

D-7

RESULTS OF PUBLIC ATTITUDE SURVEY (ALL DATA 1/13)

		SAMPLE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
<b>1. HOUSING DATA</b>																													
a.	Zona		6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	7	7	7	7	7	7	7	7	7	7	7	7
b.	Type of house																												
b.1	Humble cottage								X		X																		
b.2	Lower grade																												
b.3	Normal		X	X	X	X	X	X		X	X		X	X	X	X	X					X		X	X				
b.4	Medium high																	X	X	X	X			X		X	X	X	X
b.5	High grade																												
c. Ownership																													
c.1	Own Housing				X	X		X	X	X	X	X	X	X	X			X	X	X	X	X	X	X			X	X	
c.2	Rent Housing		X	X			X							X		X	X								X	X			X
<b>2. AGE OF HOUSE HEAD</b>			24	40	60	68	57	72	55	60	30	36	62	35	31	27	5	58	53	54	56	48	52	39	31	44	50	46	41
<b>3. MAJOR JOB</b>																													
a.	Business Owner																												
b.	Owner of Small Unregistered Business												X										X						
c.	Self Employed								X	X		X					X											X	
d.	Employee of a registered company			X			X	X			X				X					X	X		X	X					X
e.	Public Official		X																					X	X	X	X		
f.	Domestic Employee																												
g.	Other				X	X																							
<b>4. NUMBER OF HOUSEHOLD MEMBERS</b>			4	5	3	4	6	14	7	5	5	3	9	5	5	7	5	5	5	4	5	11	5	5	4	7	6	2	4
<b>5. MONTHLY FAMILY INCOME</b>																													
a.	0 through 500																												
b.	501 through 1000		X		X				X			X																	
c.	1001 through 1500					X	X	X			X		X	X	X		X							X	X				
d.	1501 through 2000																											X	
e.	2001 through 2500			X																				X					X
f.	2501 through 3000									X										X	X		X				X		
g.	3001 through 3500																	X				X							
h.	3501 through 4000																												
i.	4001 through 4500																												
j.	4501 through 5000																												X
k.	5001 or more																												
<b>6. SANITARY SYSTEM</b>																													
a.	Disposal of Excrement																												
a.1	On the ground																												
a.2	Latrine of Cesspit									X																			
a.3	Simple toilet																												
a.4	Lavatory		X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
b.	Disposal of served water																												
b.1	Cesspit								X																				
b.2	Septic Tank and Absorption Wells																												
b.3	Septic Tank																												
b.4	Public Sewars		X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
b.5	Sewage Water on the ground																												
<b>7. WATER SOURCES</b>																													
a.	Domestic municipal service		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
b.	Municipal Service by Public Spout or Basin																												
c.	Private Water System Service																												
d.	Spring Water or fountain																												
e.	Wells, exclusive of the house																												
f.	Truck or Water Tank																												
g.	Rain Water																												
h.	Bottled Water																												
<b>8. MONTHLY WATER CONSUMPTION</b>																													
a.	0 through 10 m3		X		X		X		X		X		X								X							X	
b.	11 through 20 m3			X		X		X		X																			X
c.	21 through 30 m3												X								X								X
d.	31 through 40 m3													X															
e.	41 through 50 m3																												
f.	51 through 70 m3																											X	
g.	71 through 90 m3																												
h.	91 through 120 m3																												
i.	121 through 150 m3																												
j.	151 m3 or more																												
<b>9. MONTHLY WATER CHARGE</b>																													
a.	0 through 10				X	X																							
b.	0.11 through 20		X						X	X	X																	X	
c.	0.21 through 30			X								X																	X
d.	0.31 through 40																												
e.	0.41 through 50								X																				
f.	0.51 through 60																												
g.	0.61 through 70																												
h.	0.71 through 80																												
i.	0.81 through 90						X																						
j.	0.91 through 100												X																
k.	0.101 or more													X															











# RESULTS OF PUBLIC ATTITUDE SURVEY (ALL DATA 7/13)

10. DISEASE RECORD		SAMPLE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Cholera	# Patients																					
	Hospital treatment																					
	House treatment																					
Typhoid	# Patients																					
	Hospital treatment																					
	House treatment																					
Leptospirosis	# Patients																					
	Hospital treatment																					
	House treatment																					
Paratyphoid	# Patients																					1
	Hospital treatment																					30
	House treatment																					1500
Hepatitis	# Patients																					
	Hospital treatment																					
	House treatment																					
Enteroviruses	# Patients																					
	Hospital treatment																					
	House treatment																					
Bacterial dysentery	# Patients																					
	Hospital treatment																					
	House treatment																					
Gastro-enteritis	# Patients																					
	Hospital treatment																					
	House treatment																					
Skin sepsis and ulcers	# Patients																					
	Hospital treatment																					
	House treatment																					
Trachoma	# Patients																					
	Hospital treatment																					
	House treatment																					
Conjunctivitis	# Patients																					
	Hospital treatment																					
	House treatment																					
Amoebias	# Patients																					
	Hospital treatment																					
	House treatment																					
Shigellosis	# Patients																					
	Hospital treatment																					
	House treatment																					
Total	# Patients																					1
	Hospital treatment																					30
	House treatment																					1500
11. REASON WHY WASTEWATER TREATMENT IS NEEDED *1																						
a.	To avoid bad odors					3				2	3	3			1	1						
b.	To avoid the proliferation of mosquitoes				3					1	2	1			1	2			2	4	3	4
c.	To improve the agricultural production	2			2													3	2		2	3
d.	To maintain the potable water sources	1	2		3						3							3	2	3	2	3
e.	To maintain sufficient water for the industrial use																		1	1	1	1
f.	To keep the ecosystem of animals and plants					1																2
g.	To increase the value of the properties	3																				
h.	To avoid the damage to inhabitants who receive city drainage		3	1	2	1				3	1				3			3	4			1
i.	Other																					
j.	There are no reason of importance								X				X			X						
12. WILLINGNESS TO PAY																						
a.	Q.4		X	X	X			X			X	X	X									
b.	Q.8										X	X	X								X	
c.	Q.12														X							
d.	Q.16																	X	X			
e.	Q.20																					X
f.	Q.25																					
g.	Q.30																					
h.	Q.35																					
i.	Q.40																					
j.	Q.45																					
k.	Q.50					X																
l.	Q.0									X							X					
m.	Others						X						X				X					X
13. AGE OF INTERVIEWEE					40	58	68	56	47	53	46	27	36	32	30	31	18	35	45	53	45	50
14. SERVICE LEVEL OF WATER SUPPLY																						
a. General opinion																						
a.1	Good service					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
a.2	Normal service																					
a.3	Bad service		X	X														X	X	X	X	X
b. Regularity of water service																						
b.1	Continuous service		X									X	X	X	X							
b.2	Daily service 1-4 hours																					
b.3	Daily service 5-8 hours																					X
b.4	Daily service 9-24 hours			X			X										X	X	X	X		
b.5	Each two days service 1-4 hours									X												X
b.6	Each two days service 5-8 hours										X										X	
b.7	Each two days service 9-24 hours																					
b.8	Each three days service 1-4 hours																					
b.9	Each three days service 5-8 hours																					
b.10	Each three days service 9-24 hours																					
b.11	Unknown service schedule																					
c. Opinion about the water quality																						
c.1	Reliable		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
c.2	Not Reliable			X																		

\*1 In the reasons "a" through "j", the point is scored in order of priority, therefore highly preferred reason gets higher point.

















EMPAGUA

EMPRESA MUNICIPAL DE AGUA DE LA CIUDAD DE GUATEMALA  
Gerencia

D8

PROV.
OF.

Mayo 05, 1995

Señor Usuario  
EMPRESA MUNICIPAL DE AGUA  
Presente

Estimado Usuario:

La Empresa Municipal de Agua de la Ciudad de Guatemala -EMPAGUA- está realizando con la colaboración del gobierno del Japón, un estudio para mejorar el sistema de alcantarillado de nuestra ciudad y la disposición de las aguas servidas.

Atentamente solicito su valiosa colaboración, en el sentido de dar respuesta a las preguntas que le formulará el señor encuestador, portador de la presente, lo cual nos permitirá conocer en mejor forma la opinión de nuestros usuarios del servicio, a fin de elaborar un plan que se ajuste a nuestra realidad social y económica.

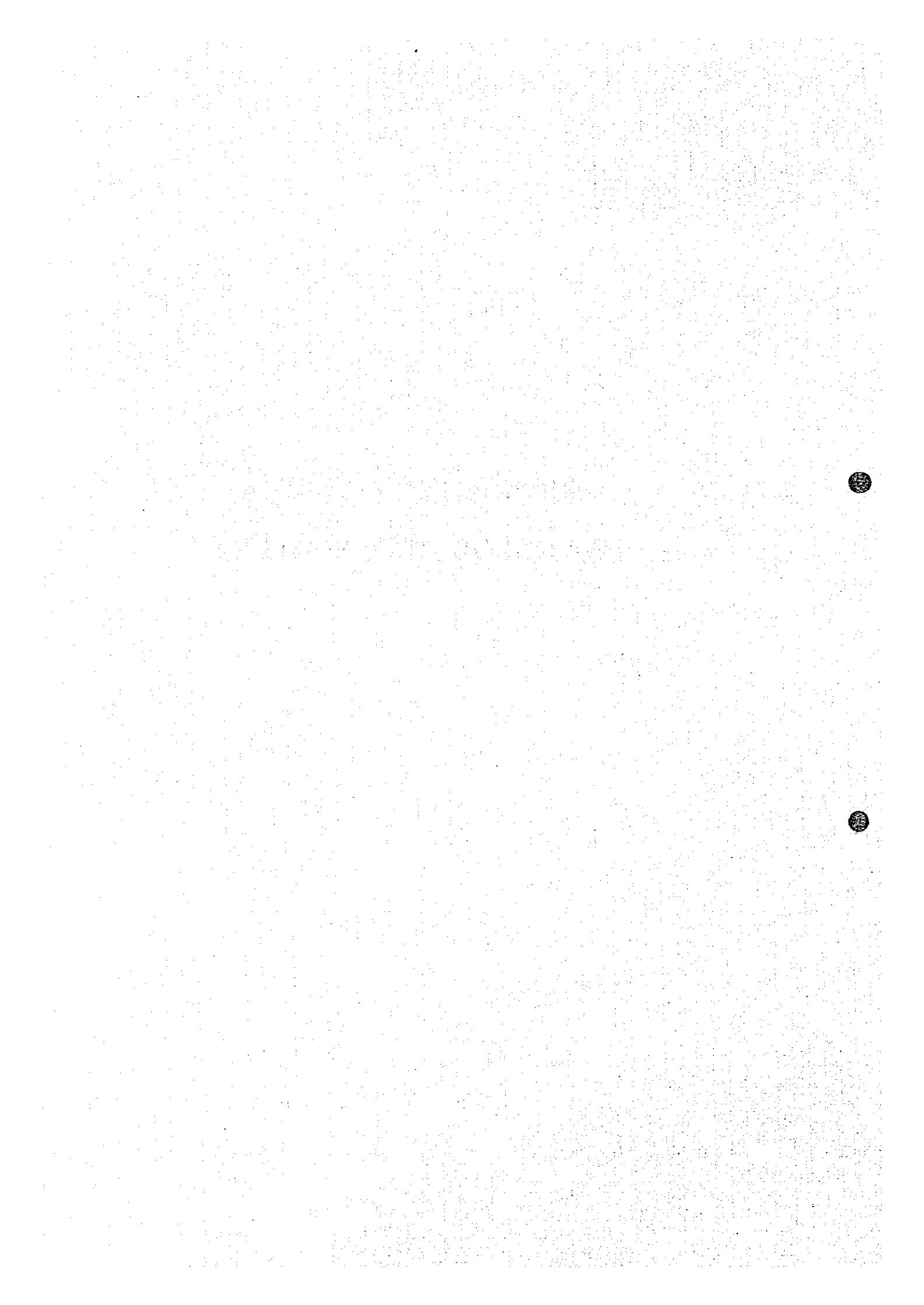
Agradezco anticipadamente su participación en esta encuesta, que redundará en beneficio de todos los vecinos de la ciudad.

Cordialmente,

  
Ing. Carlos Fco. Quezada Vega  
GERENTE



**SUPPORTING REPORT E**  
**WATER QUALITY SURVEYS**





**SUPPORTING REPORT E  
WATER QUALITY SURVEYS  
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## **E WATER QUALITY SURVEYS**

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### **E1 INTRODUCTION**

Water quality surveys were conducted in the Study Area and in Lake Amatitlan to investigate the following:

- a) Quality of public water bodies namely wells, rivers, Lake Amatitlan, collectors, and drainage channels.
- b) Water usage rate and unit pollutant load generation in 1) domestic wastewater, 2) commercial institutional wastewater, 3) industrial wastewater and 4) septic tank effluents.

Surveys were conducted during the field survey period of April~June 1995.

#### **E1.1 Sampling Locations**

Sampling locations were selected based on their suitability for the purpose, accessibility and the availability of the information required. Table E-1 shows the sampling locations, sample numbers, sample types and sampling dates.

Due to the mountainous topography with steep slopes, accessibility was generally difficult and the sampling work required special care. Manholes were generally very deep and accessibility was difficult.

#### **E1.2 Analytical Parameters**

Table E-2 shows the parameters measured and analyzed for each type of sample. Flow rate, temperature and pH were measured at the site. Dissolved oxygen was fixed at the site and only one sample was taken for each site (rivers and surface drainage), because of the limitations with DO bottles. Table E-3 shows the analytical methods used for water quality analysis. All the analysis were conducted at the Laboratory of Ministry of Energy and Mines (ALGEN).

