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REPUBLIC OF GUATEMALA

MUNICIPAL WATER SUPPLY CORPORATION

OF GUATEMALA CITY (EMPAGUA)

FEASIBILITY STUDY ON THE GROUND WATER DEVELOPMENT PROJECT (FOR EMERGENCY I)

VOLUME 3
APPENDIX II

SEPTEMBER 1986

JAPAN INTERNATIONAL COOPERATION AGENCY

FEASIBILITY STUDY
ON
THE GROUND WATER
DEVELOPMENT PROJECT
(FOR EMERGENCY I)

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WATER SUPPLY

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CHAPTER I

INTRODUCTION

1.1 Objective Area

The Study area encompasses the Guatemala City Valley as delineated under Emergency Plan (I) of PLAMABAG, with particular focus on the northern sector thereof, and the neighboring basin to the east of Guatemala City Valley.

Guatemala City Valley is demarcated by mountain ranges to the east and west of the capital, the hilly zone to the north and a range of volcanic peaks to the south. The valley is 20 km east to west and 40 km north to south, with an area of 800 km^2.

The valley is bisected by the continental divide running from NNW to ESE, with both the portions of the valley north of the divide and south thereof assuming horseshoe configurations. The Las Vacas river system to the north of the divide empties into the Caribbean sea, while the Villalobos system to the south flows via Lake Amatitlan into the Pacific ocean.

Metropolitan Guatemala is situated roughly in the center of the Guatemala City Valley, and comprises Guatemala City and its surrounding urban area which constitutes a single culturally and socio-economically interlocked community. This area includes the municipalities of Mixco, Villa Nueva, Petapa, Santa Catarina Pinula and portions of the municipalities of Villa Canales, Fraijanes and Chinautla. The Metropolitan Guatemala area encompasses 470 km^2 and occupies approximately one-half of the Guatemala City Valley.

The relationship between Guatemala Department, Guatemala City Valley, Metropolitan Guatemala and Guatemala City is depicted in FIGURE 1.1.

EMPAGUA proposes to provide water service to all of Metropolitan Guatemala.

1.2 Population

1.2.1 Population

According to the 1981 census, the population of Metropolitan Guatemala was 1,134,072 persons, or 15% of the entire population of Guatemala and 86.5% that of Guatemala Department. The population of Guatemala City was 754,243. As of 1985, the population of Metropolitan Guatemala is estimated at 1.5 million.

The population of Metropolitan Guatemala increased 99.9% from 1940 to 1950, and 105% from 1950 to 1964. Rate of increase subsequently slowed to 38.8% for 1964-1973, and to 18.4% for 1973-1981.

Annual population growth rate for Metropolitan Guatemala was 6.62% in the 1940's, 4.51% in the 1950's, 3.49% in the 1960's, and 2.14% in the 1970's.

1.2.2 Households

As of 1980, there were an estimated 204,509 households in Metropolitan Guatemala. Average number of persons per household was 4.7. Households residing in 2 room dwellings accounted for 21.3% of the total. Households occupying dwellings of 3 rooms or less corresponded to 57% of total households.

1.2.3 Employed Population

In 1980, 35% of the total population of Guatemala was employed. Unemployment was 3.6%. An average 1.9 persons were employed per household, with total employed population at 379,723. The ratio of male to female employed persons is 7 : 3. About 25.7% of the working population is self-employed.

According to the census results in TABLE 1-1 to 1-3, the following can be noted.

(1) Comparison between 1964 and 1973 shows that:

(1) These has been a remarkable decrease of population in Zone 5.

1, 3, 4, 9, 17

(2) There has been a remarkable decrease in the number of households in Zone 4.

1, 3, 4, 17

(2) Comparison between 1973 and 1981 shows that:

(1) There has been a remarkable decrease of population in Zone 10.

1, 2, 3, 4, 5, 6, 8, 9, 10, 12

(2) There has been a remarkable decrease in the number of households in Zone 7.

1, 3, 4, 5, 8, 9, 10

(3) The 1981 census had an extremely poor collection ratio of 70% due to the political instability at the time. The influence of this shows in the results (2) above.

1.3 Urban Development

With the rapid population increase in Metropolitan Guatemala, the available area in and surrounding Guatemala City has been steadily converted. The city itself consists of 22 zones roughly demarcated by rivers dissecting the area, and principal roads. Urban development in the city can be thought of a occuring historically in essentially the same sequence as the zones are numbered.

Geographicaly, zones are located as follows:

center:	zones 1, 3, 4, 8, 9
north:	zones 2,6,8
east:	zones 5, 10, 15, 16, 17
west:	zones 7, 11, 19
south:	zones 12, 13, 14

For the purpose of administering its water service system, EMPAGUA groups the zones as follows:

center:	zones 1, 2, 3, 4, 5, 8, 9, 10
northeast:	zones 17, 18, (24), (25)
north:	zones 6, Chinautla
southeast:	zones 15, 16
west	zones 7, 19, Mixco
south:	zones 11, 12, 13, 14, 22

In the case of Guatemala City, application for urban development of an area is made through the municipal government and approval granted following application review within the procedures of EMPAGUA. As shown in TABLE 1-4., 45 applications are currently in progress for both commercial and residential areas, and a breakdown by zone is as follows:

Zone 18	:	9 applications
12	:	7
11	:	6
6	:	5
7	:	5
17	:	4
16	:	4
5	:	2
1	:	1
2	:	1
13	:	1

Urban development being implemented under National Housing Bank (BANVI) financing in zones 6 and 18, which bear a direct relationship to the subject Project, is presented in TABLE 1-5.

1.4 Land Use in Metropolitan Guatemala

The Metropolitan Guatemala area consisting of some 470 km^2 includes the capital city and urban segments of surrounding municipalities. Its land use pattern is conspicuously charaterized by dissected gulleys intruding into the plateau of the city. This is caused by surface erosion and gives a petalled contour to the north and south of the city. As shown in FIGURE 1-2, steep ravines sometimes deeper than 100 m make nearly 30 percent of the Metropolitan area unsuitable for urban or any other productive purposes. It is observed, however, that recent immigrants are squatting on slopes of ravines by constructing clusters of small shacks. Such a situation readily shows the inadequacy of housing areas along the city perimeter.

From the central plateau of the Guatemala City Valley, Guatemala City does not spread along the land with comparatively moderate slopes. It is reckoned that some 30 precent of the area has a gradient of less than 4 percent, 30 percent with a gradient 4 to 16 percent, 20 percent with gradient 16 thru 32 percent and the remaining 20 percent of the area has gradient over 32 percent. Though lands are classified as such, their extensions are fragmented into small pieces except the central plateau. Land use patterns in the peripheral suburban centers are thus restricted by orogenic patterns, where recent housing developments are prevailing.

In 1982, the National Housing Bank (BANVI) prepared design criteria for urban development, which gives standards of typewise housing area developments. Five types of residential areas are clasified according to costs for construction and population densities to accommodate. The BANVI itself and the other private housing developers are encouraged to follow these criteria. At a given lot of land, however, the type can be selected arbitrarily by the developer. Therefore, land use controls based on the characteristics of the land are not effectively given. Also, no comprehensive strategy for urban develoment or land use covering the city or the metropolitan area has been established.

Owing to the above described situations, the existing land use pattern has been developed along the line of physical restrictions and economic efficiencies. A present land use pattern in FIGURE 1-3

shows that the density populated commercial center is located downtown. This area, forming the city center including governmental and public buildings, remains the core of the city throughout the historical development. It is also observed that urbanization reached the physical boundary of the plateau before 1970, and henceforth its trend has turned toward development on land with moderate slopes which are adjacent to but separated from the plateau.

Based on the data provided by National Forest Institute (INAFOR) and municipal sources, approximate distribution of present land use is estimated as follows:

PRESENT LAND USE IN METROPOLITAN AREA

	Area (km^2)	Share (%)
Residential use	97.9	20.9
Commercial use	3.7	0.8
Public and institutional	10.8	2.3
Industrial use	8.4	1.8
Green area and forest	88.5	18.9
Agricultural use	119.0	25.4
Others[1/]	140.1	29.9
Total	468.4	100

Note[1/]: Others include uncultivated grassland used for natural pasture.

It is noted that green area, forest and cultivated croplands are located sporadically and in small fragments over the area, and significant concentrations are not observed in the Metropolitan area. Most of conventional agriculture is maintained on slopes of mountains, which have been deafforested over the years. Such fields are subject to frequent erosion even in the cropping season.

Due to the absence of a future land use plan which is comprehensively coordinated among sectors of social infrastractures, individual sectors such as of transportation facilities and water supply services have projected long range master plans for their sectors. A Master Plan for Transportation in Guatemala City and the Metropolitan Area, 1978, and a Master Plan for Water Supply in Guatemala City (PLAMABAG), 1982 are two such plans.

As indicated in FIGURE 1-4, the master plan for transporation proposes as guiding strategy two circular roads surrounding the capital zones. Since this master plan is projected on basis of the urbanization structure which is delimited by physical restrictions and socioeconomic potential for development, its forecast of future development in terms of housing and industries is considered acceptable and in accordance with the present trends. For example, two suburban centers are projected in and adjacent to Zones 18 and 6, and an external circular road is proposed through them. Projected locations of these centers are already deafforested flat lands suitable for residential purposes, while most of them are utilized for uncultivated natural pasture. The growth rate of most suburban centers along the proposed external circular road is expected to accelerate with the eventual construction of the road which is now pending.

PLAMABAG also developed a future land use plan, which is projected on basis of the existing trend in each of the diversely fragmented pieces of the area to forecast the saturated population of some 12.65 million in 2,200. While this land use pattern seems to have little implication of guiding strategy of inhabitation, peripheral-areas are expected to house more of the population in the future. Thus areas are located in proxy of the aforementioned circular road. It is therefore observed that rapid urbanization is expected in areas in Zones 17, 18 and 6, around Zone 19 and Mixco.

TABLE 1-1 POPULATION CENSUS (1981)

Zone	Male	Female	Total	Private Housing	Urban Population	Rural Population
1	26,201	31,127	57,328	12,013	57,328	
2	8,714	11,515	20,229	4,196	20,229	
3	21,921	24,993	46,94	10,226	46,914	
4	2,014	2,186	4,200	884	4,200	
5	35,172	38,871	74,043	15,191	74,043	
6	35,915	38,096	74,011	14,935	74,011	
7	53,318	60,099	114,517	22,672	113,417	
8	9,745	10,649	20,394	4,439	0,394	
9	1,989	2,878	4,867	1,046	4,867	
10	6,306	8,496	14,802	3,030	14,802	
11	22,234	27,494	49,728	9,997	49,728	
12	20,464	22,845	43,309	8,902	43,309	
13	10,903	12,258	23,161	4,610	23,161	
14	7,901	8,843	16,744	3,213	16,744	
15	5,749	8,004	13,753	2,645	13,753	
16	2,706	2,687	5,393	1,013	5,393	
17	4,257	4,378	8,635	1,646	8,635	
18	45,657	48,124	93,781	17,974	93,781	
19	13,660	14,870	28,530	5,850	28,530	
22	14,734	16,070	30,804	6,162	30,804	
24	2,826	2,678	5,504	991	5,504	
25	2,376	2,320	4,696	888	4,696	
Guatemala City	354,762	399,481	754,243	152,523	754,243	
Chinautla	20,388	21,294	41,682	8,273	2,027	39,655
Mixco	94,869	102,872	197,741	38,170	11,544	186,197
Villa Nueva	35,101	35,968	71,069	13,821	20,236	50,833
San Miguel Petapa	6,584	6,687	13,271	2,398	3,766	9,505
Villa Canales	19,978	19,331	39,309	7,445	3,605	35,704
Sta. Catarina Pinula	8,626	8,761	17,387	3,249	4,272	13,155
TOTAL	540,308	594,394	1,134,702	225,879	799,693	335,049

TABLE 1-2 POPULATION CENSUS (1973)

Zone	Male	Female	Total	Private Housing	Urban Population	Rural Population
1	37,620	45,551	83,171	15,919	83,171	
2	9,461	12,789	22,250	4,143	22,250	
3	27,682	30,992	48,674	10,790	58,674	
4	2,585	2,733	5,318	1,006	5,318	
5	39,986	44,340	84,326	15,340	84,326	
6	36,702	39,753	76,455	13,371	76,455	
7	41,275	46,098	87,373	15,439	87,373	
8	12,423	13,469	25,892	5,187	25,892	
9	2,910	4,586	7,496	1,433	7,496	
10	8,888	10,557	19,445	3,327	19,445	
11	21,851	26,759	48,610	8,257	48,610	
12	23,893	26,212	50,105	8,203	50,105	
13	8,726	9,478	18,204	3,078	18,204	
14	7,025	8,081	15,106	2,806	15,106	
15	4,497	6,442	10,939	1,862	10,939	
16	2,014	2,057	4,071	740	4,071	
17	3,906	3,106	7,012	1,093	7,012	
18	15,210	15,546	30,756	5,183	30,756	
19	12,694	13,446	26,140	4,118	26,140	
22	6,106	6,427	12,533	2,526	12,533	
24	1,844	1,761	3,605	734	3,605	
25	1,546	1,477	3,023	592	3,023	
Guatemala City	328,844	371,660	700,504	125,147	700,504	
Chinautla	16,255	16,508	32,763		26,762	6,001
Mixco	62,695	67,183	129,878		115,015	14,863
Villa Nueva	21,145	20,937	42,082		32,494	9,588
San Miguel Petapa	4,053	4,025	8,078		2,661	5,417
Villa Canales	16,405	15,369	31,774		3,356	28,418
Sta. Catarina Pinula	6,531	6,403	12,934		3,129	9,805
Total	455,928	502,085	958,013		883,921	74,092

TABLE 1-3 POPULATION CENSUS (1964)

Zone	Male	Female	Total	Private Housing	Urban Population	Rural Population
1	44,641	51,554	96,195	17,536	96,195	
2	9,650	12,596	22,246	4,104	22,246	
3	29,204	31,707	69,911	11,735	60,911	
4	4,407	3,767	8,174	1,335	8,174	
5	36,305	40,018	76,323	14,141	76,323	
6	31,083	33,377	63,360	11,981	64,460	
7	29,087	31,095	60,182	13,201	60,182	
8	11,882	13,356	25,238	4,909	25,238	
9	3,342	4,856	8,198	1,333	8,198	
10	7,149	9,212	16,361	2,800	16,361	
11	16,757	18,305	35,062	6,082	35,062	
12	20,255	21,394	41,649	7,456	41,649	
13	5,170	5,685	10,855	1,844	10,855	
14	4,151	4,769	8,920	1,570	8,920	
15	1,705	2,206	3,911	683	3,911	
16	1,863	1,868	3,731	659	3,731	
17	3,975	3,412	7,387	1,212	7,387	
18	4,662	4,555	9,217	1,621	9,217	
19	6,881	7,353	14,234		14,234	
22						
24						
25						
Guatemala City	272,169	301,085	573,254		573,254	
Chinautla	10,110	10,545	20,655		2,601	18,054
Mixco	18,152	18,788	36,940		7,756	29,184
Villa Nueva	8,777	8,700	17,477		7,236	10,241
San Miguel Petapa	1,716	1,657	3,373		2,035	1,338
Villa Canales	13,837	13,059	26,896		2,373	25,523
Sta. Catarina Pinula	4,761	4,739	9,500		2,121	7,288
Total	329,522	358,573	688,095		597,376	91,628

TABLE 1-4 APPLICATION FOR URBAN DEVELOPMENT

(1)

