472	4255	6969	7786	8717	9624	11034
Unit charge req'd	Rp/cu m	66	69	87	103	126	130	136	141	153
Debt Service B										
Revenue required to cover recurrent costs & D.S. & depreciation	Rp x 10^6	1948	2569	3415	4198	6556	7338	8230	9093	10449
Unit charge req'd	Rp/cu m	66	67	85	102	118	123	129	134	145

Water production:

This is based on the existing supply and the planned augmentation over the period.

Water consumption:

An allowance of 25 percent of production for water unaccounted for has been made throughout.

Recurrent costs:

Operating and maintenance costs are based on engineering estimates together with existing operating costs and overheads. No allowance has been made for increasing P.A.M. Tirtanadi overheads as capacity is believed to exist for additional activity.

Depreciation:

Depreciation of existing assets, by the straight - line method, has been based on P.A.M. Tirtanadi's current rates. Depreciation of new assets, by the same method, has been based on the following estimated lives of assets:

Water treatment plant	30 yrs
Pipelines	50 yrs
Wells	15 yrs
Service reservoirs	50 yrs
Pumping stations	15 yrs
Public standpipes	15 yrs

Depreciation is assumed to commence in the year following acquisition of the asset. No allowance has been made for revaluation of assets.

Debt service:

Analysis has been undertaken incoporating the following combinations of loan/grant mix: 100% loan; 75% loan/25% grant; 50% loan/50% grant. Loan repayment has been calculated on an annuity basis (equal annual payments of principal and interest) under two different sets of interest and loan repayment assumption.

Debt service (A) - 10% interest; loan repayment over 15 years.

Debt service (B) - 8% interest; loan repayment over 20 years.

No moratorium has been allowed for in the case of the immediate action program expenditures and for expenditures in the period 1984/85 - 1988/89. Repayment in those cases is assumed to commence in the year following loan drawal, with interest capitalised during the year of expenditure. In the case of the major works expenditure during 1981/82 - 83/84, repayment is assumed to commence in 1984/85, interest being capitalised during the construction period.

Financial criteria:

The tariff rate requirement has been calculated for two sets of financial criteria:

- To cover recurrent costs and debt service (interest and (principal) repayments.

- To cover recurrent costs, debt service and depreciation.

The first of these (the cash approach) gives the minimum tariff rate acceptable as only the basis cash requirements of the utility would be met. No internally generated surplus would be available (even for additional working capital requirements). This approach does not satisfy the objective mentioned earlier of some internal contribution being made towards new investments.
The second approach (the rate of return approach) requires depreciation as well as recurrent and debt service costs to be covered. The more normal method of expressing this would be as a target rate of return on capital employed, after deducting recurrent costs, depreciation and interest, sufficient to cover principal repayment and provide a surplus. In effect, the approach followed here is to allow for all specific costs and charges to be covered but making no allowance for a surplus. In practice, in cash terms, a surplus equal to depreciation would be available. This is the minimum financial performance criterion often required by international lending agencies and attention is therefore concentrated below on the unit rates necessary to satisfy this condition.

Unit rate to cover recurrent costs, depreciation and debt service:

The unit rates to cover recurrent costs, depreciation and debt service, under the different debt servicing assumptions and loan/grant mixes selected at constant 1979 prices, are summarised in Table 8.11. In all cases the highest unit rates occur in 1984/85, the year repayment of the debt resulting from the major works program commences. The rate requirements fall away steadily thereafter for the remainder of the decade.

In considering whether these rates are affordable it will be assumed that water consumed through standpipes will be paid for, directly or indirectly, at the domestic rate. This does not mean that the poor people dependent on these supplies will pay this amount. Some small charge may be levied as at present and the desirability of this will be considered in more detail as part of the tariff studies in the Feasibility report. Any shortfall of revenue, however, resulting from the provision of free or cheap water through standpipes should not be to the detriment of P.A.M. Tirtanadi's financial viability. This shortfall can be recovered either by charging higher rates to other water users (that is by cross-subsidisation) or by charging it to Kotamadya Medan (that is, subsidisation through general taxation).

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TABLE 8.11

UNIT WATER RATES (RP/CU M) REQUIRED TO COVER RECURRENT COSTS, DEPRECIATION, INTEREST AND CAPITAL REPAYMENTS IN CONSTANT 1979 PRICES

% Loan/Grant	1980/81		1984/85		1988/89	
Loan Terms	15 yrs/ 10%	20 yrs/ 8%	15 yrs/ 10%	20 yrs/ 8%	15 yrs/ 10%	20 yrs/ 8%
100% Loan	60	60	120	107	112	100
75% Loan/25% Grant	60	60	105	96	98	89
50% Loan/50% Grant	60	60	91	84	84	78

This leaves the question of whether there should be cross-subsidisation between other water consumers. This exists on a substantial scale at present. The average domestic rate is currently Rp. 18 per cu m compared to the average industrial rate of Rp. 87 per cu m. As already noted (8.3.11) this results in 50% of water revenue being generated from 18% of consumption. Whether this is considered fair or equitable depends on how these terms are defined.
If fairness is defined as not treating equals differently, the question is: equal in respect of what - equal in the costs they impose on the system or equal in consumption ? If the former, different consumer categories would pay according to the different costs they impose on the system; if the latter, consumers would pay the same rate for the same consumption, irrespective of any differences in the cost of supply.

A third definition of fairness is that charges should be related to ability to pay. While this lacks the economic cost justification of the first two definitions, it is much more in tune with the social and political realities of a community such as Medan. While the existing cross-subsidisation may be excessive, any substantial dimunition of it is likely to be infeasible (even if considered desirable). This is for two reasons: as the house connection program progresses, more and more lower income households will be connected to the public system with a progressively weaker ability to pay; secondly, the easy availability of well water as an alternative source of supply provides a practical limitation to the rate which can be charged. Different rates for domestic and non-domestic comsumption are therefore assumed in the future.

In Table 8.12 possible combinations of domestic and non-domestic rates required to achieve the overall average rate in the worst year (1984/85) under different funding and debt service assumptions are given.

Before assessing the ability of consumers to pay these rates, however, a further adjustment should be made for inflation. Over time,

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the effect of inflation is to reduce the real burden of debt and hence the real level of tariff required. Assuming that incomes rise in line with inflation this results in an increased ability to pay. While the likely rates of inflation over the period under review cannot be accurately predicted, it can be assumed with some confidence that inflation will occur. For purposes of illustration a compound rate of 10% has been assumed. If the rates required in such circumstances (see Tables 8.8 - 8.10) are expressed in 1979 constant prices the rates summarised in Table 8.13 for domestic and non domestic consumers can be derived.

TABLE 8.12

COMBINATIONS OF DOMESTIC AND NON-DOMESTIC RATES (RP/CU M) WHICH GIVE THE AVERAGE RATE REQUIRED IN 1984/85 - CONSTANT 1979 PRICES

Loan terms	100% Loan		75% Loan/ 25% Grant		50% Loan/ 50% Grant	
Loan/ Grant mix	Domes-tic	Non-domestic	Domes-tic	Non-domestic	Domes-tic	Non-domestic
15 yrs/10%	70	240	58	215	50	200
20 yrs/ 8%	60	220	55	190	45	190

TABLE 8.13

COMBINATIONS OF DOMESTIC AND NON-DOMESTIC RATES (RP/CU M) WHICH GIVE THE AVERAGE RATE REQUIRED IN 1984/85 - CURRENT 1984 PRICES EXPRESSED IN 1979 PRICES

Loan terms	100% Loan		75% Loan/ 25% Grant		50% Loan/ 50% Grant	
Loan/ Grant mix	Domes-tic	Non-domestic	Domes-tic	Non-domestic	Domes-tic	Non-domestic
15 yrs/10%	50	215	44	190	35	175
20 yrs/ 8%	45	197	38	180	33	165

If the rate of inflation does not exceed 10%, the required unit rates will rest somewhere between these and the comparable figures in Table 8.14. For ease of analysis, the averages have been taken in calcula-

ting typical monthly bills, viz. Rp. 60 or Rp. 52 per cu m for domestic under 100% loan conditions, and Rp. 51 or 46 per cu m under 75% loan/ 25% grant financing.

8.4.3 Affordability of Required Tariff Rates

8.4.3.1 Examples of Monthly Domestic Bills

The average per capita consumption for existing domestic connections (excluding standpipes) is in the range of 150 - 200 litres per day. If an average of 8 people per connection is assumed, per capita consumption in 1978 was 182 litres per day. Although the average household size is smaller than this (6), it is common practice to provide water to non-household members. This, and an allowance for single meter multi-household properties, would tend to reduce the per capita allocation.

The above estimates are based on consumption among high and medium income households; lower rates of per capita consumption can be expected as house connections are extended into lower income areas. For planning future water supply requirements the per capita rates shown in Table 8.14 have been adopted for Repelitas III & IV.

TABLE 8.14

PLANNED PER CAPITA CONSUMPTION RATES - DOMESTIC CONNECTIONS

Residential type		Litres per capita per day		
Income	Density	1980	1985	1990
High	Low	265	275	285
High	Medium	265	275	285
Medium	Low	215	225	240
Medium	Medium	215	225	240
Medium	High	145	160	175
Low	Low	145	160	175
Low	Medium	100	115	125
Low	High	35	35	35

In estimating the affordability of the tariff rates in 1984/85, selected per capita consumption targets for 1985 have been taken. Low income consumers in high density areas have been excluded as it is assumed they will be dependent on standpipe supplies; high income consumers

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have been excluded as it is assumed that they will have the ability to pay. The remaining consumption levels of 115,160 and 225 lpcd have been taken for varying household sizes to calculate monthly bills at rates necessary to meet the rate of return criterion under 100% loan and 75% grant funding conditions (see Tables 8.15 and 8.16).

TABLE 8.15

EXAMPLES OF MONTHLY BILLS (RP) - 100% LOAN
15 YEARS REPAYMENT AT 10%

Persons per connection	Per capita consumption per day		
	115 litres	160 litres	225 litres
6	Rp. 1263	1757	2471
8	1684	2342	3294
10	2105	2928	4118

20 YEARS REPAYMENT AT 8%

Persons per connection	Per capita consumption per day		
	115 litres	160 litres	225 litres
6	Rp. 1115	1552	2500
8	1487	2069	2910
10	1859	2586	3637

TABLE 8.16

EXAMPLES OF MONTHLY BILLS (RP) - 75% LOAN/25% GRANT
15 YEARS REPAYMENT AT 10%

Persons per connection	Per capita consumption per day		
	115 litres	160 litres	225 litres
6	Rp. 1073	1473	2406
8	1431	1991	2800
10	1789	2489	3500

TABLE 8.16--Continued

20 YEARS REPAYMENT AT 8%

Persons per connection	Per capita consumption per day		
	115 litres	160 litres	225 litres
6	Rp. 989	1376	1935
8	1319	1835	2580
10	1649	2294	3226

8.4.3.2 Ability to Pay - Domestic

Various sources of date on household income and expenditure levels have been available to the project. These are discussed in detail in the Long Term Development Strategy report and the Technical Memorandum on household incomes and expenditure. Based on these data the following breakdown of families by income range has been derived (Table 8.17).

TABLE 8.17

FAMILY INCOME IN MEDAN - END 1977

Monthly income (Rp)	% of families	Cumulative %
20,000	4.0	4.0
20,001 - 30,000	10.7	14.7
30,001 - 40,000	14.4	29.1
40,001 - 50,000	14.6	43.7
50,001 - 60,000	11.5	55.2
60,001 - 70,000	11.2	66.4
70,001 -100,000	16.8	83.2
100,001	16.8	100.0
Total	100.0	-

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These income ranges are in end 1977 prices. To update these to 1979 prices the only appropriate price index available is the cost of living index for Medan. This increased by 13.7% between the last quarter of 1977 and the first six months of 1979. It is reasonable to assume that incomes moved in line with general cost increases, although there could be a lag effect in the period following devaluation of the rupiah (November, 1978) as the index thereafter has risen sharply.

Bearing in mind that around 20% of the population in the service area will be dependent on public standpipes and making some allowance for increases in incomes, the minimum family income level at the low consumption rate of 115 l/c.d could reasonably be taken as Rp. 35,000 per month. The higher consumption rates (see Table 8.14) will clearly relate to the higher income levels and in Table 8.18 likely charges as a percentage of minimum income at each consumption level are shown. The charges are based on the stiffest financing terms assumed, that is 100% loan at 10% interest repayable over 15 years.

TABLE 8.18

MONTHLY INCOMES COMPARED TO MONTHLY WATER BILLS
6 PERSONS PER CONNECTION

Consumption		Income Rp./month	Water bill Rp./month	Charge as % of income
l/c.d	Litres/month			
115	21045	35000	1263	3.61
160	29280	55000	1757	3.19
225	41175	75000	2471	3.29

8 PERSONS PER CONNECTION

Consumption		Income Rp./month	Water bill Rp./month	Charge as % of income
l/c.d	Litres/month			
115	28060	35000	1684	4.81
160	39040	55000	2342	4.26
225	54900	75000	2928	3.90

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A guideline often adopted in determining what low income groups should pay for water is that the water bill should not exceed 5% of family income. As can be seen from Table 8.18, in none of the examples cited is this figure exceeded. In the majority of cases, the percentage figures would be well below those shown as worst case situations have been selected for illustrative purposes.

From this analysis, the domestic unit rate required to ensure that sufficient revenue is generated to cover operating costs, depreciation, and debt service (principal and interest repayment), assuming 100% loan finance at 10% over 15 years, is likely to be affordable.

8.4.3.3 Comparative Rates

The average domestic rate derived from Tables 8.12 & 8.13 was Rp. 60 per cu m (100% loan, 15 years repayment at 10%). This is compared with domestic rates in other major cities in Indonesia in Table 8.19.

TABLE 8.19

DOMESTIC WATER RATES (RP) IN SELECTED INDONESIAN CITIES

City*	Consumption Blocks		
	First Block	Second Block	Third Block
Jakarta	< 15 cu m Rp. 25	> 15 cu m Rp. 50	-
Surabaya	< 30 cu m Rp. 30	> 30 cu m Rp. 60	-
Padang	< 15 cu m Rp. 33	> 15 cu m Rp. 60	-
Semarang	All cu m Rp. 40	-	-
Bogor	< 10 cu m Rp. 25	11-20 cu m Rp. 45	> 20 cu m Rp. 62.5

*Where different rates apply for different categories of domestic consumers, the highest have been taken.

Clearly, Rp. 60 per cu m as an average rate is higher than existing rates in other cities. In Surabaya this rate comes into effect on consumption over 15 cu m per month, and in Bogor on consumption over 20 cu m. It must be remembered, however, that the projected rate of Rp. 60 for Medan is in 1985 and that the real costs of water supply, and therefore tariff rates, are likely to increase in other cities during the next 5 years.

While rates in other cities are useful for cross-reference purposes, these should not be the determinants for fixing rates in Medan. The financial requirements of the utility and the ability of the local

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community to pay for water services should be the main considerations. Any reduction in this rate would require either easier loan conditions and/or an element of grant finance. For example, the average domestic rate drops to Rp. 52 per cu m if the loan repayment period is extended to 20 years and interest charged at 8% and not 10%. If, in addition, instead of 100% loan the funding mix is 75% loan and 25% grant, the average rate drops to Rp. 46 per cu m. In other words, to the extent that any constraint is exercised over tariff increases, so concessional financing will be necessary if P.A.M. Tirtanadi is to achieve reasonable financial objectives.

8.4.3.4 Willingness to Pay

Although ability to pay the required rate exists, willingness to pay cannot automatically be assumed. With the easy availability of free groundwater as an alternative source, there will be a reluctance to connect to the public system, particularly if connection charges are excessive and unit rates unreasonably high.

It is clear that the existing practice of making excessive charges for house connections (see 8.3.1.3) will have to cease once reasonable tariff levels are introduced. The capital costs of service connections have been included in the overall water supply loan requirement; the unit rates calculated above thus recover those costs, but it is questionable whether these should be recovered through the general tariff. This would mean that existing connections subsidise new connections and in more practical terms, moving from a charge in excess of Rp. 200,000 to nothing is unlikely to be acceptable. The justification of general recovery is that it ensures that the less well off benefit from the new investments and are not prevented from connecting to the public system because of high initial charges. A way around this problem is for new consumers to put down a small percentage of the connection fee and pay the balance over a reasonable period of time. This will naturally add to the monthly water bill over the period of repayment but should not necessarily be prohibitive. Such a payment can also be associated with a stepped rate structure with a low price initial consumption band to ensure that minimum consumption levels can be afforded by the poorer consumers. These points will be considered in detail and firm recommendations made as part of the tariff studies in the Feasibility report.

Willingness to pay higher tariff rates (as opposed to ability to pay) will also be engendered the more that the benefits of protected supplies are perceived. This will require a concerted effort of publicity and education to highlight the health benefits of public piped water compared to traditional polluted sources.

8.4.3.5 Non-Domestic Water Rates

The non-domestic rate required on average to fulfill the stiffest funding conditions discussed would be Rp. 227 per cu m. This compares with an average industrial rate of Rp. 87 per cu m at present. Industrial rates for major industries in other Indonesian cities are given in Table 8.20.

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TABLE 8.20

INDUSTRIAL WATER RATES (RP) IN SELECTED INDONESIAN CITIES

City	Consumption Blocks		
	First Block	Second Block	Third Block
Jakarta	All cu m Rp.125		-
Surabaya	All cu m Rp.250		
Padang	< 30 cu m Rp.100	> 30 cu m Rp.200	-
Semarang	All cu m Rp.120		-
Bogor	2 cu m p.c. Rp. 75	> 2 cu m Rp.150	-

As with the required domestic rate in 1985, Rp. 227 per cu m is high compared with existing rates in most other Indonesian cities. Only Surabaya has a higher rate but as noted in respect of domestic charges the real rates in those cities are likely to increase over the next five years. In terms of willingness to pay the same consideration as with domestic consumers applies in respect of alternative sources. Presently many industries use private groundwater and/or surface water for their requirements. No control over this is exercised by any public authority. If effective water resource management is to be exercised, there is clearly a case for some form of licensing and allocation to be introduced. Similarly, use of this economic resource should not be free. By the end of Repelita III most of the major private extractors will have the alternative of public supplies; if they do not opt for this and are not forced to do so, charges should be introduced, and even when public supplies are not an alternative source, metering and charging for private consumption should be effected.

For the overall financial viability of P.A.M. Tirtanadi, all major water users must pay for their water, from whatever sources; with the introduction of higher tariffs the possibility of opting out should not exist.

8.4.4 Summary

Under the assumptions made in respect of consumption and inflation, average unit water rates of Rp. 60 per cu m for domestic consumers and Rp. 227 per cu m for non-domestic consumers (in 1985 rates at constant 1979 prices) would enable P.A.M. Tirtanadi to cover its recurrent costs, depreciation, interest and loan repayments, under 100% loan conditions. These are high rates compared to the very low existing charges and are high compared to charges in other major cities in Indonesia. While it is considered that they will be affordable by the majority of consumers there may be reluctance to pay these higher prices as long as well water is available. While this can be controlled and charged for

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in the case of bulk users, it is not administratively feasible to regulate domestic groundwater consumption. A progressive block rate with an initial cheap band will help to encourage at least minimum consumption of piped potable supplies, and term payments for connection charges, based on actual costs, should ensure that hook up to public system is within range of the majority.

An important assumption made is that standpipe supplies would be made available to poor people at subsidised rates and that P.A.M. Tirtanadi would recover this loss either through cross-subsidisation or from Medan municipality.

Detailed tariff proposals will be presented in the feasibility analysis in Section 9. What has sought to be established here is the general level of tariffs necessary for P.A.M. Tirtanadi to chieve a reasonable financial performance. While it has been shown that 100% loan finance can probably be supported, the doubts which must exist about willingness to pay (as opposed to ability to pay), would make it prudent to adopt the easier debt service conditions assumed (8% over 20 years) and to allow a more generous moratorium period than the 3 years assumed here.