**Table E-1 Water Quality Survey Locations and Sampling Dates**

Survey Item	Location (Number of Samples per Day and Type of Sample)	Sampling Date	
		First	Second
<b>A Water Quality of Waterbodies</b>			
<b>A1 Wells</b>			
A1.1	Alameda Norte (1 G)	26-4-95	8-6-95
A1.2	Jardines de Minerva (1 G)	24-5-95	8-6-95
A1.3	Roosevelt Hospital (1 G)	26-4-95	13-6-95
A1.4	Molino de Las Flores (1 G)	24-5-95	13-6-95
A1.5	Ojo de Agua (1 G)	24-5-95	8-6-95
<b>A2 Rivers</b>			
A2.1 Las Vacas River (upstream )	Upstream of Grand Collector North (3 G)	3-5-95	6-6-95
A2.2 Las Vacas River (downstream )	Downstream of Grande Collector North (3 G)	3-5-95	6-6-95
A2.3 Villalobos River Mouth	Near Maya Crops (3 G)	27-4-95	18-5-95
A2.4 Villalobos River, Branch Stream 1	Puente Villa Hermosa (Pinula River) (3 G)	27-4-95	18-5-95
A2.5 Villalobos River, Branch Stream 2	Puente Villalobos (Molino River) (3 G)	27-4-95	18-5-95
A2.6 Lake Amatitlan (West)	Between Villalobos River Mouth and Power Station (3 G)	18-5-95	14-6-95
A2.7 Villalobos River (East)	South of Railway Bridge (3 G)	18-5-95	14-6-95
<b>A3 Drainage Channels</b>			
A3.1 Collector North, No. 1	Santa Elena II (3 G)	4-5-95	14-6-95
A3.2 Collector North, No. 2	El Zapote (3 G)	4-5-95	14-6-95
A3.3 Drainage Channel South, No. 1	Molino de Las Flores (3 G)	4-5-95	14-6-95
A3.4 Drainage Channel South, No. 2	Nimajuyu (3 G)	4-5-95	14-6-95
<b>B Estimation of Water Usage Rate and Unit Pollutant Load Generation</b>			
<b>B1 Domestic Wastewater</b>			
B1.1 High-income Block, North	Canada de San Angel (1 C)	10-5-95	24-5-95
B1.2 Middle-income Block, North	Pinares del Norte (1 C)	11-5-95	24-5-95
B1.3 Low-income Block, North	Santa Elena II (1 C)	11-5-95	24-5-95
B1.4 High-income Block, South	La Cañada (1 C)	10-5-95	25-5-95
B1.5 Middle-income Block, South	Bello Horizonte (1 C)	11-5-95	25-5-95
B1.6 Low-income Block, South	Villalobos II (1 C)	10-5-95	25-5-95
<b>B2 Commercial/Institutional Wastewater</b>			
B2.1 Block 1, North	School(INCA) (1 C)	17-5-95	1-6-95
B2.2 Block 2, North	Municipality Office (1 C)	17-5-95	1-6-95
B2.3 Block 3, North	Restaurant (Burger Shop) (1 C)	14-6-95	21-6-95
B2.4 Block 4, South	San Carlos University (1 C)	17-5-95	20-6-95
B2.5 Block 5, South	General Hospital (1 C)	17-5-95	20-6-95
B2.5 Block 6, South	Hotel (Hotel Plaza) (1 C)	13-6-95	21-6-95

Note : C indicates composite sample and G indicates grab sample.

**Table E-1 Water Quality Survey Locations and Sampling Dates**

Survey Item	Location (Number of Samples per Day and Type of Sample)	Sampling Date	
		First	Second
<b>B3 Industrial Wastewater</b>			
B3.1 Industry 1	Milk Products (1 C)	7-6-95	14-6-95
B3.2 Industry 2	Tannery (1 C)	13-6-95	14-6-95
B3.3 Industry 3	Brewery (1 C)	14-6-95	21-6-95
B3.4 Industry 4	Pharmaceutical (1 C)	6-7-95	7-7-95
B3.5 Industry 5	Textile /Dyeing (1 C)	21-6-95	23-6-95
B3.6 Industry 6	Meat Processing (Chicken) (1 C)	28-6-95	29-6-95
<b>B4 Septic Tank Effluent</b>			
B4.1 Location 1	Molino de Las Flores (1 G)	8-6-95	-
B4.2 Location 2	Colonia Santa Rita (1 G)	23-6-95	-
B4.3 Location 3	Colonia Villa Sol (1 G)	23-6-95	-
B4.4 Location 4	Condominio El Rosario (1 G)	23-6-95	-
B4.5 Location 5		23-6-95	-

Note : C indicates composite sample

G indicates grab sample

**Table E-2 Water Quality Parameters Measured**

Items	Existing Pollution Conditions			Water use/ Wastewater Generation and Unit pollutant Load Estimation				Sewage Treatment Works	
	Wells used for Drinking	Rivers and Lake Amalidan	Surface Drains	Domestic Wastewater	Institutional Wastewater	Industrial Wastewater	Septic Tank Effluent	Sewage and Effluent	Sludge
Sample Type	A1	A2	A3	B1	B2	B3	B4	C1	C2
Flowrate, m <sup>3</sup> /d		Q	Q	Q	Q	Q		Q	
Temperature, °C	Ambient	Ta	Ta	Ta	Ta	Ta	Ta		
	Sample	Ts	Ts	Ts	Ts	Ts	Ts	Ts	
pH	pH	pH	pH	pH	pH	pH	pH	pH	
DO, mg/L	-	DO	DO	-	-	-	-	-	-
BOD <sub>5</sub> , mg/L	BOD	BOD	BOD	BOD	BOD	BOD	BOD	BOD	BOD
COD, mg/L	COD	COD	COD	COD	COD	COD	COD	COD	COD
SS, mg/L	SS	SS	SS	SS	SS	SS	SS	SS	SS
T-N, mg/L	T-N	T-N	T-N	T-N	T-N	T-N	T-N	T-N	T-N
SO <sub>4</sub> -2, mg/L	SO <sub>4</sub>	SO <sub>4</sub>	SO <sub>4</sub>	SO <sub>4</sub>	SO <sub>4</sub>	SO <sub>4</sub>	SO <sub>4</sub>		
Fecal Coliform, MPN/100 mL	MPN	MPN	MPN	MPN	MPN	MPN	MPN	MPN	
T-P (Total Phosphorous), mg/L	T-P	T-P	T-P	T-P	T-P	T-P	T-P	T-P	T-P
Chloride (Cl <sup>-</sup> )	Cl	Cl	Cl	Cl	Cl	Cl	Cl	Cl	
Cadmium (Cd), mg/L	Cd	Cd	Cd			Cd*			Cd
Potassium (K), mg/L									K
Lead (Pb), mg/L	Pb	Pb	Pb			Pb*			Pb
Zinc (Zn), mg/L									Zn
Hexavalent Chromium (Cr <sup>6+</sup> ), mg/L	Cr <sub>6</sub>	Cr <sub>6</sub>	Cr <sub>6</sub>			Cr <sub>6</sub> *			Cr <sub>6</sub>
Arsenic (As), mg/L	As	As	As			As*			As
Total mercury (Hg), mg/L	Hg	Hg	Hg			Hg*			Hg
Copper (Cu), mg/L									Cu
Iron (Fe), mg/L									Fe
Total Manganese (Mn), mg/L									Mn
Nickel (Ni), mg/L									Ni
Apparent Specific Gravity									SG
Volatile Solids, mg/kg dry basis									VS
Water Content, %									WC
Total Number of Samples	10	34	24	12	12	12	5	9	2

Note : \* Parameters for heavy metal analysis were decided based on the industry.

**Table E-3 Analytical Methods Used For Water Quality Analysis**

Parameter	Method
Temperature, °C	Mercury / Alcohol Thermometer
pH	Digital, Portable pH meter
Laboratory pH	Selective Ion Analyzer
DO, mg/L	Winkler, Azide Modification
BOD <sub>5</sub> , mg/L	Dilution and Winkler, Azide Modification
COD, mg/L	Dichromate Reflux Method without HgSO <sub>4</sub>
SS, mg/L	Total Non-filtrable Residue at 103-105 deg C
T-N, mg/L	Persulfate Oxidation and Nitrate Determination
SO <sub>4</sub> -2, mg/L	Barium Iodate and Tannin Method
Fecal Coliform, MPN/100 mL	Multiple Tubes (3r x 6 d) Fermentation Method
T-P (Total Phosphorous), mg/L	Persulfate Oxidation and Phosphate determination
Chloride (Cl <sup>-</sup> )	Argentometric Method
Cadmium (Cd), mg/L	1-(4-Nitrophenyl)-3-(4-Phenylazophenyl)-Triazene Method
Potassium (K), mg/L	Sodium Tetrphenylbromate Method
Lead (Pb), mg/L	4-(2'-pyridylazo) Resorcinol Method
Zinc (Zn), mg/L	Pyridylazonaphotol Method
Hexavalent Chromium (Cr <sup>6+</sup> ), mg/L	Diphenylcarbazide Method
Total Chromium, mg/L	KMnO <sub>4</sub> /II+ Oxidation and Hexavalent Cr Determination
Arsenic (As), mg/L	Silver Diethyldithiocarbamate Method
Total Mercury (Hg), mg/L	Dithizone Method
Copper (Cu), mg/L	Cuprizone Method
Iron (Fe), mg/L	[3-(2-pyridyl)-5,6 bis(4-phenylsulfonic acid)]-1,2,4-Triazene
Total Manganese (Mn), mg/L	Formaloxine Method
Nickel (Ni), mg/L	Dimethylglyoxime Method
Apparent Specific Gravity	213 E Standard Methods Procedure
Volatile Solids, mg/kg dry basis	209 G. 3.a.2) Standard Methods Procedure
Water Content, %	Gravimetric Method

Source : Study Team

## E2 RESULTS

Tables E-5 through E-17 show the results of the field measurements and laboratory analysis.

### E2.1 Quality Of Public Water Bodies

The quality of public water bodies was investigated twice during the field survey period, for wet and dry season. However, the rainy season for this year started late and there was considerable rain during late April and the beginning of May. Table E-4 shows the rainfall for each week during the field survey period. In April, the rainfall was almost three times higher than the average for 1985~1994. In May '95, even though the rainfall (114.8 mm) was almost the same as the average (108.2 mm) for 1985~1994, half of the rainfall (53.6 mm) was on a single day in the first week of May.

**Table E - 4 Weekly Rainfall Variation in Guatemala City  
(Station INSUVIMEH), During Field Survey Period**

Week	Rainfall, mm		
	April	May	June
1 (31st ~ 7th)	2.3 (2)	53.6 (1)	13.8 (3)
2 (8th ~ 14th)	12.2 (1)	10.5 (1)	79.2 (5)
3 (15th ~ 21st)	5.0 (1)	15.8 (1)	80.0 (5)
4 (22nd ~ 30th)	53.1 (5)	34.5 (5)	152.9 (8)
Total (1995)	72.6 (9)	114.4 (8)	325.9 (21)
Average (1985- 1994)	27.0 (4.8)	108.2 (11.3)	250.9 (20.8)

Source : INSUVIMEH

Therefore the sampling of rivers during the last week of April and first week of May could be considered as representative for wet season while that for late May could be considered as a dry season.

#### E2.1.1 Wells

Water quality of the wells surveyed was generally good in terms of fecal coliform levels except for slightly high concentrations of BOD, COD and SS in some of the samples. Presence of high SS may be due to very fine sand which may have escaped through strainers because the samples were clear at the time of sampling. The presence of high BOD and COD in some samples was not consistent in the first and second sampling. For example, for



sample A1.2, COD concentration for the first and second sampling were 21.5 and 0 mg/L. Further, total nitrogen concentrations measured for Ojo de Agua were in the range of 0.91-10.26 in February 1995 compared to the 27.7 and 1.4 mg/L (A1.5) in this survey. Since, existing data for the wells does not include BOD or COD, a comparison could not be made.

Heavy metal concentrations were also negligible except for cadmium and mercury. However, cadmium concentrations for all wells are in the same range 43.5-70.1 µg/L while those of mercury showed drastic difference between the first and second sampling (e. g. for A1.1, concentrations were 10.4 and 0.3 µg/L. The possibility of these wells, located in various parts of the Study Area been polluted by cadmium and Mercury is very remote. It is recommended that analytical techniques be improved to get reliable data.

Considering the drastic difference between the first and second sampling and the importance of the water supply wells, it is recommended that regular monitoring be done including the parameter COD.

#### **E2.1.2 Rivers and Lake Amatitlan**

Flowrates of rivers showed variation during the day indicating the effect of wastewater discharges from both domestic and industrial origin.

Serious pollution exists in all of the rivers as was indicated by the high levels of BOD and fecal coliform concentrations. BOD concentration ranged from 11 ~ 292 mg/L.

SS concentrations were also high and included sediment due to erosion and sand dredging activity along rivers in the Study Area.

Except for lead, heavy metal concentrations were in trace concentrations.

Water quality of Lake Amatitlan were different between east and west parts of the lake, especially in terms of chloride concentrations. Chloride concentrations were 99.3-165.1 mg/L in the eastern part while those in the western part was 23.2-25.2 mg/L. However, the range of concentrations was similar to the values measured in 1970 for the west and east stations which were in the range of 147-170 mg/L and 83-90 mg/L, respectively. Sulfate concentrations did not show much difference and are also similar to the values measured in 1970.

Probably the most important characteristic of Lake Amatitlan is its low concentration of T-P which has not varied much during the last forty years. It was 0.0455-0.053 in 1950, 0.035-0.046 in 1970 and 0.028-0.042 mg/L in this survey (excluding 0.391 mg/L for A2.7, which need to be confirmed). A previous study by Charles Weiss (1970) pointed out this characteristic, noting that this may be the limiting factor preventing any large-scale eutrophication from taking place even though pollutant load to the lake is increasing.

COD concentrations for west did not show much variation (59-24 mg/L) while those for the east showed extreme variation (67-7.5 mg/L). Unfortunately, COD (or BOD) values, which indicate direct contamination, are not available for 1970 or thereafter so that a comparison could not be made.