Nos.	NAME	NUMBER OF HOUSES	ZONE	l/s	AREA (ha)		
1	NUEVA CHINAULTA		6	3.544			(BANVI)
2	EL RODE YSN. MARTIN		7	7.02	1.285	"	
3	LINEA JARDINES		5	32.00	75.60		
4	EL EDEN	362	5	9.16	8.30		
5	LINEA MIRA FLORES		11	41.09			
6	PAMPLONA		13	18.80	64.44	"	
7	JABANA ARRIBA	300	16	7.54	29.86		
8	PROYECTO LO DE ROARIGUE 2 AND ROARIGUITOS		18	139.75	457.93		
9	COLONIA EL ROSARIO	460	18	7.89	15.96	"	
10	PROYECTO EL YALLE AND EL RINCONCITO	285	18	3.51			
11	LINEA 21-A		18	69.0			(BANVI)
12	LOTIFICATION AVENIDA DE LOS ARBOLES	28	1	0.567	0.83		
13	LOTIFICATION JARDIN EL ZAPOTE		2		0.455	"	
14	SAN JUAN DE DIOS I AND II	155	6	5.15	6.43		
15	COLONIA 30 DE JUNIO JOYITA DE SN. ANTONIO	296	6			"	
16	COLONIA MARTINICO II	236	6	3.10	5.17	"	(BANVI)
17	COLONIA ADE FEBRERO	850	6	8.60	10.65	"	"

Cont'd (2)

Nos.	NAME	NUMBER OF HOUSES	ZONE	l/s	AREA (ha)	
18	COND. LA ARBOLEDA		7	1.25	1.04	
19	RESID. JACRARNDAS	47	7	0.65	1.05	
20	NINO DORMIDO AND KJELL LAUGERUP	377	7	3.02	2.23	(BANVI)
21	EL ANPARO	2.259	7	25.36	3.76	"
22	RESIDENCIAL V	282	11	5.74	13.08	
23	PROY. LAS MAJADAS	800 548	11	9,842	22.67 19.45	
24	RESID. MIRAFLORES	407	11	9.00	11.90	
25	RESID. EYCLUSIVAS MIRAFLORES		11			
26	NINA JUYA	3.456	12 21	48.00	53.36	
27	LOS CEDROS	190 195	12	2.37	6.82	
28	SOLUVIONES ECONOMICAS	43	12	0.63	0.467	
29	COLONIA MORSE		12	2.08	10.45	
30	VILLA LOBOS I	2.309	12	29.04	35.0	
31	MONTE MARIA III (AMDLIACION)	57	12			
32	SN. RAFAEL GUAJITOS	90 93	21 12	2.0	2.81 2.724	
33	JACARANDAS DE CAYALA	1221	15 16		247.22	
34	LOTIFICACION LA MONTANA	302	16	9.79	51.99	
35	KANAJOYU	503	16	1702	63.32	
36	RESIDENCIALES DEL NORTE	775	17	19.27	22.55	

Cont'd (3)

Nos.	NAME	NUMBER OF HOUSES	ZONE	1/s	AREA (ha)
37	COL. DEL COLEGIO DE MAESTROS	858	17	15.77	9.73
38	RESID. COVITIGSS	110	17	1.91	3.283
39	COVIFIARI (GROUPO 20)	20	18	0.748	0.698
40	LOS DARDANELOS	580	18	14.61	9.64
41	ALAMEDA NORTE	650	18	6.61	
42	RESIDENCIALES ATLANTICO	292	18	10.64	4.72
43	LOTIFICATION SN. AGUSTIN	153	18	1.594	6.56
44	SN FERNANDO	29	11	0.80	0.487
45	LA HACIENDA REAL	596	16 17		

TABLE 1-5 URBAN DEVELOPMENT IN ZONE 6 AND ZONE 18

Zona 6

8	Cipresales III (4-10)	200
10	" IV	325
13	Bienestar Social	34
31	El Quintanal	595
32	4 de Febrero Zona 6	74
33	30 de Junio	194
34	San Juan de Dios I	298
35	San Juan de Dios II	152
55	Tecun Uman II	171
65	Nueva Chinautla	401
TOTAL	10	2,444

Zona 18

17	San Refael La Laguna 1	322
21	" 2	704
22	" 3	820
23	La Alameda	2.003
36	El Paraiso 1	783
37	" 2	2.944
38	Alameda Norte	659
39	El Limon	1.610
40	Santa Elena 2	310
41	" 3	573
43	Los Pinos	309
TOTAL	11	

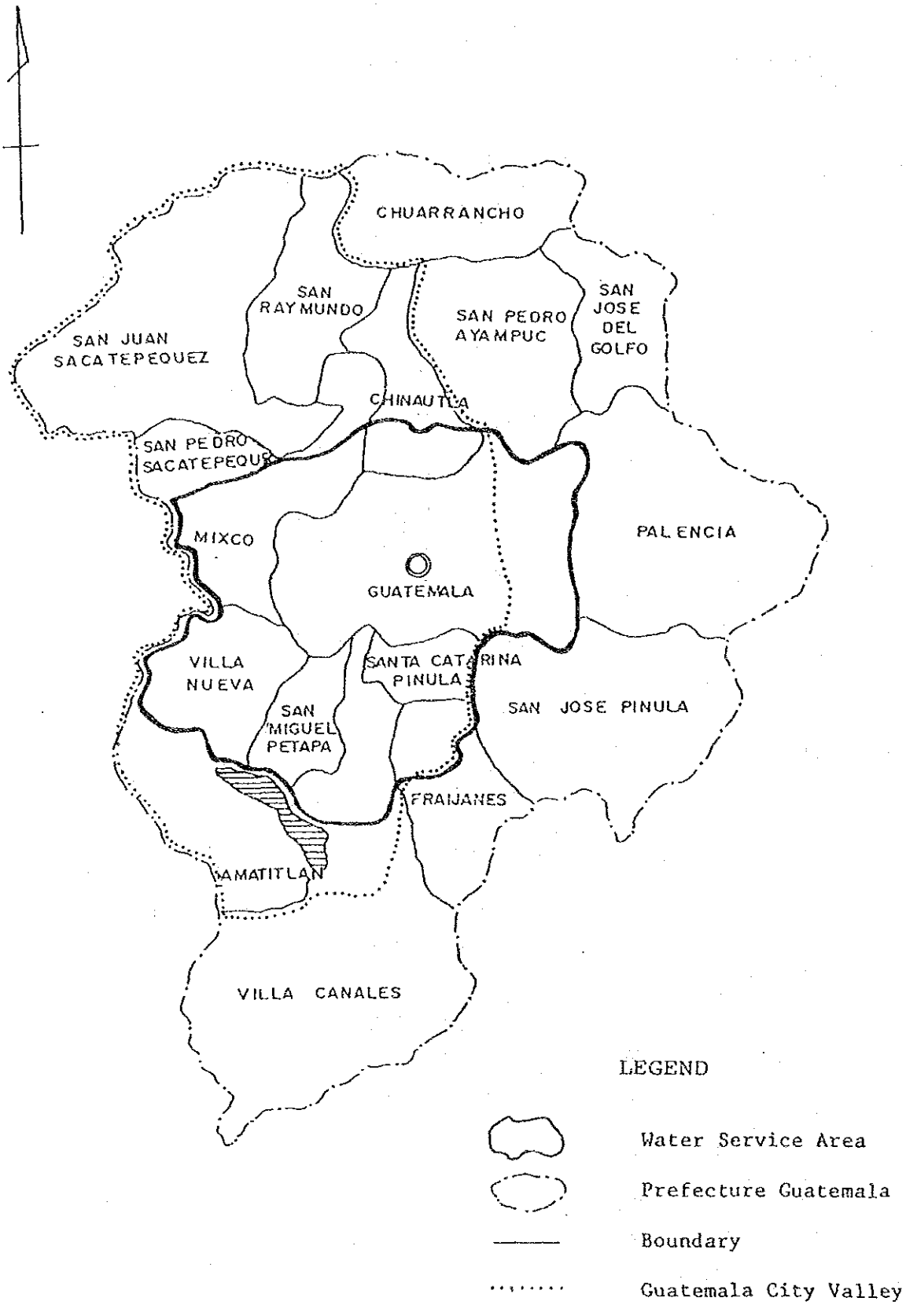

FIG.1-1 WATER SERVICE AREA (METROPOLITAN GUATEMALA)

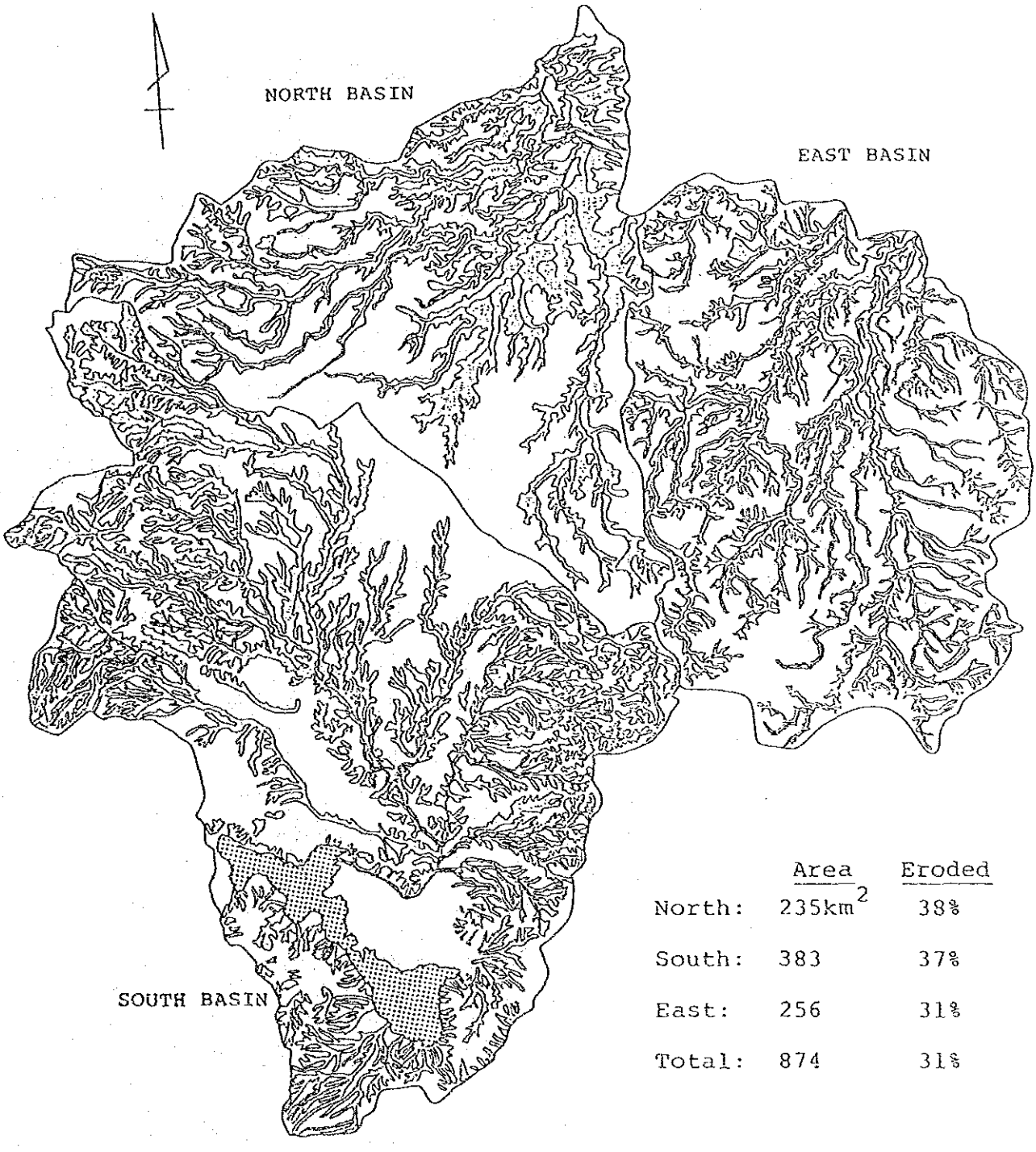

FIG. 1-2 SURFACE SOIL EROSION AND GULLEY INTRUSION

CHAPTER II

PRESENT STATUS OF WATER SERVICE

2.1 Water Service Entities

Water service in Metropolitan Guatemala is provided by EMPAGUA, and various private water supply companies principal among which is MARISCAL. Major water supply is as follows:

(1) EMPAGUA

EMPAGUA is a public corporation created in 1972 on the basis of an agreement between the Government of Guatemala and Guatemala Municipality, and is engaged in water supply and sewerage service.

In line with national development policy, EMPAGUA was moved forward with plans to expand and upgrade its water service system. In particular, the Guatemala City Water Supply Master Plan (PLAMABAG) was completed in 1982 which aims to address water shortage problems to the year 2010. The Emergency Plan (I) component of (PLAMABAG) is formulated to alleviate shortages over the short-term (1988-1995) and EMPAGUA is seeking its prompt implementation.

(2) Private Water Supply Companies

Principal among private water supply companies is MARISCAL, S.A. The company utilizes the Mariscal river to the west of the city as its main water source and has been providing water service to parts of Guatemala City since 1930

(3) Independent water supply systems maintained by the military, government institutions, schools, hospitals, etc.

(4) Independent wells maintained by hotels, office, factories, etc.

(5) Direct drafting of domestic water from springs and rivers by local population.

2.2 Existing Facilities

The existing water supply system within the Study area consists primarily of the EMPAGUA service network, the MARISCAL supply system, the military supply system, independently operated wells at hospitals, hotels, etc., and other private wells.

The EMPAGUA system encompresses purification plants at Lo de Coy, Ojo de Aqua, Santa Luisa, Las Ilusiones, El Cambray and La Brigada. It likewise includes a network of wells situated throughout Guatemala City. Water services for the EMPAGUA system consist of surface flows, springs and groundwater.

The Team conducted a field survey of the above existing water supply systems and utilized the results thereof as a parameter for groundwater development planning in the Study area.

(1) EMPAGUA Supply System

1) Lo de Coy Supply Network

This supply network centers on the Lo de Coy plant located in MIXCO in the southwest of Metropolitan Guatemala.

Water resources:	the Xaya River; Pixcaya river; El Tesoro river	
Related Structures:	12 tunnels, total length 13.5km 27 syphons, total length 8.5km	
Discharge:	Maximum (actual) 1.5m^3/s Mean (annual) 0.88m^3/s	
Condition:	Good	
Lo de Coy Treatment Plant:	EL1680m	
Capacity of Treatment plant:	max.:	86.800m^3/day (theory) 101,000m^3/day (practice)
	mean:	76.370m^3/day (1980-83)

Treatment Plant:	Flocculation, canal with screen Decantation, chute (gravity) Filtration, chute (gravity) Disinfection, chloro liquid
Distribution Tank:	Lo de Coy (1 tank) mean level: 1.675.60 m capacity: 25,40m^3
Service Zone:	Lo de Coy - La Brigada networks (through Lo de Coy, Belen and La Brigada); TP-9-El Guarda networks (through TP-9); Central city networks (through TP-1, TP-2 and El Guarda)
Measurement:	
Entrance to the plant:	Parshall flume, hour hand reading
Exit of filter:	Parshall flume, hour hand reading
Exit of distribution tank:	velocity gauge (out of service)
Level of distribution tank:	hour hand reading

Problem with existing facilities:

Existing pipeline in the vicinity of Lo de Coy plant is of varying diameter, preventing nationalization of the water distribution system.

2) Ojo de Aqua Supply Network

This network centers on the Ojo de Aqua plant locatd in the southern position of Metropolitan Guatemala.

Water resources:	Spring at Ojo de Agua (gravity); El Diamante Wells (4 horizontal pumps); The plant Wells (4 vertical pumps)
Production Volume:	mean 48,940m^3/day (1980-83)
Conveyance Pipeline:	Two pipe lines of 450 mm diameter, made of cast iron pipe with mortar cement lining inside are installed

	up to the El Guara distribution tank. Total length of pipeline is 20,400 m (10,200 m length each).
Ground level of El Guarda Distribution tank:	EL 1544.74
Tank capacity (2 tanks):	12,805m^3
Service Zone:	Middle networks (through El Guarda); Ojo de Agua-Cerro Gordo networks (through Cerro Gordo)
Measurement:	
Entrance to the Plant:	Partial with narrow crest rectangular sink without lateral contractions L=1,30 m, only for the wells of El Diamante.
Exit of the Plant:	Velocity gauge (out of service)
Entrance of Distribution Tank:	Two vertical wells with rectangular fin crest sinks without apparent lateral contraction L=1.07 m, hour hand reading.

Problem with existing facilities:

High water pressure in the vicinity of the pump station, and malfunctioning valves on the conveyance pipeline prevent proper water management.