SECTION 9

THE RECOMMENDED FIRST STAGE WATER SUPPLY PROJECT

9.1 GENERAL

The master plan studies defined a staged program of water supply improvements selected on the basis of cost, reliability, implementability, flexibility and environmental impact. The short term (Repelita III) objectives incorporated in the master plan were those given by the government of Indonesia, namely:

1. To provide access for at least 60 percent of the population to pipe-borne water at an average rate of 60 l/c.d and

2. To achieve an overall ratio of 1:1 for those served by house or yard connections to those served by standpipes.

The master plan investments were devised such that these objectives would be achieved by the end of Repelita III, in line with official policy.

During the review of the master plan however, the GOI requested that not only should these objectives be realised by the end of Repelita III but sooner, if feasible. In particular it was emphasized that no Government funds (grants or loans) would be made available for investments that were not directed exclusively to achieving the above social/equity objectives. Thus, while the master plan had given priority to extending coverage to the poor during Repelita III through an enhanced standpipe program, it also made provision for improving system pressures and increasing the number of private house connections.

A result of concentrating all program activities on achieving the above objectives and undertaking to other works is that the potential benefits of cross-subsidization from additional private connections are lost. The program required would be one which geared supply and distribution to maximizing coverage among the poor people through public standpipes while ignoring any extension of private connections and other system improvements.

The first stage program of the master plan was therefore adjusted to reflect this approach. In 1980/81 and 1981/82 total attention has been given to providing water through standpipes to the poor people of East Medan. The only effective means of providing suitable quantities of water under pressure in this area is from wells. Source augmentation in the first two years is therefore exclusively from wells (apart from the water treatment plant extension at Sunggal now under construction).

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The revised first stage program means that the 60 percent coverage objective is achieved by the end of 1981/82, two years earlier than under the initial master plan program. The parallel objective of 60 l/c.d average consumption is irrelevant in the case of Medan as it already has an established water utility providing an average domestic consumption of around 176 l/c.d. The emphasis in the first two project years on standpipe supplies has the effect of reducing this average but at the end of Repelita III it is still 87 l/d.d, considerably higher than the official objective. The other policy objective for Repelita III of an overall ratio of 1:1 for those served by house or yard connections to those served by standpipes is also achieved by 1981/82 when the ratio is 1 : 1.14, compared to the current 1 : 0.04.

The reshaping of the first stage program such that only investments relating directly to the achievement of Repelita III objectives (maximum coverage of the poor people through standpipes) should be undertaken first, results in a change to the master plan phasing originally recommended. The first stage master plan capital costs discussed in Section 7 and summarized in Table 7.5 are superseded by the costs given in this section. The opportunity has also been taken to update the costs to 1st January 1980 prices from the mid 1979 prices used in the earlier master plan costings. For these reasons - rescheduling and price updating - the first stage program costs discussed in the remainder of this section are not directly comparable with those given in Section 7.

9.2 SUMMARY OF REVISED MASTER PLAN OBJECTIVES

The strategy for improving and expanding the water supply system is as follows:

1. Implement a groundwater development program both to augment the existing supply and to ascertain the extent to which cheaper groundwater can safely be supplied in place of the expensive surface supplies

2. Establish flow monitoring stations at recommended points on the Belawan and Deli rivers to provide additional data on which to base estimates of the safe yield of these watersheds

3. Expand the Sunggal Plant and construct a second water treatment plant on the Deli river near Deli Tua

4. Erect public standpipes for those who have no access to or are unable to afford individual connections

5. Implement a shallow well improvement program for residents having no access to the public system

6. Lay feeder mains, minor distribution mains and metered service connections in the presently unserved urban areas

7. Improve the trunk-main network

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8. Provide a minimum storage of 25 percent of the average daily demand in different parts of the city, together with booster stations.

The long-term master plan program has been staged as follows:

Stage I - Repelita III

Phase I (1980/81 - 1981/82)

This is the most important and urgent phase, the primary objective of which is to provide a supply of potable, pipe-borne water to at least 60 percent of the total population of Kotamadya Medan by the end of 1981/82. This will be achieved by laying emphasis on an intensive program of work in East-Medan:

Installation of major and minor distribution mains to serve East-Medan will be mainly done under the Netherlands Aid Program. Additional water requirements will be provided by the first stage augmentation of the Sunggal plant from 52,000 cu m/d to 78,000 cu m/d

Construction of two test wells and 11 additional wells

An intensive program for standpipe coverage of the area

Initiation of surface water monitoring program

Phase II (1982/83 - 1983/84)

This will consist of:

Laying of the remainder of the major distribution mains in the existing built up area

Construction of the two reservoirs and booster-stations in kampungs Titi Kuning and Sei Kera Hulu

Continuation of laying feeder mains

Construction of Stage II of the Sunggal augmentation, from 78,000 to 104,000 cu m/d

Construction of 40 more wells

Provision of additional standpipes and individual service connections

Continuation of the surface water monitoring program

Stage II (1984/85 to 1990)

Continuation of the well drilling and groundwater exploration program and analyses of monitoring and well data

Continuation of feeder mains installation

Installation of standpipes and service connections within existing built up area

Construction of two reservoirs and booster stations in kampungs Babura Sunggal and Polonia

The extension of the major distribution network and feeder mains outside the existing built up area but within the year 2000 development boundary

Construction of Stage II of the Sunggal augmentation from 104,000 to 130,000 cu m/d

Construction and commissioning of the first stage of the Deli Tua plant

Stage III (1990 and beyond)

Increasing the capacity of the four reservoirs and booster stations

Construction of two reservoirs and booster stations in kampungs Pulau Brayan Kota and Tanjung Sari

Installation of trunk mains to meet the year 2000 demand

Continuation of the groundwater and surface water monitoring programs

Construction of feeder mains and service connections

Construction of the second stage of the Deli Tua plant, and if necessary the third stage, increasing the total daily production to 120,000 cu m/d

9.3 DESCRIPTION OF THE FIRST STAGE WATER SUPPLY PROJECT

9.3.1 Augmentation of Sources

The supply and demand curves for the period 1980 to 1990 are shown in Figure 9.1. In Stage I the immediate program objectives will be satisfied by Stage I of the Sunggal Treatment Plant augmentation and 13 deep wells, including the two test/pumping wells, to be installed under the groundwater investigation program.

Figure 9.2 shows the proposed layout of the Sunggal water treatment plant to an ultimate capacity of 130,000 cu m/d and a listing of additions to be carried out is provided in Table 9.1.

MUNICIPAL SUPPLY VS DEMAND
1980-1990

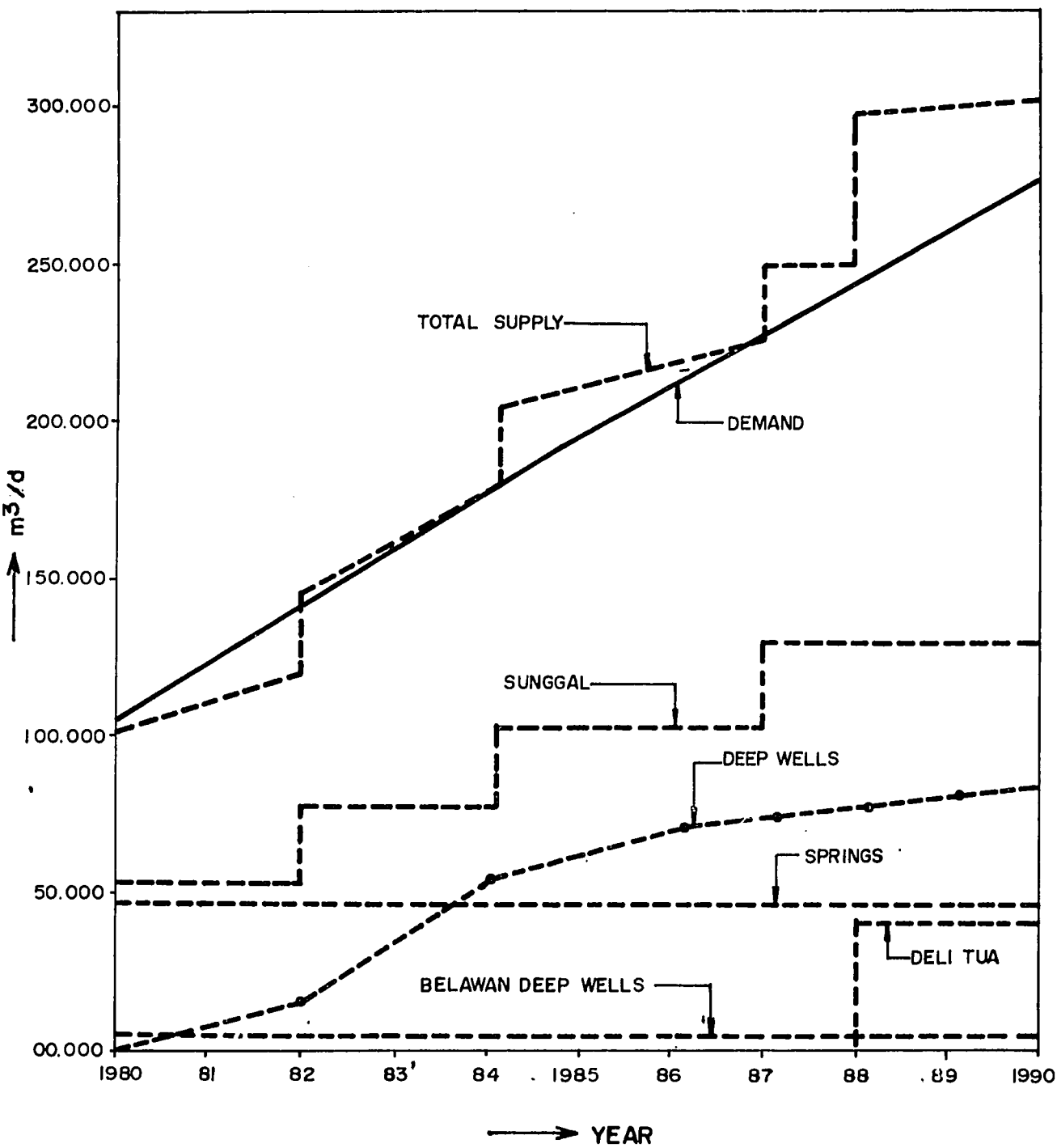

TABLE 9.1

EXPANSION PROGRAM SUNGGAL TREATMENT PLANT
STAGE I COSTS

Item	Estimated Cost Millions of Rupiah
* 1 One Clearator	NA
* 2 One Set filters	NA
* 3 One or two Clear Water Reservoirs	NA
* 4 One Clear water pump house	NA
5 Pre Settling Tank, including raw water channel	45
6 Raw Water Pumphouse, including pumping and electrical equipment (200 HP provided in 2 stages)	71**
7 Raw Water Pumping Main, 210 m of 900 mm and 60 m of 600 mm mortarlined steel pipe	45
8 Two Clearators, each capacity 26,000 cu m. including mechanical equipment, effluent weir and channel, chemical mixing and dosing equipment, pipes, etc.	300**
9 Two sets of declining rate of flow type filter units, each consistsing 6 filters approx. 2.3 m x 10 m with 1.25 m of unisized filter media, effective size 1 mm, underdrains, filter galleries, weir, clear water channel, and pipework, including orifice meter for each filter.	318**
10 Clearwater Tank, 12,000 cu m (approx. 6 hours storage) capacity, built in two units of 6,000 cu m each	135**
11 Filtered Water Pumphouse, including pumping and electrical equipment (500 HP, provided in two stages)	93**
12 Administrative, office and laboratory building, 3 floors, including chlorinator house and chemical mixing and dosing room, similar to existing building.	128**
13 Stand-by diesel generator house, with two 200 HP generators, sufficient to work entire plant at half capacity in emergency.	65**
Total	1,200

* Denotes included in current PAM Tirtanadi program.
** Items to be constructed in Stages.

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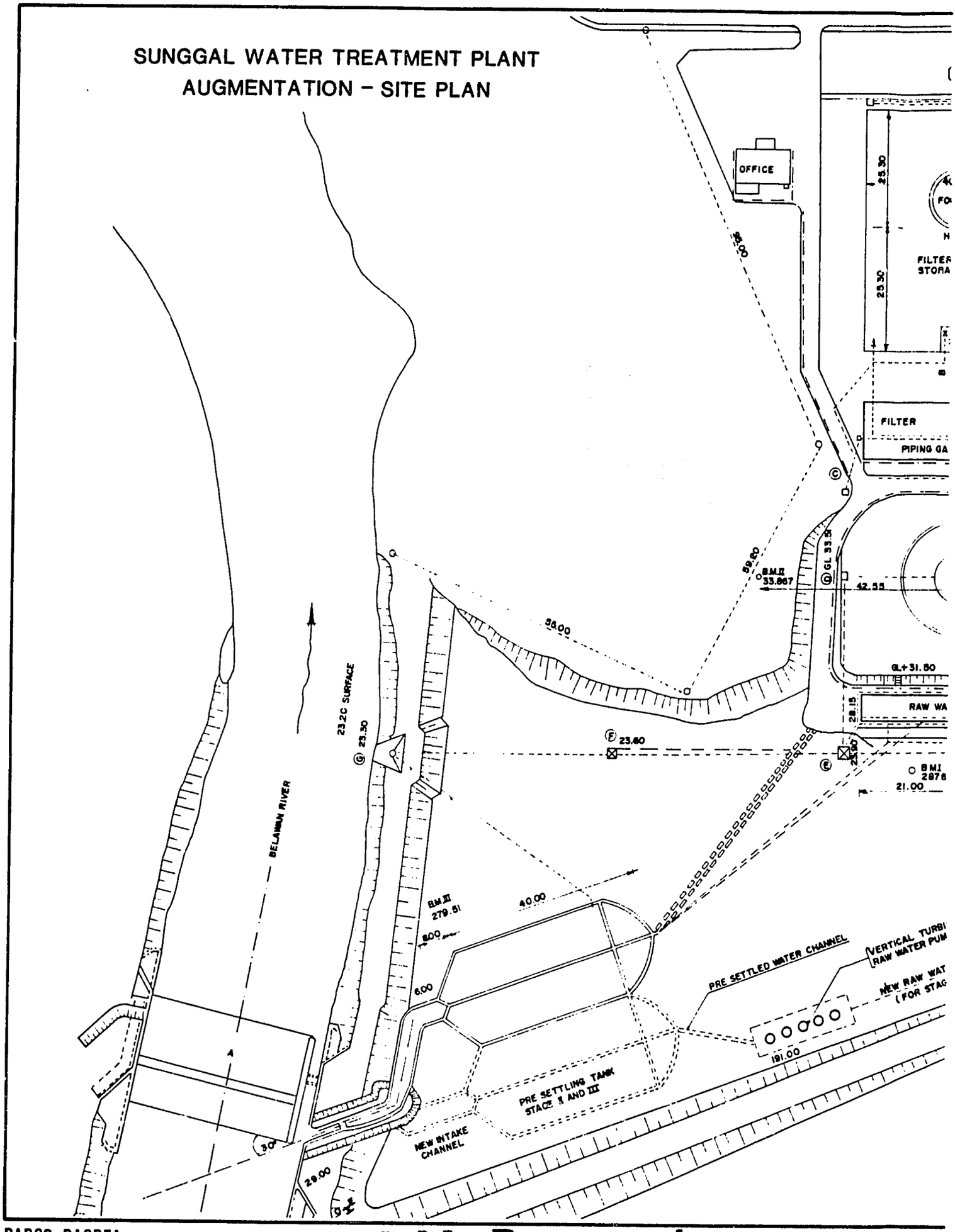

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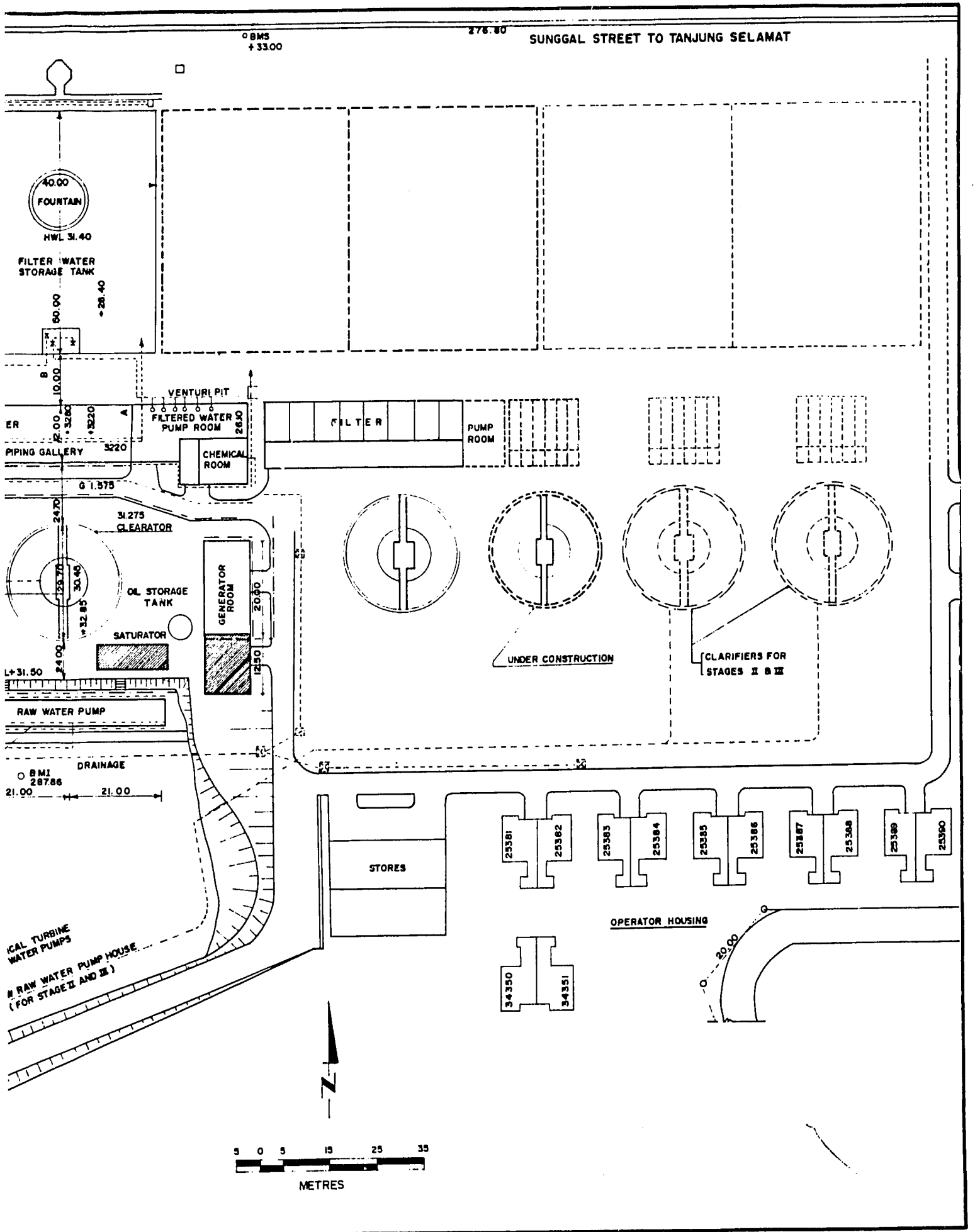
FIGURE 9.2



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The dates at which further source increments must become operational can be generally identified however; timing of future stages of the Sunggal plant and the initiation of the proposed Deli Tua plant will depend on the results of the groundwater drilling program.

The comparative unit costs of various potential sources have been estimated as follows:

	Rp./cu m
Deep Wells	30
Sunggal Water Treatment Plant	37
Deli Tua Water Treatment Plant	48
Regional Water Treatment Plants	60+

The foregoing illustrates the significant financial advantage that can be realized if treatment plant expenditures can be deferred and emphasizes the importance of the ground water exploration and surface water monitoring programs to future program planning.

A total amount of Rp. 1,988 million is required in Stage I for the installation of 53 production wells. Funding for the additional 2 exploration wells is from central government sources. The Sunggal extension will cost Rp. 1,401 million. The water supply augmentation in Stage I is summarized in Table 9.2.