**Table E-5 Water Quality of Wells Used for Drinking Water**

Parameter		Well No. 1 Alameda Norte		Well No. 2 Jardines de Minerva		Well No. 3 Roosevelt Hospital		Well No. 4 Molino de las Flores		Well No. 5 Ojo de Agua	
		A1.1		A1.2		A1.3		A1.4		A1.5	
		26-04-95	8-06-95	24-05-95	8-06-95	26-04-95	13-06-95	24-05-95	13-06-95	24-05-95	8-06-95
Temperature, °C	Ambient	21	22	23	24	20	30	23	22	24	27
	Sample	23	25	22	26	22	26	24	24	25	25
pH		7.7	7.6	7.8	7.8	6.9	9.3	7.7	6.9	7.6	7.1
BOD5, mg/L		0.4	6.2	6.9	0.0	1.3	2.0	1.0	1.1	7.0	6.4
COD, mg/L		0.0	6.6	21.5	0.0	5.0	31.0	1.5	1.4	21.5	17.8
SS, mg/L		24	0	8	4	24	164	4	4	0	16
T-N (Total Nitrogen), mg/L		2.59	0.46	5.93	0.09	4.19	14.00	1.24	61.00	27.70	1.40
T-P (Total Phosphorous), mg/L		0.282	0.248	0.055	0.201	0.636	9.90	0.117	4.60	0.133	0.310
Fecal Coliform, MPN/100 mL		<3	3	<3	<3	<3	<3	<3	<3	<3	3
SO4-2, mg/L		113.0	2.5	8.2	1.8	256.0	8.5	7.7	21.2	4.3	5.5
Chloride (Cl-), mg/L		2.47	0.0	24.7	26.2	1.98	28.2	5.4	33.6	5.9	5.4
Cadmium (Cd), µ g/L		53.0	53.0	59.1	53.0	43.5	64.7	63.1	70.1	62.5	59.1
Lead (Pb), µ g/L		0.6	23.6	73.7	17.6	0.6	1,212	73.7	25.6	65.7	37.6
Hexavalent chromium (Cr6+), µ g/L		1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Arsenic (As), µ g/L		10.3	3.5	4.4	1.8	10.0	9.4	6.9	1.0	2.7	1.0
Total mercury (Hg), µ g/L		10.4	0.3	14.6	8.8	16.8	2.7	11.2	0.3	19.2	11.2

Table E-6 Water Quality of Rivers / I

Parameter	Las Vacas River (near Grand Collector Outfall)						Villalobos River and Its Tributaries													
	Upstream of Outfall			Downstream of Outfall			Villalobos River Mouth (near Maya Crops)		Pinula River (Puente Villa Hermosa)		Molino River (Puente Villalobos)									
	A2.1	A2.2	A2.3	A2.4	A2.5	A2.6	A2.7	A2.8	A2.9	A2.10	A2.11	A2.12								
Flowrate, m <sup>3</sup> /s	7:45	12:30	15:10	8:30	13:15	16:30	8:30	13:25	15:15	9:00	12:45	16:00	11:30	14:00	15:30					
	0.525	0.729	0.633	1.646	1.547	1.448	1.119	0.792		0.313	0.276		0.114		0.148					
Temperature, °C	Ambient						18	24	21	22	23	22	18	23	22	21	20	21	22	
	Sample						19	26	26	24	25	24	20	26	26	22	24	25	22	25
pH	7.7	7.7	7.7	7.9	7.7	7.7	8.1	7.7	7.7	7.7	7.7	8.6	7.3	7.9	8.0	8.0				
DO, mg/L	4.86	-	-	3.80	-	-	0.49	-	-	-	-	-	3.11	-	-	3.30	-	-	-	-
BOD <sub>5</sub> , mg/L	11	25	40	213	111	200	214	49	112	292	122	117	177	190	168					
COD, mg/L	12	36	42	219	192	208	222	257	230	332	202	161	280	264	188					
SS, mg/L	148	6	80	128	274	156	2,176	496	1,252	536	996	292	388	444	416					
T-N, mg/L	0.55	1.95	0.61	62.4	20.4	27.1	32.9	30.3	10.0	62.9	24.0	19.4	37.1	39.1	9.9					
T-P (Total Phosphorous), mg/L	0.90	1.52	1.93	5.45	4.86	4.48	8.87	5.82	4.04	2.64	2.46	2.59	5.83	3.94	3.34					
Fecal Coliform, MPN/100 mL	4.6E06	>24E06	40E+02	11E+06	2.1E06	>24E06	>24E06	>24E06	>24E06	1.5E05	1.1E06	>24E06	>24E06	>24E06	>24E06					
SO <sub>4</sub> -2, mg/L	12.1	6.1	3.4	78.4	24.0	27.8	16.1	4.0	12.0	6.0	4.8	0.7	267	329	29					
Chloride (Cl-), mg/L	13.8	18.3	20.3	30.6	56.8	41.0	28.2	22.7	27.2	88.5	21.3	20.3	34.6	18.3	18.8					

Table E-6 Water Quality of Rivers /1 (continued)

Parameter	Las Vacas River (near Grand Collector Outfall)			Villalobos River and Its Tributaries											
	Upstream of Outfall	Downstream of Outfall		Villalobos River Mouth (near Maya Crops)	Pinula River (Fuente Villa Hermosa)		Molino River (Puente Villalobos)								
		A2.1	A2.2		A2.3	A2.4	A2.5								
	3-05-95	3-05-95	3-05-95	27-04-95		27-04-95									
	7:45	12:30	15:10	8:30	13:15	16:30	8:30	13:25	15:15	9:00	12:45	16:00	11:30	14:00	15:30
Cadmium (Cd), $\mu$ g/L	46.3	70.3	59.4	63.1	67.0	62.8	35.6	43.2	54.1	46.8	22.7	56.1	65.6	56.6	46.8
Lead (Pb), $\mu$ g/L	260.0	177.9	224.0	272.1	240.0	206.0	137.8	113.8	165.9	81.7	21.6	17.6	27.7	1.6	212.0
Hexavalent chromium (Cr6+), $\mu$ g/L	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Arsenic (As), $\mu$ g/L	15.1	11.7	8.9	24.1	15.1	7.5	22.4	15.1	15.1	14.2	12.2	13.9	10.0	8.9	8.9
Total mercury (Hg), $\mu$ g/L	14.0	0.3	7.5	8.4	6.3	21.2	23.8	9.2	12.4	7.1	20.4	25.2	11.2	12.0	8.8

Table E-7 Water Quality of Rivers / 2

Parameter	Las Vacas River (near Collector outfall)				Villalobos River and its Tributaries									
	Upstream of Outfall		Downstream of Outfall		Villalobos River Mouth (near Maya Crops)		Pinula River (Puente Villa Hermosa)		Molino River (Puente Villalobos)					
	A2.1		A2.2		A2.3		A2.4		A2.5					
	7-06-95		7-06-95		18-05-95		18-05-95		18-05-95					
Flowrate, m <sup>3</sup> /s	7:15	12:30	7:45	13:15	16:00	9:30	13:30	15:30	8:30	12:30	16:00	7:30	12:30	15:30
	0.443	0.511	1.512	1.149	1.483	0.140	0.468	0.397	0.224	0.350	0.099	0.226	0.022	0.036
Temperature, °C	Ambient		20	25	21	21	24	22	20	23	22	24	26	24
	Sample		21	27	26	22	27	26	22	25	26	19	21	20
pH	7.5	7.5	7.6	7.4	7.5	7.7	7.7	7.7	8.4	7.5	7.5	8.1	8.7	9.1
DO, mg/L	3.6	-	1.85	-	-	2.3	-	-	2.00	-	-	1.79	-	-
BOD <sub>5</sub> , mg/L	42	47	107	209	146	135	112	192	110	175	117	74	110	96
COD, mg/L	44	86	117	222	272	167	177	203	142	299	172	175	271	98
SS, mg/L	36	40	660	264	156	24	636	876	252	768	24	88	4	12
T-N, mg/L	4.9	0.17	6.3	31.5	9.8	16.7	47.7	26.7	27.2	47.2	15.3	58.6	47.5	52.8
T-P (Total Phosphorous), mg/L	2.0	3.3	2.3	6.1	5.1	4.3	7.2	6.5	5.6	3.9	1.8	4.9	4.4	3.6
Fecal Coliform, MPN/100 mL	28E+04	30E+04	20E+04	11E+04	15E+04	>11E+06	02E+06	02E+06	04E+04	20E+04	30E+04	28E+04	07E+04	21E+02
SO <sub>4</sub> -2, mg/L	0.6	6.7	4.9	3.4	7.3	13.2	11.9	12.9	7.9	24.4	9.9	22.0	17.4	20.0
Chloride (Cl <sup>-</sup> ), mg/L	14.8	9.4	23.2	30.2	42.0	51.9	60.3	43.5	26.2	58.3	19.3	38.6	39.0	34.6

**Table E-7 Water Quality of Rivers / 2 (continued)**

Parameter	Las Vacas River (near Collector outfall)				Villalobos River and Its Tributaries									
	Upstream of Outfall		Downstream of Outfall		Villalobos River Mouth (near Maya Crops)		Pintia River (Puente Villa Hermosa)		Molino River (Puente Villalobos)					
	A2.1		A2.2		A2.3		A2.4		A2.5					
	7-06-95		7-06-95		18-05-95		18-05-95		18-05-95					
	7:15	12:30	7:45	13:15	9:30	13:30	15:30	8:30	12:30	16:00	7:30	12:30	15:30	
Cadmium (Cd), $\mu$ g/L	74.8	65.0	75.1	77.9	70.3	54.1	49.3	91.6	63.1	73.1	57.7	13.2	58.6	64.2
Lead (Pb), $\mu$ g/L	544.6	69.7	264.1	169.9	87.7	169.9	670.9	1006.0	843.2	214.0	348.2	630.8	222.0	478.5
Hexavalent chromium (Cr6+), $\mu$ g/L	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Arsenic (As), $\mu$ g/L	12.2	11.7	18.4	8.3	12.5	12.0	7.5	14.8	6.6	7.2	4.6	9.2	8.9	15.6
Total mercury (Hg), $\mu$ g/L	35.9	10.4	14.0	9.8	12.0	11.8	29.6	35.1	17.8	20.4	18.0	13.6	6.9	17.2

**Table E-8 Water Quality of Lake Amatitlan**

Parameter		West (north of railroad)		East (south of railroad)	
		A2.6		A2.7	
		18-05-95 12:45	14-06-95 14:00	18-05-95 12:15	14-06-95 15:00
Temperature, °C	Ambient	22	23	23	24
	Sample	25	26	25	26
pH		8.9	8.5	9.0	8.3
DO, mg/L		2.11	2.77	2.00	2.67
BOD5, mg/L		17	15	17	7
COD, mg/L		59	24	67	7.5
SS, mg/L		16	9	20	8
T-N, mg/L		37.04	52.34	41.48	5.65
T-P (Total Phosphorous), mg/L		0.042	0.028	0.028	0.391
Fecal Coliform, MPN/100 mL		70	40	210	150
SO4-2, mg/L		2.7	4.0	9.3	9.6
Chloride (Cl-), mg/L		165.1	99.3	25.2	23.2
Cadmium (Cd), µg/L		47.4	64.7	70.6	58.0
Lead (Pb), µg/L		21.6	41.6	3.6	125.8
Hexavalent chromium (Cr6+), mg/L		1.4	1.4	1.4	1.4
Arsenic (As), µg/L		46.0	19.0	32.5	28.6
Total mercury (Hg), µg/L		12.8	4.5	14.8	9.0

Note : Samples were collected from approximately 0.5 m from the lake water surface.

The values are extremely high and does not agree with other recent results.



### **E2.1.3 Water Quality of Collector Sewers and Drainage Channel Discharges**

Since no treatment is provided, it is obvious that the concentrations of collector sewer and drainage channel discharges are similar to those of raw sewage and represent the wastewater concentrations that could be expected. For example, BOD concentrations are in the range of 74~442 mg/L, with an average concentration of 172 mg/L and standard deviation of 104 mg/L during day time. Compared with river waters, SS concentrations are lower indicating the effect of eroded soil in the river water.

There are seventy four (74) known discharges in Pacific or Lake Amatitlan basin and ninety five (95) discharges in the Atlantic basin, including those of storm sewers. The quality of discharges from those could be expected to be the same in the same range as that for the sewer discharges surveyed.