3) Santa Luisa - Acatan Supply Network

This supply network centers on the Santa Luisa plant in the eastern part of Guatemala City.

Water resources:	El Teocinte dam (the rivers of El Teocinte, La Piedrona and San Jose Pinula); the Acatan river; move than 30 small spring; the canalitos rever

El Teocinte - Santa Luisa:	Two conveyance pipe lines of 14.2 km length made of cast iron pipe, without lining. One is 450 mm in diameter and the other is 500 mm in diameter.
Total conveyance discharge:	mean 0.264m^3/s (1980-83)
Acatan - Santa Luisa:	One conveyance pipe line of 7 km length ø600 mm L = 400 m (cast iron) ø300 mm L = 1,300 m (cast iron) ø400 mm L = 5,300 m (concrete)
Conveyance discharge:	mean 0.064m^3/s (1980-83)
Canalitos - Santa Luisa:	3 vertical pumps are installed at Canalitos intake weir. Pipe line (1) is 2.6 km in length; ø200 mm; cast iron without lining
Conveyance discharge:	mean 1,540m^3/day (1980-83)x
Capacity of Treatment Plant:	EL 1564 m max.: 40,000m^3/day (theory) 38,000m^3/day (practice) mean: 30,080m^3/day (1980-83)
Treatment Plant:	
Eloculation:	canal with screen
Decantation:	high ratio metal plate
Filtration:	high pressure
Disinfection:	cloro-liquid
Distribution Tank:	Acatan (2 tanks) mean level: 1,550.50 capacity: 41,810m^3
Service zone:	middle networks

Measurement:

Entrance to the Plant:	Four vertical wells with rectangular fin crest sink without apparent lateral contractions; hour hand reading.
Pipeline Length:	Canalitos + Sta. Rosita L = 1,485 m Teocinte ø500 mm L = 1,485 m Teocinte ø450 mm L = 1,475 m Acatan L = 1,078 m
Entrance Tank of Distribution:	Two vertical wells with rectangular narrow crest sink without apparent lateral contractions L = 1.55 m, without hour hand reading, of similar characteristics, but with lateral contractions L = 1.98 m with hour hand gauge.
Exit of Distribution Tank:	no existing facilities
Water level of Distribution Tank:	hour hand reading

Problem with existing facilities:

A gravity dam was constructed on the Teocinate river in 1936. In order to increase intake, diversion works were constructed in 1953. However, due to inadequate desilting at the said diversion works, sedimentation build-up is marked along the length of the induction canal to the Santa Luisa plant. Dredging and filter replacement to deal with this problem requires a large expenditure each year.

In addition, the earthquake of 1976 damaged the desilting basin of the Santa Luisa plant, even further diminishing the filtering capabilities.

4) El Cambray Supply Network

This supply network centers on the El Cambray plant located in southeast Guatemala City.

Water resources:	Pinula rever and Las Minas River;
	Hincapie pumping station;
	Pinula river

Pinula, Las - Minas - El Cambray:

Induction canal/pipe line of 8 km length from Las Minas dam is in bad poor Induction pipeline of 1.2 km length from the Pinula river is in good condition.

Total discharge: mean 0.081m^3/s (1980-83)

Hincapie - El Cambray

4 vertical pumps are installed at intake weir. One is an induction pipe line of 350 mm diameter made of cast iron. Total length of pipe line is 4,490 m from pump station to El Cambray treatment Plant. Cast iron pipes are lined with mortar cement.

Discharge:	mean:	7,910m^3/day (1980-)
Capacity of	max.:	16,000m^3/day (theory)
Treatment plant:		19,000m^3/day (practice)
	mean:	15,240m^3/day (1980-83)

Treatment Plant:

Floculation:	canal with screens
Decantation:	chute (gravity)
Filtration:	chute (presure)
Disinfection:	chloro liquid

Distribution Tank:	El Cambray (2 tanks)	
	mean level:	1,592.50 m
	capacity:	3,300m^3
	mean level:	1,605.49 m
	capacity:	2,820m^3

Service Zone:	El Cambray - Vista Hermosa networks central city networks.
Measurement:	
Entrance to the Plant	Two vertical wells with rectangular fin crest sinks, without apparent lateral contractions, hour hand reading. Dams L = 1.39 m Hincapie L = 1.36 m
Entrance to Distribution Tank:	none
Level of Distribution Tank:	hour hand reading

Note: The spring Agua Bonita is located within the El Cambray system, and is situated near the El Cambray plant (2 km to the northeast thereof). The spring has a mean annual production of $340m^3$/day (1980-83), supplied by gravity the El Cambracy - Vista Hormosa network through a distribution tank (mean elevation 1,735 m and capacity of $895m^3$). Treatment consists solely of disinfection with hypochloride. This source has been utilized by the City since 1955.

Problem with existing facilities:

The induction pipeline is old and in a deteriorated condition. Likewise, the filter at the El Cambray Plant has deteriorated with age and no longer functions adequately, with adverse effects for the plant facilities in general and the water supply tank in particular.

5) Las Ilusiones Supply Network

This supply network centers on Las Ilusiones Plant situated in Zone 18, northeast Guatemala City.

Water resources:	the rivers of Bijague, Ocotos and Teocinte; El Atlantico pumping station
El Atlantico - Las Ilusiones:	4 vertical pumps are installed at El Atlantico. One pipe line of 500 mm diameter made of cast iron with mortar cement lining inside is installed up to the treatment plant. Total length is 5,800 m.
Discharge:	mean 15,380m^3/day (1980-)
Las Ilusiones Treatment Plant:	EL. 1564 m
Capacity of Treatment Plant:	Max.: 25,000m^3/day (theory) 21,500m^3/day (practice) Mean: 15,380m^3/day (1980-83) 1/
Treatment Plant:	
Flocculation:	in chimney of decantation
Decantation:	decant floculation type "Pulsator"
Filtration:	gravity chute type "Aquazur"
Disinfection:	cloro-liquid

1/ Mean production is restricted by the turbidity of the water reaching the plant, for which EMPAGUA is studying implementation of a pre-sedimentation plan at the pump station during periods when turbidity of water is greater than that which the treatment plant can handle. It is expected that this will increase mean production.

Distribution Tank:	Las Ilusiones,
mean level:	1,558.51 m
capacity:	4,150m^3
Service zone:	Las Ilusiones networks (Zone 17, 18)
Measurement:	
Entrance to the Plant:	Venturi gauge (out of service) and one vertical well with two rectangular sinks without apparent lateral contractions L = 1,575 m
Entrance to Distribution Tank:	none
Exit of Distribution Tank:	Velocity gauge (out of service)
Level of Distribution Tank:	hour hand reading

Problems with existing facilities:

Due to absence of desilting basin at intake weir, water pumped at El Atlantico pump station is of excessive turbidity. Also, as the Las Ilusiones plant facilites are of iradequately small scale, current water demand cannot be met, highly turbid discharge during the rainy season in particular, cannot be appropriately purified at the plant.

Further population increases will require new groundwater development to meet demand in the area serviced by this system.

6) La Brigade Supply Network

This supply network centers on the La Brigada plant located in Mixco, west of Guatemala City.

Water resources:	La Brigada dam; the rivers of El Milagro, Las Limas, Pancocha, Pansalic and La Brigada and El Sifon
La Brigada pump station:	4 horizontal pumps and 4 vertical pumps have been installed.

El Molino pump station:	One horizontal pump has been installed.
Total discharge:	0.087m^3/s (1980-83)
La Brigada Treatment Plant:	EL 1,609 m
Capacity of Treatment Plant:	Max.: 16,000m^3/day (theory) Mean: 7,550m^3/day (1980-83)
Treatment Plant:	
Floculation:	canal with screens
Decantation:	chute (gravity)
Filtration:	chute (gravity)
Disinfection:	chloro - liquid
Distribution Tank:	La Brigada (2 tanks) mean level: 1,603.60 m capacity: 9,380m^3 mean level: 1,622.15 m capacity: 295m^3
Measurement:	
Entrance to the Plant:	Vertical well with rectangular fin crest sink, without apparent lateral contractions L = 1,395 m hour hand reading
Exit of Filter:	none
Exit of Tank:	none
Level of Distribution Tank:	hour hand reading

Note: Six wells of 6" and 8" diameter exist in the plant area. The average life of these wells is 25 years. At present, only 2 are actually functioning. The wells pump water directly to the distribution tank without discharge gauges. Production volume per well is about 2,200m^3/day (annual average for 1980-83) with maximum potential production estimated at 5,000m^3/day.

Also depending on production of water at Lo de Coy, significant discharge is diverted to the tank at La Brigada. Said discharge is received and measured at the plant by means of a rectangular, narrow crested sink without leteral contractions (L = 2.01m), situated in a rectangular canal with calmer.

Problem with existing facilities:

La Brigada dam, where intake for the system occurs, is 90 years old and suffers from excessive sedimentation and deterioration of facilities to the extent that stable intake is difficult to achieve.

The existing 6 wells were constructed on the average 23 years ago, and at present only 2 are in operation.

7) Zone 6 Supply Network

The water source for the Zone 6 supply network in northern Guatemala City consists of wells situated along the Las Vacas river. At present, there are 10 wells under the jurisdiction of EMPAGUA. Water from these wells is stored in recently constructed tanks at Cerro del Carman and TP-3, and subsequently distributed by gravity through the table. The tank capacities are 2,990m^3 and 3,515m^3, respectively.

8) Distribution Pipe (See FIG. 2-1)

Size and total length of pipe within EMPAGUA's distribution system is as follows:

ø 14" or less: 22,600 m
ø 16 - 24" : 16,150 m
ø 28" or more: 20,200 m
Total : 58,950 m

9) Wells

EMPAGUA operates 57 wells. The status of these wells is classified into 5 categories as shown in TABLE 2.1. Distribution of these wells within the Guatemala City Valley is as indicated in FIGURE 2-1.

(2) MARISCAL

MARISCAL was established as a private water supply company in 1930. Its principal water sources are surface (12 km) and river bed (both banks, 16 km) flow of the Mariscal River (a tributary of the Molino river), situated to the southeast of the city, river bed flow of the San Benardo river, and 7 deep wells.

Water is pumped to Guarda, stored by tank and subsequently distributed through MARISCAL's service network by gravity to customers in Guatemala City. The water service area of MARISCAR is shown in FIGURE 2-2.

2.3 Water Distribution

Each zone within the EMPAGUA service system has been subdivided into several blocks, and said blocks have been grouped on the basis of supply status into categories of i) continuous service, ii) intermittent service and iii) discontinuous service. (Total number of blocks is 87)

a) Continuous service:	all of zones 7, 8-A; 9, 5 and 19; and blocks 2-C; 4-B; 10-A - C; 11-B - C and G-H; 12-B, J and L; 13-B - C; 15-A
b) Intermittent service:	all of zones 1, 2 (except block C) 6, 17, 18 and 19; and blocks 3-A - D; 4-A and C; 8-B; 10-D, E and F; 11-A, D, E and F; 12-A, C, E - I, K and M; 12-A, D, E; 15-B - D
c) Discontinuous service:	blocks 1-C; 3-B - C; 6-E - F; 18-B - C and E - H

Zones of particularly irregular service are 1, 3, 6 and 18. (This applies to 2/5 of blocks in zone 1, 9/5 of those in zone 3, 2/7 of these in zone 6, and 6/11 of those in zone 18)

Status of water supply on a zone-wise basis is further depicted in TABLE 2.2.

2.4 Status of Operation and Maintenance

The EMPAGUA operation and maintenance structure is contained administratively within its technical division. Its O/M structure consists of a production section, environmental control section, laboratory (water quality control) and a water distribution section. The production section overseas 5 management offices with a total staff of 71 persons.

Of these 5 officies, the well and pump management office performs overseas operation and maintenance of wells and pumps. The electro-mechanical maintenance section is responsible for the maintenance of electrical systems, and is staffed with 25 persons. At present, both of these sections have critical manpower and spare parts shortages.

Refitting and rehabilitation of city wells is currently being planned with financing from CABEI.

Electro-Mechanical Maintenance Section Staff

Section manager	1
Assistant section manager	1
Secretary	1
Clerical staff	1
Lubrication specialist	1
Assistant electricians	8
Pump Mechanic	1
Welders	2
Lathe operator	1
Assistant lathe operator	1
Chemist	1
Assistant chemist	1
Security guard	1
Total	25

Well and Pump Management Office Staff

Clerical	3
Operations	54
Boring equipment	6
Pump assembly	1
Driver	3
Maintenance and cleaning	4
TOTAL	71

TABLE 2-1 STATUS OF EMPAGUA WELLS

Category	Status	Number	Comments
A	Abandoned	5	Well collapse; Low pump-up volume
B	Suspended operation	8	Deterioration of facilities, insufficient maintenance, low pump-up volume
C	Currently producing	14	
D	Incompletely outfitted	7	Tendering in progress for pumps (BCIE)
E	Requires rehabilitation	23	
Total		57	

TABLE 2-2 WATER SUPPLY STATUS IN GUATEMALA CITY

Zone	Continuous service	Intermittent service	Discontinuous service	Zone	Continuous service	Intermitent service	Discontinuous service
1-A	2	9	1	11-C	12	-	-
B	2	10	-	D	11	1	-
C	1	8	3	E	1	11	-
D	-	12	-	F	4	8	-
E	3	9	-	G	12	-	-
2-A	2	10	-	H	12	-	-
B	8	4	-	12-A	10	2	-
C	12	-	-	B	12	-	-
D-	-	12	-	C	3	9	-
E	1	11	-	D	12	-	-
3-A	9	3	-	E	11	1	-
B	3	8	-	F	1	11	-
C	3	8	1	G	1	11	-
D	6	6	1	H	6	6	-
E	-	-	-	I	8	4	-
4-A	5	7	-	J	12	-	-
B	12	-	-	K	9	3	-
C	9	3	-	L	12	-	-
5	12	-	-	M	10	2	-
6-A	6	6	-	13-A	9	3	-
B	6	6	-	B	12	-	-
C	7	5	-	C	12	-	-
D	1	11	-	D	5	7	-
E	1	5	6	E	9	3	-
F	2	7	3	F	-	-	-
G	2	10	-	14	12	-	-

Cont'd

Zone	Continuous service	Intermittent service	Discontinuous service	Zone	Continuous service	Intermitent service	Discontinuous service
7-A	12	-	-	15-A	12	-	-
B	12	-	-	B	8	4	-
C	12	-	-	C	10	2	-
D	12	-	-	D	-	12	-
E	12	-	-	17-A	3	9	-
F	12	-	-	B	11	1	-
G	12	-	-	18-A	3	9	-
8-A	12	-	-	B	2	7	3
B	1	11	-	C	2	9	1
9	12	-	-	D	1	11	-
10-A	12	-	-	E	1	10	1
B	12	-	-	F	-	7	5
C	12	-	-	G	2	6	4
D	8	4	-	H	2	6	4
E	-	12	-	I	8	4	-
F	5	7	-	J	3	9	-
11-A	7	5	-	K	3	9	-
B	12	-	-	19	1	11	-

TABLE 2-3 CONSUMPTION BY USE AND ZONE OF THE CITY (1985)

Zone	Residence m^3/month	Public m^3/month	Industry m^3/month	Total m^3/month	Remarks Number of taps
1	330,841	125,255	104,342	560,4348	9,002
2	105,135	5,875	9,352	120,362	2,962
3	118,536	40,785	9,758	169,089	4,057
4	22,178	30,780	17,929	70,887	582
5	287,171	24,445	15,314	326,930	9,265
6	323,879	28,475	14,815	367,167	11,969
7	544,077	30,450	27,295	601,822	18,008
8	94,008	5,950	10,272	110,230	2,272
9	90,170	19,275	68,472	177,917	1,451
10	113,916	15,530	40,906	170,352	2,899
11	306,386	18,015	86,129	410,530	8,591
12	388,596	44,800	53,386	486,782	13,115
13	109,479	20,620	18,347	148,446	3,196
14	86,171	2,690	23,307	112,168	2,053
15	116,373	.2,200	23,435	142,008	2,684
16	10,172	9,735	991	20,898	338
17	73,900	3,710	23,017	100,627	2,286
18	329,432	7,980	4,796	342,208	15,025
19	90,622	13,915	1,483	106,020	2,922
21	22	1,800	-	1,822	1
Total	3,541,064	452,295	553,346	4,456,705	112,678

Note: Public consumption refers to water consumed through the municipal markets, public institutions and offices, parks, schools, public tanks and public taps.