9.3.2 Distribution System Improvements

9.3.2.1 Transmission

In addition to the two existing 600 mm diameter mains from Sunggal to the city one additional 600 mm transmission main from the plant to node 95, as shown in Figure 9.3, will have to be laid and connected to the two existing 600 mm mains. Two butterfly valves for controlling the distribution of flow to these two mains will also be necessary. This work is estimated to cost 180 million rupiahs, and has been scheduled for Phase II.

The aggressiveness of soils is an important consideration in selecting materials for transmission and distribution system piping. Soil conditions in the study area were investigated to evaluate their agressiveness and their potential to cause the external corrosion of buried pipes and fittings. Historically corrosion has not been a serious problem in the Medan water distribution system.

Many externally unprotected cast and ductile iron pipes have been in service for many years, some for more than 50 years, with significant external corrosion.

In addition to actual corrosion experience soil conditions were evaluated in relation to the American Water Works Association's soil test procedures for the use of grey and ductile iron pipes which are the principal metallic pipe materials used in the distribution system in Medan. The AWWA procedures are summarized in Table 9.3.

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TABLE 9.2

WATER SUPPLY SOURCES - STAGE I
(CU M/DAY - GROSS)

Source	Daily Production (cu m, gross)				
Existing Supply	1980/81	81/82	82/83	83/84	84/85
Springs	46,000	46,000	46,000	46,000	46,000
Sunggal Treatment Plant [a]	52,000	78,000	78,000	78,000	78,000
Wells (Belawan)	3,000	3,000	3,000	3,000	3,000
Sub Total	101,000	127,000	127,000	127,000	127,000
New Supply					
Sunggal Treatment Plant [b]	-	-	-	-	26,000
Test Wells	1,000	2,000	2,000	2,000	2,000
New Wells [c]	3,000	9,000	23,000	43,000	53,000
Sub Total	4,000	11,000	25,000	45,000	81,000
Total	105,000	138,000	152,000	172,000	208,000

Notes:

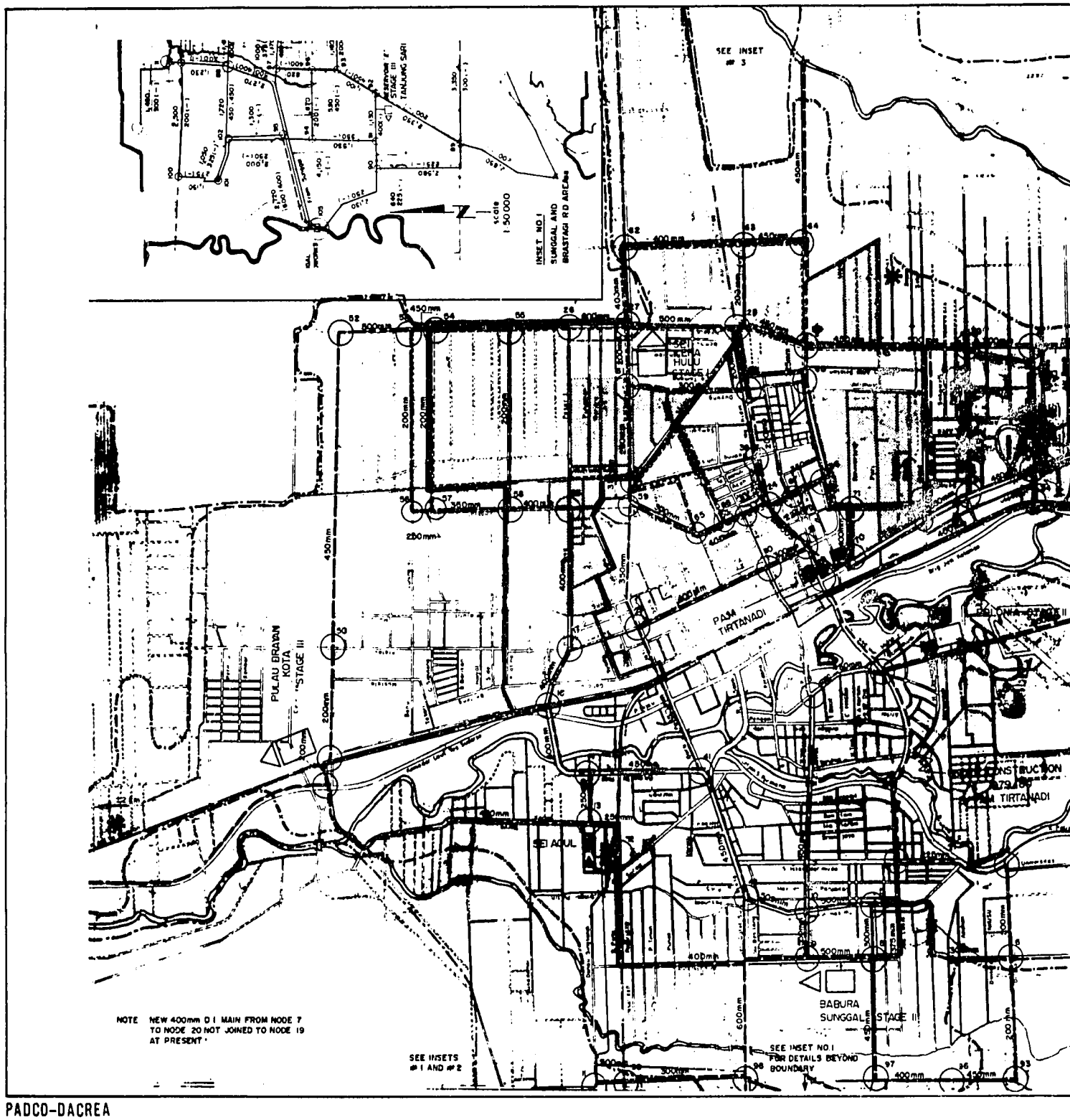
a. The increase in Sunggal capacity from 52,000 cu m/d to 78,000 cu m/d in 1981/82 is the additional 26,000 cu m/d which will result from works currently being undertaken by PAM Tirtanadi. The capital cost of these works are not included in the project costs.

b. The additional 26,000 cu m/d resulting from the proposed project investment will become available at the start of 1984/85.

c. The construction of new wells is assumed as follows:

1980/81: 5 wells
1981/82: 8 wells
1982/83: 20 wells
1983/84: 20 wells

It is assumed that well construction is spread evenly across each year. Maximum supply is therefore reached in 1984/85.



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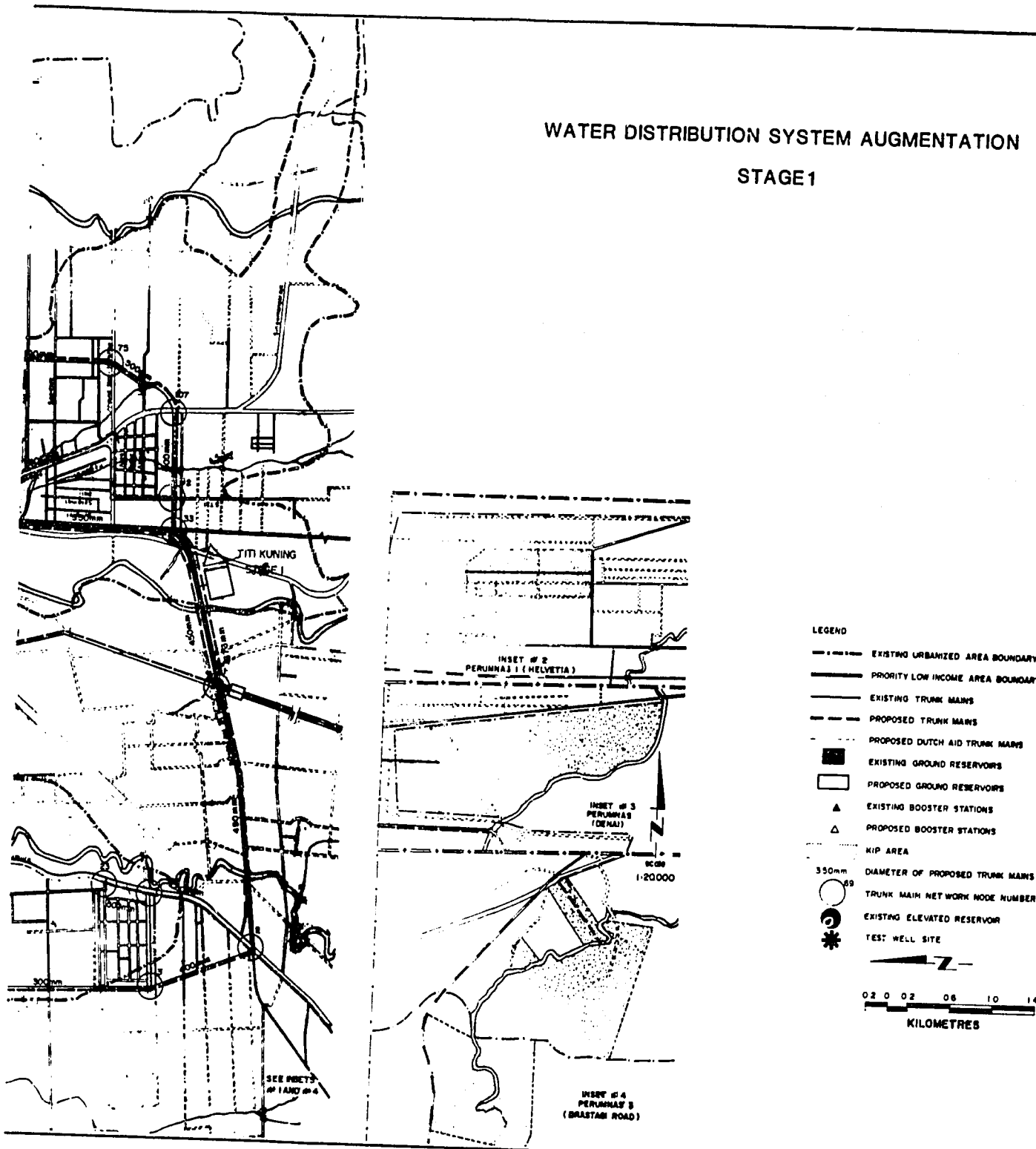

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TABLE 9.3

SOIL TEST EVALUATION

Factor		Corrosion Potential Rating Points	Estimated Rating of Medan Soils
Resistivity ohm/cm	< 700	10	0 to 5
	700 - 1,000	8	
	1,000 - 1,200	5	
	1,200 - 1,500	2	
	1,500 - 2,000	1	
	> 2,000	0	
pH	0 - 2	5	0
	2 - 4	3	
	4 - 6.5	0	
	6.5 - 7.5	0*	
	7.5 - 8.5	0	
	> 8.5	3	
Redox Potential	> +100 mV	0	3.5 to 4.0
	+50 to +100 mV	3.5	
	0 to +50 mV	4	
	Negative	5	
Sulfides	Positive	3.5	2 to 3.5
	Trace	2	
	Negative	0	
Moisture	Poor drainage continuously wet	2	1 to 2
	Fair drainage generally moist	1	
	Good drainage, generally	0	
Total Rating			6.5 to 14.5

* If sulfides are present with low or negative redox potential score 3 for pH range 6.5 - 7.5.

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A rating of 10 points or more indicates that the soils are corrosive to grey or ductile cast iron pipe and protection is indicated in the form of polythylene encasement.

From the foregoing it is concluded that corrosion protection for cast or ductile iron pipe is not generally required in Medan. The data also indicates that the soils are not corrosive to concrete or asbestos cement pipe. Measures which can be used to control or avoid corrosion problems when cast or ductile iron pipe are used under unfavourable conditions are:

- Additional wall thickness in addition to standard allowances for corrosion
- Improving trench conditions by encasing pipe in sand, stone or a mixture of sand and cement
- Polythylene encasement (AWWA standards)
- Use of pipe made from corrosion resistant materials (PVC, asbestos cement, concrete).

Because of the properties of Medan soils (generally wet soil conditions - high water table) steel pipe, when used, should be protected.

9.3.2.2 Reservoirs and Pumping Stations

At the end of Stage I, distribution system storage capacity will be as follows:

		cu m
Existing Reservoirs		
Jalan Singamangaraja	Ground level	3,500
	Elevated	1,200
Sei Agul		1,400
New Reservoirs		
Titi Kuning		12,000
Sei Kera Hulu (East Medan)		12,000
Total		30,100

The construction of the additional storage facilities shown in Figure 9.3 is essential if optimum use is to be made of the source improvements, reinforcement and laying of additional trunk mains and the extension of the feeder main coverage. The total storage available at the end of Stage I will be about half of that required to meet the storage objective of 25 percent of the average daily demand. Additional storage increments are scheduled for Stages II and III to meet the long-term storage objective within the program period.

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Figure 9.4 shows the schematic layout of the piping and pumps at a typical reservoir and booster station site. Two of three pumps provided will be sufficient for peak flows up to about 1990, the third being stand-by. The need for additional pumping capacity will be assessed by monitoring the pressure at the booster pump station from pressure gauges located at critical points in the distribution system. The control of pump operations will be manual.

9.3.2.3 Trunk Distribution Mains

Stage I of the distribution system improvement program consists of that part which lies mainly within the existing built-up area. Priority is given to the East Medan Sector which at present has the poorest service in the city. In recognition of this fact, steps have been taken to obtain immediate financial assistance from the Netherlands Government to augment the supply to the East Medan area. Detailed planning of these items has recently been initiated. The estimated cost of this program is Rp. 2,517 million.

Phase II will consist of the laying of the trunk mains in the remainder of the existing built-up area at an additional cost of Rp.3,924 million. The following items are given the highest priority:

1. 400 mm diameter main from the western boundary of the city where the Sunggal transmission main enters the city, to the existing tanks and booster station at the Jalan Singamangaraja site. PAM Tirtanadi has completed this main in 1980.

2. 550 mm diameter main from the southern boundary of the city at Johore to meet the above 400 mm main. This will enable more water from the springs to reach the existing tanks.

3. 550/400 mm diameter main from the southeast corner of the existing network to the existing tanks, improving the flow to the existing tanks from the existing transmission main from Sibolangit via Deli Tua.

Other trunk mains to be laid in Stage I are shown in Figure 9.3.

9.3.2.4 Minor Distribution Mains

The presently built up area of 9500 hectares is estimated to contain 3020 hectares of residential area that requires access to the municipal system. Minor distribution mains have been provided in approximately 50 percent of this area.

It is estimated that nearly 176 kilometres of minor distribution mains will be required in Stage I. The priorities for coverage are given below:

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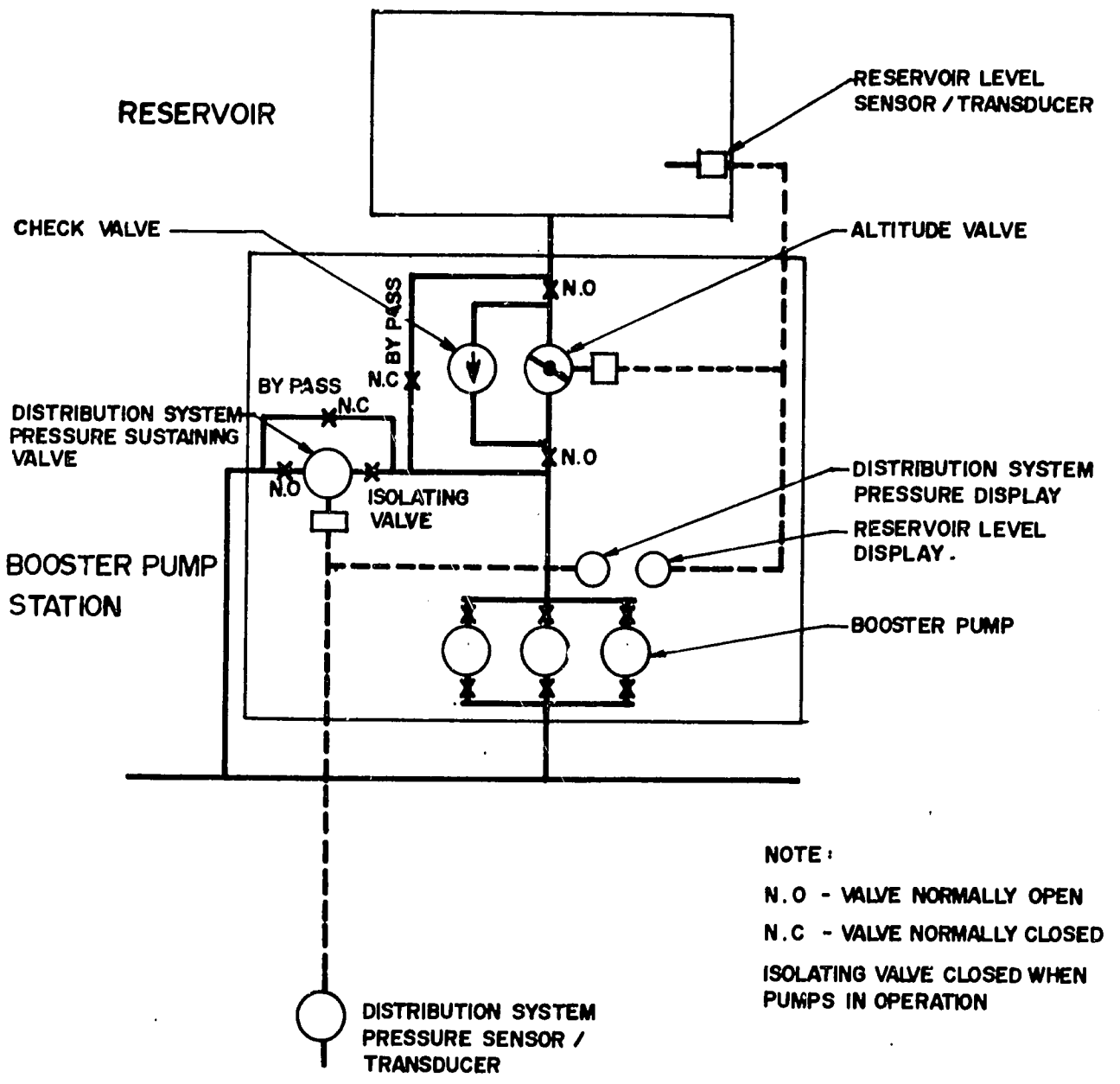
FIGURE, 9.4

RESERVOIR AND BOOSTER PUMP STATION SCHEMATIC



NOTE:

N.O - VALVE NORMALLY OPEN

N.C - VALVE NORMALLY CLOSED

ISOLATING VALVE CLOSED WHEN PUMPS IN OPERATION

1. Kampung Improvement Projects in priority low-income area

2. The remainder of the priority low-income area

3. Sites and service, core housing and low-cost housing

4. The remainder of the existing built up area

The locations of the above areas are shown in Figure 9.3. The minimum size of any new minor distribution mains or replacements should be 80 mm. The estimated cost of this work is Rp.793 million.

9.3.3 Public Standpipes

Public standpipes are usually erected on public property, mainly on road allowances. Water from standpipes usually is supplied free of charge. When there is a charge, the payment is calculated according to the unit rate charged by the water authority and is usually paid to one of its employees or agents who is stationed at the standpipe.

In Medan standpipes are invariably built on private property and are metered. The owner of the property pays the monthly bill to the water authority. Other users pay for the water at rates which are higher than the standard rates. The current shortage of standpipes and the erratic supply and low pressures discourage their use. Water is alternatively obtained from neighbours with individual connections, from vendors, at relatively high rates, or from shallow wells and surface waters which are usually polluted. The unfair financial burden placed on these consumers can be overcome by providing sufficient standpipes to make their use convenient and by charging an equitable rate for water consumed.

The recommended criteria for standpipe spacing is to provide one for every 300 persons and not less than one per hectare. This provides a maximum travel distance of 50 metres which has been found to be acceptable to most standpipe consumers. The full service area would need about 1,300 standpipes on this basis.