**Table E-9 Water Quality of Collector Sewer and Drainage Channel Discharges /I**

Parameter	North						South						
	Santa Elena II			El Zapote			Molino de las Flores			Nimajuyu			
	A3.1			A3.2			A3.3			A3.4			
	4-05-95			4-05-95			4-05-95			4-05-95			
	8:30	13:00	16:00	7:30	12:00	15:00	9:00	12:00	15:30	7:30	12:00	15:00	
Flowrate, l/s	11.8	43.4	48.8	33.7	11.8	10.5	2.8	1.6	2.1	23.9	19.0	13.1	
Temperature, °C	Ambient	19	17	22	20	24	19	26	27	22	19	22	21
	Sample	22	23	22	22	23	23	21	26	23	23	24	23
pH	7.7	7.1	8.2	7.8	6.9	7.5	7.0	7.8	7.7	8.0	7.1	7.0	
DO, mg/L	-	1.40	-	-	1.78	-	-	1.73	-	-	2.12	-	
BOD5, mg/L	442	136	225	148	265	130	141	434	182	371	390	161	
COD, mg/L	754	221	259	160	276	191	201	764	194	456	470	272	
SS, mg/L	118	318	234	58	142	154	126	90	14	256	26	8	
T-N, mg/L	24.7	5.4	12.8	27.8	6.1	15.8	58.8	10.2	62.7	65.9	63.1	51.0	
T-P (Total Phosphorous), mg/L	18.7	4.50	4.98	4.76	5.51	4.24	6.22	5.57	4.63	5.41	7.02	5.90	
Fecal Coliform, MPN/100 mL	> 24E+06	> 24E+06	> 24E+06	> 24E+06	11E+06	40E+02	02E+06	> 24E+06	21E+06	> 24E+06	> 24E+06	15E+06	
SO4-2, mg/L	1.0	2.0	9.0	6.7	1.4	1.2	1.8	1.8	0.9	2.0	2.4	1.8	
Chloride (Cl-), mg/L													
Cadmium (Cd), µg/L	62.2	67.3	73.1	65.6	44.0	60.8	58.9	67.3	54.9	75.1	88.3	63.9	
Lead (Pb), µg/L	109.8	81.7	202.0	9.6	204.0	41.6	476.5	9.6	9.6	43.7	29.6	21.6	
Hexavalent chromium (Cr6+), µg/L	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	
Arsenic (As), µg/L	36.5	12.0	6.6	6.9	14.5	14.2	8.9	12.8	7.2	8.6	1.6	9.4	
Total mercury (Hg), µg/L	16.4	19.6	17.8	21.0	21.6	15.2	18.2	21.8	16.6	16.2	16.6	19.0	

**Table E-10 Water Quality of Collector Sewer and Drainage Channel Discharges /2**

Parameter		North						South					
		Santa Elena II			El Zapote			Molino de las Flores			Nimajuyu		
		A3.1			A3.2			A3.3			A3.4		
		31-05-95			31-05-95			31-05-95			31-05-95		
		8:00	13:10	15:00	8:30	12:30	16:00	9:00	12:00	15:30	7:30	13:00	17:00
Flowrate, L/s		14.6	10.3	6.3	33.5	10.8	6.1	1.3	1.5	1.2	15.0	12.4	18.7
Temperature, °C	Ambient	20	28	29	22	28	23	24	31	26	20	29	23
	Sample	24	24	25	24	25	25	24	25	25	25	26	25
pH		8.3	7.3	7.3	7.7	7.1	7.1	7.6	7.7	7.3	7.5	7.7	7.4
BOD5, mg/L		266	200	222	74.4	104	125	158	160	154	300	216	134
COD, mg/L		289	249	327	108	168	178	248	272	195	331	259	217
SS, mg/L		140	168	320	80	44	152	132	294	80	435	228	76
T-N, mg/L		55.7	21.8	50.3	26.6	17.2	45.0	30.5	21.8	21.2	93.2	10.9	7.8
T-P (Total Phosphorous), mg/L		7.4	5.7	7.5	4.3	5.1	6.1	7.6	7.7	4.4	8.5	7.6	6.6
Fecal Coliform, MPN/100 mL		28E+04	11E+06	01E+06	> 24E+06	11E+06	> 24E+06	> 24E+06	28E+04	07E+04	07E+04	07E+04	04E+04
SO4-2, mg/L		15.8	16.4	16.6	16.4	18.9	15.8	14.2	9.4	8.3	8.9	13.4	20.7
Chloride (Cl-), mg/L		34.1	38.0	54.4	24.2	28.7	37.6	17.3	19.8	23.7	44.5	51.9	47.5
Cadmium (Cd), µg/L		88.3	77.1	74.3	60.8	68.1	62.2	63.3	64.7	41.8	68.9	71.2	65.9
Lead (Pb), µg/L		33.6	55.7	99.8	35.6	37.6	137.8	33.6	49.7	5.6	81.7	13.6	49.7
Hexavalent chromium (Cr6+), µg/L		1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Arsenic (As), µg/L		4.4	10.0	3.5	7.2	9.4	8.3	1.6	11.1	1.8	0.7	6.6	6.9
Total mercury (Hg), µg/L		16.0	12.8	4.5	11.2	5.5	10.2	8.8	4.5	5.1	6.3	7.5	2.3

## **E2.2 Water Usage Rate and Unit Pollutant Load Generation**

This survey was conducted during the day-time only due to security reasons, and assumptions will be made for calculating unit pollutant loads. Tables E-11, E-12, E-13, E-14, E-15, E-16 and E-17 show the results of the analysis for domestic, institutional / commercial, industrial and septic tank effluents.

### **E2.2.1 Domestic Sources**

Existing small-scale sewage treatment plants in the north and south receive sewage from domestic origin and therefore selected for sampling based on the income level of residents. Sampling locations were at the inlet to the treatment plants

Water meters are provided only for individual houses and the water consumption rate was obtained from water meter data for the last year. Except for La Canada, BOD concentrations during the day-time varied between 120~503 mg/L with an average of 297 mg/L. La Canada is a very high-income area with high water consumption. Average day-time SS concentrations were 183 mg/L (172~380 mg/L). Similarly, T-N and T-P concentrations were 36.3 and 6.22 mg/L, respectively.

### **E2.2.2 Institutional / Commercial Sources**

Compared to domestic wastewater, the concentration of institutional / commercial wastewater is low, especially in terms of SS. BOD concentrations were in the range of 65~354 mg/L, the highest being from the school and the lowest from the municipality building.

### **E2.2.3 Industrial Sources**

Of the six industries surveyed, only four of the industries could be sampled within the industry's compound so the rest were sampled at the street manhole. Meat processing, brewery and textile industries used the most water.

High BOD concentrations were found for the brewery and tannery at 3,544 and 3,028 mg/L respectively. The BOD concentration for brewery was unexpectedly low, possibly due to dilution by bottle cleaning wastewater.

SS concentrations were higher for all industries, most probably exceeding settleable solids standards.

**Table E-11 Wastewater Flow Measured at Domestic Sources (L/s)**

Location	1995/5/10 & 11			1995/5/24 & 25		
	1	2	3	1	2	3
Cañada de San Angel	4.74	1.75	1.52	7.79	2.02	1.85
Pinares del Norte	20.43	8.88	10.82	13.32	17.19	9.10
Santa Elena II	3.39	2.17	2.29	1.80	0.56	1.84
La Cañada	1.44	0.60	0.43	0.58	0.76	0.94
Bello Horizonte	23.80	9.03	10.27	9.50	3.10	12.60
Villa Lobos II	20.38	8.16	8.16	14.18	4.30	4.68

Note : Samples 1, 2 and 3 are collected at 7:00-7:30, 12:00-12:30 and 15:30-16:00, approximately.

Table E-12 Water Quality of the Domestic Wastewater Sources

Parameter	Northern Region						Southern Region					
	Cañada de San Angel (High-Income) B1.1		Pinares Del Norte (Middle-Income) B1.2		Santa Elena II (Low-Income) B1.3		La Cañada (High-Income) B1.4		Bello Horizonte (Middle-Income) B1.5		Villalobos II (Low-Income) B1.6	
	10-05-95	24-05-95	11-05-95	24-05-95	11-05-95	24-05-95	10-05-95	25-05-95	11-05-95	25-05-95	10-05-95	25-05-95
Temperature, °C												
	Ambient											
	Sample											
pH	7.6	7.4	7.3	7.6	7.2	7.2	7.6	7.4	7.1	7.4	7.1	7.1
BOD <sub>5</sub> , mg/L	351	407	342	120	360	138	37	32	280	236	229	503
COD, mg/L	389	461	360	260	426	354	69	121	308	245	418	797
SS, mg/L	172	68	208	244	204	208	208	32	380	216	228	276
T-N, mg/L	42.5	27.5	37.8	26.6	38.8	20.9	27.5	42.7	67.2	38.8	67.2	68.6
T-P (Total Phosphorous), mg/L	8.30	9.11	10.12	5.70	6.00	5.52	2.83	3.47	6.86	6.86	7.08	9.08
Fecal Coliform, MPN/100 mL	> 24E+06	> 24E+06	> 24E+06	11E+06	46E+04	28E+04	> 24E+06	28E+04	> 24E+06	> 24E+06	> 24E+06	> 24E+06
SO <sub>4</sub> -2, mg/L	15.6	13.5	20.4	11.9	15.4	10.8	7.2	9.3	22.4	10.6	29.6	13.5
Chloride (Cl <sup>-</sup> ), mg/L	28.7	29.2	20.2	25.2	47.0	23.7	26.2	7.4	35.6	17.8	38.1	31.6

**Table E-13 Wastewater Flow Rate Measured at Institutional / Commercial Sources (L/s)**

Location	1	2	3	1	2	3
School (INCA)	0.00	0.16	0.48	0.00	0.02	0.09
Municipality Building	0.55	0.71	0.90	0.71	3.85	0.60
Restaurant	0.01	0.22	0.01	0.10	0.20	0.10
USAC	3.44	4.56	5.76	2.96	4.47	5.57
General Hospital	2.79	2.43	3.97	5.39	2.01	3.89
Hotel	0.10	0.05	0.16	0.13	0.03	0.01

Note : Samples 1, 2 and 3 were collected at 7:00~7:30, 12:00~12:30 and 15:30~16:00, approximately, except for school for which Sample 1 was taken at 10:00~10:30.

Table E-14 Water Quality of Institutional / Commercial Wastewaters

Parameter	School		Municipality Building		Restaurant		University of San Carlos		General Hospital		Hotel	
	B2.1	B2.2	B2.3	B2.4	B2.5	B2.6	B2.7	B2.8	B2.9	B2.10	B2.11	B2.12
Temperature, °C	17-05-95	01-06-95	17-05-95	01-06-95	14-06-95	21-06-95	17-05-95	01-06-95	17-05-95	01-06-95	13-06-95	21-06-95
	Ambient											
	Sample											
pH	8.5	8.7	7.8	7.9	7.2	7.2	7.8	8	7.8	7	2.02	7.2
BOD <sub>5</sub> , mg/L	126	354	65	84	106	164	256	106	256	173	302	69
COD, mg/L	245	529	110	99	125	215	181	253	200	324	76	247
SS, mg/L	68	80	32	8	24	16	44	36	36	92	88	56
T-N, mg/L	27	35	42	9	82	16	36	37	27	30	22	78
T-P (Total Phosphorous), mg/L	9.89	0.98	3.27	0.971	2.511	8.134	5.29	3.27	7.3	5	6.5	1.4
Fecal Coliform, MPN/100 mL	40E+02	11E+04	30E+02	11E+06	<3	70	11E+06	02E+06	03E+04	15E+04	02E+02	15E+02
SO <sub>4</sub> -2, mg/L	38.5	245.6	3.6	9.3	88.3	12.5	17.1	13.7	7.7	109.3	12.3	17.8
Chloride (Cl-), mg/L	270.8	44.4	26.7	38.1	29.2	53.9	43.5	41	36.6	47	34.1	40.0



**Table E-15 Wastewater Flow Rate Measured at Industrial Sources (L/S)**

Location	First Sampling			Second Sampling		
	1	2	3	1	2	3
B3.1 Milk Products	-	-	-	-	-	-
B3.2 Tannery	1.52	1.05	2.66	0.84	5.50	2.60
B3.3 Brewery	-	-	-	-	-	-
B3.4 Pharmaceutical	0.60	0.70	0.70	0.31	0.14	0.18
B3.5 Textile /Dyeing	5.85	4.85	19.00	3.88	14.20	6.25
B3.6 Meat Processing (chicken)	7.0	6.5	10.5	7.0	9.3	10.5

Note : Samples 1, 2 and 3 were collected at 8:00-9:00, 12:00-12:30 and 15:30-16:00, approximately.

**Table E-16 Water Quality of Industrial Wastewaters**

Parameter		Milk Products		Tannery		Brewery		Pharmaceutical		Textile Dyeing		Meat Processing / Chicken	
		B3.1		B3.2		B3.3		B3.4		B3.5		B3.6	
		08-06-95	14-06-95	13-06-95	14-06-95	14-06-95	21-06-95	06-07-95	07-07-95	21-06-95	23-06-95	23-06-95	29-06-95
Temperature, °C	Ambient												
	Sample												
pH		3.9	7.2	5.3	7.2	7.2	6.0	7.2	7.2	8.3	7.3	6.9	6.8
BOD <sub>5</sub> , mg/L		556	1,145	953	1,358	47	87	127	123	144	413	152	133
COD, mg/L		3,544	1,593	1,264	3,028	178	118	164	172	268	515	164	172
SS, mg/L		1,016	268	920	868	28	40	36	48	92	252	228	236
T-N, mg/L		15.3	40.2	342	566	72	16.9	8.2	24.8	31	99.0	59.6	54.0
T-P (Total Phosphorous), mg/L		10.3	11.5	8.1	7.1	2.5	2.5	6.7	3.2	2.7	1.8	10.8	9.2
Fecal Coliform, MPN/100 mL		11E+06	20E+04	<3	<3	02E+06	11E+04	09E+04	<3	<3	<3	11E+06	>21E+06
SO <sub>4</sub> -2, mg/L		14	54.6	1,131	681	20.3	10.2	13.7	11.5	37.0	12.3	153	11.6
Chloride (Cl-), mg/L		33.6	33.1	29.2	27.2	28.2	45.0	45.0	47.5	56.8	47.9	51.9	54.4
Cadmium (Cd), µg/L		-	-	86.9	98.3	-	-	65.0	41.8	73.7	-	70.9	73.4
Lead (Pb), µg/L		-	-	45.7	37.6	-	-	45.7	5.6	37.6	-	105.8	85.7
Hexavalent chromium (Cr <sup>6+</sup> ), µg/L				1.4	1.4			1.4	1.4	1.4		93.1	156.4
Total Chromium µg/L		-	-	150.0	0.04	-	-	-	-	-	-	-	-
Arsenic (As), µg/L		-	-	3.5	12.8	-	-	6.3	2.4	6.3	-	5.5	2.7
Total mercury (Hg), µg/L		-	-	8.8	3.9	-	-	3.5	3.7	3.9	-	9.6	10.4
BOD <sub>5</sub> /COD Ratio		0.16	0.72	0.75	0.45	0.26	0.74	0.77	0.72	0.54	0.80	0.93	0.77

The ratio of BOD/COD for pharmaceutical, textile dyeing and meat processing wastewaters was in the range of 0.54-0.93 indicating the possibility of using biological treatment. For milk product wastewater, the BOD/COD ratio for the first sample was very low ( $556/3544=0.16$ ) at 0.16 while that for second sample was 0.71. The presence of detergents or fat may have caused the low BOD/COD ratio. Brewery wastewater also showed much difference of BOD/COD ratio for the first and second sampling (0.26 and 0.74).