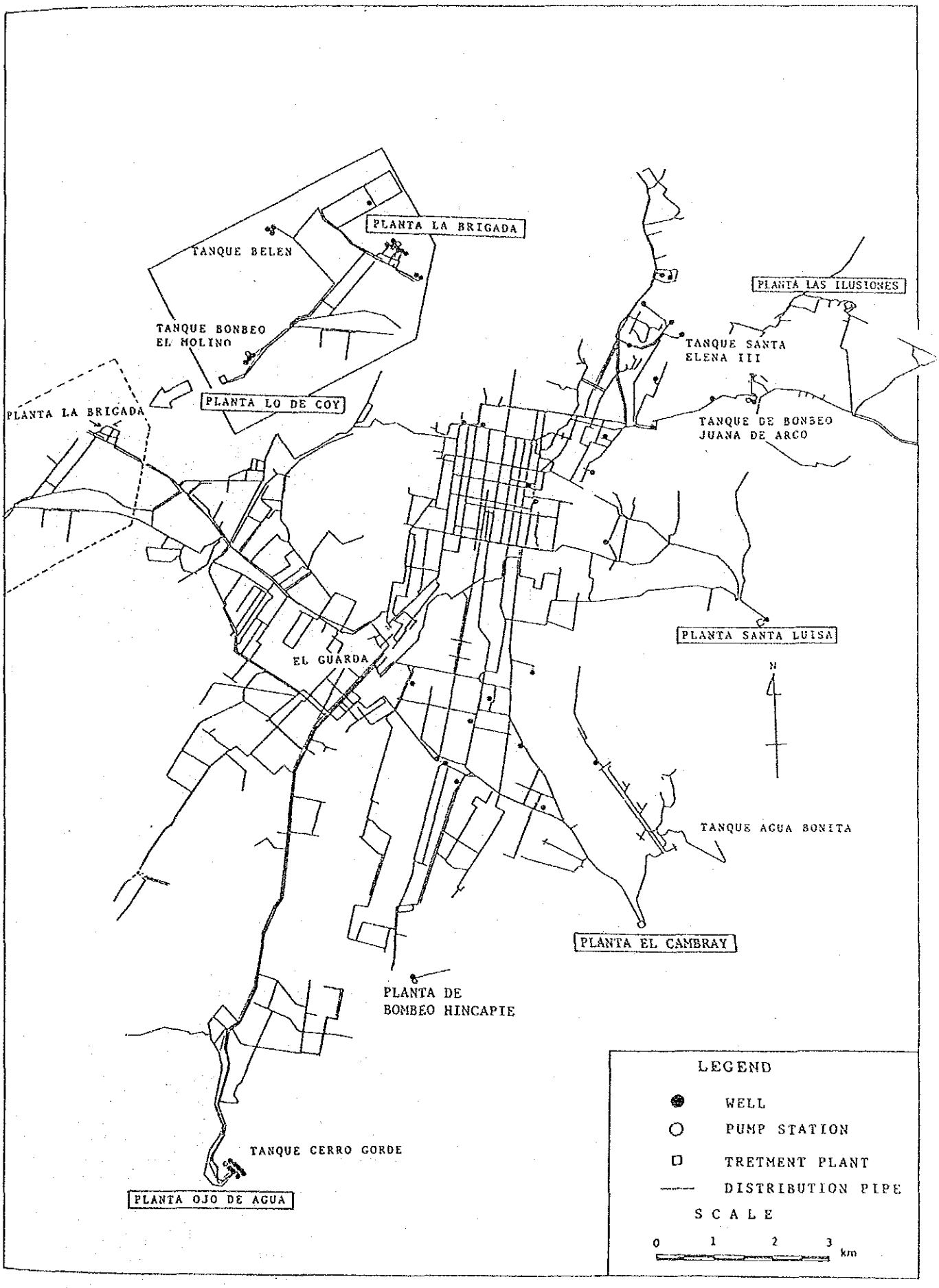

FIG.2-1 DISTRIBUTION PIPE LINE AND WELLS OF EMPAGUA

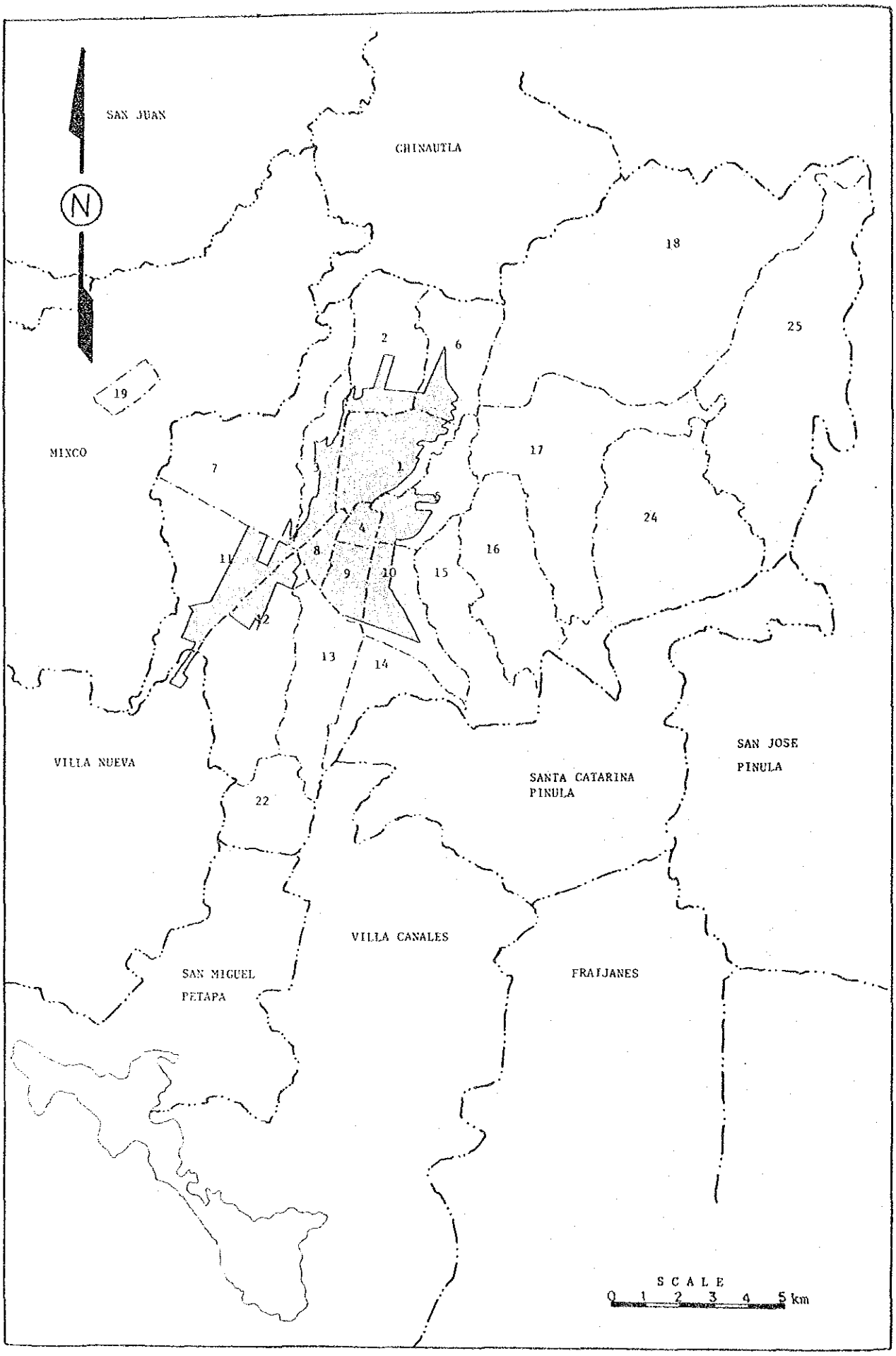

FIG.2-2 WATER SERVICE AREA BY MARISCAR S.A.

CHAPTER III

DISTRIBUTION NETWORK

3. PROJECTION FOR WATER DEMAND AND PRODUCTION (1985-1995)

3.1 Present situation

3.1.1 Water Production

Over the last five years, EMPAGUA has maintained an essentially constant level of production, as indicated in the following TABLES and FIG. 3-1 based on mean monthly production volumes for each of the 7 production systems. This has resulted in a steady deterioration of the ratio of drinking water supply capacity to the every growing demand for water in the area.

EMPAGUA PRODUCTION

Year	Yearly average m^3/s.	Monthly average	
		Minimum	Maximum
1980	2.17	2.05	2.25
1981	2.26	2.10	2.56
1982	2.54	2.36	2.67
1983	2.54	2.41	2.62
1984	2.52	2.36	2.72
1985	2.56	2.37	2.74
Average	2.43	2.28	2.59

MEAN YEARLY PRODUCTION PER SYSTEM (m^3/s)

Year	SANTA LUISA	EL COMBRAY	LO DE COY	LA BRIGADA	OJO DE AGUA	LAS ILUSIONES	CITY WELLS	TOTAL
1980	0.363	0.174	0.697	0.555	0.582	0.161	0.133	2.164
1981	0.367	0.186	0.795	0.084	0.543	0.164	0.124	2.263
1982	0.331	0.179	1.043	0.123	0.534	0.177	0.154	2.541
1983	0.332	0.167	1.000	0.055	0.607	0.211	0.140	2.512
1984	0.311	0.174	1.000	0.062	0.562	0.233	0.180	2.522
1985	0.325	0.177	1.022	0.097	0.539	0.219	0.177	2.556
Average	0.338	0.176	0.926	0.079	0.561	0.194	0.151	2.425
% of total	14%	8%	38%	3%	23%	8%	6%	

Water production by month and by system over the last 2 years is presented in TABLES 3-1 and 3-2.

3.1.2 Consumption

In order to obtain a picture of water consumption in Guatemala City within the EMPAGUA system, information available for the period October 1984 - September 1985 was analyzed. This information is subject to the following comments:

- The selected period was limited to that described above despite the fact that data for both October and November 1985 was also presented. The data for these months was eliminated due to serious problems in supply for zones 17 and 18 (1/3 of the output of the El Atlantico station) which resulted in the meters in these zones not being read (15% of total meters for EMPAGUA's System).
- Data is not available for March 1985 due to problems in the Computer Center which prevented the said data from being processed
- Meter effectivity during the above cited period averaged only 62%, a fact which required computation of total consumption as a function of unit amount per connection, which indicates consumption as described below.

3.1.2.1 Estimation of Consumption

Given that the effectivity of meters during the subject period averaged only a 62% efficiency, it was necessary to estimate the total consumption as a function of the total number of connections per connection reporting consumption.

Based on the available information, consumers were first classified by zone and class of service for the months of December 1984 and January, July and August 1985 as shown in the TABLES A-1 to A-15 of the annex to this appendix.

Upon comparison of the relatively small deviation (average of 3.6%) between weighted unit consumption based on class of service and the average without this weighting for each zone (see TABLE 3-3), it was decided to adopt the latter average for estimation of consumption during the period in question.

The total number of installed service connections by month and by zone, unit consumption per service connection and total measured and estimated consumption are shown in TABLES A-16 - A-28 to this appendix. The following TABLE 3-4 presents a summary of this information for the subject period contrasted with the total production reported.

3.1.2.2 Relationship Between Consumption and Production (October 1984 - September 1985)

The information presented above implies the following for the subject period from October 1984 to September 1985:

Average number of service connections

Reported consumption:	69,679	.....	62%
Reported consumption:	42,970	.....	38%
Total	112,169	.....	100%
Measured private consumption:	1.018m^3/s	.....	40%
Estimated private consumption:	1.636m^3/s	.....	64%
Probable public consumption: *	0.100m^3/s	.....	4%
Accounted consumption:	1.736m^3/s	.....	68%
Unaccounted consumption:	0.191m^3/s	.....	7%
Probable total consumption:	1.927m^3/s	.....	75%
System losses: **	0.626m^3/s	.....	25%
Total measured production:	2.553m^3/s	.....	100%

* Public consumption is estimated on the basis of averages normally utilized by EMPAGUA

** System losses are estimated on the basis of the nature and characteristics thereof, and in common agreement with EMPAGUA

The difference between the accounted for consumption and the probable total consumption in other words the unaccounted consumption, is assumed due to illicit connections and excessive wastage by those consumers whose meters are out of service. The volume of unaccounted consumption is estimated to be split 50 - 50 between these two causes (illicit connetions and excessive usage).

From the above described relationship, the following unit parameters may be devided:

Unit consumption per service connection:	1.26m^3/day/service connection
Unaccounted for volume:	17,000m^3/day
Illicit connections:	17,000/2/1.26 = 6,750 connections
Unit amount of wastage:	17,000/2/42490 = 0.2m^3/day/connection

3.1.3 Demand

The current service offered by EMPAGUA is not capable of completely covering the water demand in Guatemala City as evidenced by intermittent or deficient service in various sectors. This is also indicated in the following TABLE 3-5 which presents a summary of the capacity of service by zone and by month in 1985, and is based on consideration of data provided by EMPAGUA's Departmento de Distribucio*n.

As a result, it was necessary to undertake series of comparasons and considerations between the capacity of reported service and estimated consumption for the various zones of the city, contrasting such with information from related studies recently carried out by the city (Projecto Nor-Occidental) and other estimates based on this data and socio-economic characteristics of the various zones of Guatemala City.

The results of this analysis is shown in TABLES 3-6 and 3-7 below, from which it may be concluded that the most probable unit demand for the entire service area of EMPAGUA, including large scale consumers, is 1.40m^3/day/service connection.

3.1.3.1 Mean Production Demand (October 1984 - September 85)

On the basis of information gathered, as well as the previously cited estimations, the overview of water demand in the service area of EMPAGUA may be calculated for the period october 1984 - September 1985 as follows:

Average Number of Service Connections (October 1984 -September 1985)		
Accounted consumption	69,680 -	62%
Unaccounted consumption	42,490 -	38%
Total with meters	112,170 -	100%
Illicit connections	6,750 -	6%
Total	118920 -	106%

Most Probable Demand (October 1984 - September 1985)		
Private demand: 112,170 x 1.4:	157,040m^3/day -	64%
Public demand: (0.1m^3/s)	8,660m^3/day -	4%
Accounted demand:	165,700m^3/day -	68%
Unaccounted demand:*	18,000m^3/day -	7%
Total probable demand:	183,700m^3/day -	75%
System losses:	61,300m^3/day -	25%
Required production:	245,000m^3/day -	100%

* Unaccountable demand:		18,000m^3/day
Illicit:	6750 x 1.4=	9,500m^3/day
Wastage:	42,490 x 0.2=	8,500m^3/day

3.1.3.2 Relation Between Demand and Production

From the above it may be concluded that the actual situation of potable water service in the area of Guatemala City covered by EMPAGUA during the subject period October 1984 - September 1985 was as follows:

Comparison Between Demand and Actual Production:

Mean demand of production:	$2.836 m^3/s$ -	100%
Mean reported production:	$2,553 m^3/s$ -	90%
Mean deficit:	$0.283 m^3/s$ -	10%
Mean demand of production:	$2.836 m^3/s$ -	100%
Minimum reported production:	$2.374 m^3/s$ -	85%
Maximum deficit:	$0.462 m^3/s$ -	15%
Mean demand of production:	$2.836 m^3/s$ -	100%
Maximum reported production:	$2.717 m^3/s$ -	96%
Minimum deficit:	$0.119 m^3/s$ -	4%

As can be seen, production was never able to completely cover demand, averaging a deficit of 10%.

3.2 Demand Projection

EMPAGUA services at present only around 60% of the potable water demand in Metropolitan Guatemala, with the rest (Particularly in the municipios of Mixco and Villa Nueva) being supplied by various private companies which have obtained connections for service from the respective municipality.