The minimum pressure in the distribution system of 15 metres, is generally adequate for the operation of the standard design as shown in Figure 9.5. However, initially it would be advisable to provide standpipes in low pressure areas which incorporate a cistern. Figure 9.6 shows the type of cistern standpipe recommended. Each has an approximate storage capacity of 1,000 litres and is provided with 4 waste prevention taps from which water could be drawn off simultaneously. The cisterns will fill up when the pressures are as low as 3 to 4 metres.

The standpipe program has top priority and virtually all 1300 units are to be provided in the Phase I period 1980/81, 1981/82 viz :

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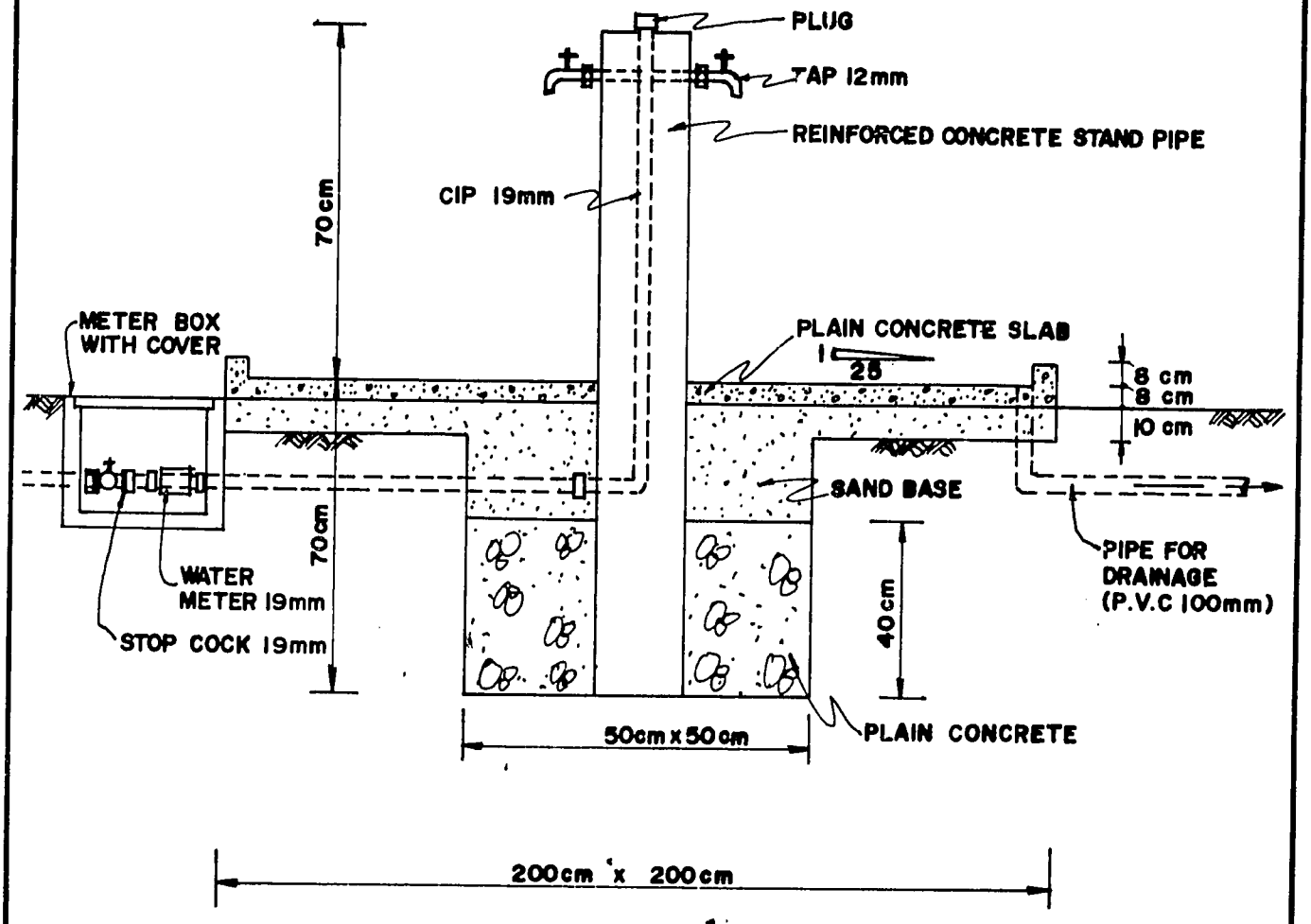
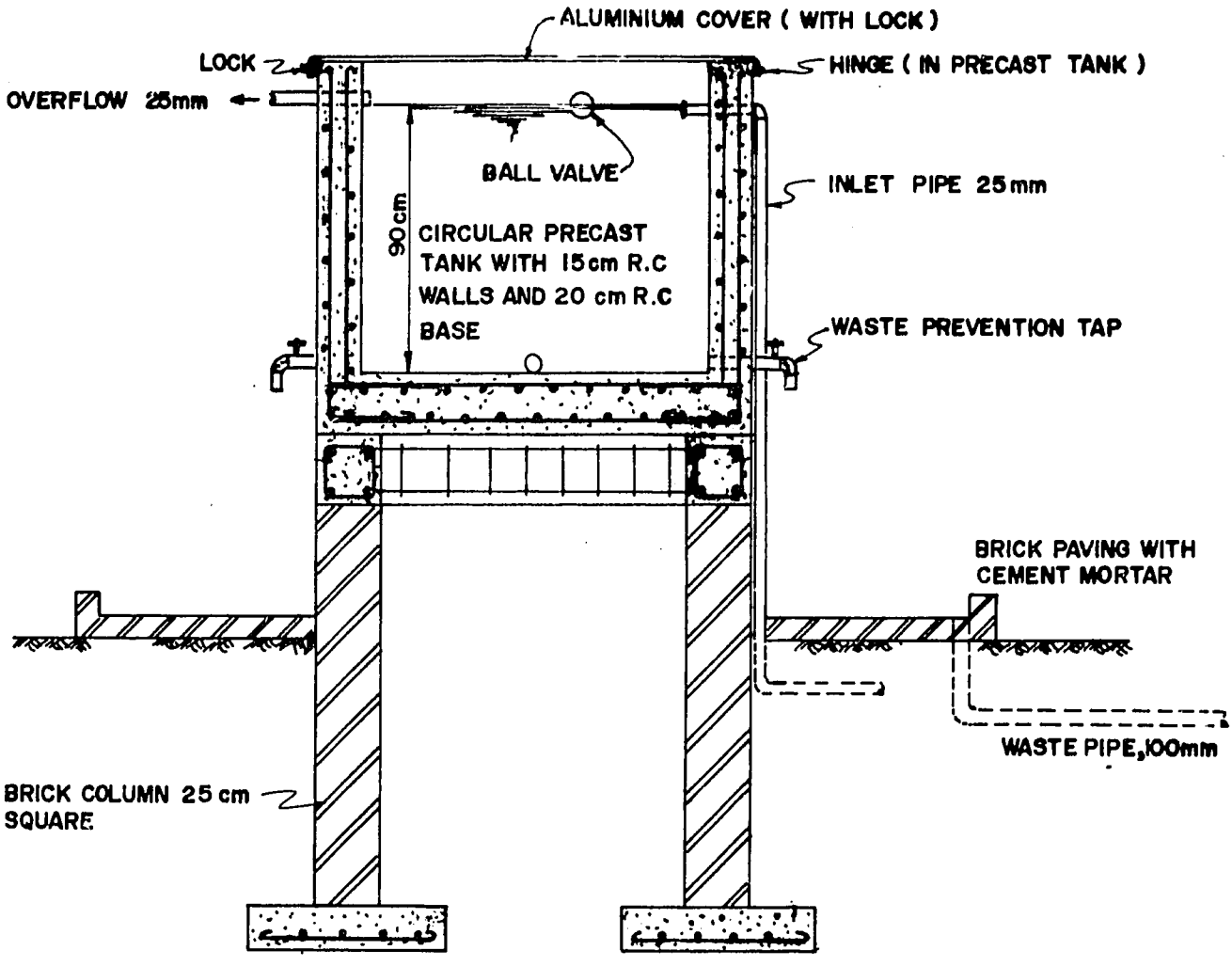
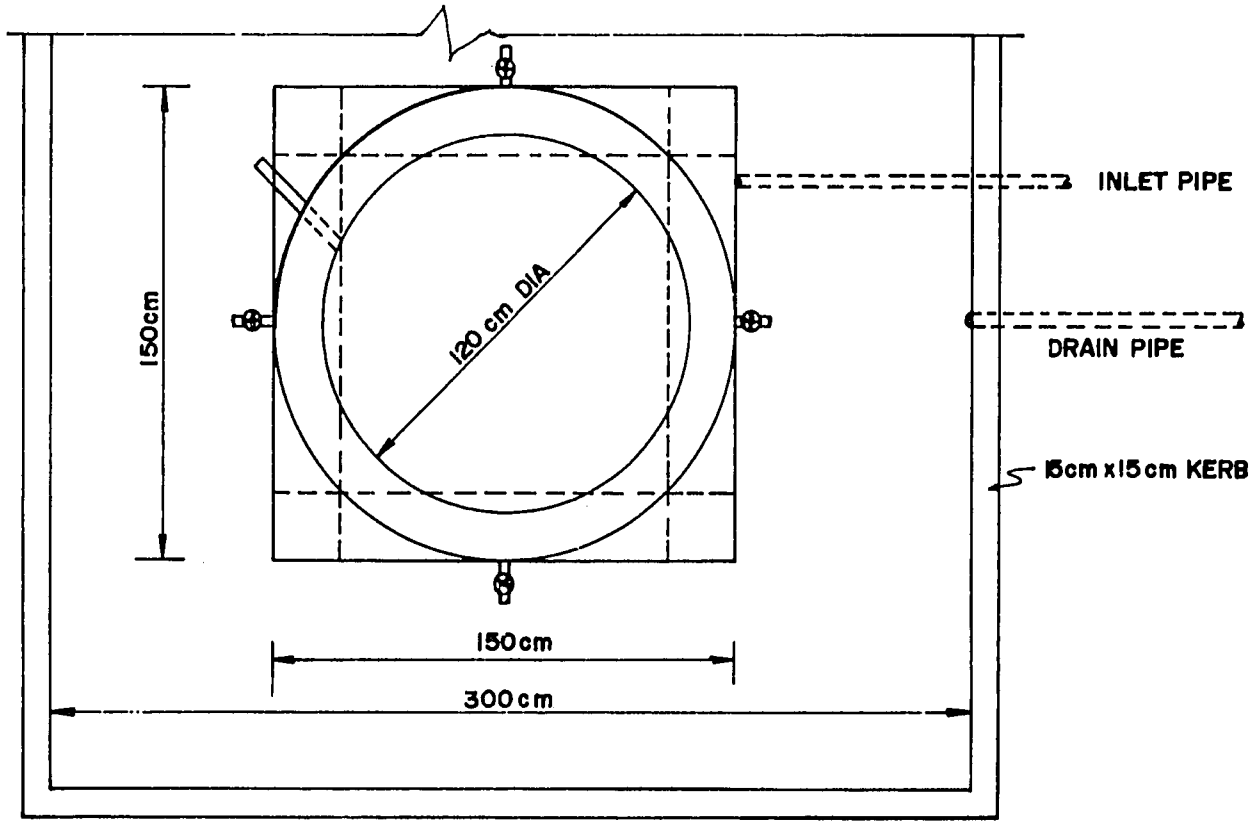
FIGURE 9.5

STANDARD STAND PIPE



CISTERN STANDPIPE FOR LOW PRESSURE AREAS





1980/81: 500
1981/82: 700
1982/83: 50 and
1983/84: 50

Estimated capital cost of the standpipe program is Rp. 168 million.

9.3.4 Service Connections

A total of 10,000 new service connections are proposed for Stage I under this program. These will be installed exclusively in Phase II (1982/83-1983/84) because of the high priority given to standpipes in Phase I. There will, however, be new service connections in 1980/81 and 1981/82 as part of PAM Tirtanadi's on-going program and as part of the proposed new Perumnas housing project. Existing and proposed service connections are summarized in Table 9.4.

TABLE 9.4

CUMMULATIVE SERVICE CONNECTIONS IN REPELITA III

	1980/81	81/82	82/83	83/84
Tirtanadi				
Existing *	43,900	43,900	43,900	43,900
On-going	2,000	4,000	4,000	4,000
Perumnas Project	-	1,600	4,170	6,880
Project	-	-	5,000	10,000
Total	45,900	49,500	57,070	64,780
Domestic	38,600	42,100	49,070	55,980
Non-domestic	7,300	7,400	8,000	8,800

* The increase from the 1978 connection level of 36,460 (see 3.2.1) is mainly due to connections made to the Perumnas I housing project.

Two types service connections are proposed:

1. Standard service connections serving a single privately owned property.

2. Multiple service connections serving up to 8 or 10 properties from a single metered connection to the water main.

The multiple service connection is suggested as part of the program so that the benefits of a service connection can be provided at a reduced cost and connections will be affordable by a greater number of households. Two alternative procedures have been considered for providing individual connections beyond the meter and for billing, as follows:

1. The meter is located on public property and the complete installation carried out by PAM Tirtanadi. Billings for each connection are based on the average metered water use per connection.

2. The meter is located on private property. The connection is registered in that owners name. PAM Tirtanadi's responsibility ends at the meter and the owner assumes all responsibility for further connections, payment of the water bill and collections from other connected consumers.

Alternative 1 is recommended because closer control over the quality of individual connections can be maintained and potential abuses on the part of the connection owner of Alternative 2, similar to those now occuring with private standpipes and vendors, can be avoided. Under both alternatives incentives to control consumer wastage are maintained although less directly than with standard service connections. The estimated total cost of house connections to be provided under this program is Rp. 464 million. This excludes the cost of connections made by Tirtanadi in 1980/81 & 1981/82 and the Perumnas housing connections.

Connection fees charged by PAM Tirtanadi should be based upon direct installation costs. A standard metered connection fee would be about Rp. 40,000, rather than the current connection fee of Rp. 200,000. The fee decrease is expected to result in a sharp increase in the number of connection requests.

9.3.5 Shallow Well Improvement

Shallow wells will continue to be required for some time in the urbanized part of the study area as a result of the staging of the program of water distribution system development. Shallow wells will also be retained in rural areas beyond the distribution system boundaries.

The features necessary to improve existing shallow wells to a sufficient degree that they become safe sources of potable water are:

1. The construction of a concrete or brick wall sufficiently deep to prevent the entry of polluted groundwater from outside sources.

2. The construction of a paved access and washing area around the well.

3. The construction of a drain to carry the wastewater to an existing ditch or drain or to a soak away pit located at a

sufficient distance from the well where it could harmlessly perlocate into the soil with no danger of pollution to the well.

4. The provision of a hand pump.

Figures 9.7, 9.8, 9.9, and 9.10 show details of improvements that could be adopted under various circumstances.

The bamboo hand pump shown in Figure 9.10 was introduced by Mr. Yusuf at Ciamis in West Java and is now being developed by the Technical Development Center of the Bandung Institute of Technology.

The amount of assistance to be provided for individual wells will depend upon specific requirements which will be determined by a trained officer of the implementing agency.

A sum of 46 million rupiah has been provided in the Stage I estimates. Priority should be given to communal wells. The program is scheduled to commence in 1982/83.

9.3.6 Groundwater Exploration

Work on a groundwater exploration program has been completed under the project as part of the Stage I-Phase I well program. Two test wells which will be converted to production wells were installed at the locations shown in Figure 9.3. The funds required for this program were Rp.120 million and were provided by Central Government with the assistance of the United States Agency for International Development.

9.3.7 Surface Water Monitoring

Flow measurements have been made on the larger rivers, the Wampu, Ular, Binjei and Belumai which are fairly distant from the Medan study area. Extraction of water from these rivers will not become necessary within the study period or even longer, if future studies of the flows in the Belawan, Deli, Babura and Percut reveal larger safe yields.

Surface sources within the study area, and of immediate relevance to the project, are the Belawan, Deli (together with its tributary, the Babura) and the Percut Rivers. Further hydrological data is needed to determine accurately the safe yields of these watersheds. The Belawan river has been monitored for the last 7 years by the Hydrological Investigation (Bandung) and the Department of Public Works (Hydrological Design Unit) at Asam Kumbang. Before 1978 the gage was located approximately one kilometre upstream of the Sunggal Plant. In 1978, however, the gage was moved about 200 metres downstream due to the instability of the cross-section. A second gage has been installed on the Belawan River nearly 25 kilometres downstream of the former gage site, close to the mouth of the river. Available data include the average daily flows for three years and 52 measurements of instantaneous discharge over a 7 year period.

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SHALLOWS WELLS
Depth up to 6 Meters