#### **E2.2.4 Septic Tank Effluents**

BOD concentrations of septic tank effluent were in the range of 108-231 mg/L. Three of the septic tanks showed SS concentrations in the range of 76-152 mg/L indicating poor sedimentation while the other two showed very low SS concentrations.

#### **E2.2.5 Summary of Pollutant Load Generation**

##### **a) Domestic sources**

Water consumption of the households in the colonies surveyed was estimated using the meter reading data of EMPAGUA for January 1994-May 1995, except for Cañada De San Angel and Pinares Del Norte. Only actual readings excluding estimated readings were used. Meter readings below 3 m<sup>3</sup> and above 90 m<sup>3</sup> were excluded. Water consumption for Cañada De San Angel was obtained from the water meter reading of the whole colony for the months of February-April '95 and that for Pinares Del Norte was estimated from pump capacity and operating time. Table E-18 shows the water consumption of households in the colonies surveyed. Except for La Cañada which is a very high-income colony, average monthly water consumption per household was in the range of 15.88-24.10 m<sup>3</sup>/month. Average per capita water consumption was 136-97 lpcd, assuming an average of 5.5 persons per household.

Table E-19 shows results of unit per capita load estimated assuming that the ratio of day-time load to total load is 0.6. Per capita BOD load for medium and low-income colonies was between 15-27gpcd, while that for Cañada De San Angel was 53 gpcd.

##### **b) Institutional / Commercial Sources**

Table E-20 shows the estimated unit pollutant load for institutional / commercial sources. Highest unit pollutant load was 39 g BOD per bed for General Hospital while the lowest was for San Carlos University at 0.5 g BOD per registered population. Actual number of persons vary for both during the day, higher than the number of

beds for General Hospital and lower than the number of registered population for San Carlos University.

c) Industrial Sources

Table E-21 shows the estimated pollutant load generation. The average BOD load from tannery , textile and meat processing industries were 115, 94 and 53 kg/d which are equivalent to approximately 2,050, 1,680, and 950 persons assuming per capita load of 56 g BOD.

**Table E-17 Water Quality of Septic Tank Effluent**

Parameter		1	2	3	4	5
		B4.1	B4.2	B4.3	B4.4	B4.5
		08-06-95	23-06-95	23-06-95	23-06-95	23-06-95
Temperature, °C	Ambient	24	20	23	23	22
	Sample	27	26	29	24	24
pH		7.5	8.1	7.6	7.5	7.6
BOD5, mg/L		231	205	166	157	108
COD, mg/L		252	226	195	208	199
SS, mg/L		152	144	76	12	0
T-N, mg/L		80	36.0	29.4	29.4	20.0
SO4-2, mg/L		8.1	11.24	17.68	8.56	12.57
Fecal Coliform, MPN/100 mL		07E+04	02E+06	43E+04	11E+06	28E+04
T-P (Total Phosphorous), mg/L		17.6	9.4	11.4	5.1	9.3
Chloride (Cl-), mg/L		22.2	38.1	40	41.5	41.0

Table E-18 Water Consumption of Households in January 1994 ~ May 1995

Colony	Number of Data	Median	Average	Standard Deviation	Per Capita Water Consumption lpcd
La Cañada	1471	55	66.00	38.00	333
Bello Horizonte	11660	22	24.10	12.83	133
Villalobos II	92	16	15.88	5.35	97
Cañada De San Angel **1	193	-	22.40	-	136
Pinares Del Norte **2	-	-	17.77	-	108
Santa Elena II	2945	19	21.26	12.21	115

Note:

\*\*1 Estimated from water meter readings of Colonia Canada and la Floresta for the months of February~April '95.

\*\*2 Estimated from pump capacity and pump operation time.

All other data are water meter readings by EMPAGUA. Water meter readings are indicated as actual or estimated. Only actual readings were used excluding the estimated water consumption.

Per capita water consumption was estimated assuming 5.5 persons per household on an average.

Source : Study Team

Table E-19 Unit Per Capita Load Generation for Domestic Sources

Colony	Water Consumption lcpd	Wastewater Generation ** lcpd	Per Capita Load, g/(person.day)				
			BOD	COD	SS	T - N	T - P
Cañada De San Angel	136 #	167	53	60	15	4.7	1.2
Pinares Del Norte	108 *	122	23	31	23	3.2	0.8
Santa Elena II	115	63	15	21	11	1.7	0.3
La Cañada	333	-	-	-	-	-	-
Bello Horizonte	133	121	27	29	33	5.8	0.7
Villalobos II	97	86	24	41	18	4.9	0.6

E-2

Note:

# Estimated from water meter readings of Colonia Canada and la Floresta for the months of February~April 195.

\* Estimated from pump capacity and pump operation time.

\*\* Wastewater generation is estimated from the wastewater flow rate measured during day time with the following assumptions. They are 1) ratio of day time flow to total flow is 0.5, 2) ratio of day time load to total load is 0.6 and 3) average number of persons per household is 5.5

Source : Study Team

**Table E-20 Unit Pollutant Load Generation for Commercial/Institutional Sources**

Source	Area (ha)	Population	Average Daily Water Consumption m <sup>3</sup> /d	Wastewater Generation m <sup>3</sup> /d		Per Capita Load gpcd				
				1	2	BOD	COD	SS	T-N	T-P
School (INCA)	-	406	13.8	2.9	0.4	1	2	87	0.114	0.036
Municipality Office		1,050	118.0	21.5	69.1	6	7	1	0.726	0.065
Restaurant(Burger Shop)		200	14.7	3.5	4.6	5	6	15	0.902	0.116
San Carlos University	1.8	80,228	615	182	202	0.5	0.6	0.2	0.094	0.011
General Hospital	1.4	1,000	33.3*	146.0	173.0	39	43	30	4.559	0.964
Hotel(Hotel Plaza)	0.7	100	6.6	4.5	2.8	6	6	140	1.920	0.199

Note : Ratio of day-time load to total load is assumed to be 0.5-0.6.

Population of San Carlos University is total population. It was summer holidays during sampling and only summer classes and research activities were going on. For General hospital population is expressed as number of beds.

Note : \*Water supply data from meters are estimates, as meters were not working.

Source : Study Team

**Table E-21 Pollutant Load Generation for Industrial Sources**

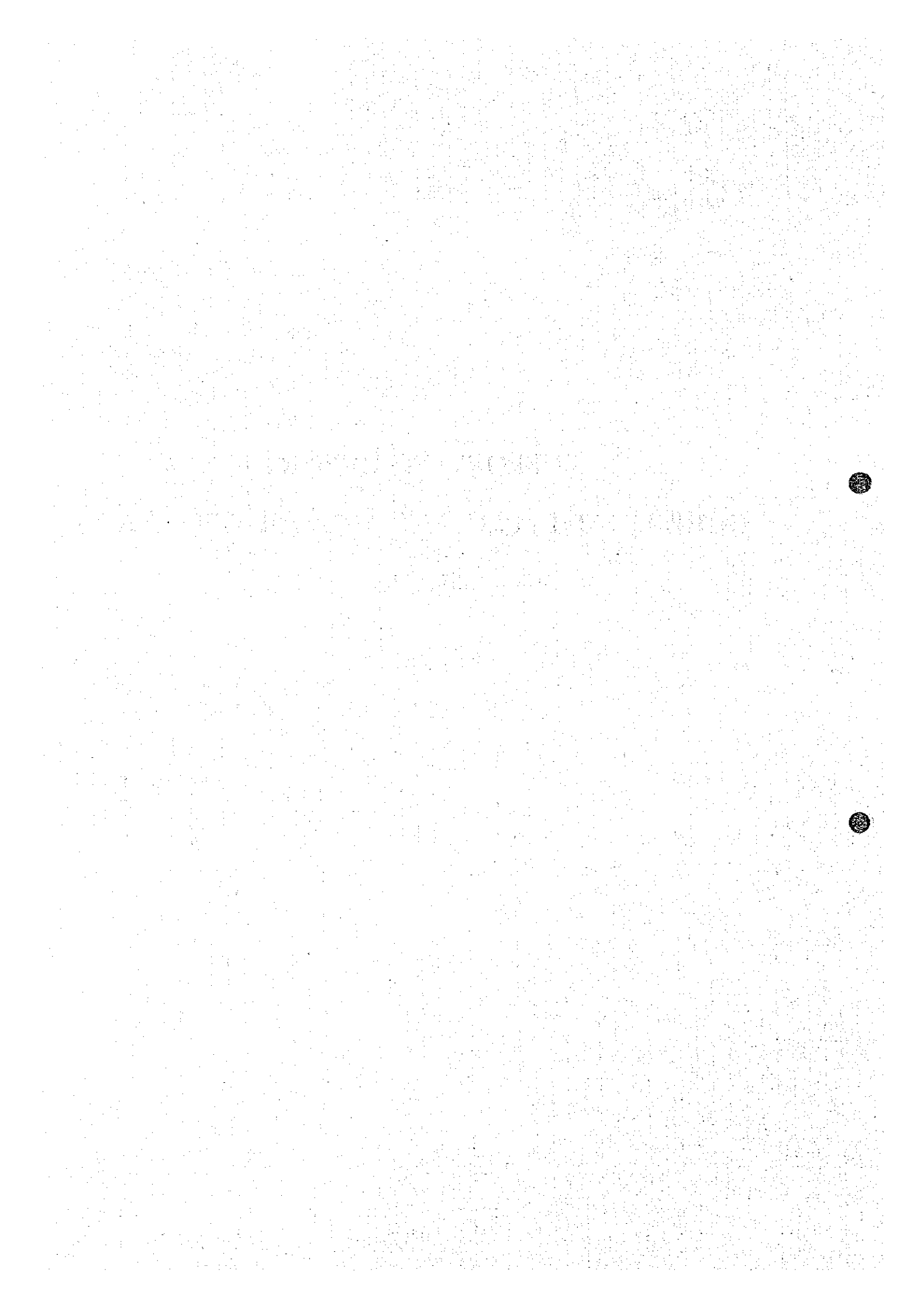
Source	Number of Employees	Water Consumption m <sup>3</sup> /day	Wastewater Generation m <sup>3</sup> /day		BOD	SS	COD	T-N	T-P
			Load kg/d	Load kg/d	Load kg/d	Load kg/d	Load kg/d		
Milk Products	200	40	-	-	-	-	-	-	-
Tannery	50	25	45	104	115	232	165	92.82	1.38
Brewery	-	-	-	-	-	-	-	-	-
Pharmaceutical	-	-	19.4	5.5	2	3	1	0.37	0.18
Textile/Dyeing	100	130	249	277	94	131	116	43.93	1.46
Meat Processing (chicken)	550	1380	275	325	53	63	174	42.43	7.45

Note : Water consumption is either estimated from water supply data or based on data provided by the industries which are not confined.

Source : Study Team



**SUPPORTING REPORT F**  
**INDUSTRIAL EFFLUENTS AND QUESTIONNAIRE**  
**SURVEY**



**SUPPORTING REPORT F**  
**INDUSTRIAL EFFLUENTS AND RESULTS OF QUESTIONNAIRE**  
**SURVEY**  
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## F INDUSTRIAL EFFLUENTS AND RESULTS OF QUESTIONNAIRE SURVEY

### F1 INTRODUCTION

In this supporting report, the distribution and type of industries in the Study Area and the results of the Questionnaire Survey on Industrial Effluents are discussed. From the viewpoint of sewerage system, recommendations are made on the issue of industrial effluents.

### F2 DISTRIBUTION AND TYPE OF INDUSTRIES

Table F-1 shows the number of industries by size (based on the number of employees in each industry) in Guatemala as of 1993 (INE, 1993). Out of the total number of large industries (Class V), 71.6% are situated in Guatemala City and the surrounding areas, indicating a concentration of industries in Guatemala City and surrounding areas. Table F-2 shows the distribution of large industries in each zone and the type of industry. A wide variety of industries can be found, among them textiles (code 3220, 15 industries), yarn and textile finishings (code 3211, 7 industries) and food industries (code 3111 to 3119, 20 industries) are significant. Among the zones, Zone 12 has large number of industries with eighteen followed by Zone 1, Zone 7, Zone 4 and Zone 11 with ten (10), seven (7), six (6) and six (6) large industries respectively.

**Table F - 1 Number of Industries by Size in Guatemala as of 1993**

Class of Industry	Number of Employees	Total Number of Industries	Number of Industries in Study Area
I	5 - 19	1,506	Not evaluated
II	20 - 49	467	Not evaluated
III	50 - 99	244	Not evaluated
IV	100 - 199	156	Not evaluated
V	200 or more	106	76
Total		2,479	

The number of employees and value of production for 1989 and 1993 are shown in Table F-3 (INE, 1989 and 1993). Food products, textiles and clothing, and chemical products are the major industries employing a total of almost 50% and 53.6% in 1989 and 1993 respectively. The number of employees in these industries increased from 85,184 to 136,668 from 1989 to 1993; all increased except for clothing, which showed almost 32% decrease in staff numbers.