In view of the uncertainly surrounding the creation of a Central District and the consequent uncertainty as to when EMPAGUA would assume responsibility for service to the entire Metropolitan Guatemala area, the demand projection presented below refers only to natural expansion anticipated within the area already serviced by EMPAGUA. It must also be noted that EMPAGUA would not be able to assume responsibility for water service to the entire metropolis without first an expansion in major water supply sources which according to planning under PLAMABAG (Master Plan for Water Supply in Guatemala City) would occur only upon increase of capacity of the Xayá - Pixcayá National Aqueduct, the said works of which are scheduled over the medium term (Emergency Plan II), in other words not before 1990.

It also should be noted that the demand projection of propulation growth as reliable census data is available only up to 1973. The census data for 1981, in addition to being somewhat dated already, is believed in the opinion of various experts consulted to exhibit significant deviations from the real situation. As a result, demand projection is based on the historical behavior of growth in the number of service connections, which is considered to be the sole indicator with logical correlation to actual conditions.

3.2.1 Projected Growth in Number of Service Connections

The historical sequence considered in the projection of growth in number of service connections of EMPAGUA consists of the annual average for the following years:

Year	Average no. of service connections
1975	63,009
1976	65,912
1977	69,926
1978	74,253
1979	78,471
1980	85,336
1981	89,836
1982	95,763
1983	104,185
1984	106,984
1985	113,268

Two projections were attempted. One follows a lineal regression:

$$Nn = No + nI$$

Where:

No= supposed number of service connections in 1974 = 54,860

I= annual growth = 5207

n= number of years since 1974

This formula yields a coefficient of correlation of: 0.99522

The second projection was based on an exponential type regression curve:

$$Nn = No(1 + i)^n$$

Where:

No= supposed number of service connections in 1974

i= annual rate of growth = 6.287%

n= number of years since 1974

This second formula yields a coefficient of correlation of: 0.99824.

The results of both projections are shown as following.

Projected Growth in Number of Sevice Connections of EMPAGVA

Year	Number of Service Connections Deviation			
	Lineal Regression	Exponential Regression	Total	%
1985	112,140	114,640	2,500	2.2
1986	117,350	121,850	4,500	3.7
1987	122,550	129,510	6,960	5.4
1988	127,760	137,660	9,900	7.2
1989	132,970	146,310	13,340	9.1
1990	138,180	155,510	17,330	11.1
1991	143,380	165,290	21,910	13.3
1992	148,590	175,680	27,090	15.4
1993	153,800	186,730	32,930	17.6
1994	159,000	198,470	39,470	19.9
1995	164,210	210,950	46,740	22.2
1996	169,420	224,200	54,780	24.4
1997	174,630	238,290	63,660	26.7
1998	179,830	253,270	73,440	29.0
1999	185,040	269,200	84,160	31.3
2000	190,250	286,120	95,870	33.5

The exponential regression was ultimately selected as the more appropriate in that its correlation with the historical sequence is more congruent with reality, as well as the fact that its is on the safe side.

3.2.2 Projection Hypothesis

Within its planning, EMPAGUA has conceieved a program for optimization of its system from both an administrative as well as physical point of view and which consists basically of progressive elimination of losses in the system.

This program, which has been considered in the following projections, encompasses basically:

- Increase in the effectivity of meters from the present 65% to 95% in the next 10 years.
- Steady reduction of the estimated 6,700 unauthorized connections to the system, existing at present, as well as those which might continue to occur in the period from now to the end of the century.
- Steady reduction of leakages in the distribution system through a program of replacement of the old secondary distribution network, particularly that composed of galvanized iron and which is found in extremely deteriorated state, with a view to reduce said leakage from the current estimated 15% to some 20% in the next 10 years.
- Steady reduction of public consumption, in a fashion that permits the best coverage of demand, as well as by application of modernized tariffs which would make possible large access to service by the general population.

The following have been further assumed as a basis for the subject projections to be discussed below:

- Number of service connections: that which signifies the growth in connections based on the projection derived from an exponential reguession (see previous section 1.2.1), plus the number of ilicit connections eliminated
- Mean volume par connection: 1.40m ^{3}/day/connection, which is that identified as the unit demand in this study (see previous section 1.1.3).
- Volume of wastage: 0.2m ^{3}/day/connection, which represents an average estimate of wastage occuring at connections where meters are not functioning (see previous section 1.1.2.2)

Finally, variations in the projections to be discussed below rest upon whether or not it is possible to reduce the relative percentage of public consumption, and whether or not there is a possibility for reduction of mean unit consumption through application of revised tariffs.

3.2.3 Demand Projection

3.2.3.1 Low Demand Projection

This projection is expressed quantitatively in Table 3-8 and graphically in Figure 3-2. This projection encompasses a lowering of the parcentage of public consumption in relation to total authorized consumption from 6% at present to 4% by 1992, and in the same period reduce the unit consumption per connection by 5% from 1.4m ^{3}/day/connection to 1.33m^3/day/connection, to be achieved through the application of a new tariff structure.

These reductions would occur as shown in following TABLE.

Projected Reduction in Unit Consumption

Year	Unit consumption per connection		Public consumption
	%	m^3/day/connection	% of authorized connection
1985	100	1.40	6
1986	100	1.40	6
1987	99.5	1.40	5.7
1988	99	1.39	5.4
1989	98	1.37	5.1
1990	98	1.36	4.8
1991	96	1.34	4.4
1992	95	1.33	4
1993	95	1.33	4
1994	95	1.33	4
1995	95	1.33	4
1996	95	1.33	4
1997	95	1.33	4
1998	95	1.33	4
1999	95	1.33	4
2000	95	1.33	4

3.2.3.2 Mean Demand Projection

This projection is expressed quantitatively in TABLE 3-9 and graphically in FIGURES 3-2. The projection is based on lowering only the percentage of public consumbtion, which is accordingly stipulated at a constant 1.40m^3/day/connection.

3.2.3.3 High Demand Projection

This projection is indicated quantitatively in TABLE 3-10 and graphically in FIGURE 3-2. It assumes no reduction in either the percentage of public consumption or in the unit volume per connection.

3.2.3.4 Comparative Demand Projection (PLAMABAG)

In order to establish a parameter for comparison of the previously cited demand projections, the related studies carried out under PLAMABAG were analyzed.

For this purpose, and based on the demand projection for the year 2000 in the volume referring to the distribution network of the said master plan (PLAMABAG), the subject demand was quantified by the geographic sector taking into account only the actual area of EMPAGUA service within the central District. The resultant demand distribution is given in the following TABLE.

Demand per Geographic Sector, Year 2000 (PLAMABAG)
(Within the Actual Service Area of EMPAGUA)

Location	Network	Deviced per network m^3/h	Total Demand	
			m^3/h	m^3/s
Center	Center	7838	7838	2.18
North	BN-1A-2A	1350	1350	0.38
Northeast	z-17 y 18*	3666	3666	1.02
Southeast	AO-1A	929		
	AG-1G	219	1148	0.32
West	AP-1A	2856		
	AP-2A	1184	4040	1.25
South	BS-1A	1203		
	BS-1D	583		
	BS-2A	934		
	BS-3A	326	3046	0.85
Total area of EMPAGUA			21088	6.0

* Recent planning under "Proyecto Nor-Occidental" was utilized, making pertinent corections in the central network and network BN-1A-2A.

Likewise, actual demand was quantified according to the same geographical sectors, using as a basis the area covered approximately in each zone by the networks planned under PLAMABAG. As volume of demand, the normal consumption (100%) presented in the previous TABLE 3-7 was adopted, with corrections made taking into account public consumption and volume of leakage in the network. The result of this quantification is the following.

Demand per Geographic Sector, 1985 (Actual Service Area of EMPAGUA)

South: networks BS - 1A - 1D - 2A - 3A ..... 0.251m^3/s

2/3 zone 12 = 1701/c = 0.251 m^3/s

West: networks AP - 1A - 2A ..... 0.742m^3/s

2/3	zone 3	= 2701/c	= 0.051m^3/s
	zone 7	= 19133/c	= 0.361m^3/s
	zone 8	= 2586/c	= 0.049m^3/s
1/2	zone 11	= 6621/c	= 0.125m^3/s
1/6	zone 12	= 3306/c	= 0.062m^3/s
1/3	zone 13	= 1824/c	= 0.034m^3/s
	zone 19	= 3171/c	= 0.060m^3/s

Southeast: networks AQ - 1A - 1G ..... 0.089m^3/s

1/4	zone 14	= 932/c	= 0.018m^3/s
2/3	zone 15	= 315/c	= 0.060m^3/s
	zone 16	= 518/c	= 0.011m^3/s

Northeast: networks zones 17 y 18 ..... 0.334m^3/s

1/2	zone 17	= 1722/c	= 0.032m^3/s
	zone 18	= 1600/c	= 0.302m^3/s

North: networks BN - 1A - 2A ..... 0.266m^3/s

zone 6 = 14122/c = 0.266m^3/s

Center: central network ..... 1.218m^3/s

	zone 1	= 16134/c	= 0.304m^3/s
	zone 2	= 4439/c	= 0.084m^3/s
1/3	zone 3	= 1351/c	= 0.025m^3/s
	zone 4	= 1758/c	= 0.033m^3/s
	zone 5	= 10560/c	= 0.199m^3/s
	zone 9	= 5180/c	= 0.098m^3/s
	zone 10	= 5533/c	= 0.104m^3/s
1/2	zone 11	= 6621/c	= 0.125m^3/s
1/6	zone 12	= 3306/c	= 0.062m^3/s
2/3	zone 13	= 3647/c	= 0.069m^3/s
3/4	zone 14	= 2796/c	= 0.053m^3/s
1/3	zone 15	= 1579/c	= 0.030m^3/s
1/2	zone 17	= 1722/c	= 0.032m^3/s

2.900m^3/s

The results of this comparative projection are shown in the following, where demand for intermediate years is projected exponetially.

Growth in Demand by Geographical Sector (PLAMABAG)
(Within the Actual Service Area of EMPAGUA, in m^3/s)

Geographic Sector	1985	1990	1995	2000
Central	1.22 (42.0%)	1.48 (40%)	1.80 (38.4)	2.18 (36.3)
North	0.27 (9.3%)	0.30 (8.1)	0.34 (7.2)	0.38 (6.3)
Northeast	0.33 (11.4%)	0.48 (13.0)	0.70 (14.9)	1.02 (17.0)
Southeast	0.09 (2.1%)	0.14 (3.8)	0.21 (4.5)	0.32 (5.3)
West	0.74 (25.5%)	0.88 (23.8)	1.05 (22.4)	1.25 (20.8)
South	0.25 (8.6%)	0.42 (11.4)	0.59 (12.6)	0.85 (14.2)
TOTAL	2.90	3.70	4.67	6.00

When contrasting this projection with that considered under PLAMABAG for the entire Central District, it appears logical in relation to predicted growth for all of Guatemala City as following.

Water Demand in the Central District, m^3/s

Year	Actual Area of Coverage		Total according to PLAMABAG
	EMPAGUA Muni. of Guate.	Other Municipals of the Central District	
1985	2.90	0.60	3.50
1990	3.70	1.00	4.70
1995	3.69	1.71	6.40
2000	6.00	2.40	8.40

3.2.3.5 Adopted Demand Projection

In FIGURE 3-2, the three previous projection are contrasted with that of PLAMABAG for the actual service area of EMPAGUA.

In common agreement with the authorities of EMPAGUA, and following discussion of the various projections cited earlier, it was decided to adopt the intermediate projection described in the previous section 3.2.3.2 as the most valid. This projection is expressed graphically in its various compornents in FIGURE 3-3, with the further superimposition of

a tentative program for increase of production that would permit in the minimum time feasible coverage of potable water demand in the area of Guatemala City serviced by EMPAGUA.

3.3 Location of Current Demand and Production

3.3.1 Location and Amounts of Current Production

EMPAGUA currently produces water through seven systems, whose locations are given in FIGURE 3-3 and which, as indicated in the production statistics in the previous section 3.1, achieved its overall minimum production for 1985 in April. These production amounts are as follows:

East:	Sauta Luisa System:	0.34 m^3/s - 14%
Southeast:	EL Cambray System:	0.15 m^3/s - 6%
Southwest:	Lo De Coy System:	0.83 m^3/s - 35%
West:	La Brigade System:	0.07 m^3/s - 3%
South:	Ojo de Agua System:	0.54 m^3/s - 23%
Northeast:	Las Ilusiones System:	0.23 m^3/s - 10%
Center:	System of City wells:	0.21 m^3/s - 9%
Minimum production for 1985		2.37 m^3/s - 100%

3.3.2 Location and Amounts of Current Demand

In order to analyse water demand in Guatemala City in regards to its location, the area was divided into 6 geographical regions, whose boundaries approximated those of the various netwarks of supply distribution. These regions are indicated in FIGURE 3-4.

The amounts of current demand for those geographic sectores of the area serviced by EMPAGUA in Guatemala City were established in the previous section 3.2.3.4 with regard to the study on demand growth, and are as follows:

Center:	1.22 m^3/s - 42%
North:	0.27 m^3/s - 9%
Northeast:	0.33 m^3/s - 11%
Southeast:	0.09 m^3/s - 3%
West:	0.74 m^3/s - 26%
South:	0.25 m^3/s - 9%
Total demand in 1985	2.90 m^3/s - 100%

3.3.3 Relationship between Current Demand and Production

TABLE below presents by geographic sector of the service area of EMPAGUA the existing demand and the manner in which it is covered by the seven present production systems, and shown in FIG. 3-5.

Breakdown of Volumes by Geographic Sector - 1985
(Volumes in m^3/s)

System	Center	North	Northeast	Southeast	West	South	TOTAL
Santa Luisa	0.24	0.10	-	-	-	-	0.34
El Cambray	0.07	-	-	0.08	-	-	0.15
Lo de Coy	0.21	-	-	-	0.62	-	0.83
La Brigada	-	-	-	-	0.07	-	0.07
Ojo de Agua	0.32	-	-	-	-	0.22	0.54
Las Ilusiones	-	-	0.23	-	-	-	0.23
City wells	0.11	0.10	-	-	-	-	0.21
Consumption	0.95	0.20	0.23	0.08	0.69	0.22	2.37
Demand	1.22	0.27	0.33	0.09	0.74	0.25	2.90
Deficit	0.27	0.07	0.10	0.01	0.05	0.03	0.53
Deficit/Demand	22%	26%	30%	11%	7%	10%	18%

Analysis of TABLE above brings to light the following principal facts.

a) The sector where demand is being least met is that situated to the noutheast and consisting of zones 17 and 18. This sector experiences a deficit of 30%. This sector which will see its demand triple over the next 15 years to 1.02 m^3/s is furthermore the most disadvantaged at present in regards to access to centers of production of which the two principal ones (Lo de Coy and Ojo de Agaa) are situated on the oppsite side of the city.

b) In similar fashion to that described above, the sector situated to the north in zone 6 confronts problems of supply and satisfaction of demand. As seen in 1985, 26% deficit was experienced. Nevertheless, through the start-up of a series of wells which have been recently constructed in this sector of the city.

c) Regarding the central sector, although a total deficit of 22% in demand coverage was experienced in 1985, this was concentrated more in the northen region of the sector. The deficit in general was due in part to problems with EMPAGUA production capacity in general and with problems at points along the distrubution network in general.

d) In the other sectors, the small deficiencies evident were more atributable to local problems in distribution networks rather than the location and production capacity of the production systems feeding those networks. Despite that demand will nearly double in these sectors over the next 15 years, supply to this area is essentially assured with current production of existing systems and the program for inprovements and new introduction of water to the city.