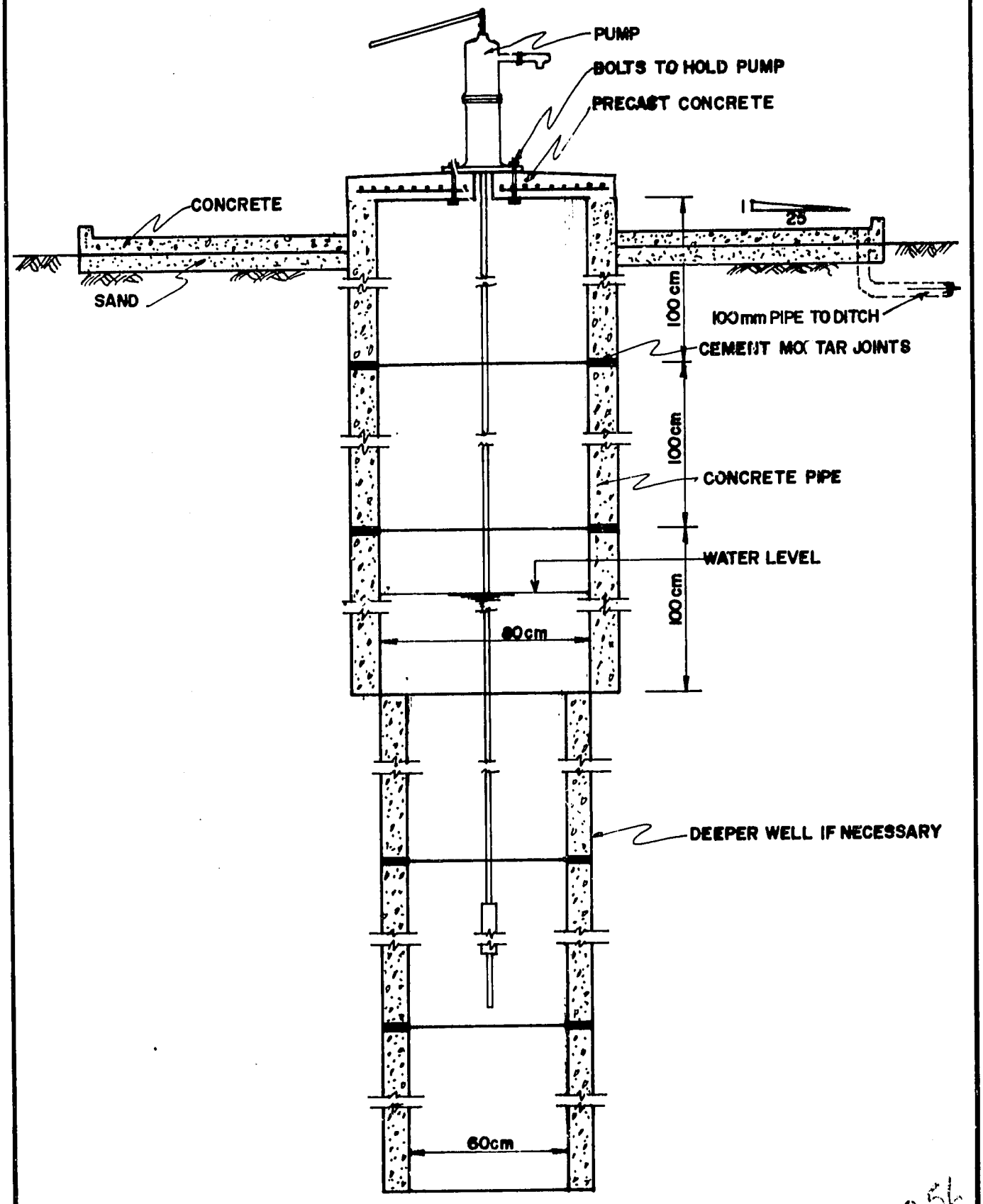

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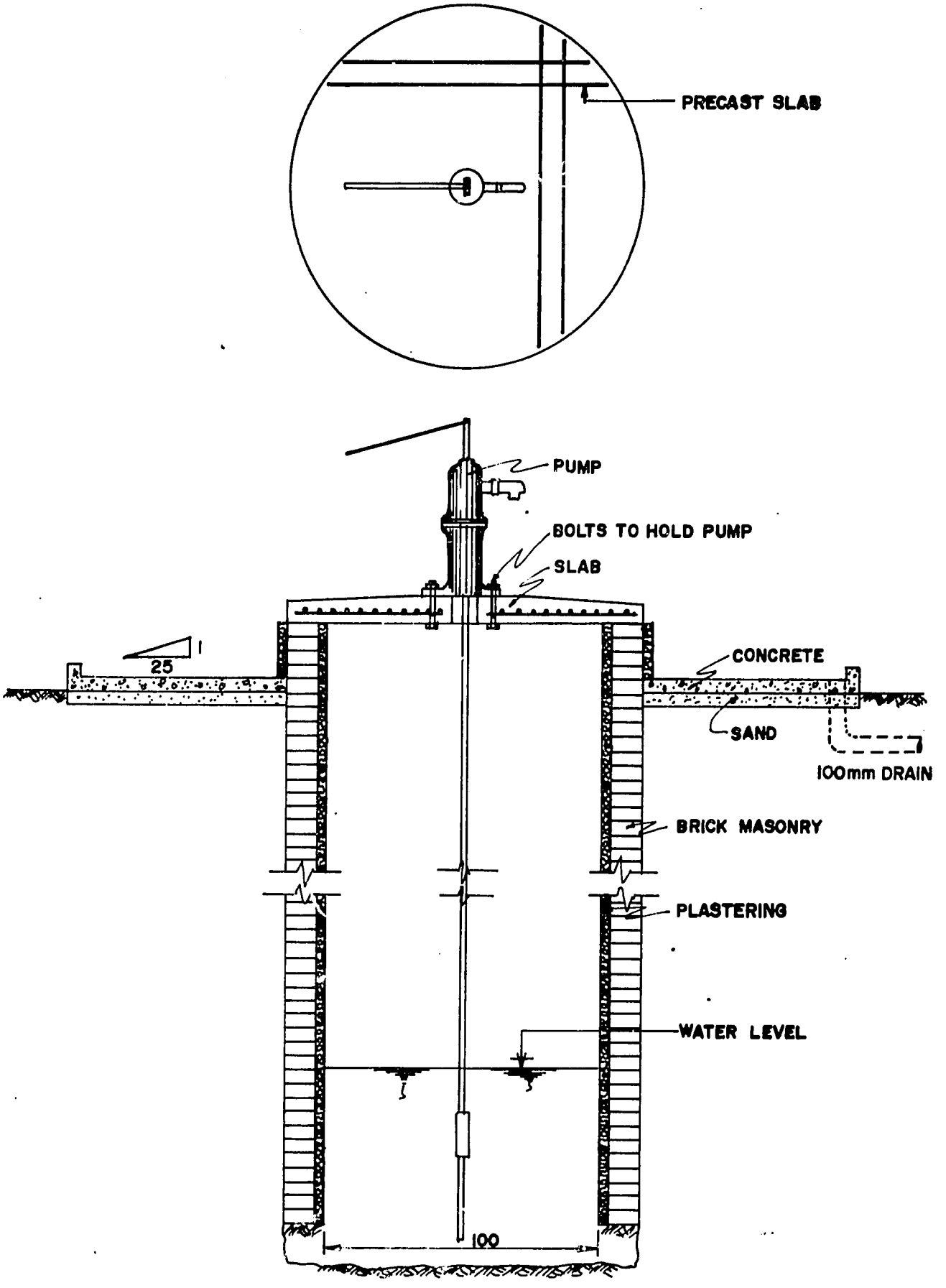
FIGURE 9.8

PUMP INSTALLATION ON EXISTING SHALLOW WELL



COMMUNITY SHALLOW WELL WITHOUT HAND PUMP

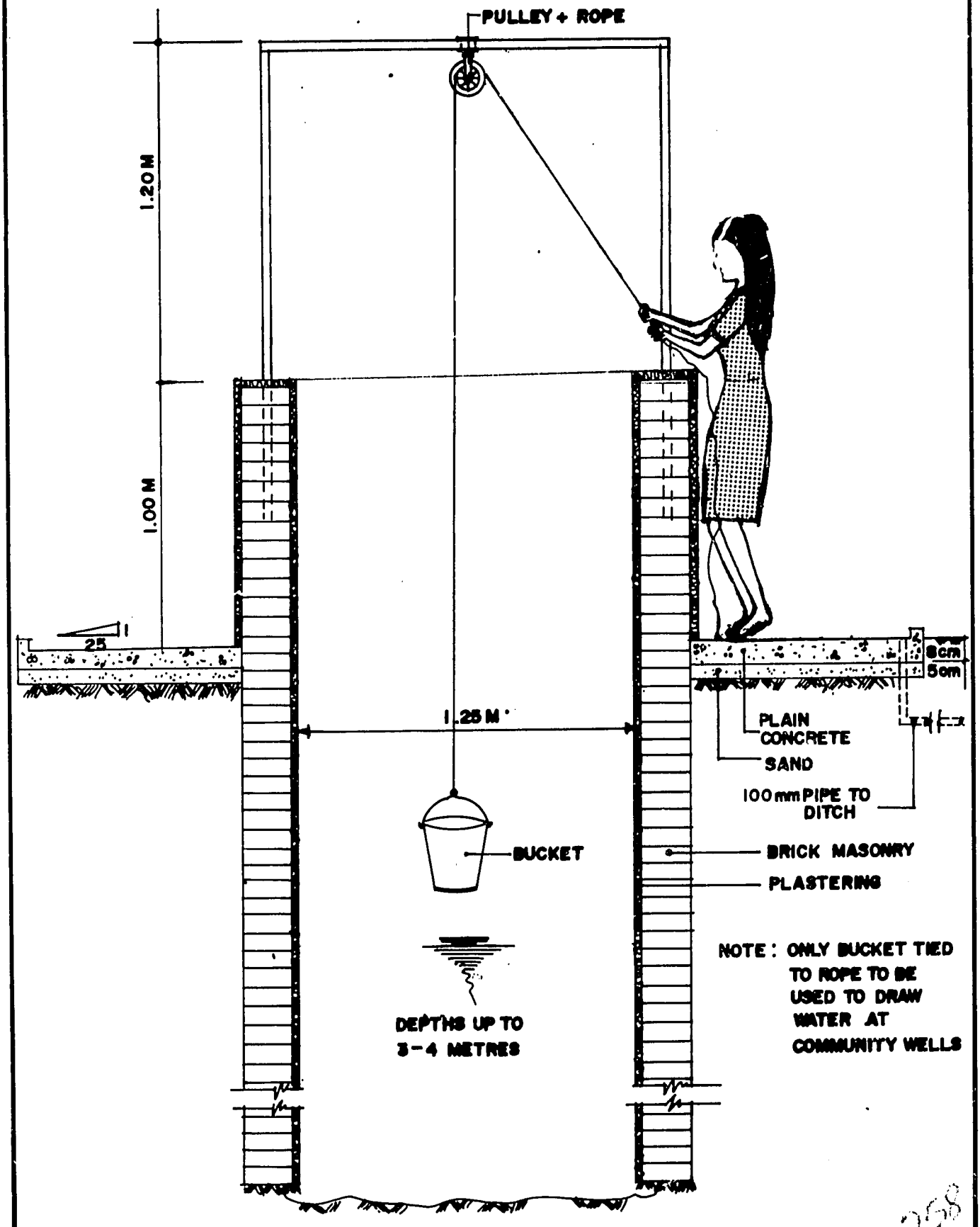
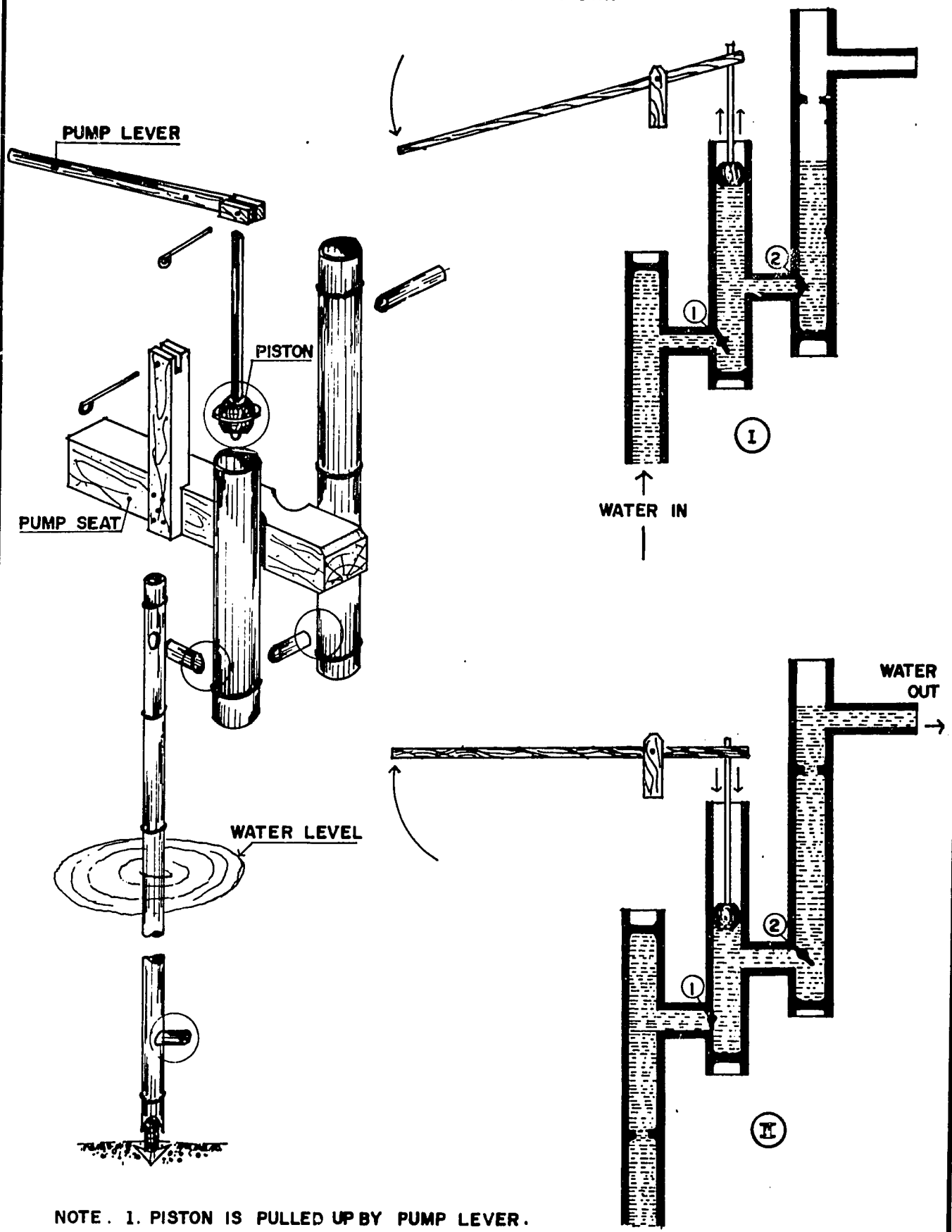


FIGURE 9.10

BAMBOO HAND PUMP



NOTE. I. PISTON IS PULLED UP BY PUMP LEVER.
VALVE 1 OPENS AND VALVE 2 CLOSES.
II. PISTON IS PUSHED DOWN BY PUMP LEVER.
VALVE 1 CLOSES AND VALVE 2 OPENS.

Similarities of the yield rates, that is, the averaged low flows over the total catchment area of the gage, as compared with those for areas upstream of the Belawan, Deli, Binjei, Belumai and Ular river gages have provided the basis for estimating the 1 percent and 5 percent low flows used as a general guide for surface water development assesments for this project.

The Deli river has been monitored by the same agencies for about 9 years. The gage is sited at Simeme on the main river nearly 3 kilometres south of Deli Tua and does not measure the contribution of the Babura tributary.

The Percut river flows have not been monitored. In view of the above, it is recommended that the hydrological studies of the larger rivers outside the study be continued by the Hydrological Investigation (Bandung) and the Department of Public Works. The rivers in the study area, however, are of vital importance to the Medan city water supply, and PAM Tirtanadi who will be responsible for the adequacy of the city supply, should immediately start monitoring programs for the Belawan, Deli, Babura and Percut rivers. Gages could be located at the sites at which intake or diversion structures have been indicated in the master plan, and in addition to flow measurements, Tirtanadi should carry out monthly analysis for determination of physical, chemical and bacteriological characteristics of these sources. More frequent analyses should be made if any relevant characteristic reveals marked changes, and the probable causes for such changes should be carefully investigated.

9.4. SOCIAL CONSIDERATIONS

9.4.1 Population Served

Table 9.5 summarized the population served in relation to the service objectives of the water supply program

The percentage of the population served through domestic connections and public standpipes is 58% in 1981/82. If allowance is also made for people obtaining water from social and religious sources, the percentage would certainly be 60% or higher.

The overall ratio of 1:1 between those served by house connections and standpipes is achieved by 1981/82 and fluctuates only slightly thereafter.

9.5 ECONOMIC CONSIDERATIONS

9.5.1 Importation of Engineering Materials

In addition to construction machinery, a large number of items that are required for the Medan Water Supply Project will be either

TABLE 9.5

POPULATION SERVED AND PER CAPITA CONSUMPTION
1980/81 - 1983/84

Population Served		1980/81	1981/82	1982/83	1983/84
Private domestic connection[a]	(000)	309	337	393	448
Public standpipes[b]	(000)	162	384	399	414
Total served[c]	(000)	471	721	792	862
Total population	(000)	1204	1236	1267	1299
% Served[d]		39	58	63	66
House connection/ standpipe ratio		1 : 0.52	1 : 1.14	1 : 1.01	1 : 0.92
Domestic consumption 000 cu m/y		18,880	21,820	23,560	27,460
Average Consumption l/c.d		110	83	82	87

a Assumes that 8 people on average obtain water from a private connection.
b Assumes each standpipe serves 300 people with an average per capita consumption of 35 l/c.d. This is a maximum estimate.
c Excludes people who obtain water from social/religious sources for domestic/private purposes.
d As consumption from social/religious sources is excluded, this percentage understates the total population served. This would certainly increase to 60 percent in 1981/82 with inclusion of this consumption.

imported from abroad or supplied from sources elsewhere in Indonesia. This section examines the feasibility of manufacturing or assembling some of these items locally thereby contributing to the general economic development of the area including increased employment.

9.5.1.1 Asbestos Pressure Pipes and Special Fittings

A large quantity of asbestos pressure pipe, particularly of the larger sizes, will be used in the project. At present ACP pipes supplied in Medan are manufactured in Jakarta. Cast iron specials, such as bends and tees are also manufactured in Jakarta. Pipes sizes range from 80 mm to 600 mm and are suitable for working pressures up to 15 kg/sq cm or approximately 150 metres.

Asbestos pipes from 100 mm to 400 mm diameters are manufactured in Medan along with asbestos roofing sheets, gutters and pipes, but these pipes are not intended to withstand pressures. It is understood that local manufacturers have expressed an interest in manufacturing pressure pipe if a steady demand is assured. The experience already gained in the manufacture of asbestos cement gravity pipe could provide an adequate basis for the possibly future production of pressure pipe.

9.5.1.2 PVC Pipe

This material is also sometimes referred to as deplasticized PVC (u PVC) to distinguish it from the flexible alkathene pipes used for irrigation and other purposes but seldom in water supply projects. Rigid PVC pipes varying from 9 mm to 600 mm in diameter are manufactured by two organizations in Jakarta. The following are Medan's future potential requirements for PVC pipe.

200 mm to 300 mm diameter	1980-1985	60,000 m	already included in figures for ACP pipes
	1986-2000	negligible	
75 mm to 150 mm diameter	1980-1985	258,000 m	
	1986-2000	636,000 m	
		894,000 m	
less than 75 mm diameter			all new building connections and standpipes are likely to be of PVC

9.5.1.3 Pre-stressed Concrete Pipes

Pre-stressed concrete pressure pipes become progressively more competitive in price, in relation to other makes, as the size increases, the minimum economical size usually being around 400 mm. In the

recommended water project approximately 120,000 metres of 400 mm or more will be required in the period 1980/85 and a further 90,000 metres during the period 1986/2000.

Although a good case can be made for setting up ACP and pre-stressed pipe manufacturing industies, in the size range 400 mm to 600 mm the market will be shared, and the success of one would be partly at the expense of the other. The manufacture of PVC pipes would almost be unaffected by either as it would mainly manufacture sizes uneconomical or technically unsuitable for the other two.

9.5.1.4 Ferrules, Stop-cocks and House Taps

The number of ferrules needed during the 20 year period 1980/2000 will be about 120,000. The number of stop cocks will be almost double this quantity as each service connection needs two stop-cocks according to present practice. Any industry combining the manufacture of these two items will therefore have a steady market during the next 20 years. The manufacture of house taps to various standards could be combined with these advantageously.

9.5.1.5 Gate Valves, Meters, Hand-pumps for Shallow Wells, and Meter Boxes

The manufacture of the first two items are precision jobs and at most, only the local assembly of the imported components would be feasible at present. The demand for these and also for shallow well hand-pumps is limited in comparison with those discussed earlier and their local manufacture therefore does not appear to be attractive yet. Meter boxes are already being made locally and the expected sharp increase in demand will require close supervision and production control.

9.5.2 Labour Intensive Methods

The potential economic benefits of utilizing labour intensive methods in the recommended water supply project are discussed in this section. The use of labour intensive methods in construction can be considered at the tendering stage, as few elements of the project will need the exclusive use of construction machinery or equipment for their completion. Tenderers can be required to state the construction procedures they propose to use or to submit alternative prices one including the use of labour intensive methods for specific operations.

The use of labour intensive maintenance and operational procedures have also been evaluated. The operations at booster stations, for example will be almost totally manual to ensure simplicity and reliability of operation. The proposed filters at the water treatment plants are recommended to be the declining rate type which need the minimum of equipment and are controlled almost entirely by manual methods.

The manual operations of process and stand-by equipment such as generators can be considered as an alternative to automatic control equipment and high technology instrumentation in the interest of improved reliability of operation.

9.6 OPERATIONS AND MAINTENANCE

9.6.1 Organization

Figure 9.11 illustrates the organizational modifications proposed for PAM Tirtanadi. Below the manager level some flexibility exists for a gradual transition from the existing situation. The final form of the organization structure must be based on a detailed inventory of existing functions and personnel needs.

Management systems for water companies of 20,000 connections and above are currently under review by Central Government the latest guidelines having been published in 1974. Guidelines for smaller water companies were published in 1977. These guidelines include recommendations for the design of reporting, billing, accounting and materials handling forms.

At present PAM Tirtanadi maintains a modern double entry financial accounting system, and management and materials handling accounting systems. In general terms these systems appear adequate for PAM Tirtanadi's current needs. The systems, however, differ from the guidelines thus far established by Central Government and it is recommended that the proposed reorganization of PAM Tirtanadi include the adoption of the most recent applicable management practices in line with Central Government policies.

Now that the future program is more clearly defined it is recommended that an intensive management study of PAM Tirtanadi's operations be initiated.

9.6.2 Staffing

The total estimated staff requirement for PAM Tirtanadi's water supply operations at 1985 conditions is summarized in Table 9.6. Operating staff requirements where continuous service is required have assumed no overtime, a 40 hour basic work week, and 300 regular working days per year, 2 weeks vacation with pay and 12 days of sick leave also with pay. Factors applied to shift positions to determine the gross number of operational employees required are 1.6, 3.2 and 4.8 for one, two and three shift operations respectively.