**Table F-3 Number of Employees and Industrial Production in Guatemala in 1989 and 1993**

Code No.	Type of Industry	Number of Employees		Value of Production, Quetzal	
		1989	1993	1989	1993
311	Food Products for Humans	45,217	83,868	2,416,158,097	9,979,008,376
312	Animal Foods	4,815	7,156	474,663,712	550,047,032
313	Drinks (alcoholic and non-alcoholic)	8,098	21,052	586,838,127	2,676,423,172
314	Tobacco products	1,234	4,128	131,250,790	616,628,120
321	Textiles	14,540	27,224	626,336,498	1,865,563,056
322	Fabrication of clothing	12,546	8,516	190,665,053	187,169,244
323	Tannery and leather articles	956	1,616	53,940,657	50,444,540
324	Leather shoes	6,395	6,996	146,986,611	194,935,188
331	Wood products	5,158	6,252	81,801,483	79,403,372
332	Furnitures made of wood	3,674	2,508	88,648,941	56,940,656
341	Paper products	4,618	6,768	423,663,829	335,236,760
342	Printing and lithography	8,727	9,448	254,164,830	218,250,880
351	Basic chemical and agrochemicals	1,746	2,716	309,113,553	325,154,604
352	Chemical products	12,881	17,060	1,234,470,032	1,654,986,912
353	Petroleum products	375	376	565,968,114	595,008,872
354	Products of carbon and aliphatic compounds	82	344	3,379,392	55,507,728
355	Rubber products	4,953	5,000	480,115,661	310,246,792
356	Plastic products	8,127	8,772	455,419,345	810,829,076
361	Clay, crockery products	705	1,104	62,480,791	63,070,220
362	Glass and glass products	427	2,088	2,292,264	109,295,612
369	Non-metallic mineral products	7,585	7,512	882,550,779	627,139,572
371	Primary products of iron and steel	1,706	3,176	233,357,910	353,160,548
372	Non-ferrous metal products	64	120	15,329,794	1,878,016
381	Metallic products except machinery	7,608	9,292	285,894,258	373,389,728
382	Machineries and mechanical equipment	1,397	2,444	63,221,460	140,872,272
383	Electrical and electronic appliances	2,123	2,672	195,500,186	191,014,230
384	Transport equipment	1,435	3,956	41,858,611	86,821,620
385	Professional scientific/optic equipment	493	940	102,861,574	411,446,296
390	Jeweleries, toys and similar articles	1,053	1,536	56,144,813	224,579,272
	Total	168,738	254,640	10,465,077,165	23,144,451,766

Source : INE 1989,1993



### **F3 INDUSTRIAL WASTEWATER**

In this Section, data available on industrial effluent in Guatemala is presented and the results of the questionnaire survey is discussed.

#### **F3.1 Previous Data**

Table F-4 shows data available on industrial effluents in Guatemala for plating and textile industries. Effluent from the plating industry is of very low pH (1.20~1.24) and high temperature. Results of the heavy metals concentrations are not available but high levels could be expected.

Textile wastewater is of high pH (6.90~10.80) and of high BOD (110~1,800 mg/L). One of the data shows that the ratio of BOD/COD is very low (i.e. 1.8/328), indicating non-biodegradable substances in the effluent.

Data available on industrial effluent is limited but is essential for deciding whether the effluent can be treated by biological treatment or not.

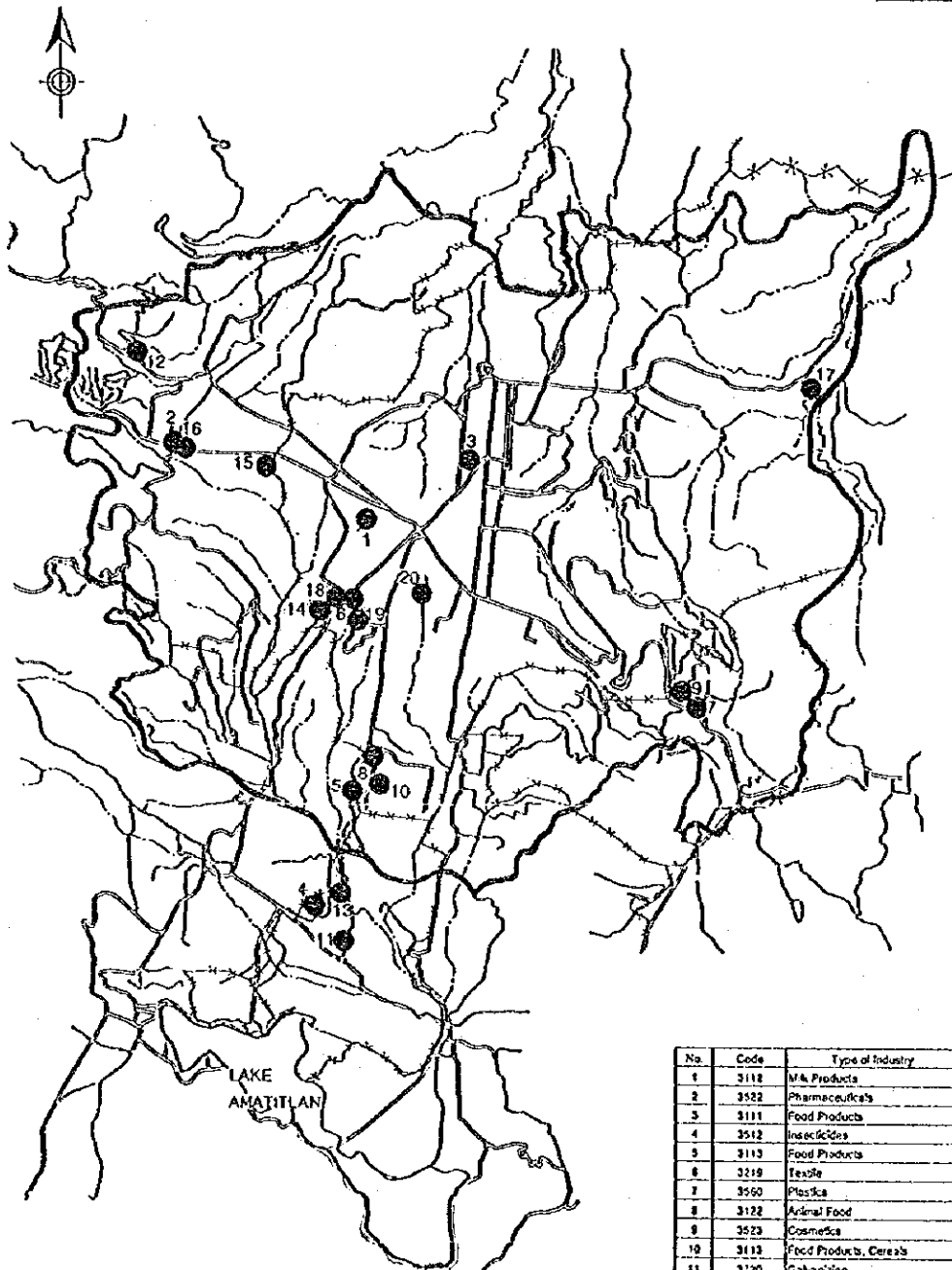
#### **F3.2 Results of Questionnaire Survey**

A questionnaire survey of industrial effluents was conducted by selecting twenty one industries. The questionnaire is shown in Annex FA. Industries were selected based on the type of industry and the possibility of obtaining data. Table F - 5 shows the list of industries and their location for the questionnaire survey and Table F - 6 shows the number and type of industries surveyed. Fig. F - 1 shows the location of industries for the questionnaire survey.

Results of water consumption and wastewater generation are shown in Tables F - 7 and F - 8. Only one industry have water consumption more than 1,000 m<sup>3</sup>/day and five industries use more than 100 m<sup>3</sup>/day. Industries using more than 50 m<sup>3</sup>/day have their own ground water wells for water supply.

Wastewater disposal is mainly by public sewer or private absorption wells. Almost two thirds of the industries surveyed have treatment for process wastewater and the rest have only treatment for domestic wastewater. Generally, treatment is by septic tank and absorption wells. Monitoring of the treatment process is virtually absent and generally only done visually.

Fig. F-1



No.	Code	Type of Industry
1	3118	M&A Products
2	3522	Pharmaceuticals
3	3111	Food Products
4	3512	Insecticides
5	3113	Food Products
6	3219	Textile
7	3560	Plastics
8	3122	Animal Food
9	3523	Cosmetics
10	3112	Food Products, Cereals
11	3720	Sawmilling
12	3231	Tannery
13	3710	Metal Processing (transforming)
14	3212	Nylon Products
15	3112	Food Products
16	3522	Pharmaceuticals
17	3832	Battery (wet cell) Charging
18	3112	M&A Products
19	3513	Plastic Pouches
20	3220	Textiles
21	3112	Meat Processing

THE REPUBLIC OF GUATEMALA  
 GUATEMALA MUNICIPAL WATER  
 SUPPLY PUBLIC CORPORATION  
 (EMPAGUA)

THE STUDY ON  
 THE IMPROVEMENT OF WASTEWATER  
 MANAGEMENT IN THE GUATEMALA  
 METROPOLITAN AREA

JAPAN INTERNATIONAL COOPERATION AGENCY

TITLE  
 LOCATION OF INDUSTRIES  
 SURVEYED

**Table F-4 Data Available on Industrial Effluents in Guatemala**

Parameter	Unit	Plating	Textiles		Textiles		Meat Processing
		2~10 Aug 93	26 Aug 94	26 Aug 94	8~17-Aug-94		
					Range	Average	
Color					650~1,700	1,136	
pH		1.20~1.24	13.2		6.9~10.8		
Temperature		42~43	31.4				
Conductivity	mS/cm	13.23~13.50	12.9				
BOD5	mg/L	-	-	1.8	110~1800	507	640
COD	mg/L	80	248	328	263~4000	1,096	
Dissolved Solids	mg/L	868	18188	592			
Suspended Solids	mg/L				289~1436	910	
Volatile Solids	mg/L				283~2284	1,103	
Total Solids	mg/L	1212	18236	1044	548~6391	2,426	
NH4-N	mg/L	1.08	0.001	-	0.01~0.06	0.05	
NO2-N	mg/L	0.004	0.026	0.003	0~0.66	0.27	
NO3-N	mg/L	5	3.431	1.962	47.3~88.7	73.5	
T-N	mg/L	25.4		2.48			
Organic Soluble-N	mg/L				0.03~0.15	0.12	
PO4-P	mg/L	0.81	1.239	0.302	6.0~18.0	9.7	
T-P	mg/L	1.1	1.361	0.295			
Alcalinity	mg/L	0	0.724	0.118			
Acidity	mg/L	38.5					
Silicate	mg/L	36.79	11.39				
Chloride	mg/L	1.59		0.01			
Bisulphite	mg/L	0.002					
Sulphate	mg/L					120	
Lead	mg/L					ND	
Cadmium	mg/L					0.015	
Total Chromium	mg/L					0.2	
Zinc	mg/L					0.8	
Nickel	mg/L					0.15	
Arsenic	mg/L					< 0.05	
Mercury	mg/L					< 0.01	

Note: ND - Not detectable

Source : Ministerio de Energia y Minas and EMPAGUA

**Table F-5 List of Industries for Questionnaire Survey**

No.	Code	Type of Industry	Zone
1	3112	Milk Products	11
2	3522	Pharmaceuticals	7
3	3111	Food Products	3
4	3512	Insecticides	Villa Nueva
5	3113	Food Products	12
6	3219	Textile	12
7	3560	Plastics	10
8	3122	Animal Food	12
9	3523	Cosmetics	10
10	3113	Food Products, Cereals	12
11	3720	Galvanizing	San Miguel Petapa
12	3231	Tannery	San Juan Sacatepequez
13	3710	Metal Processing (transforming)	San Miguel Petapa
14	3212	Nylon Products	12
15	3113	Food Products	11
16	3522	Pharmaceuticals	7
17	3833	Battery(wet-cell) Charging	Atlantic Road
18	3112	Milk Products	12
19	3513	Plastic Resins	12
20	3220	Textiles	12
21	3112	Meat Processing	Villa Nueva

Source : Study Team

**Table F-6 Number and Type of Industries for Questionnaire Survey**

Code	Type of Industry	Number of Industry
311	Food Products for Humans	7
312	Animal Foods	1
321	Textile	2
322	Fabrication of Clothes	1
323	Tannery	1
351	Basic Chemicals and Agrochemicals	2
352	Chemical Products	3
356	Plastic Products	1
371	Primary Metal Products	1
372	Non-ferrous Metal Products	1
383	Electrical Electronic Appliance	1
Total		21

Source : Study Team

**Table F-7 Average Water Consumption of Industries Surveyed**

Industry	Water Source		Metering yes / no	Water Consumption m3/day	Water Usage, m3/day		
	EMPAGUA	Private			Cooling	Process	Domestic
1	X	X	YES / NO	112	20	80	12
2		X	NO	290	175	70	45
3		X	NO	100	40	20	40
4		X	NO	4	0	3.5	0.5
5		X	NO	60	15	36	9
6		X	NO	22	5	15	2
7	X		YES	27	7	15	5
8	X		YES	10	7	2	1
9	X		YES	10	4	1	5
10	X	X	YES / NO	37	2	20	15
11		X	NO	15	12	1	2
12		X	NO	26	0	10	15
13		X	NO	30	18	4	12
14		X	NO	11	2	7	2
15	X		YES	4	1	1	2
16		X	NO	250	50	150	50
17	X		YES	15	4	8	3
18	X	X	YES / NO	40	6	30	4
19	X		YES	8	6	0	2
20	X		YES	130	104	13	13
21		X	NO	1,384	-	1,330	54

Source : Study Team

Table F-8 Average Wastewater Generation, Wastewater Treatment and Disposal for the Industries Surveyed

Industry	Wastewater Disposal		Wastewater Generated, m <sup>3</sup> /day				Wastewater Treatment			Monitoring	Sludge Disposal	
	Sewer	Private (well)	Storm Drainage	Cooling	Process	Domestic	Pretreatment	Primary *1)	Domestic			
1	X			6	25	12			X		NO	NO
2	X	X		75	30	45	X	X/2			YES	PUBLIC
3	X			20	15	40			X		NO	NO
4		X		0	0.5	0.5	X	X/3			YES	PUBLIC
5		X		5	10	9	X	X/4			NO	PUBLIC
6		X		1	12	2	X	X/4			NO	PUBLIC
7	X			2	10	5			X		NO	NO
8	X	X		3	0	1	X	X/4			NO	PUBLIC
9	X			4	0.5	5			X		NO	NO
10	X	X		0	15	15	X	X/1			YES	PUBLIC
11		X	X	6	0	2	X	X/4			NO	PUBLIC
12			X	0	8	15			X		NO	NO
13		X		0	4	12	X	X/4			NO	PUBLIC
14		X		2	7	2	X	X/4			NO	PUBLIC
15	X			0.5	0.25	2			X		NO	NO
16		X		30	30	50	X	X/4			NO	PUBLIC
17	X			2	8	3		X/5			YES	NO
18	X	X		3	20	4	X	X/4			NO	PUBLIC
19	X			4	0	2			X		NO	NO
20	X			104	13	13			X		NO	NO
21	X				1010	25	X		X		YES	PRIVATE

Note : \*1 ) Septic Tank, absorption well and filtration, 2 Flocculation Tank, 3 Septic Tank, 4 Septic Tank and absorption well, 5 Recycling and treatment

Source : Study Team

## **F4 PREREQUISITES FOR ACCEPTING INDUSTRIAL EFFLUENTS**

Compared to domestic wastewater, the quality and quantity of industrial effluents vary greatly. Increasing number of artificial substances are being used in industrial processes and are eventually found in the industrial effluents. For this reason, industrial effluents must be treated with care. Basically, the following basic information is required for deciding whether or not to accept industrial effluents into the public sewerage system and to impose appropriate tariff.