3.4 Location of Future Demand and Production

3.4.1 New Sources of Supply and Their Location

The program for new introduction of water to Guatemala City which EMPAGUA wishes to pursue will begin first with optimization of production systems, to be followed by the envisaged planning under PLAMABAG. This program can be divided into the following stages.

a) Immediate term: Start-up of wells in the northern sector which EMPAGUA has just constructed and which are anticipated to argment production immediately by some 0.30 m^3/s.

b) Short term: Optimization of production systems, of which the most promising would be rehabilitation of existing wells (a theme to be presented in a chapter separate from this report) from which additional discharge of some 0.30 m^3/s is anticipated. The major percentage of this new water supply

would center in the Ojo De Aqua system. Likewise, improvement of performance of purification plants would be undertaken, of which that at Las Ilusines would yield the most targible results (the actual plant is not appropriate for the quality of water requiring treatment) wherein an anticipated recoupment of 0.03 m^3/s of discharge would be achieved.

c) Short term: Also over the short-term, the Emergency Plan I (the principal subject of this report) is planned for inplementation. Under this program, an augmentation of 1 m^3/s would be achieved. New water would come from a series of wells to be constructed primarily in the northeast of the city, precisely where the largest descrepancy between water demand and production current exists. This area is also where the greatest urban growth is evident, to such an extent that demand is expected to triple therein over the next 15 year.

d) Medium term: Program for augmentation of the capacity of the Xayá-Pixcayá National Aqueduct referred to under PLAMABGA as Emergency Plan II, and which consists basically in the expansion of supply sources for this aqueduct in such a manner as a provide a steady, effective supply of 2 m^3/s to Lo de Coy.

In summary, additional supply to be provided to Guatemala City in the immediate future is as follows in regard to volume and location.

East:	Santa Luisa System	0.34 m^3/s
Southeast:	El Cambray System	0.15 m^3/s
Southwest:	Lo de Coy System	0.83 m^3/s
West:	La Brigada System	0.07 m^3/s
South:	Ojo De Aqua System	0.54 m^3/s
Northwest:	Las Ilusiones System	0.23 m^3/s
Center:	City wells System	0.21 m^3/s
Current EMPAGUA Production		2.37 m^3/s
North:	Start-up of northern wells	0.24 m^3/s
South and Center:	Rehabilitation of existing wells	0.38 m^3/s
Northeast:	Rehabilitation of plants	0.03 m^3/s
Northwest:	Wells under Emergency Part I	1.00 m^3/s
Southeast:	Emergency Plan II	1.98 m^3/s
Future EMPAGUA Production		6.00 m^3/s

3.4.2 Breakdown of Volumes and Coverage of Demand

The volumes of future demand of the various geographic sectors of the EMPAGUA service area are established in the provious section 1.2.3.4 with regards to the study on demand growth.

In the following 3 TABLES, a breakdown is presented of production to cover demand in the various geographic sectors into which the city has been divided for the proposes of this study. Figures correspond to the years 1990, 1995 and 2000.

DISTRIBUTION OF PRODUCTION FOR GEOGRAPHIC SECTORS - 1990 -

Production in m^3/s

SYSTEM	CENTER	NORTH	NORTHEAST	SOUTHEAST	WEST	SOUTH	TOTAL
Santa Luisa:	0.34	-	-	-	-	-	0.34
El Cambray:	0.01	-	-	0.14	-	-	0.15
Lo de Coy:	0.02	-	-	-	0.81	-	0.83
La Brigada:	-	-	-	-	0.07	-	0.07
Ojo de Agua:	0.12	-	-	-	-	0.42	0.54
Las Ilusiones:	-	-	0.23	-	-	-	0.23
City wells:	0.18	0.03	-	-	-	-	0.21
Rehabilitation:	0.35	0.03	-	-	-	-	0.38
New pump installation in north area:	-	0.24	-	-	-	-	0.24
Rehabilitation of plant:	-	-	0.03	-	-	-	0.03
EMERGENCIA I:	0.46	-	0.22	-	-	-	0.68
DEMAND:	1.48	0.30	0.48	0.14	0.88	0.42	3.70

DISTRIBUTION OF PRODUCTION FOR GEOGRAPHIC - 1995 -

Production in m^3/s

SYSTEM	CENTER	NORTH	NORTHEAST	SOUTHEAST	WEST	SOUTH	TOTAL
Santa Luisa:	0.28	-	-	0.06	-	-	0.34
El Cambray:	-	-	-	0.15	-	-	0.15
Lo de Coy:	-	-	-	-	0.83	-	0.83
Ojo de Agua:	-	-	-	-	-	0.54	0.54
La Brigada:	-	-	-	-	0.07		0.07
Las Ilusiones:	-	-	0.23	-	-	-	0.23
City wells:	0.21	-	-	-	-	-	0.21
Rehabilitation:	0.33	-	-	-	-	0.05	0.38
New pump installation in north area:	-	0.24	-	-	-	-	0.24
Rehabilitation of plant:	-	-	0.03	-	-	-	0.03
EMERGENCIA I:	0.46	0.10	0.44	-	-	-	1.00
EMERGENCIA II:	0.52	-	-	-	0.15	-	0.67
DEMAND:	1.80	0.34	0.70	0.21	1.05	0.59	4.69

DISTRIBUTION OF PRODUCTION FOR GEOGRAPHIC SECTORS - 2000 -

Production in m^3/s

SYSTEM	CENTER	NORTH	NORTHEAST	SOUTHEAST	WEST	SOUTH	TOTAL
Santa Luisa:	0.17	-	-	0.17	-	-	0.34
El Cambray:	-	-	-	0.15	-	-	0.15
Lo de Coy:	-	-	-	-	0.83	-	0.83
La Brigada:	-	-	-	-	0.07	-	0.07
Ojo de Agua:	-	-	-	-	-	0.54	0.54
Las Ilusiones:	-	-	0.23	-	-	-	0.23
Pozos Ciudad:	0.21	-	-	-	-	-	0.21
Recup. pozos:	0.23	-	-	-	-	0.15	0.38
Now pump installation in north area:	-	0.24	-	-	-	-	0.24
Rehabilitation of plant:	-	-	0.03	-	-	-	0.03
EMERGENCIA I:	0.10	0.14	0.76	0	0	0	1.00
EMERGENCIA II:	1.47	-	-	-	0.35	0.16	1.98
DEMAND:	2.18	0.38	1.02	0.32	1.25	0.85	6.00

TABLE 3-1

AVERAGE MONTHLY PRODUCTION BY SYSTEM - 1984

MONTH	STA. LUISA		EL CAMBRAY		LO DE COY		LA BRIGADA		OJO DE AGUA		ILUSIONES		POZOS CIUDAD		TOTAL	
	Mm^3/month	m^3/s	Mm^3/month	m^3/s	Mm^3/month	m^3/s	Mm^3/month	m^3/s	Mm^3/month	m^3/s	Mm^3/month	m^3/s	Mm^3/month	m^3/s	Mm^3/month	m^3/s
JAN.	949.82	.35	384.70	.14	2489.33	.93	233.40	.09	1604.40	.60	633.90	.24	511.23	.19	6806.78	2.54
FEB.	974.25	.40	374.31	.15	2180.55	.90	180.38	.07	1435.00	.59	605.48	.25	343.37	.14	6093.34	2.52
MAR.	948.75	.35	386.23	.14	2245.71	.84	161.22	.06	1524.80	.57	577.11	.22	505.16	.19	6348.98	2.37
APR.	899.77	.35	367.80	.14	2085.83	.80	163.84	.06	1440.90	.56	589.86	.23	576.38	.22	6124.38	2.36
MAY	964.54	.36	372.22	.14	2462.00	.92	181.09	.07	1474.66	.55	566.35	.21	630.67	.24	6651.53	2.48
JUN.	931.59	.36	462.00	.18	2596.69	1.00	164.73	.06	1445.90	.56	554.30	.21	500.73	.19	6655.94	2.57
JUL.	853.81	.32	565.09	.21	3275.34	1.22	58.01	.02	1462.42	.55	577.74	.22	355.47	.13	7147.88	2.67
AUG.	622.63*	.23	532.51	.20	2781.87	1.04	73.25	.03	1491.90	.56	637.00	.24	476.56	.18	6615.72	2.47
SEP.	685.98*	.26	535.09	.21	2481.06	.96	128.62	.05	1443.75	.56	600.18	.23	358.37	.14	6233.05	2.40
OCT.	622.18*	.23	560.44	.21	2949.91	1.10	38.88	.01	1517.40	.57	640.43	.24	377.61	.14	6706.85	2.50
NOV.	602.03*	.23	466.70	.18	3119.68	1.20	268.85	.10	1433.55	.55	671.49	.26	480.19	.19	7042.40	2.72
DEC.	766.05	.29	491.52	.18	2867.30	1.07	313.55	.12	1457.84	.54	691.46	.26	552.65	.21	7140.37	2.67
AVE.	818.45	.311	458.22	.174	2627.98	1.00	163.81	.06	1477.71	.562	612.11	.233	472.36	1.80	6630.60	2.52
Ratio of Total Production	12.4%		6.9%		39.6%		2.5%		22.3%		9.2%		7.1%		100%	

* In Santa Luisa Out of Service Pipe Line 18" of El Teocinte.

TABLE-3-2

AVERAGE MONTHLY PRODUCTION BY SYSTEM - 1985

MONTH	STA. LUISA		EL CAMBRAY		LO DE COY		LA BRIGADA		OJO DE AGUA		ILUSIONES		POZOS CIUDAD		TOTAL	
	Mm^3/month	m^3/s	Mm^3/month	m^3/s	Mm^3/month	m^3/s	Mm^3/month	m^3/s	Mm^3/month	m^3/s	Mm^3/month	m^3/s	Mm^3/month	m^3/s	Mm^3/month	m^3/s
JAN.	898.62	.34	462.98	.17	2658.00	.99	301.85	.11	1461.00	.55	673.91	.25	529.84	.20	6986.20	2.61
FEB.	790.42	.33	408.45	.17	2306.76	.95	319.52	.13	1329.80	.55	589.90	.24	375.83	.16	6120.68	2.53
MAR.	883.93	.33	405.92	.15	2360.80	.88	216.27	.08	1407.85	.53	690.43	.26	437.91	.16	6403.11	2.39
APR.	879.78	.34	398.91	.15	2142.63	.83	171.10	.07	1411.60	.54	591.72	.23	556.58	.21	6152.32	2.37
MAY	937.49	.35	421.78	.16	2390.93	.89	182.30	.07	1358.35	.51	599.83	.22	518.77	.19	6409.45	2.39
JUN.	837.78	.32	445.62	.17	2622.22	1.01	118.48	.05	1365.90	.53	579.25	.22	476.43	.18	6445.68	2.49
JUL.	874.02	.33	513.54	.19	3006.50	1.12	331.98	.12	1404.30	.52	581.81	.22	486.70	.18	7198.85	2.69
AUG.	818.66	.31	514.78	.19	2475.09	.92	271.28	.10	1514.48	.10	663.33	.25	532.35	.20	6789.97	2.54
SEP.	833.62	.32	510.71	.20	2589.84	1.00	278.57	.11	1461.80	.56	579.32	.22	425.97	.16	6679.83	2.58
OCT.	859.97	.32	560.57	.21	3254.29	1.22	130.79	.05	1501.05	.56	477.94*	.17	427.09	.16	7181.70	2.68
NOV.	806.29	.31	463.72	.18	3349.36	1.29	356.78	.14	1315.20	.51	434.51*	.17	386.32	.15	7112.18	2.74
DEC.	840.55	.31	468.83	.18	3088.79	1.15	369.49	.14	1461.50	.55	477.12	.18	441.06	.16	7147.34	2.67
AVE.	855.09	.32	464.65	.18	2687.10	1.02	154.03	.10	1416.07	.54	575.76	.22	466.24	.18	6718.94	2.56

* In Las Ilusiones, Out of Service 1/3 of the El Atla'ntico Station.

TABLE 3-3

COMPARISON BETWEEN AVERAGE UNIT CONSUMPTION AND PONDERED UNIT CONSUMPTION

Discharge : m^3/month/service

ZONE	AUGUST 1985			JUNE 1985			JANUARY 1985			DECEMBER 1984		
	PONDERED	AVE.	DEVIATION	PONDERED	AVE.	DEVIATION	PONDERED	AVE.	DEVIATION	PONDERED	AVE.	DEVIATIO
1	53.30	52.29	1.02	58.31	56.70	1.03	51.04	50.07	1.02	63.17	60.74	1.04
2	36.98	36.23	1.02	42.91	42.26	1.02	43.62	42.96	1.02	36.26	35.62	1.02
3	48.83	42.35	1.15	35.27	33.72	1.05	35.39	30.55	1.16	36.16	34.20	1.06
4	75.88	101.98	0.74	92.34	94.21	0.98	93.08	114.05	0.82	98.23	90.12	1.09
5	36.55	36.13	1.01	34.64	34.05	1.02	35.14	33.99	1.03	32.27	31.95	1.01
6	30.78	28.76	1.07	31.56	30.43	1.04	32.46	30.83	1.05	30.29	28.93	1.05
7	32.47	31.61	1.03	40.69	40.20	1.01	30.74	30.27	1.02	30.31	29.44	1.03
8	52.55	50.42	1.04	51.14	49.13	1.04	44.42	42.52	1.04	46.23	43.64	1.06
9	93.15	102.10	0.91	100.78	111.22	0.91	117.32	96.79	1.21	82.59	80.9	1.02
10	54.56	103.16	0.53	62.69	58.92	1.06	52.67	50.19	1.05	56.84	52.89	1.07
11	42.80	32.61	1.31	48.80	50.15	0.97	34.52	35.27	0.98	46.06	46.70	0.99
12	39.47	36.95	1.07	39.89	36.06	1.11	30.02	27.99	1.07	38.03	36.14	1.05
13	44.83	42.35	1.06	45.27	42.95	1.05	35.00	33.91	1.03	50.71	48.62	1.04
14	53.41	53.63	0.99	65.47	66.10	0.99	43.34	43.65	0.99	68.87	69.22	0.99
15	55.20	110.84	.50	61.80	60.36	1.02	49.90	48.71	1.02	57.86	56.76	1.02
16	61.68	64.79	0.95	37.74	36.57	1.03	51.30	58.76	0.87	53.34	46.64	1.14
17	40.45	43.72	0.93	39.55	41.66	0.95	35.18	32.30	1.09	35.90	37.67	0.95
18	24.89	24.43	1.02	23.35	22.67	1.03	24.30	23.79	1.02	23.26	22.40	1.04
19	35.81	34.23	1.05	35.42	34.54	1.03	35.81	33.68	1.06	37.08	34.77	1.07
G	540.01	540.01	1.00	643.59	643.59	1.00	484.67	484.67	1.00	611.23	611.23	1.00
TOTAL	40.35	41.17	0.98	42.85	40.98	1.06	37.40	35.23	1.06	40.31	37.95	1.06

TABLE 3-4

NUMBER OF SERVICE, CONSUMPTION AND PRODUCTION OF POTABLE WATER IN GUATEMALA CITY

FROM OCTOBER - 1984 TO SEPTEMBER - 1985

	NUMBER OF SERVICE				TOTAL CONSUMPTION		TOTAL PRODUCTION		
	TOTAL INSTALLATION	WITH CONSUMPTION TOTAL	%	MEAN m^3/mes	m^3/s	ESTIMATED m^3/mes	m^3/mes	m^3/s	l/s
OCT - 84	108,687	58,042	53.4	2,206,134	0.824	4,131,113	1.542	6,706,850	2.504
NOV - 84	110,052	71,063	64.6	3,032,714	1.170	4,696,625	1.812	7,042,400	2.717
DEC - 84	110,820	69,872	63.1	2,651,740	0.990	4,205,774	1.570	7,140,370	2.666
JAN - 85	110,650	67,943	61.4	2,400,208	0.896	3,908,909	1,459	6,986,200	2.608
FEB - 85	112,080	67,019	59.8	2,189,787	0.905	3,662,716	1.514	6,120,680	2.530
MAR - 85	-	-	-	-	-	-	-	6,403,110	2.391
APR - 85	113,147	65,512	57.9	2,629,501	1.014	4,541,460	1.752	6,152,320	2.374
MAY - 85	113,290	70,904	62.6	2,435,951	0.909	3,892,148	1.453	6,409,450	2.393
JUN - 85	113,747	74,055	65.1	2,851,156	1.100	4,379,319	1.690	6,445,680	2.487
JUL - 85	113,614	73,341	64.6	3,005,395	1.122	4,655,717	1.738	7,198,850	2.688
AUG - 85	113,614	74,087	65.2	3,050,167	1.139	4,682,231	1.748	6,789,970	2.535
SEP - 85	114,043	74,633	65.5	2,920,183	1.127	4,462,187	1.722	6.679,830	2.577
AVERAGE	112,169	69,679	62.1	2,670,267	1.018	4,292,509	1.636	6,697,510	2.533