9.6.3 Training

Staff training programs for new recruits, reassigned employees and key personnel are essential for effective long term operations.

At the supervisory level recruits are likely to possess some minimum specified educational qualification. Recruits to the operator and assistant operator grades are unlikely to possess the required degree of technical knowledge and skill.

Training should preferably be divided into the following phases:

PROPOSED ORGANIZATION CHART PAM TIRTANADI

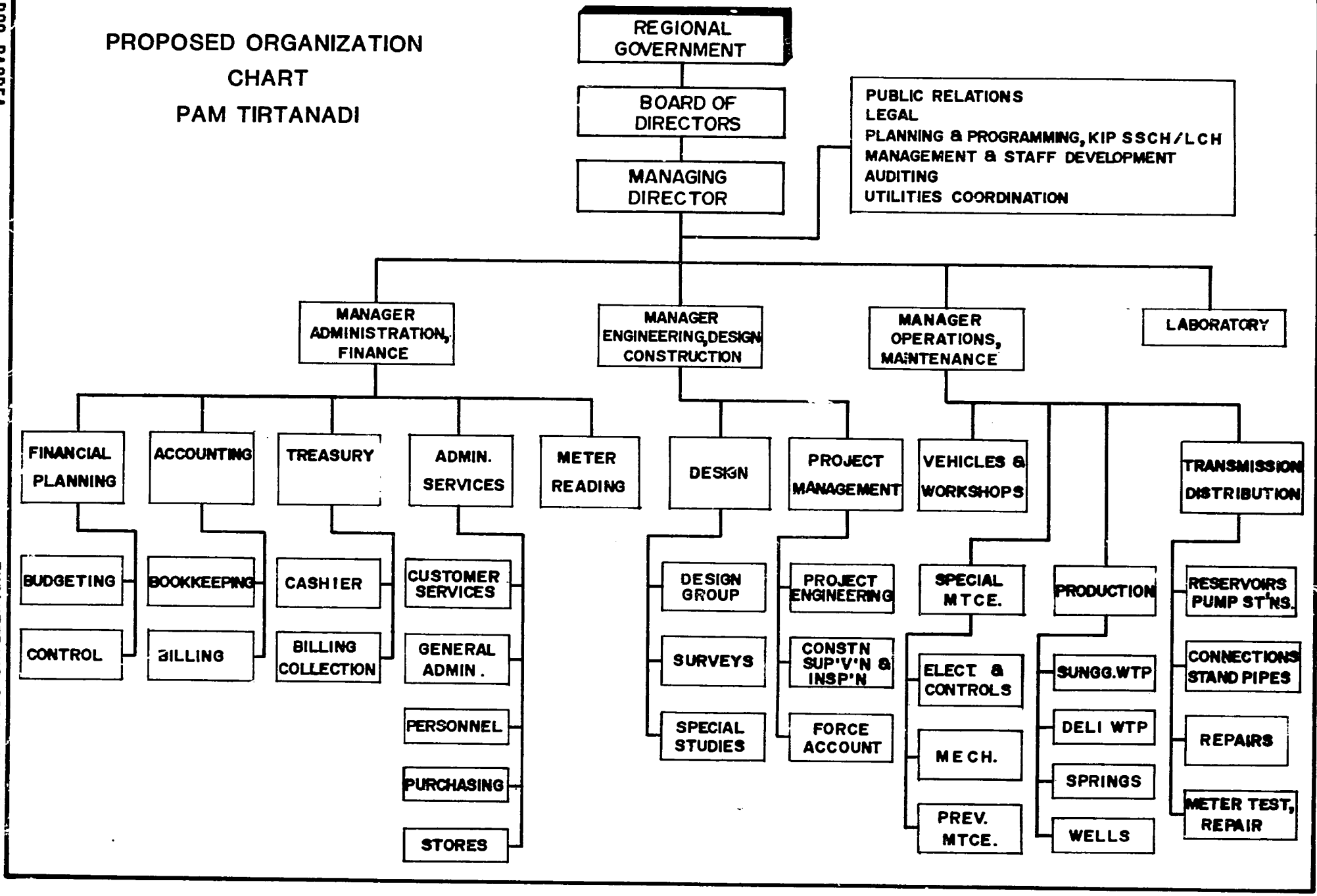


TABLE 9.6

PROJECTED STAFF REQUIREMENTS - PAM TIRTANADI
1985*
(WATER SUPPLY)

	Proposed Staff	Existing Staff
Management		
Managing Director	1	
Special Staff	3	
Clerical	4	
Sub-Total Management	8	4
Administration and Finance		
Manager	1	
Clerical	2	
	3	
Chief Financial Planning Section	1	
Senior Financial Planning Analyst	1	
Senior Budgeting Analyst	1	
Senior Financial Evaluation	2	
Clerical	2	
	7	
Chief Accounting Section	1	
Bookeepers,Accounting Clerks	5	
Construction cost Accounting Clerks	4	
Billing Clerks	20	
	30	
Chief Treasury Section	1	
Cashiers	4	
Bill collections	40	
	45	
Chief Administrative Services	1	
Customer Services Officer	3	
Clerical-Customers Services	3	
Clerical-Gen.Admin.	9	
Clerical-Personnel	4	
Senior Buyer	3	
Senior Supply Officer	2	
Stores Clerks	5	
	30	

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TABLE 9.6 — Continued

	Proposed Staff	Existing Staff
Superintendent Maintenance	1	
Foremen	3	
Tradesemen	6	
Laborers	3	
Preventive Maintenance Supervisors	3	
Clerical	2	
	18	
Superintendent Production	1	
Clerical	2	
Chief Operator Sunggal WTP	1	
Operators	7	
Assistant Operators	12	
Skilled Labor	9	
Chemical Analyst	1	
Laboratory Assistants	2	
Store keeper	2	
Laborer	4	
Security Police	9	
Clerical	2	
	52	
Chief Operator Springs	1	
Assistant Operators	13	
Laborers	5	
	19	
Chief Operator Wells	1	
Operators	38	
Laborers	2	
	41	
Superintendent Transmission Distribution	1	
Chief Operator Reservoirs and Booster Pumpstations	1	
Operators	12	
Assistant Operators	24	
	38	
Supervisor Connections	1	
Foremen	4	
Pipe Fitters	8	
Assistants	8	
Laborers	8	
	29	

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TABLE 9.6 — Continued

	Proposed Staff		Existing Staff
Chief Meter Reading Section	1		
Meter Readers	40		
	41		
Sub-Total Administration & Finance		156	147
Engineering Design and Construction			
Manager	1		
Clerical	2		
	3		
Chief Design Section	1		
Design Engineers	4		
Draftsmen	10		
Estimator	3		
Surveyor	2		
Survey Assistants	4		
Clerical	2		
	26		
Chief Project Management Section	1		
Project Managers	2		
Specification Writers	2		
Construction Supervisors	2		
Foremen	6		
Skilled Labor	12		
Laborer	24		
Inspectors	6		
Clerical	6		
	61		
Sub-Total Engineering Design and Construction		90	24
Operations and Maintenance			
Manager	1		
Clerical	2		
	3		
Superintendent Workshops and Vehicles	1		
Tradesmen	3		
Laborers	6		
Drivers	17		
Assistant Drivers	17		
	44		

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1. Initial introductory training to enable the new recruits to acquire an over-all knowledge of water supply and working initially under or alongside more experienced personnel.

2. Periodical in-plant training courses which would enable them to discuss problems identified during the course of their work and to obtain more specialized knowledge and training. This would be the stage at which the level of performance, and aptitude for particular jobs such as filter operation, clarifier operation, mixing and dosing, electrical and mechanical work could be judged and evaluated. The process of evaluation and re-deployment should be entrusted to instructors with wide experience and a competent knowledge of water supply.

3. Promotional courses for employees who show exceptional promise and a desire for advancement. It is of course presumed at this stage that the personnel division will ensure promotional facilities for all grades of employees within the organization. Written and practical tests or examinations should be avoided as far as possible, the emphasis being placed rather on work performance and, to an appreciable degree, the ability to maintain good human relationships and impart their knowledge to other employees or subordinates.

All grades of training described above can be done within the organization on a continuous basis by a small training unit. Employees showing exceptional promise could however be sent for short-term training courses in national and international technical institutions and agencies.

9.7 ESTIMATED COSTS AND RECOMMENDED IMPLEMENTATION SCHEDULE

9.7.1 Capital Costs

The capital costs of the recommended first stage water supply program are summarised by year in Table 9.7.

9.7.2 Operation and Maintenance Costs

The annual operation and maintenance cost of the recommended first stage water supply program are summarized by year in Table 9.8.

9.7.3 Implementation Schedules

The implementation schedule of the proposed water supply is illustrated in Figure 9.12.

TABLE 9.7

SCHEDULE OF CAPITAL EXPENDITURES*
Millions of Rupiah
1st Year, 1980 Prices

Item	1980/81			1981/82			1982/83			1983/84			Total		
	C	S	T	C	S	T	C	S	T	C	S	T	C	S	T
Sunggal Treatment Plant Stage 2	-	-	-	-	-	-	382	198	580	537	284	821	919	482	1401
Well Program	66	121	187	102	191	293	262	492	754	262	492	754	692	1296	1988
Transmission Mains	-	-	-	-	-	-	32	74	106	32	74	106	64	148	212
Service Reservoirs	-	-	-	-	-	-	218	5	223	326	8	334	544	13	557
Booster Pumping Stations	-	-	-	-	-	-	49	67	116	73	101	174	122	168	290
Major Distribution Mains	454	553	1007	679	831	1510	880	1082	1962	880	1082	1962	2893	3548	6441
Minor Distribution Mains	31	47	78	47	70	117	120	180	300	119	179	298	317	476	793
Service Connections	-	-	-	-	-	-	93	139	232	93	139	232	186	278	464
Public Standpipes	53	10	63	80	14	94	4	1	5	5	1	6	142	26	168
Shallow Well Improvements	-	-	-	-	-	-	18	5	23	18	5	23	36	10	46
Total	604	731	1335	908	1106	2014	2058	2243	4301	2345	2365	4710	5915	6445	12360

C = Civil Works; S = Materials and Equipment; T = Total

* Excludes Land Engineering and Contingencies.

TABLE 9.8

SCHEDULE OF ANNUAL OPERATING AND MAINTENANCE COSTS
Millions of Rupiah
1 January, 1980 Prices

Item	1980/81	1981/82	1982/83	1983/84
Direct Costs				
Materials	552	614	676	738
Employee Costs	373	446	519	592
Other	62	72	82	92
Indirect Costs				
Wages	94	107	120	133
Insurance	8	9	10	11
Other	82	94	106	118
Total	1171	1342	1513	1684

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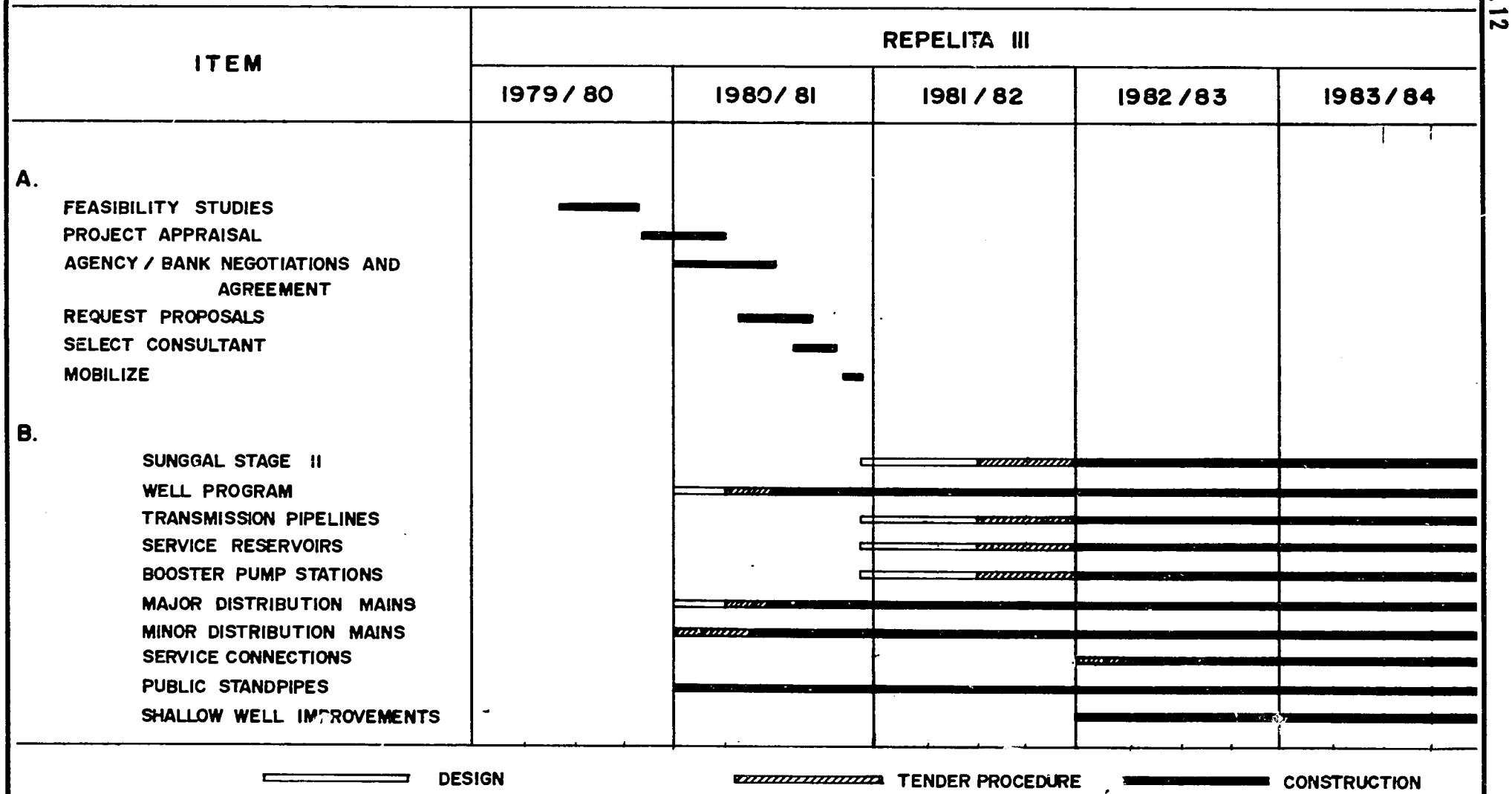
RECOMMENDED FIRST STAGE WATER SUPPLY PROJECT PHASED IMPLEMENTATION PROGRAM



NOTE. — SERVICE CONNECTIONS, PUBLIC STANDPIPES START EARLIER AFTER SUNGGAL STAGE I

— SHALLOW WELL IMPROVEMENT PROGRAM STARTS EARLY, NO DESIGN, TENDERS BEING NECESSARY

SECTION 10

ECONOMIC AND FINANCIAL ANALYSIS OF FIRST STAGE PROGRAM

10.1 INTRODUCTION

In this section, financial and economic appraisal is undertaken of the water supply investments proposed during 1980/81 - 1983/84 as part of the MUDS program. The economic and financial internal rates of return have been calculated and full financial projections undertaken for the period 1980/81 - 1989/90. The overall financial viability of P.A.M. Tirtanadi has also been assessed.

The tariff and funding analysis undertaken here supersedes that contained in sub-section 8.4. The latter was based on earlier master plan estimates and before GOI loan terms had been confirmed.

10.2 PROJECT COSTS

10.2.1 Capital Costs

The recommended water supply investment costs are summarized in Table 10.1. A breakdown of these costs by year is given in Appendix H. These costs are based on the engineering estimates contained in sub-section 9.7 and adjusted as follows:

- Physical contingencies at 15 percent of total capital costs and engineering supervision at 10 percent of costs (excluding land) have been incorporated into the estimates.

- Price contingencies (inflation allowances) have been added, based on estimates provided by the Asian Development Bank. These rates are:

	1980	1981	1982	1983	1984
Local Currency	15%	15%	10%	10%	8%
Foreign Exchange	8%	8%	7%	6%	6%

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TABLE 10.1

CAPITAL COSTS - FIRST STAGE PROGRAM

Rp. in Millions

Item	Foreign			Local	Total
	Direct	Indirect	Total		
Land Acquisition	-	-	-	358	358
Civil Works	1065	733	1798	4117	5915
Equipment & Materials	3464	1116	4580	1865	[illegible]45
Engineering & Construction Supervision	616	-	616	618	1234
Sub-total	5145	1849	6994	6958	13952
Physical Contingencies	771	277	1048	1043	2091
Sub-total	5916	2126	8042	8001	16043
Price Contingencies	1246	455	1701	3040	4741
Total	7162	2581	9743	11041	20784

The overall investment program consists of two distinct phases - Phase I (1980/81 - 1981/82) and Phase II (1982/83 - 1983/84). The costs of each of these phases is given in Tables 10.2 and 10.3. Phase I costs are the investments necessary to achieve the Repelita III objective of providing 60 l cd of potable water to 60 percent of the people. This program is geared entirely to providing water to the poor people of Medan and will be financed by GOI from a combination of its own resources and committed foreign aid. The Phase II program is aimed at improving the existing low quality of service among the whole community. It is for the latter investments (Phase II) that financing will be sought from an international lending agency.

10.2.2 Foreign Exchange Costs

Out of the total cost of Rp.20,784 million just under half (47.3%) is in foreign exchange. This is considered a maximum estimate. There is always a considerable degree of uncertainty when estimating foreign exchange requirements as the allocation of supply and civil contracts between foreign and local companies cannot be predicted with certainty. For instance, although Indonesia manufactures asbestos cement pipes there is no guarantee that the contract will be won locally if it is put out to international competitive bidding. The foreign exchange estimate assumes that when construction and supply contracts are considered likely to attract international bids, the latter would be successful. Further assumptions used in calculating the direct and indirect foreign exchange costs are as follows:

- The classification of a foreign exchange cost as either direct or indirect has been made on the basis of whether payment is made in local or foreign currency by the project. If payment is made in local currency the cost is classified as indirect. For instance, Indonesia is a net importer of cement and is likely to remain so during the project construction period. Cement is therefore considered a foreign exchange cost but as it will be purchased by the project in rupiah it is classified as indirect. Similarly, a number of other items will be acquired locally which contain imported components and this latter element is classified as an indirect foreign cost.

- In cases when materials and equipment are imported direct to the project, c.i.f. prices have been taken as the foreign exchange component. Customs duties, taxes and subsequent handling and transportation charges are local costs.

- Foreign contractors profits and overheads have been taken as 20 percent, with 5 percent allowance for depreciation on imported plant. These are treated as direct foreign exchange costs.

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TABLE 10.2

PHASE I CAPITAL COSTS (1980/81 - 1981/82)

Rp. in Millions

Item	Foreign			Local	Total
	Direct	Indirect	Total		
Land Acquisition	-	-	-	140	140
Civil Works	-	152	152	1360	1512
Equipment & Materials	1078	256	1334	503	1837
Engineering & Construction Supervision	166	-	166	167	333
Sub-total	1244	408	1652	2170	3822
Physical Contingencies	186	61	247	325	572
Sub-total	1430	469	1899	2495	4394
Price Contingencies	139	42	181	441	622
Total	1569	511	2080	2936	5016

TABLE 10.3

PHASE II CAPITAL COSTS (1982/83 - 1983/84)

Rp. in Millions

Item	Foreign			Local	Total
	Direct	Indirect	Total		
Land Acquisition	-	-	-	218	218
Civil Works	1065	581	1646	2757	4403
Equipment & Materials	2386	860	3246	1362	4608
Engineering & Construction Supervision	450	-	450	451	901
Sub-total	3901	1441	5342	4788	10130
Physical Contingencies	585	216	801	718	1519
Sub-total	4486	1657	6143	5506	11649
Price Contingencies	1107	413	1520	2599	4119
Total	5593	2070	7663	8105	15768

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10.2.3 Operating And Maintenance Costs

Operating and maintenance costs associated with the new investments, and for improving existing standards and performance where necessary, have been incorporated into the financial and economic analyses. These costs are as discussed and detailed in Section 9.7.2.