- flowrate of wastewater
- characteristics and composition of wastewater

In the Guatemala Municipality Regulation of 1971 on 'Reglamento de Localizacion e Instalacion Industrial', the above information is required to be submitted to the Urban Planning Department when industries are set-up. However, the records are not available. This situation needs to be corrected and the information should be made available to EMPAGUA, to ensure proper planning of the sewerage system and to ensure the safety and reliability of the sewerage system that will be operated by EMPAGUA. Legal provisions and the organizational ability of EMPAGUA need to be strengthened for this purpose.

### **F4.1 Information on Wastewater Characteristics**

Based on the wastewater quantity and quality, industries could be classified into one or more of the following categories;

- producer of large quantity of wastewater
- producer of highly concentrated wastewater
- producer of toxic or hazardous material

Basically, discharge standards need to be imposed on the industrial categories shown above and should be monitored.

### **F4.2 Discharge Standards and Monitoring**

As discussed in Section 4.4 of the Main Report, existing discharge standards for industrial wastewater do not differentiate between direct and indirect discharges. Further, as EMPAGUA begins to construct a sewerage system, it is necessary that discharge standards with an adequate number of parameters be set and that either EMPAGUA or the municipality be legally entrusted to enforce discharge standards for industry. Provisions shall also be made for monitoring. For

reference, wastewater discharge standards to sewers for Japan and Buenos Aires, Argentina, are shown in Tables F - 9, F - 10 and F - 11.

Wastewater disposal underground using absorption wells is widely used in industry as well as for domestic wastewater. However, existing legislation does not control this practise. Eventhough, the ground water table is low and infiltration is generally good, uncontrolled discharge of wastewater underground could be disastrous.



**Table F -9 Standards for Discharge into Public Sewers in Japan**

Item	Case 1	Case 2
pH	5 ~ 9	7 ~ 8
SS, mg/L	600	300
BOD5, mg/L	600	300
Oil (n-Hexane extract), mg/L		
a) animal/vegetable origin	30	N/A
b) petroleum origin	5	N/A
Total Nitrogen, mg/L	240 <sup>a</sup>	150 <sup>b</sup>
Ammonium nitrogen, mg/L	N/A	N/A
Nitrite, NO <sub>2</sub> <sup>-</sup> , mg/L		
Total Phosphorus, mg/L	32 <sup>a</sup>	20 <sup>b</sup>
Phosphate (PO <sub>4</sub> <sup>3-</sup> )	N/A	N/A

Note: N/A: Not Available

- (1) For industrial effluent below one quarter of the capacity of sewage treatment works and greater than 50 m<sup>3</sup>/d
- (2) For industrial effluents above one quarter of the capacity of sewage treatment works
- (a) If effluent discharge standard is specified, the limit shall be 1.25 times that of the effluent discharge standard.
- (b) If effluent standard is specified, the limit shall be twice that of the effluent discharge standard.

Source : Study Team

**Table F - 10 Effluent Standards for Parameters Related to Health in Japan (ie. toxic materials)**

Item	Limits
Cadmium (Cd), mg/L	0.1
Cyanide (CN <sup>-</sup> ), mg/L	1
Lead (Pb), mg/L	1
Hexavalent Chromium (Cr <sup>6+</sup> ) mg/L	0.5
Arsenic (As), mg/L	0.5
Mercury (Hg), mg/L	0.005
Alkyl Mercury, mg/L	not detectable
PCB, mg/L	0.003
Organo phosphorous Pesticides, mg/L	1

**Table F - 11 Industrial Effluent Standards of Buenos Aires, Argentina**

Parameter	Unit	To Sanitary Sewers	To Storm Sewer / Surface Water	To Ground Absorption	To Sea / Ocean
Temperature	°C	≤45	≤45	≤45	≤45
pH		7 - 10	6.5 - 10	6.5 - 10	6.5 - 10
Settleable Solids, 10 min	ml/L	absent	absent	absent	NE
Settleable Solids, 2 hrs	ml/L	≤5	≤1	≤5	≤5
Sulfides	mg/L	≤2	≤1	≤5	NE
SS	mg/L	≤100	≤50	≤50	
Ammonia Nitrogen	mg/L	≤10	≤3	NE	NE
Cyanides	mg/L	≤0.1	≤0.1	absent	≤0.1
Total Hydrocarbon	mg/L	≤100	≤30	absent	≤30
Organic Chlorides	mg/L	≤2	≤1	≤1	≤1
Free Chlorides	mg/L	NE	≤0.5	≤0.5	≤0.5
BOD5	mg/L	≤200	≤50	≤200	
COD	mg/L	≤700	≤250	≤500	
Phenols	mg/L	≤2	≤0.5	≤0.1	NE
Sulfates	mg/L	≤1000	NE	≤1000	NE
TOC	mg/L	NE	NE	NE	NE
Iron (soluble)	mg/L	≤10	≤2	≤0.1	NE
Manganese (soluble)	mg/L	≤1.0	≤0.5	≤0.1	NE
Zinc	mg/L	≤5.0	≤2.0	≤1	NE
Nickel	mg/L	≤3	≤2	≤1	NE
Chromium (total)	mg/L	≤2	≤0.5	absent	≤0.5
Mercury	mg/L	≤0.02	≤0.005	absent	≤0.005
Copper	mg/L	NE	≤0.1	NE	≤0.1
Arsenic	mg/L	NE	≤0.5	≤0.1	≤0.5
Lead	mg/L	≤2	≤0.1	absent	≤0.1
Cobalt	mg/L	NE	≤2	≤1	≤2
Organochlorine Pesticides	mg/L	≤0.5	≤0.05	absent	≤0.05
Organophosphorous Pesticides	mg/L	≤1	≤0.1	absent	≤0.1
Total Nitrogen	mg/L	≤30	≤10	NE	NE
Total Phosphorous	mg/L	≤10	≤1	NE	NE

Source : Study Team

Note: Limit not decided at present time.

APPENDIX FA

ESTUDIO PARA EL MEJORAMIENTO DEL  
MANEJO DE LAS AGUAS RESIDUALES EN  
EL AREA METROPOLITANA DE GUATEMALA

EMPAGUA Y SEGEPLAN

ENCUESTA PARA INDUSTRIAS

A. INFORMACION GENERAL

A.1 Tipo de la Industria : \_\_\_\_\_

A.2 Zona : \_\_\_\_\_

B. PRODUCTO

B.1 Nombre de los productos: \_\_\_\_\_

B.2 Principales materias primas usadas: \_\_\_\_\_

B.3 Cantidad de Producción Anual: \_\_\_\_\_

B.4 Valor de Producción Anual: \_\_\_\_\_  
(Quetzales)

C. USO DE AGUA

C.1	Fuente de Abastecimiento de Agua	-	EMPAGUA / MARISCAL
		-	Agua Subterránea
C.2	El suministro de agua es medido?	-	Si / No
C.3	Consumo diario de agua	-	m3 / día
C.4	Estimar el consumo de agua para cada uso		
	Enfriamiento	-	m3 / día
	Proceso	-	m3 / día
	Doméstico	-	m3 / día
	Otros	-	m3 / día

D. GENERACION DE AGUAS RESIDUALES

D.1 Qué disposición se le da a las aguas residuales?

a.	Al alcantarillado público	_____
b.	Disposición privada	_____
c.	Drenaje Superficial	_____

D.2 Caudal estimado de aguas residuales

	Enfriamiento	-	m3 / día
	Proceso Industrial-	-	m3 / día
	Doméstico	-	m3 / día
	Otros	-	m3 / día

D.3 Se aplica algún tratamiento a las aguas residuales, antes de la descarga?

Tratamiento Preliminar	Si / No
Tratamiento Primario	Si / No
Tratamiento Secundario	Si / No

D.4 Si el tratamiento está siendo proporcionado, favor demostrar la calidad eficiente del objetivo

\_\_\_\_\_

D.5 Se practica algún tipo de monitoreo? Si / No

D.6 Qué disposición se le da a los lodos? \_\_\_\_\_

E. PLANES DE EXPANSION

E.1 Hay planes para expansión, relocalización o cierre de la industria?

E.1.1 Expansión: (fecha aproximada) \_\_\_\_\_ ( )

E.1.2 Relocalización / Cierre: (fecha aproximada) \_\_\_\_\_ ( )

**THE STUDY ON THE IMPROVEMENT OF  
WASTEWATER MANAGEMENT IN THE  
METROPOLITAN GUATEMALA AREA**

**EMPAGUA AND SEGEPLAN**

**QUESTIONNAIRE SURVEY ON INDUSTRIES**

**A. GENERAL INFORMATION**

A.1 Type of Industry: \_\_\_\_\_

A.2 Zone : \_\_\_\_\_

**B. PRODUCT**

B.1 Name of Products: \_\_\_\_\_

B.2 Major Raw Materials Used: \_\_\_\_\_

B.3 Annual Production Quantity: \_\_\_\_\_

B.4 Annual Value of Products: \_\_\_\_\_

**C. WATER USAGE**

C.1	Water Supply Source	- EMPAGUA / MARISCAL	
		- Groundwater	
C.2	Is your water supply metered	- Yes / No	
C.3	Daily Water Consumption	-	m3 / day
C.4	Show usage of water for each uses		
	Cooling	-	m3 / day
	Processing	-	m3 / day
	Domestic	-	m3 / day
	Others	-	m3 / day

**D. WASTEWATER GENERATION**

D.1	Is your facility connected to public sewer system?	Yes / No
D.2	Estimated wastewater generation	
	Cooling	- m3 / day
	Processing	- m3 / day
	Domestic	- m3 / day
	Others	- m3 / day
D.3	Is there any wastewater treatment provided before discharge?	
	Preliminary Treatment	Yes / No
	Primary Treatment	Yes / No
	Secondary Treatment	Yes / No
D.4	If treatment is being provided, please show target effluent quality.	

\_\_\_\_\_

\_\_\_\_\_

D.5 Is there any monitoring practiced? Yes / No

D.6 Where the sludge is disposed? \_\_\_\_\_  
\_\_\_\_\_

E. EXPANSION PLANS

E.1 Is there any plans for expansion, relocation or closure?

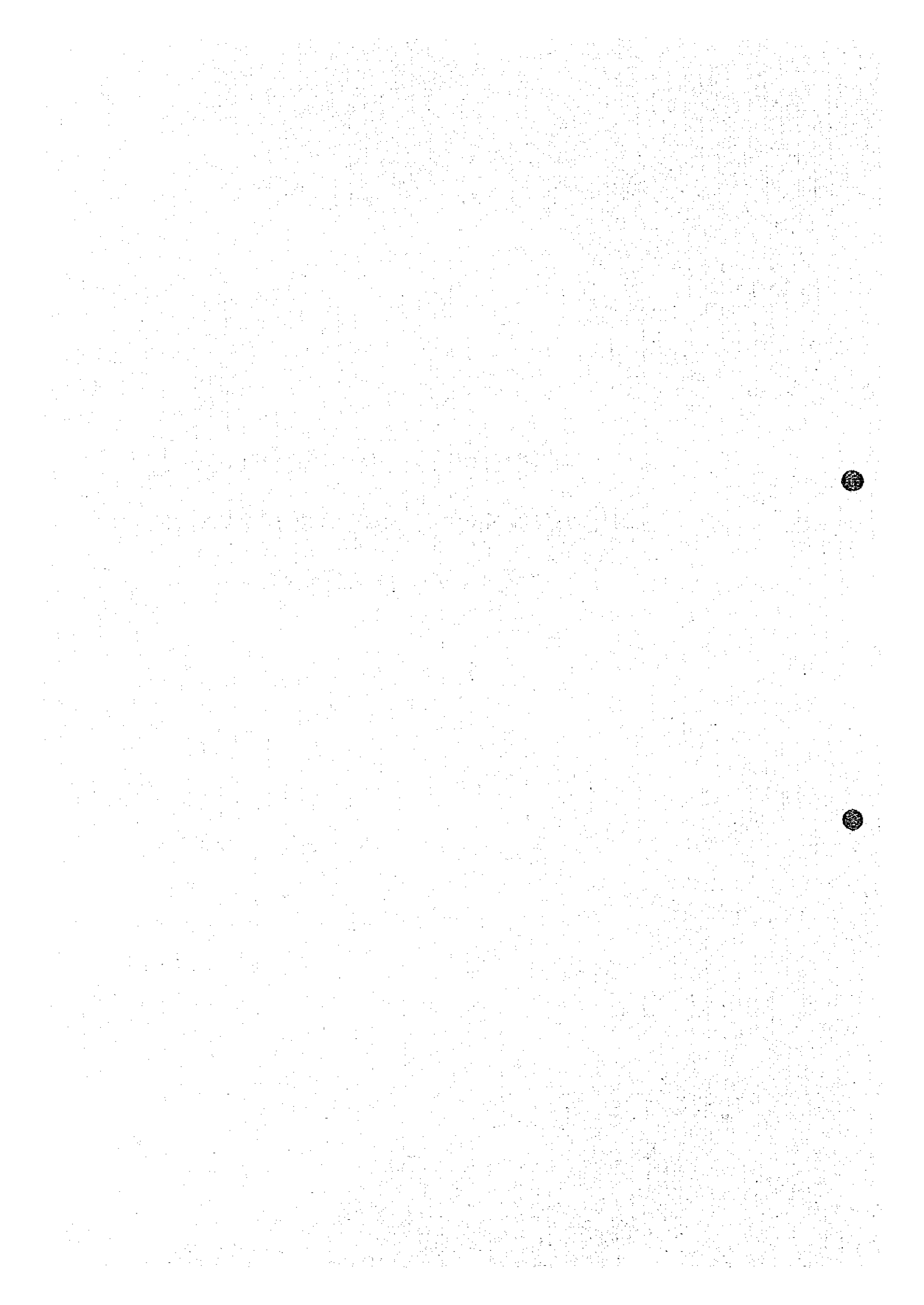
E.1.1 Expansion \_\_\_\_\_ ( )

E.1.2 Relocation/Closure \_\_\_\_\_ ( )

DATE \_\_\_\_\_

SIGNATURE \_\_\_\_\_

**SUPPORTING REPORT G**  
**EXISTING SMALL-SCALE SEWAGE**  
**TREATMENT PLANTS**





**SUPPORTING REPORT G  
EXISTING SMALL-SCALE SEWAGE TREATMENT PLANTS  
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## **G EXISTING SMALL-SCALE SEWAGE TREATMENT WORKS**

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### **G1 INTRODUCTION**

The existing sewage treatment works are described in Section 6.2. The results of the survey of these works are summarized in Table G-1. The flow capacity, population and drainage area served and the cost required to carry out rehabilitation has been estimated for each facility and are as shown.