TABLE 3-5

CAPACITY OF SERVICE BY POSTAL ZONE, IN 1985

N = Normal I = Intermittent D = Deficient

ZONE	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	SUMMARY
1	N-95	N-80	I-60	I-100	I-100	N-80	N-95	N-80	N-80	N-80	N-80	N-80	N - 60
2	N-85	N-85	I-100	I-100	I-80	N-50	N-50	N-50	N-50	N-50	N-50	N-100	I - 60
3	N-100	N-60	I-70	I-70	I-70	N-60	N-60	N-60	N-60	N-60	N-60	N-100	I - 60
4	I-70	I-70	I-100	I-100	I-100	I-60	N-100	N-100	N-100	N-100	N-100	N-100	N - 50
5	N-70	N-70	N-70	N-70	N-70	N-100	N-100	N-100	N-100	N-100	N-100	N-100	N - 90
6	N-85	N-60	N-60	I-60	I-70	N-50	N-60	N-60	N-60	N-60	N-60	N-50	I - 60
7	N-95	N-60	I-60	I-70	I-70	N-70	N-80	N-80	N-95	N-100	N-100	N-100	N - 65
8	I-80	I-80	I-80	I-100	I-100	I-100	I-100	I-100	I-100	I-80	I-80	I-80	I - 90
9	N-100	N-100	N-100	N-100	N-100	N-100	N-100	N-100	N-100	N-100	N-100	N-100	N - 100
10	N-90	N-90	I-70	I-70	I-70	I-70	N-60	N-90	N-90	N-09	N-90	N-90	N - 60
11	N-85	N-85	I-80	I-90	I-90	N-60	N-85	N-70	N-70	N-80	N-75	N-75	N - 60
12	N-70	N-60	I-80	I-90	I-90	I-60	N-80	N-80	N-90	N-90	N-80	N-80	N - 50
13	N-70	N-70	D-60	D-60	D-60	I-100	N-80	N-80	N-80	N-80	N-80	N-80	I - 50
14	N-100	N-100	N-100	I-100	N-100	N-100	N-100	N-100	N-100	N-100	N-100	N-100	N - 80
15	N-100	N-75	N-75	I-50	N-75	N-50	N-100	N-100	N-100	N-100	N-100	N-100	N - 80
16	N-100	N-100	I-100	I-100	N-100	N-100	N-100	N-100	N-100	N-100	N-100	N-100	N - 80
17	I-100	I-60	I-100	I-100	I-100	K-100	I-60	I-60	I-60	N-100	N-100	N-100	I - 60
18	I-100	I-100	I-100	I-100	D-100	I-100	I-100	I-100	I-100	D-80	D-80	I-80	I - 100
19	N-100	I-100	I-100	I-100	I-100	I-100	I-100	I-100	I-100	I-100	I-100	I-100	I - 90

TABLE 3-6 ESTIMATED UNIT DEMAND

Zone	Condition of unit consumption: Month	Percentage normal lendition	Estimated unit consumption (m^3/d/serv.): Month	Average	Estimated Unit Demand m^3/d serv.
1	Jan. Jul.	95	1.62 1.83	1.73	1.82
2	Jan. Feb.	85	1.39	1.28	1.51
3	Jan.	100	0.99	0.99	0.99
4	Jul. Aug. Sep.	100	3.04 3.29 2.77	3.00	3.00
5	Jun. Jul. Aug. Sep.	100	1.18 1.10 1.17 1.11	1.14	1.14
6	Jan.	85	1.00	1.00	1.18
7	Jan. Sep.	95	0.98 1.03	1.00	1.06
8	Intermittent whole year		Adopted	1.70	
9	All	100		Year	3.56
10	Jan. Feb. Sep.	90	1.62 1.61 1.91	1.71	1.90
11	Jan. Feb. Jul.	85	1.14 1.50 1.30	1.31	1.54
12	Sep.	90	1.32	1.32	1.51
13	Jul. Aug.	80	1.39 1.37	1.38	1.75
14	All	100		Year	1.80
15	Jan. Jul. Sep.	100	1.57 1.95 1.75	1.75	1.75
16	All	100		Year	1.70
17	Intermittent whole year		Adopted	1.50	
18	Intermittent whole year		Adopted	1.06	
19	Jan.	100	1.09	1.09	1.09
G	Adopted Average Year		Adopted	18.00	

TABLE 3-7

ESTIMATED OF PRIVATE DEMAND IN M^3/DAY FOR MAY IN 1985

Zone	Nº service	Average Consumption		Demand for Consumption N= 100%		Demand for Similar zone		Used demand in NOR-WEST PROJECT	
		Unit	Total	Unit	Total	Unit	Total	Unit	Total
1	9115	1.77	16134	1.82	16589	2.00	18230	1.92	17501
2	2940	1.30	3822	1.51	4439	1.50	4410	1.49	4381
3	4093	1.16	4748	0.99	4052	1.15	4707	1.71	6999
4	586	2.92	1711	3.00	1758	3.00	1758	3.35	1963
5	9265	1.04	9634	1.14	10562	1.15	10652	1.13	10467
6	11968	0.98	11729	1.18	14122	1.15	13763	1.09	13045
7	18050	1.01	18231	1.06	19133	1.15	20758	1.10	19855
8	2268	1.49	3379	1.70	3856	1.50	3402	1.33	3016
9	1455	3.72	5413	3.56	5180	3.75	5456	2.71	3943
10	2912	1.93	5620	1.90	5533	1.90	5533	1.92	5591
11	8599	1.41	12125	1.54	13242	1.50	12899	1.26	10835
12	13138	1.18	15503	1.51	19838	1.25	16423	1.20	15766
13	3218	1.46	4698	1.70	5471	1.75	5632	1.59	5517
14	2071	1.94	4018	1.80	3728	1.90	3935	1.75	3624
15	2707	1.94	5252	1.75	4737	1.90	5143	2.26	6118
16	340	1.92	653	1.70	578	1.90	646	2.20	748
17	2295	1.25	2869	1.50*	3443	1.50	3443	1.05	2410
18	15096	0.75	11322	1.06*	16002	1.15	17360	1.04	15700
19	2909	1.07	3113	1.09	3171	1.15	3345	1.23	3578
G	267	17.44	4656	18.00*	4806	2.00	5340	2.00	5340
Total	113290	1.277	144627	1.414	160240	1.437	162834	1.377	155996

*Adopted

TABLE-3-8 LOW DEMAND PROJECTION OF PRODUCTION
(PROGRAM-A)

Year	Service Number (x10^3)				Accountable Demand						Required Production	
	Normal Increase	Unauthorized	Authorized	%	Without Consumption	Connection		Wastage	Public	Total	Leakage %	Net m^3/S
						Authorized	Unauthorized					
1985	114.6	6.7	114.6	35	46.8	1.857	0.109	0.108	0.111	2.185	25	2.913
1986	121.9	6.7	121.9	31	44.5	1.975	0.109	0.103	0.119	2.306	25	3.075
1987	129.5	6.0	130.2	27	41.2	2.095	0.097	0.095	0.119	2.406	24.5	3.187
1988	137.7	5.5	138.9	23	37.4	2.219	0.089	0.087	0.120	2.515	24	3.309
1989	146.3	5.0	148.0	19	33.1	2.347	0.081	0.077	0.120	2.625	23	3.409
1990	155.5	4.5	157.7	15	28.2	2.482	0.073	0.065	0.119	2.739	22	3.512
1991	165.3	4.0	168.0	12	24.2	2.606	0.065	0.056	0.115	2.842	21	3.597
1992	175.7	3.5	178.9	9	19.6	2.754	0.057	0.045	0.110	2.966	20	3.708
1993	186.7	3.0	190.4	7	16.3	2.931	0.049	0.038	0.117	3.135	20	3.919
1994	198.5	2.5	202.7	5	12.6	3.120	0.041	0.029	0.125	3.315	20	4.144
1985	211.0	2.0	215.7	5	12.8	3.320	0.032	0.030	0.133	3.515	20	4.394
1996	224.2	1.5	229.4	5	11.5	3.531	0.024	0.027	0.149	3.731	20	4.664
1997	238.3	1.0	244.0	5	12.2	3.756	0.016	0.028	0.158	3.958	20	4.948
1998	253.3	0.5	259.5	5	13.0	3.995	0.008	0.030	0.168	4.201	20	5.251
1999	269.2	0.0	275.9	5	13.8	4.247	0.000	0.032	0.179	4.458	20	5.573
2000	286.1	0.0	292.8	5	14.6	4.507	0.000	0.034	0.190	4.731	20	5.914

TABLE-3-9 MEAN DEMAND PROJECTION OF PRODUCTION
(PROGRAM-B)

Year	Service Number ($x10^3$)				Accountable Demand						Required Production	
	Normal Increase	Unauthorized	Authorized	%	Without Consumption	Connection		Wastage	Public	Total	Leakage %	Net m^3/S
						Authorized	Unauthorized					
1985	114.6	6.7	114.6	35	46.8	1.857	0.109	0.108	0.111	2.185	25	2.913
1986	121.9	6.7	121.9	31	44.5	1.975	0.109	0.103	0.119	2.306	25	3.075
1987	129.5	6.0	130.2	27	41.2	2.110	0.097	0.095	0.120	2.422	24.5	3.208
1988	137.7	5.5	138.9	23	37.4	2.251	0.089	0.087	0.122	2.549	24	3.354
1989	146.3	5.0	148.0	19	33.1	2.398	0.081	0.077	0.122	2.678	23	3.478
1990	155.5	4.5	157.7	15	28.2	2.555	0.073	0.065	0.123	2.816	22	3.610
1991	165.3	4.0	168.0	12	24.2	2.722	0.065	0.056	0.120	2.963	21	3.751
1992	175.7	3.5	178.9	9	19.6	2.899	0.057	0.045	0.116	3.117	20	3.896
1993	186.7	3.0	190.4	7	16.3	3.085	0.048	0.038	0.123	3.295	20	4.119
1994	198.5	2.5	202.7	5	12.6	3.284	0.041	0.029	0.131	3.485	20	4.356
1995	211.0	2.0	215.7	5	12.8	3.495	0.032	0.030	0.140	3.697	20	4.621
1996	224.2	1.5	229.4	5	11.5	3.717	0.024	0.027	0.149	3.917	20	4.896
1997	238.3	1.0	244.0	5	12.2	3.954	0.016	0.028	0.158	4.156	20	5.195
1998	253.3	0.5	259.5	5	13.0	4.205	0.008	0.030	0.168	4.411	20	5.514
1999	269.2	0.0	275.9	5	13.8	4.471	0.000	0.032	0.179	4.682	20	5.853
2000	286.1	0.0	292.8	5	14.6	4.744	0.000	0.034	0.190	4.968	20	6.210

TABLE-3-10 HIGH DEMAND PROJECTION OF PRODUCTION
(PROGRAM-C)

Year	Service Number (x10^3)					Accountable Demand						Required Production	
	Normal Increase	Unauthorized	Authorized	%	Without Consumption	Connection		Wastage	Public	Total		Leakage %	Net m^3/S
						Authorized	Unauthorized						
1985	114.6	6.7	114.6	35	46.8	1.857	0.109	0.108	0.111	2.185	25	2.913	
1986	121.9	6.7	121.9	31	44.5	1.975	0.109	0.103	0.119	2.306	25	3.075	
1987	129.5	6.0	130.2	27	41.2	2.110	0.097	0.095	0.127	2.424	24.5	3.210	
1988	137.7	5.5	138.9	23	37.4	2.251	0.089	0.087	0.135	2.562	24	3.371	
1989	146.3	5.0	148.0	19	33.1	2.398	0.081	0.077	0.144	2.700	23	3.506	
1990	155.5	4.5	157.7	15	28.2	2.555	0.073	0.065	0.153	2.846	22	3.649	
1991	165.3	4.0	168.0	12	24.2	2.722	0.065	0.056	0.163	2.006	21	3.805	
1992	175.7	3.5	178.9	9	19.6	2.899	0.057	0.045	0.174	3.175	20	3.969	
1993	186.7	3.0	190.4	7	16.3	3.085	0.049	0.038	0.185	3.357	20	4.196	
1994	198.5	2.5	202.7	5	12.6	3.284	0.041	0.029	0.197	3.551	20	4.439	
1995	211.0	2.0	215.7	5	12.8	3.495	0.032	0.030	0.210	3.767	20	4.708	
1996	224.2	1.5	229.4	5	13.0	3.717	0.024	0.027	0.223	3.991	20	4.989	
1997	238.3	1.0	244.0	5	13.2	3.954	0.016	0.028	0.237	4.235	20	5.294	
1998	253.3	0.5	259.5	5	13.5	4.205	0.008	0.030	0.252	4.495	20	5.619	
1999	269.2	0.0	275.9	5	13.8	4.471	0.000	0.032	0.268	4.771	20	5.964	
2000	286.1	0.0	292.8	5	14.6	4.744	0.000	0.034	0.285	5.063	20	6.329	