10.3 PROJECT FUNDING

In determining the funding basis for the proposed investment program account has been taken of both the GOI funding guidelines for the water supply sector and the financial objectives outlined in the study's terms of reference.

The GOI objectives for the water supply sector can be summarised as follows:

1) The Repelita III target for major towns (as discussed in 9.1) is an average domestic consumption of 60 lcd with 60 percent of the population served. GOI will fund investments necessary to attain this level of service.

2) Once the above minimum standard has been attained the GOI will provide loan assistance for further improvements in consumption up to an average of 120 lcd.

The specific financial objective given in the terms of reference requires that the financial status of the enterprise be improved to enable it to finance at least a reasonable part of future investments of water supply development from its own resources, thereby reducing the need for Government equity capital, grants or subsidies This objective dovetails with the likely requirement of an international funding agency such as the Asian Development Bank. The latter requires a six percent (minimum) return on revalued assets, the attainment of which should certainly lead to internally generated funds for capital investment. All the above considerations have been incorporated into the funding arrangements recommended for the first stage investment program which are summarised in Table 10.4.

TABLE 10.4

FUNDING OF STAGE I INVESTMENTS

Source of Funds	Phase I		Phase II		Total	%
	80/81	81/82	82/83	83/84	80/81 - 83/84	
Grant/Equity *	1,793	2,207	-	-	4,000	19
L o a n	-	-	5,200	6,500	11,700	56
Internal Contribution	-	1,016	2,241	1,827	5,084	25
T o t a l	1,793	3,223	7,441	8,327	20,784	100

* The terms grant and equity are used interchangably in this report.

A discussed in Section 9, the first two years investments (Phase I) are geared to achieving a 60% coverage of Medan's population. The costs of this have been given in Table 10.2. Under the GOI funding policies this investment of Rp.5,016 million is eligible for central government grant financing. However, as P.A.M. Tirtanadi should be able to make a contribution to this investment from internally generated funds, the grant required has been correspondingly reduced.

The Phase II (1982/83 - 1983/84) investments have been funded on the basis of a mix of loan finance and internal funds. The GOI funding policy for investments which increase per capita consumption in the range 60 lpc - 120 lpc is for GOI loan assistance. As the proposed investments result in per capita domestic consumptions which qualify for such assistance (see Table 9.5), this has been assumed to be available. Loan terms are given in sub-section 10.5.2.3.

The overall funding pattern for Stage I investments, as shown in Table 10.4, is 19 percent grant, 56 percent loan and 25 percent internal contribution. For P.A.M. Tirtanadi to achieve this level of contribution, increases in tariff levels will be essential, as now discussed.

10.4 TARIFF STRUCTURE AND RATES

10.4.1 General

In considering the future tariff rates and structure it is necessary to determine, first, the overall revenue requirements of PAM Tirtanadi and second, how this burden should be shared among the different categories of consumers. GOI has issued guidelines on both these points and they have been taken into account in arriving at the tariff proposals contained here. In addition, the administrative feasibility and affordability of the proposed charges have been assessed.

In determining the overall level of revenue, the likely requirements of potential funding agencies have been taken into account, namely, a minimum rate of return of 6 percent on revalued average net fixed assets (less accumulated consumer contributions). A considerable increase in average tariff levels will be necessary to achieve this objective.

10.4.2 Tariff Increase Proposals

The inadequacy of existing tariff rates has been discussed in Section 8. At present tariff levels, revenue from water sales is inadequate to cover existing operating and maintenance costs, even before allowing for depreciation. This results from a combination of inadequate water supply (and thus limited potential for sales) and tariff rates which have remained unchanged since 1973.

PAM Tirtanadi is now attempting to rectify this and has submitted proposals for a substantial increase in rates. These are currently being considered by the regional government and by the governor of North Sumatra. The increases proposed are summarized in Table 10.5 and would significantly

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improve the financial performance of the utility. It is proposed to double domestic rates, with even heavier increases for commerce and industry. This reflects the governments social/equity policy of placing the largest burden on those with the greatest ability to pay.

In order to reinforce this policy requirement, it is recommended that PAM Tirtanadi introduces a third and cheaper band into its proposed rate structure. Under its existing proposals, domestic customers would pay Rp.30 per cu m for the first 30 cu m of water consumed. It is possible that this could cause some hardship among lower income consumers, especially as house service connections are extended down the income scale. To ensure a minimum consumption level to meet basic health and hygiene needs, it is recommended that the first 5 cu m of consumption is charged at Rp.20 per cu m. This 'lifeline' band is based on an essential consumption level of 20 l per day and an average of 8 people per connection. As most existing domestic connections are in the upper income sector and as the program to substantially increase house connections will not commence until 1982/83 (that is, after completion of the East Medan standpipe program), the introduction of a cheaper band could be delayed until then. It is also recommended that public standpipes and social customers are charged for all their consumption at the low band rate of Rp.20 per cu m.

TABLE 10.5

TARIFF INCREASES PROPOSED BY PAM TIRTANADI

Existing Rates

Customer Category	Rp/cu m
Domestic	
Initial allowance*	15
Additional	30
Commerce/Industry	
Light Users	80
Heavy Users	100
Government Offices	30
Social/Religious	
Initial Allowance	5
Additional	15
Schools	20
Army	20
Standpipes	15

Proposed Rates

Customer Category	Rp/cu m
Domestic	
0 - 30 cu m	30
> 30 cu m	60
Commerce	
Small	200
Large	225
Industry	250
Government Offices	80
Social	30
Standpipes	30

* 4.5 cu m per person per month

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A second modification recommended to the existing proposals is that the rates for industry and commerce should be the same and that within this combined category, differential rates should be based on consumption and not on size. This would be a more equitable basis for charging. If ability to pay is the criterion for determining consumer categories, industry is no better placed than commerce in this respect. Further, a large establishment does not necessarily consume more water than a small establishment; it depends on the nature of the respective operations. It is recommended therefore that commerce/industry be charged at the same rates and that these rates should be Rp.200 for the first 30 cu m of consumption and Rp.250 thereafter.

In order to meet the required rate of return objective a further increase in rates will be necessary when the first stage program investments have been completed. It is recommended that the low domestic rate is increased to Rp.30 and the second and third bands are increased to Rp.40 and Rp.75 respectively. The industrial/commercial band rates should increase to Rp.250 and Rp.300. The recommended modified proposals are summarized in Table 10.6, and ability to pay these higher rates is considered in 10.4.4 below.

TABLE 10.6

MODIFIED TARIFF PROPOSALS

Consumer Category	Immediate Rp. per cu m	1984/85 Rp. per cu m
Domestic		
0 - 5 cu m	20	30
6 - 30 cu m	30	40
30 cu m	60	75
Industry/Commerce		
0 - 30 cu m	200	250
30 cu m	250	300
Social/Religious	20	30
Standpipes	20	30
Port	250	300

10.4.3 Service Connection Charges

In addition to paying for water consumption, new consumers will be faced with the costs associated with connecting to the system. The existing connection fee is extremely high (Rp.208,000), and is 462 percent of actual cost. By this means, PAM Tirtanadi has been able to supplement its inadequate water sales revenues and generate limited funds for investments. This policy is acceptable as long as rate increases

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cannot be effected and there is a paucity of supply. However, with a substantial program to augment supplies it is essential that the connection charge is reduced; if the poorer sections of the community are to benefit from the investments, connection to the public system must not be priced beyond their means. To ensure this, it is recommended that the service connection charge is reduced to reflect actual cost and that this is recovered from the beneficiaries over a period of years through fixed monthly payments. The assumption adopted in the financial analysis (see 10.5.2.3) is that a down payment of one fifth will be made and the balance repaid over five years.

10.4.4 Affordability of Proposed Tariff Rates

10.4.4.1 Estimated Income Levels

Various published sources of data on family/household incomes and expenditure have been available to the project. These have been supplemented by limited surveys undertaken by the study team. The different sources are discussed in detail in the final Housing Development Program report. The estimate of family incomes resulting from these studies is summarized in Table 10.7.

TABLE 10.7

PERCENTAGE AND NUMBER OF FAMILIES BY INCOME GROUP ADJUSTED TO JANUARY 1980 PRICES

Monthly Family Income Rupiah	Percentage of Families % in Group	Cummulative	Families by Income Number	Cummulative
Under - 20,000	3.1	3.1	6,043	6,043
20,001 - 30,000	10.2	13.3	19,885	25,928
30,001 - 40,000	14.2	27.5	27,683	53,611
40,001 - 50,000	13.2	40.7	25,733	79,344
50,001 - 60,000	12.1	52.8	23,589	102,933
60,001 - 70,000	11.3	64.1	22,029	124,962
70,001 - 85,000	10.0	74.1	19,495	144,457
85,001 - 100,000	7.6	81.7	14,816	159,273
100,001 - 120,000	6.5	88.2	12,672	171,945
120,001 - 140,000	4.3	92.5	8,383	180,328
140,001 - 200,000	4.1	96.6	7,993	188,321
200,001 +	3.4	100.0	6,629	194,950

10.4.4.2 Examples of Monthly Domestic Bills

In planning future water supply requirements the per capita consumption rates shown in Table 10.8 have been adopted for Repelitas III and IV.

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TABLE 10.8

PLANNED PER CAPITA CONSUMPTION RATES - DOMESTIC CONNECTIONS

Residential Type		Litres per capita per day		
Income	Density	1980	1985	1990
High	Low	265	275	285
High	Medium	265	275	285
Medium	Low	215	225	240
Medium	Medium	215	225	240
Medium	High	145	160	175
Low	Low	145	160	175
Low	Medium	100	115	125
Low	High	35	35	35

For assessing the affordability of the proposed tariff rates, selected per capita consumption targets for 1985 have been taken. This is after the second increase in tariffs will hve been implemented. Low income consumers in high density areas have been excluded from the analysis at it is assumed they will be dependent on standpipe supplies; high income consumers have been excluded as it is assumed that they will have the ability to pay.

10.4.4.3 Ability to pay - Domestic

On the basis of the above consumption levels, monthly water bills (including an allowance for monthly connection charge payments) have been compared with incomes for the average family of 6 (Table 10.9).

TABLE 10.9

MONTHLY INCOMES COMPARED TO MONTHLY WATER BILLS

Consumption		Water Charge	Connection fee	Total Bill	Income	Charge as
l/c.d	L/Month	Rp./Month	Rp./Month	Rp./Month	Rp./Month	% of Income
115	21045	792	533	1325	45000	2.9%
160	29280	1121	533	1654	65000	2.5%
225	41175	1988	533	2521	85000	3.0%

If a correlation is assumed between per capita consumption and family incomes, the monthly charge for water will be between 2.5 - 3 percent of income. The income analysis (Table 10.7) shows 79,000 families with incomes below Rp.50,000 per month. The public standpipe program recommended for implementation by 1985 will provide water to around 75,000 families. It is reasonable to assume therefore that the minimum family income level at the low consumption rate of 115 l/c.d will be around Rp.50,000 and Rp.45,000 has been conservatively used in the example given in Table 10.9. The higher consumption rates will clearly relate to the higher income levels, as shown.

At around 3 percent of income, the water charges are within the guidelines normally adopted for determining the maximum that low income groups should pay for water. These range from 3 percent to 5 percent of family income. A further element of caution incorporated into the analysis is that no allowance has been made for a real increase in incomes. The rates proposed for 1984/85 have been compared (in 1980 prices) with 1980 income levels. It can be reasonably assumed that there will be some increase in real incomes between 1980 and 1985, thereby improving further the ability to pay the proposed rates.

10.4.4.4 Willingness To Pay

Although ability to pay the required rates can be assumed, willingness to pay does not automatically follow. With the easy availability of free ground water as an alternative source, there could be a reluctance to connect to the public system. It has not been possible to establish the price elasticity of demand for piped water, for several reasons:

- The price is artificially low at present and has remained unchanged since 1973.
- Water supply is intermittent and at low pressure so that actual consumption levels do not reflect desired consumption.
- The water connection charge at present is extremely high and gives no indication of willingness to connect at the proposed, much lower, rate.

A pattern which is likely to emerge is that water for consumption and personal use will be taken from piped supplies while water for other uses will be obtained from wells. This assumption is inherent in the low per capita consumption rate (115 l/c.d) assumed for planning purposes among lower income groups connected to the public system.

Willingness to pay higher (but reasonable) tariff rates will be engendered the more that the benefits of protected supplies are perceived. This will require a concerted effort of publicity and education to highlight the health benefits of public piped water compared to traditional polluted sources.

10.4.4.5 Non-Domestic Ground Water - Regulation and Charges

Of equal concern is the willingness of industrial and commercial consumers to pay the higher charges proposed when virtually free groundwater is available as an alternative. At present many industries use private groundwater and/or surface water for their requirements. The water demand projections assume, however, that there will be a gradual switch to public supplies as this service is improved and extended. To encourage such a pattern, control over groundwater extraction should be introduced; if effective water resource management is to be exercised, some form of licensing and allocation will be required. This is particularly the case as the proposed water augmentation program relies heavily on PAM Tirtanadi sinking new wells. This is the cheapest source of water available and to the extent that it is usurped by private industrial extraction it forces PAM Tirtanadi to find more expensive alternative sources of supply. This is clearly inequitable as these higher costs have to be borne by the multitude of small consumers served by the utility. There are strong arguments therefore for both regulating groundwater extraction and charging bulk users for it. Groundwater is an increasingly scarce resource and should be paid for.

In order to regulate and control the use of groundwater, it is recommended that all non-domestic wells are licensed and that, in future, the sinking of new wells is conditional upon the granting of a licence. In considering the issue of a licence account should be taken of:

- The purpose for which groundwater is used.
- The availability of groundwater.
- The effect on other sources of supply.
- The compatibility with the existing water supply system.
- The quality of water and pollution risks.

In excercising these licensing powers, it is recommended that the so-called appropriation rule is followed which treats appropriations prior to the regulation as vested rights, with subsequent appropriations being decided on the first-in-time, first-in-right maxim. Thus the rights of existing users would be registered and guaranteed and only for exceptional reasons would conditions or restrictions be imposed.

It is recommended that domestic wells are excluded from these provisions. The number of shallow dug domestic wells in Medan is unknown but is believed to be extremely high; the administrative costs of initial licensing and updating are therefore likely to be considerable. Also, any attempt at regulation in such a sensitive area is likely to lead to implementation problems. A pragmatic and probably cost-effective approach would be to recognise, as in the UK and USA for instance, the domestic user's de facto right to water under his property and make no attempt to charge for it.

There are different approaches which can be followed in charging for groundwater. A periodic flat charge can be imposed, varying by some water use indicator such as well dimensions or pump rating. Alternatively, and more equitably, meters can be installed and charges based on consumption. Which ever method is followed the charge should be fixed below that for public piped supplies to industry.

10.4.5 Summary

The level of charges necessary for PAM Tirtanadi to achieve the financial performance required by international funding agencies is within the ability to pay of the different consuming categories. To ensure a commensurate willingness to pay, the health and general hygiene advantages of piped supplies should be propogated by an intensive educational campaign among domestic consumers. Also, bulk groundwater users should either be connected to the public system as it is expanded or charged for their own extraction from the groundwater basin.

10.5 FINANCIAL PROJECTIONS

10.5.1 Introduction

Financial projections have been prepared for the period 1980/81 - 1989/90. These are based on the capital expenditure and operating and maintenance costs associated with the first stage program, together with PAM Tirtanadi's on-going operations. Possible investments in Repelita IV have not been included owing to the uncertain nature of these and the basis on which they might be funded. The exception to this is allowance for service connections in 1984/85 and 1985/86 to ensure full distribution of the additional water resulting from the project investments.

The financial statements - income statement, flow of funds statement and balance sheet - are shown in Tables 10.10 through 10.12.

10.5.2 Financial Assumptions

10.5.2.1 General

All financial calculations are in current prices, based upon the inflation assumptions for local and foreign costs provided by the Asian Development Bank (1980 to 1984 - see 10.2.1) and a composite rate of 7 percent from 1985 onwards.

10.5.2.2 Income Statement

Revenue. Water consumption is based on the demand projections by type of consumer given in the master plan and summarized in Table 10.13.

TABLE 10.11

P A M TIRTANADI - WATER SUPPLY
PROJECTED FLOW OF FUNDS STATEMENT
Rp. Million in Current Prices

	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90
Sources of Funds										
Income before depreciation	856	1717	1565	1912	3055	3400	4129	4375	4639	4929
Consumer contributions	-	-	77	144	303	456	417	416	355	290
GOI loan	-	-	5200	6500	-	-	-	-	-	-
GOI grant	1793	2207	-	-	-	-	-	-	-	-
Total sources	2649	3924	6842	8556	3358	3856	4546	4791	4994	5219
Application of Funds										
Project Investment	1793	3223	7441	8327	-	-	-	-	-	-
Other Investment	905	-	-	-	876	937	-	-	-	-
Other Investment	2698	3223	7441	8327	876	937	-	-	-	-
Increase/decrease in working capital	- 277	+ 277	- 186	+ 231	+ 549	+ 142	+ 184	+ 150	+ 163	+ 173
Loan interest	-	-	-	-	-	-	1053	1039	1024	1008
Loan amortisation	-	-	-	-	-	-	152	166	181	197
Total applications	2421	3500	7255	8558	1425	1079	1389	1355	1368	1378
Net cash generated	228	424	- 413	- 2	1933	2777	3157	3436	3626	3841
Opening cash balance	85	313	737	324	322	2255	5032	8189	11625	15251
Closing cash balance	313	737	324	322	2255	5032	8189	11625	15251	19092

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TABLE 10.12

P A M TIRTANADI - WATER SUPPLY
PROJECTED BALANCE SHEET
Rp. Million in Current Prices

	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90
Assets										
Fixed assets - water	10187	14525	19421	28738	39840	43514	47496	50700	54173	57910
Less depreciation	4216	5301	6642	8282	10444	12837	15547	18572	21945	25699
Net book value	5971	9224	12779	20456	29396	30677	31949	32128	32228	32211
Work in progress	2666	2965	7176	8327	876	937	-	-	-	-
Inventories	403	497	966	1105	414	444	375	401	429	459
Accounts receivable	1142	1447	1236	1459	2044	2194	2339	2492	2659	2835
Cash	313	737	324	322	2255	5032	8189	11625	15251	19092
Total current assets	1858	2681	2526	2886	4713	7670	10903	14518	18339	22386
Total Assets	10495	14870	22481	31669	34985	39284	42852	46646	50567	54597
Equity and Liabilities										
Revaluation surplus	4097	5047	6162	7752	9889	11956	14103	16219	18392	20593
Government equity	3519	5726	5726	5726	5726	5726	5726	5726	5726	5726
Operational surplus	1154	2250	3025	3848	5379	7117	8381	9780	11322	13025
Total Equity	8770	13023	14913	17326	20994	24799	28210	31725	35440	39344
Long term debt (net)	-	-	5200	11700	11700	11548	11382	11201	11004	10798
Accounts payable	396	518	962	1093	438	476	368	397	429	462
Current maturities	-	-	-	-	-	152	166	181	197	206
Total current liabilities	396	518	962	1093	438	628	534	578	626	668
Consumer contributions	1329	1329	1406	1550	1853	2309	2726	3142	3497	3787
Total Equity/Liabilities	10495	14870	22481	31669	34985	39284	42852	46646	50567	54597

Current Ratio	4.69	5.18	2.63	2.64	10.76
% Debt/(Debt + Equity)	0.00	0.00	25.85	40.31	35.79
Working Capital	1462	2163	1564	1793	4275

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TABLE 10.13

PROJECTED WATER CONSUMPTION
cu m (000) p.a.

Customer Type	1980/81	1981/82	1982/83	1983/84	1984/85 - 1989/90
Domestic	18,880	21,820	23,560	27,460	30,548
Commercial/ Industrial	6,300	8,610	9,040	9,605	9,766
Social	2,500	3,700	3,880	4,115	4,184
Standpipes	1,000	3,450	5,000	5,200	5,354
Port	320	420	520	620	714
Total	29,000	38,000	42,000	47,000	50,566

Water revenue projections incorporate the proposed real rate increases discussed in 10.4.2 and assume that the rate proposals submitted for approval, adjusted in line with our recommendations, will be effective from 1st August, 1980. However, at the time of writing, we understand that Tirtanadi's original proposals (without the modifications recommended here) have received Government approval. As the difference is very small it makes no material difference to the revenue projections. It is assumed that rates will be increased annually in the line with inflation.