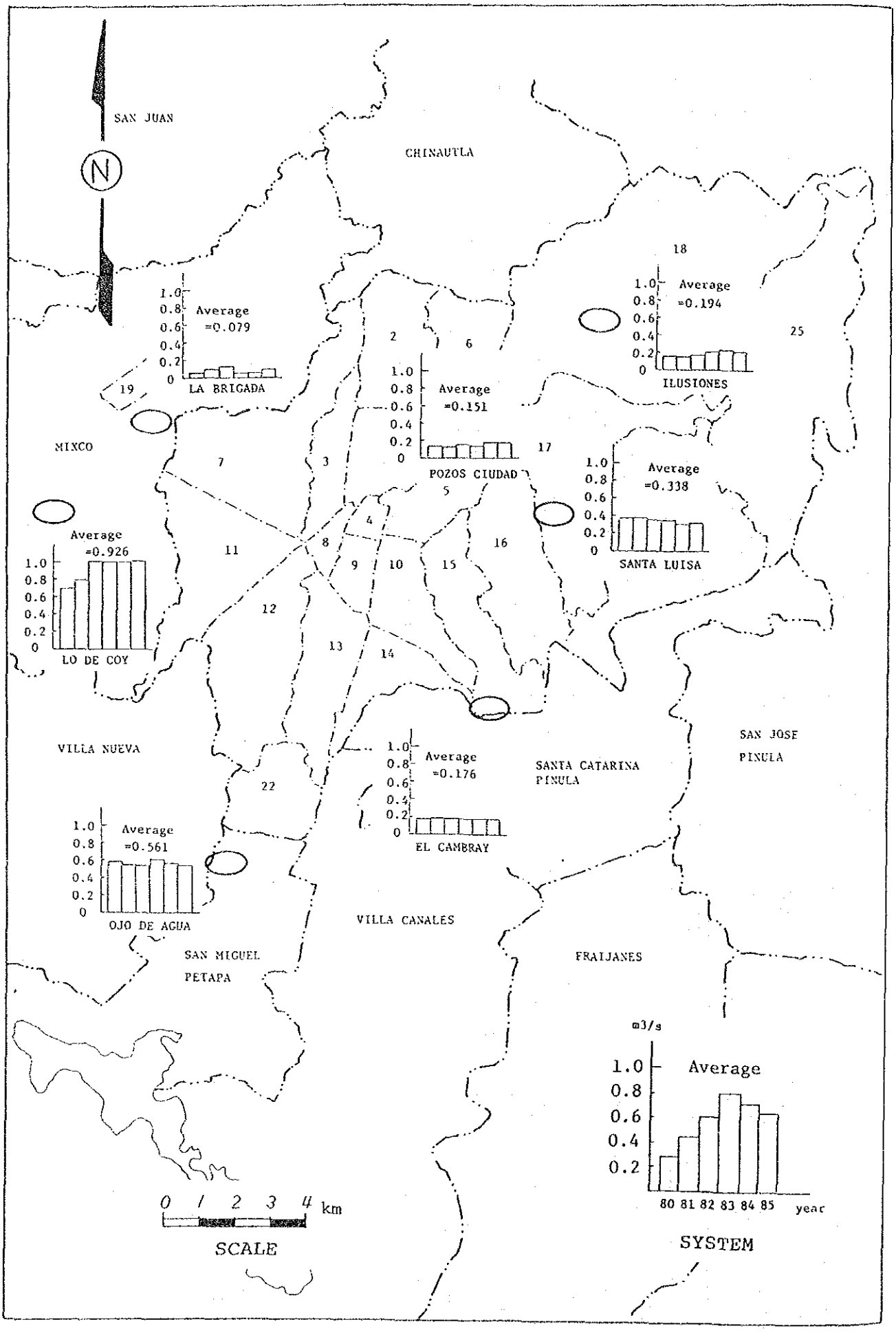

FIG.3-1 PRODUCTION OF ANNUAL AVERAGE FOR EACH SYSTEM

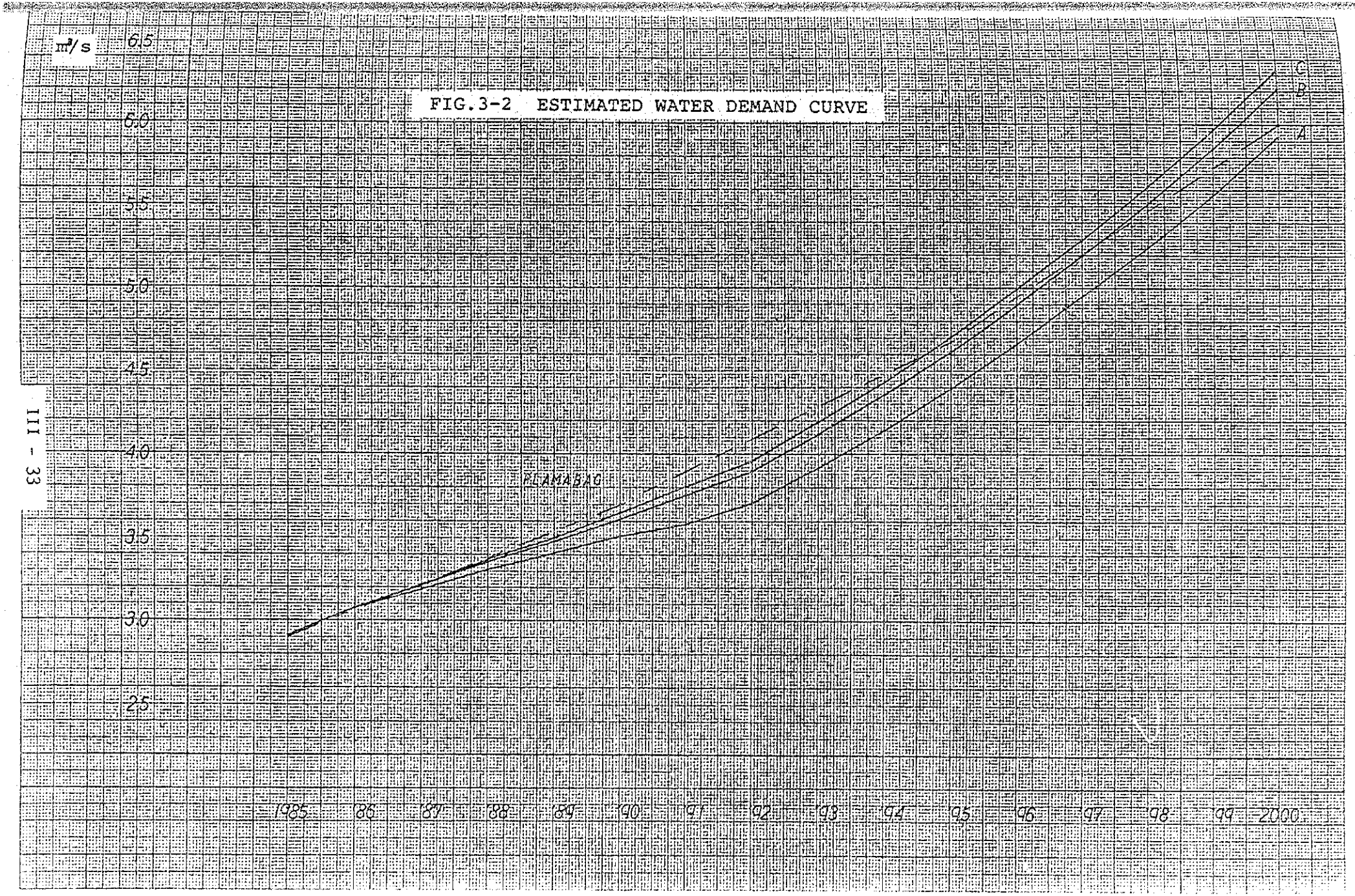

FIG.3-2 ESTIMATED WATER DEMAND CURVE

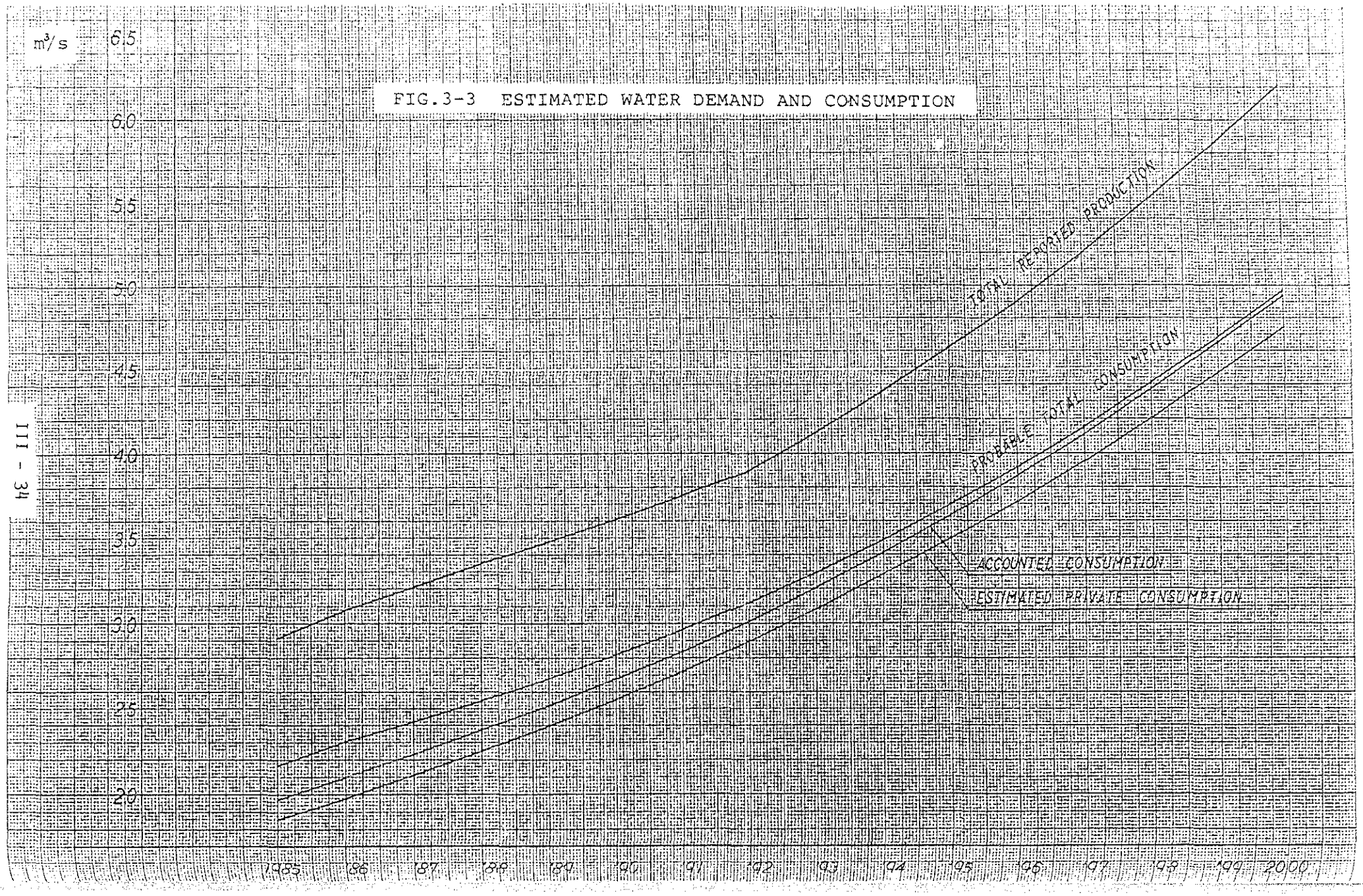

FIG.3-3 ESTIMATED WATER DEMAND AND CONSUMPTION

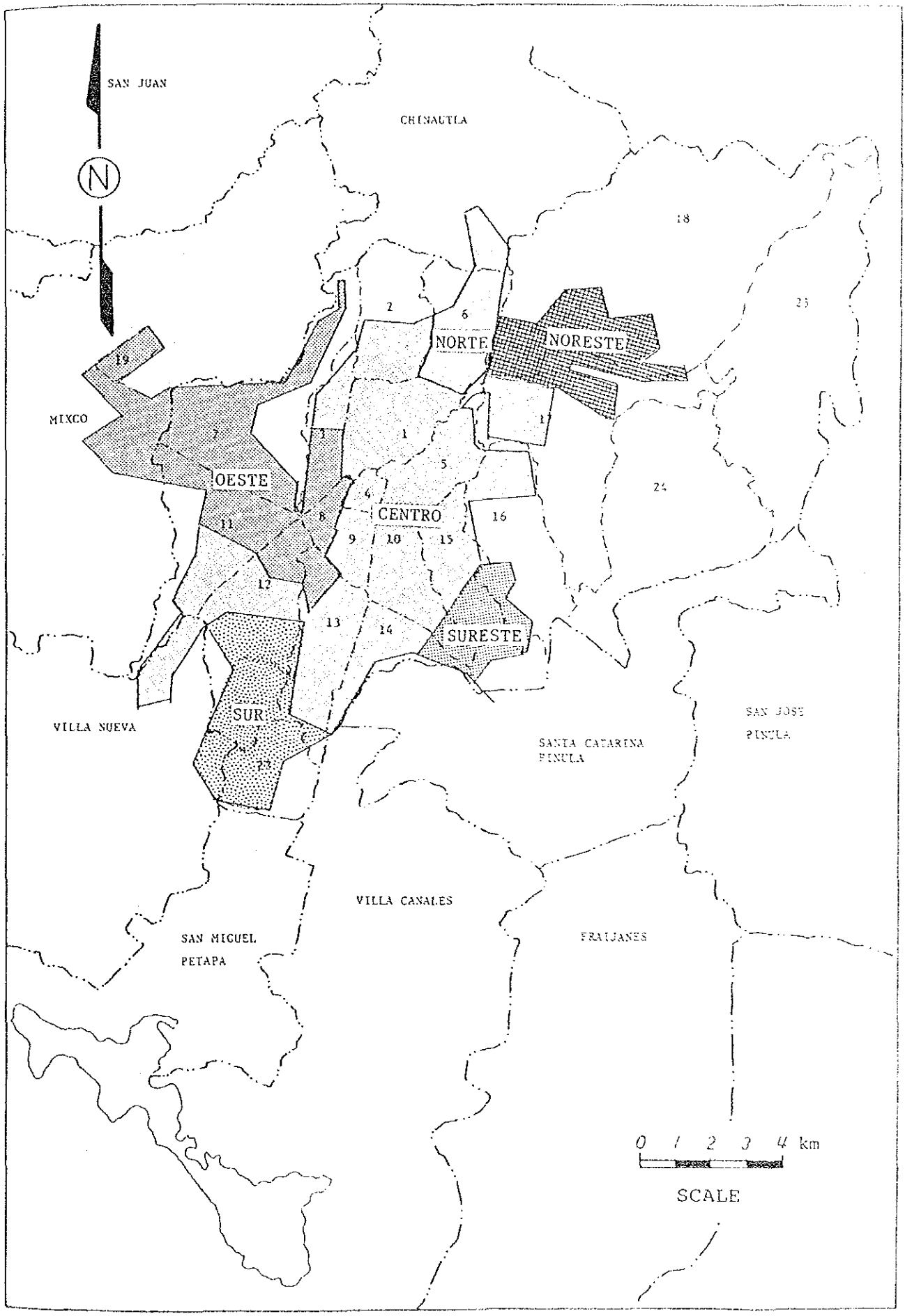

FIG. 3-4 GEOGRAPHIC SECTORS OF DISTRIBUTION

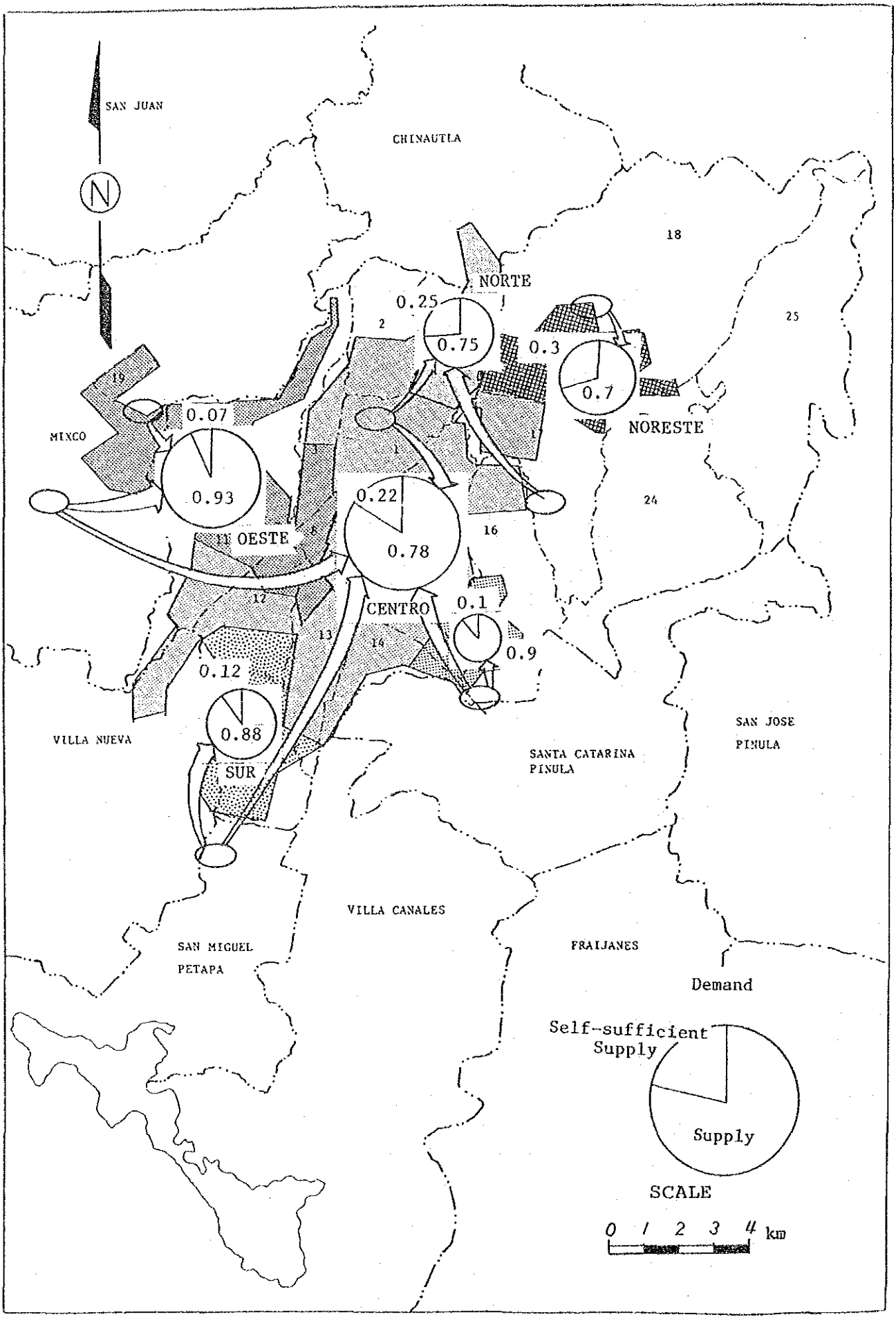

FIG.3-5 RELETION BETWEEN SUPPLY AND SELF-SUFFICIENT SUPPLY 1985