In 1980/81 and 1981/82 consumer payments for new connections made by PAM Tirtanadi are shown as income, in line with current practice. From 1982/83 onwards, when the service connection program as part of the project commences, consumer payments for new service connections are included in consumer contributions in the balance sheet and flow of funds statements. Meter rents have been increased at the same percentage rate as new connections, with allowance for inflation.

Operating Expenses. Operating and maintenance expenses are as detailed in sub-section 9.6, adjusted for inflation.

Bad debts have been taken as 5 percent of revenues (excluding connection fees) for 1980/81 - 1984/85, decreasing to 3 percent therafter. This relatively high initial allowance is in anticipation of collection difficulties following the increase in tariff rates.

A further Rp.150 million in 1980/81 and Rp.157 million in 1981/82 has been charged to bad debts in respect of long outstanding amounts.

Taxes have been based on the current rates applicable to audited companies, as follows:

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1st Rp.100 million	- 20%
Rp.101 - 250 million	- 30%
Rp. > 250 million	- 45%

These rates are applied to the surplus remaining after deducting operating and maintenance expenses, depreciation and interest. The above tax rate bands have been adjusted annually for inflation on the assumption that periodic adjustments will be made by the central government.

No allowance has been made for a potential tax by the provincial government. Under the Perda regulations governing PAM Tirtanadi, the utility is liable to a 55 percent provincial tax - in addition to the central government tax. The provincial regulations do not clearly define surplus for purposes of taxation and the utility management are assuming that investment expenditure will be allowable before tax liability arises. This would be unusual by normal accounting/taxation practices but it is argued that the objective of generating an internal contribution to future investments will be severely undermined if the utility is taxed twice at such penal rates. This is a strong argument which is likely to be received sympathetically by a foreign aid donor.

Clearly this issue needs to be resolved and it should be borne in mind that if the surplus remaining after central tax payment is subjected to a further tax at the rate of 55 percent, this will substantially affect PAM Tirtanadi's cash flow and investment contribution potential. For instance, if Tirtanadi's projected cash position at the end of Repelita III (Rp.322 million) is considered to be around the desired level for operating purposes (equivalent to 5 weeks direct-operating expenses) this would still only be attainable if the proposed investment contribution from the utility was reduced by 55 percent.

Depreciation. The following depreciation rates have been applied to the project investments:

Asset	Rate %
Treatment plant	3.3
Bore wells	6.5
Transmission lines	2.5
Service reservoirs	2.5
Pumping stations	6.5
Distribution lines	2.5
Service connections	3.3
Public standpipes	6.5
Shallow wells	2.5

PAM Tirtanadi's existing assets have been depreciated at current rates. Depreciation is applied on a straight line basis.

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10.5.2.3 Balance Sheet and Flow Of Funds

Fixed Assets. An opening balance sheet was prepared based on Tirtanadi's accounting records and expected performance in 1979. This was prepared initially on an historic cost basis and then converted to a current cost basis. In order to do this, the only suitable index available (the Medan cost of living index) was applied to individual assets from their date of acquisition. As Tirtanadi maintains a detailed fixed asset register this method is likely to give a reasonable approximation to current values. The resulting opening balance sheet is summarised in Table 10.14.

TABLE 10. 14

PAM TIRTANADI - OPENING BALANCE SHEET
Rp. in Million

Assets		Liabilities	
Fixed assets	9,641	Revaluation reserve	3,789
Less depreciation	3,556	Equity	1,726
Net bbok value	6,085	Operating surplus	752
Work in progress	-	Accounts payable	232
Inventories	400	Consumer contributions	1,329
Accounts receivable	1,258		
Cash	85		
Total current assets	1,743		
Total Assets	7,828	Total Liabilities	7,828

Both existing assets and newly acquired assets have been revalued annually throughout the projection period based on the inflation rates discussed above. Backlog depreciation has been incorporated into the cumulative depreciation allowance for the purpose of deriving net fixed assets. This excess depreciation has in turn been deducted from the asset revaluation surplus.

Capital expenditure is shown as work in progress in the year of asset acquisition and transferred to fixed assets in the following year, from which time depreciation commences. This treatment is appropriate for most items of expenditure (wells and distribution lines) as they will be readily incorpated into the existing network and become quickly operational. The exception to this is the water treatment plant which has a longer construction period and remains as work in progress until completion at the end of Repelita III.

As from 1982/83, costs of new service connections are included in fixed assets and payments received from consumers for connections are credited to consumer contributions. Average connection costs of Rp.40,000, adjusted annually for inflation, are assumed. These would be payable one-fifth upon installation and the balance in equal monthly installments over a five-year period. No Interest charge has been included.

Working Capital. Accounts receivable are estimated at 4 months billings for 1980/81 - 1981/82, reducing to 3 months thereafter. This assumes that PAM Tirtanadi is able to improve its collection performance, particularly with the army and government institutions, where payment is made from Jakarta at infrequent intervals.

There is an amount of Rp.307 million in account receivables in the opening balance sheet made up of the amounts in respect of historical services rendered to two other public bodies. After discussion with PAM Tirtanadi management it is considered that these are uncollectable and have been written out over 1980/81 - 1981/82.

Inventories have been taken as 10 percent of current year capital expenditure and 25 percent of annual expenditure on materials.

Accounts payable are estimated at 10 percent of current year capex and one month's cash operating expenses.

Cash is calculated as a residual figure on the sources and application of funds statement.

Loan Terms. The sources of funds for the proposed investment program have been discussed in sub-section 10.3. The terms on which the loan finance would be made available was advised by GOI as follows:

- Loan repayment 30 years (including grace period of 6 years).
- Interest rate 9 percent per annum - waived during construction.
- Repayment by way at a flat rate annuity of Rp.1,205 million, commencing 1986/87.

Financing Plan. The financing plan for 1981/82 - 1983/84 derived from the source and application of funds statement is shown below:

Summary of Financing Plan 1981/82 - 1983/84

	Rp. Million	US$ Million	%
Application of Funds			
Project Cost	20,784	33.2	94.6
Other Costs	905	1.5	4.1
Working Capital	282	0.5	1.3
Total	21,971	35.2	100.0
Source of Funds			
GOI Loan	11,700	18.7	53.1
GOI Grant	4,000	6.4	18.2
Internal Cash Generation	6,050	9.7	27.6
Consumer Contributions	221	0.4	1.1
Total	21,971	35.2	100.0

It is anticipated that, at minimum, the foreign exchange element of the Phase II project costs would be lent to GOI by ADB. This represents Rp.7.7 million of total investment costs and would be on-lent by GOI to the project as part of its loan funding. It is understood that the foreign exchange requirements of the Phase I East Medan program would be met through Dutch aid.

10.5.3 Financial Evaluation

The projections resulting from the assumptions just discussed indicate a satisfactory financial performance.

The rate of return on revalued average net fixed assets (less consumer contributions) is in the range of 6 - 9 percent following completion of the project.

There is a positive cash balance throughout and the cash position builds up strongly towards the end of the decade. It is important to remember, however, that no investments beyond 1983/84 (apart from service connections in 1984/85 and 1985/86) have been included in the projections. Clearly capital expenditure will be required and what the projections show is that PAM Tirtanadi will be in a position to finance part of this from its own resources.

The ratios on the balance sheet (current ratio, debt/(debt + equity) ratio and working capital are all favourable during the project period. These have not been shown beyond 1984/85 as possible investments in Repelita IV have not been included. An unrealistically favourable position would thus be indicated if the performance ratios were shown for that period.

The combination of government grant finance in the early years, favourable loan terms, a generous grace period and increased tariffs result in a sound operating performance for the utility. Two points, however, should be emphasised:

1) While it is understood that the new tariff rates have been approved, rigorous enforcement will be essential. The increases are substantial, particularly for commercial and industrial consumers. This combined category is projected as accounting for around 70% of water sales revenue over the Repelita III period. This contribution is thus absolutely essential to the financial well-being of the utility. The possibility of these consumers opting out of the public supply in favour of groundwater following the tariff hike is very real (see sub-section 8.4.3.5.). This can be prevented by introducing groundwater exploitation regulations to control the sinking of new wells (see discussion in sub-sections 7.3.3.3 and 10.4.4.5). The latter must be subject to licensing by an appropriate authority and charges should be introduced for the bulk extraction of groundwater by both existing and new consumers.

2) As noted in discussing taxes (see 10.5.2.2) if PAM Tirtanadi is required to pay a provincial government tax at 55 percent in addition to the national government tax, this will substantially affect the utility's financial performance. Such a tax would absorb 90 percent of

the net surplus during Repelita III, thereby sharply reducing the anticipated internal investment contribution. This would necessitate higher loan and/or grant funding. Different views were expressed on whether both taxes would be payable but this clearly needs to be resolved before project funding details are finalised.

10.6 ECONOMIC EVALUATION

10.6.1 The inadequacy of the existing water supply facilities in Medan and the urgent need for improvement have already been discussed extensively in preceding sections of the report. The major short comings can be summarized as:

- Only 25 percent of the population are served by the public water supply system causing the majority of people to rely on alternative sources, the quality of which in many cases is not of potable standard.

- Even those connected to the system face health risks. Because of the low pressure in the system contaminated water can enter the system through leaks, plumbing fixtures, cross-connections and from private storage tanks when the pressure in these is greater than pressures in the system.

- Many public standpipes can only be used at night or during very brief periods of the day, leading to dependence on alternative contaminated sources.

- Wells are often adjacent to drainage ditches carrying wastewaters from privies and latrines.

- Most shallow wells (including public wells) are not designed, constructed or equipped to keep the water free of contamination from the surface.

- These is inadequate chlorination to maintain acceptable water quality in the distribution system.

The types of benefits which can be anticipated from the proposed investments are considered below, followed by calculation of the internal economic rate of return.

10.6.2 Benefits of Proposed Investments

10.6.2.1 Health benefits

The major benefit normally attributed to investments in water supply and sanitation is an improvement in the general level of health in the community. It is generally accepted that an adequate supply of water for drinking, personal hygiene and other domestic purposes are essential to public health and well-being.

The prevalence of water-related diseases in Medan has been discussed in Section 4. As is so often the case, the statistical data

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available for quantifying the incidence of different diseases is incomplete and so understates the true prevalence of diseases. Nevertheless, on the evidence available from public records and from investigations undertaken as part of the project studies, the unsanitary living conditions of many people in Medan has been unequivocally established. Diarrhoeal diseases are rampant, typhoid fever and hepatitis are endemic.

While the extent of water-borne and water-related diseases cannot be precisely quantified, it is reasonable to assume that the recommended improvement in water supply and sanitation would lead to improvements in health. It is important to realise, however, that for the maximum health benefits to be achieved widespread educational programs need to be undertaken. Improved drinking water and sanitary conditions are necessary conditions for health improvement, but they are not sufficient in themselves. For example, if through ignorance people continue to take water from polluted surface and groundwater sources or do not practice reasonable standards of personal hygiene, many of the potential benefits will not be realised. In addition to the obvious personal benefits of improved well being and lack of suffering which result from better health, there are two other benefits which often accrue: lower medical expenses and increased income and output. It is unlikely that these benefits will be significant in the case of Medan.

The extent of reduction in medical costs (if any) depends on the degree of health care supplied and the level of demand for public health care and services. As discussed in Section 4 of the Long Term Urban Plan Development report, the current provision of medical facilities in Medan does not meet the required needs. Increased expenditure on these facilities is considered essential and while a lower incidence of water related diseases may reduce the demand (and thus costs) for treatment of these specifically, this will merely release resources for use elsewhere in the medical system. In this sense, an indirect benefit can be claimed for the water improvement program if it leads to better treatment of other diseases.

The benefit of increased output and earnings in a community results if a reduction in mordibity and mortality enables a greater quantity of labor to be used in the local economy. In Medan, however, where there is considerable un-and under-employment, the economic costs of disease associated with lost earnings and productivity are likely to be very limited.

10.6.2.2 Fire prevention benefits

This would be a major benefit of the proposed scheme. There are very few working fire hydrants in Medan. The Phase I program would greatly increase their numbers as well as rehabilitate existing hydrants. Also, the increased water pressure in the system will greatly improve the city's fire fighting capability. As with improved health, it is impossible to quantify the benefits resulting from better fire control facilities. The statistics on the number of fires and damage caused by fires are incomplete. The published figure for fire damage in 1977 is $ 350,000 but as many fires go unrecorded this is likely to be understated. Certainly fire is a frequent hazard in the city where many of the structures are wooden,

and officers of Kotamadya Medan perceive improved fire control as one of the major benefits of the proposed water investments.

10.6.2.3 Other Benefits

There are other personal and economic benefits which could result from the water program. Under Phase I the number of standpipes would be greatly increased. This will reduce the time and effort required in carrying and fetching water for many poor people. This provides an obvious personal benefit. Whether a public benefit would also result depends whether the increased free time was used for the pursuit of more directly productive activities, thereby increasing economic output and earnings. Because of limited employment opportunities in Medan and because most water carriers are women and children, this is unlikely.

A final indirect economic benefit which can be associated with major capital investment schemes is the multiplyer effect. This is the short run increase in income generated when surplus capacity in the economy is activated by additional rounds of spending resulting from the investment. Certainly the MUDS program overall should produce a multiplyer effect in the local economy but quantification and subsequent allocation of this benefit to the different sectoral programs would be highly conjectural.

10.6.2.4 Valuation of Health, Economic and Social Benefits

In discussing the potential benefits of the water investment program emphasis has been laid on the extreme difficulties of quantification and valuation. Probably the most common method of solving this problem is to assume that the price the consumer is willing to pay is equivalent to the benefit value. Certain caution is needed however in using willingness to pay as a surrogate for benefit measurement. First, the price a consumer pays understates the true value of the service to him because of consumer surplus. Normally, a consumer would be willing to pay more than the actual price; only the value of the last unit purchased is likely to be as low as the price under conditions of unconstrained supply. Thus, taking price as the benefit measurement understates the true value to the individual. Second, the consumer does not normally take into account indirect and external benefits in his assessment of the value of the service to him. Such externalities include fire prevention, non-personal health improvements, and indirect economic benefits of the sort discussed above. Third, when increased tariff rates are proposed it is not certain whether willingness to pay will be forthcoming, even though ability to pay exists. This has been discussed in 10.4.4.

In the end, if the project is to be evaluated in anything other than purely qualitative terms, some basis for benefit quantification has to be selected. The proposed new water rates have therefore been taken. Although willingness to pay these has yet to be established, the fact that consumer surplus and external benefits would be additional (non-valued) benefits, make this a reasonable assumption.

10.6.3 Economic Costs

The project costs have been summarized in Table 10.1 and Appendix H. For economic analysis certain adjustments to these costs are necessary. Economic costs are real resource costs which means that inflation (a monetary phenomenon) and custom duties and taxes (internal transfer payments) are not taken into account. These have therefore been deducted from the project costs.

The other major adjustment which has been made is in respect of unskilled labour. This labour may be regarded as overvalued, in terms of its opportunity cost, particularly in the construction industry. There is considerable unemployment in Medan and it may be assumed that a certain proportion of workers used in construction work will be drawn from the ranks of the unemployed or workers will be attracted from other industries, which in their turn will employ some of the unemployed. From consideration of their alternative uses, their opportunity cost may be considered very low, i.e. the cost to the economy of employing previously unemployed or under-employed resources will be minimal. A shadow price of 0.5 times the actual market price has therefore been adopted.

No other major distortions are believed to exist between market and economic costs. It is common in developing countries for the rate of exchange to inadequately reflect the real worth to the economy of foreign goods, leading to an excess demand for the latter and to a shortage of foreign exchange. However, since the devaluation of the rupiah in November 1978, the rate of exchange can be taken as a realistic indicator of the true value of the Indonesian currency in the world economy, and no further adjustment is considered necessary.

10.6.4 Economic Internal Rate of Return

The economic rate of return on investment is the discount rate at which the present worth of the incremental capital and operating and maintenance costs of the proposed project over its economic life equals the present worth of the benefits attributable to it. The project life is taken as 50 years, with all costs and benefits being discounted to base year 1980, the first year of expenditure on the project. Because of the length of the discounting period, scrap values have been ignored. Regeneration costs - costs incurred in replacing capital equipment, mainly mechanical and electrical, which wear out during the project period - have been included.

The benefits are measured by incremental water sale revenues and service connection fees. All costs and benefits are in 1st January 1980 prices and are shown in Table 10.15.

Based on the above assumptions, the economic internal rate of return is 9.8 percent.

TABLE 10.15

WATER SUPPLY - ECONOMIC INTERNAL RATE OF RETURN

Year		Incremental Cost				Incremental Revenues			Net
		Capital	Replacement	O & M	Total	Revenues	Connection fees	Total	Flow
1	80/81	1,466		9	1,475	75		75	-1,400
2	81/82	2,370		53	2,423	232		732	-1,691
3	82/83	4,861		140	5,001	452	58	510	-4,491
4	83/84	5,043		308	5,351	884	104	988	-4,363
5	84/85	404		535	939	1,521	207	1,728	789
6	85/86	404		535	939	1,862	300	2,162	1,223
7	86/87			535	535	1,862	277	2,139	1,604
8	87/88			535	535	1,862	277	2,139	1,604
9	88/89			535	535	1,862	231	2,093	1,558
10	89/90			535	535	1,862	185	2,047	1,512
11	90/91			535	535	1,862	93	1,955	1,420
12	91/92			535	535	1,862		1,862	1,327
13	92/93		54	535	589	1,862		1,862	1,273
14	93/94		54	535	589	1,862		1,862	1,273
15	94/95			535	535	1,862		1,862	1,327
16	95/96		33	535	568	1,862		1,862	1,294
17	96/97		53	535	588	1,862		1,862	1,274
18	97/98		133	535	668	1,862		1,862	1,194
19	98/99		232	535	767	1,862		1,862	1,095
20-50									-1,295*
EIRR : 9.84%									

* The average net flow for years 20 - 50 taken.

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10.6.5 Financial Internal Rate of Return

The financial internal rate of return has been calculated on the same assumptions used for the economic rate of return, with the following two exceptions:

- Unskilled labor is costed at its market price.
- Taxes and duties are included (i.e. market prices are taken throughout).

The revenue and cost streams are shown in Table 10.16 and give a financial internal rate of return of 7.6 percent.

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TABLE 10.16

WATER SUPPLY - FINANCIAL INTERNAL RATE OF RETURN

Year		Incremental Cost				Incremental Revenues			Net
		Capital	Replacement	O & M	Total	Revenues	Connection fees	Total	Flow
1	80/81	1,692		9	1,701	75		75	-1,626
2	81/82	2,702		56	2,758	232		232	-2,526
3	82/83	5,691		147	5,838	452	58	510	-5,328
4	83/84	5,958		324	6,282	884	104	988	-5,294
5	84/85	576		563	1,139	1,521	207	1,728	589
6	85/86	576		563	1,139	1,862	300	2,162	1,023
7	86/87			563	563	1,862	277	2,139	1,576
8	87/88			563	563	1,862	277	2,139	1,576
9	88/89			563	563	1,862	231	2,093	1,530
10	89/90			563	563	1,862	185	2,047	1,484
11	90/91			563	563	1,862	93	1,955	1,392
12	91/92			563	563	1,862		1,862	1,299
13	92/93		75	563	638	1,862		1,862	1,224
14	93/94		75	563	638	1,862		1,862	1,224
15	94/95			563	563	1,862		1,862	1,299
16	95/96		46	563	609	1,862		1,862	1,253
17	96/97		74	563	637	1,862		1,862	1,225
18	97/98		186	563	749	1,862		1,862	1,113
19	98/99		325	563	888	1,862		1,862	974
20-50									1,255*
FIRR : 7.56%									

* The average net flow for years 20-50 taken.