Figures G-1 to G-26 show the layout of the existing facilities.

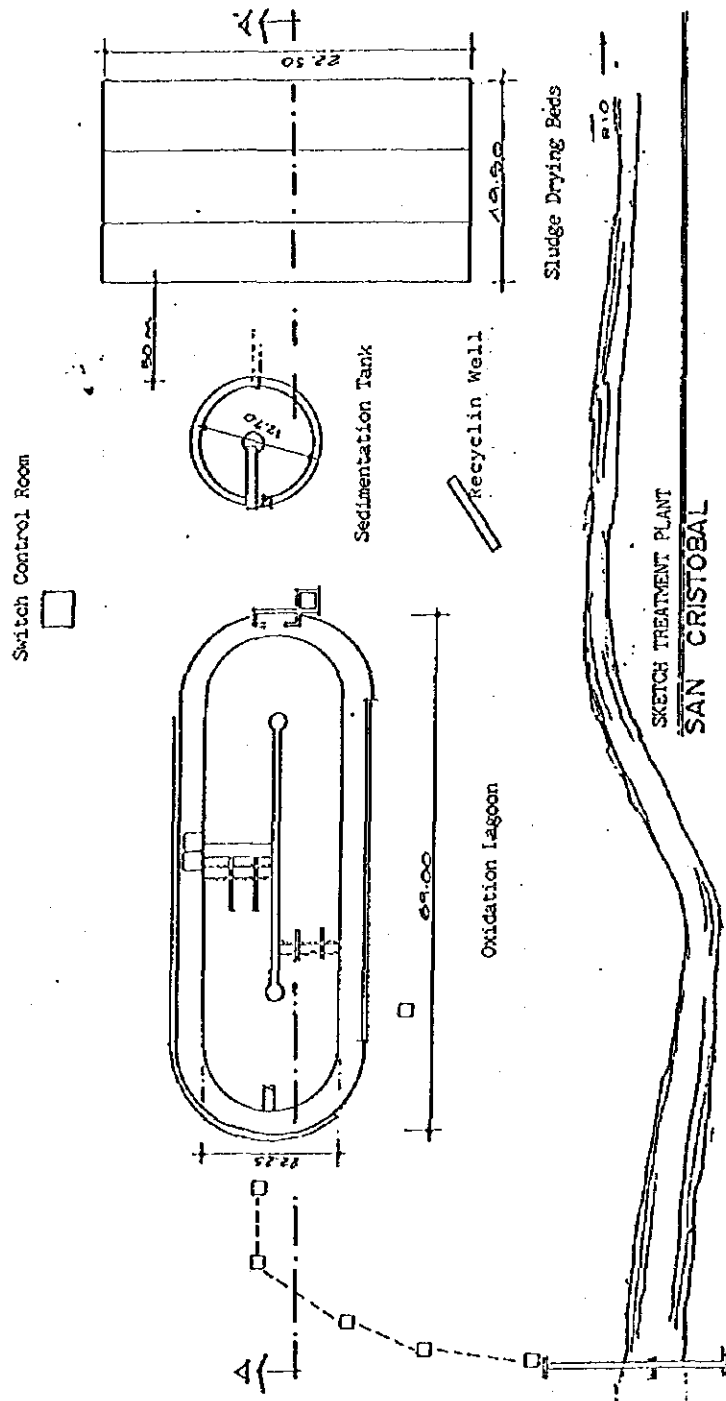
Table G-1 Results on the Preliminary Survey on Existing Small-scale Sewage Treatment Plants

No.	Name	Owner / responsible institution	Process	Operational State	Flow Rate (Estimated) m <sup>3</sup> /day	Population (Estimated)	Drainage Area (Estimated)	Rehabilitation Cost (Estimate)
1	San Cristobal	DEINCO	Oxidation ditch->sedimentation->infiltration well sludge drying bed	inlet blocked, most of the flow by-passed, activated sludge in the ditch was not good, FC full of sludge, infiltration well (approx. 2m diameter & 70 m depth) under construction	2,100	10,000	200	Q 975,000
2	Villa Lobos I	DAHVI	Sedimentation->trickling filter(I,II,III)->Final Clarifier, Sludge Digester->Sludge Drying Bed	distributor pipes are disconnected state	1,900	25,000	41	Q 1,115,000
3	Villa Lobos II	DAHVI	Sedimentation->trickling filter(I, II)->Final Clarifier Sludge drying beds	inlet screen blocked and flow by-passed without any treatment	1,800	25,000	47	Q 1,220,000
4	El Mexquital	DAHVI	Sedimentation->trickling filter(I, II, III)-> Final Clarifier, Sludge Digester->Sludge Drying Bed	flow is by-passed because of blockage between sedimentation tank and filter I for last two years	1,300	25,000	47	Q 738,000
5	Nimajuyu	DAHVI	Sedimentation->trickling filter(I, II)-> Final Clarifier, Sludge Drying Bed	trickling filter distributor pipe blocked	1,200	11,000	26	Q 98,000

Table G-1 Results on the Preliminary Survey on Existing Small-scale Sewage Treatment Plants

No.	Name	Owner / responsible institution	Process	Operational State	Flow Rate (Estimated) m <sup>3</sup> /day	Population (Estimate)	Drainage Area (Estimate)	Rehabilitation Cost (Estimate)
6	USAC	USAC	Sedimentation --> Trickling filter(I, II, III) --> Final Clarifier --> Sludge drying beds --> Digester		1,700	18,000	123	Q 521,000
7	Eureka	Private	Sedimentation --> Trickling Filter --> Final Clarifier --> Digester	Trickling filter under rehabilitation, sedimentation tank under construction	200	1,800	3	Q 90,000
8	Caña de San Angel	IHNSA	Imhoff Tank --> Filtration		500	3,200	4	Q 192,000
9	Bello Horizonte	DAHVI	Sedimentation --> trickling filter (I,II) --> final clarifier --> Sludge Drying beds	Primary sedimentation tank full of scum/sludge, filter distributors and filter I-filter II connection pipe blocked	800	8,800	13	Q 697,000
10	El Roble	IHNSA	Imhoff Tank --> Ground infiltration	not working, covered with soil	100	1,400	4	Q 120,000
11	Alameda Norte	ARMISA	Imhoff tank	Not working	200	500	1	-
12	Molino de Las Flores	MIXCO	Septic tank --> ground infiltration	Water-way has developed along the slope second stage is discharged to Molino River	600	3,000	19	Q 131,000
13	Lomas de Portugal	MIXCO	Septic tank --> ground infiltration	no trace of being used since construction, no influent	100	700	16	Q 699,000
14	El Carmen	Private	Septic Tank --> ground infiltration	covered with soil	-	-	2	-
							TOTAL	Q 6,556,000

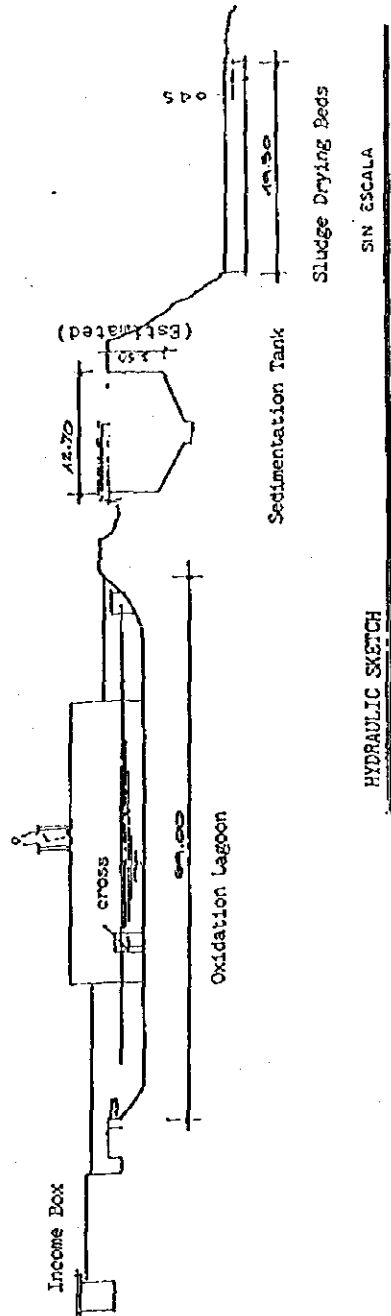
Fig. G-1



THE REPUBLIC OF GUATEMALA  
 GUATEMALA MUNICIPAL WATER  
 SUPPLY PUBLIC CORPORATION  
 (EMPAGUA)

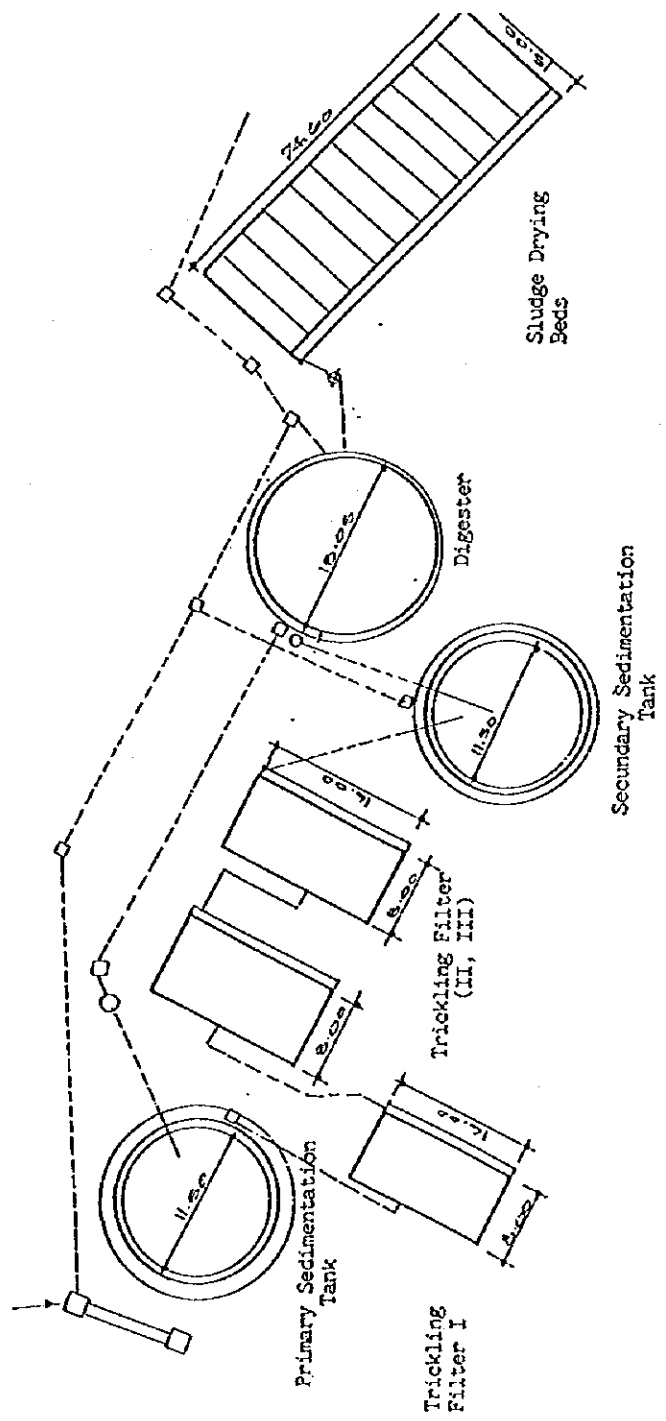
THE STUDY ON  
 THE IMPROVEMENT OF WASTEWATER  
 MANAGEMENT IN THE GUATEMALA  
 METROPOLITAN AREA  
 JAPAN INTERNATIONAL COOPERATION AGENCY

TITLE  
 San Cristobal - Layout Plan



HYDRAULIC SKETCH  
SAN CRISTOBAL

<p>THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)</p>	<p>THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA</p>	<p>TITLE San Cristobal - Vertical Profile</p>
	<p>JAPAN INTERNATIONAL COOPERATION AGENCY</p>	

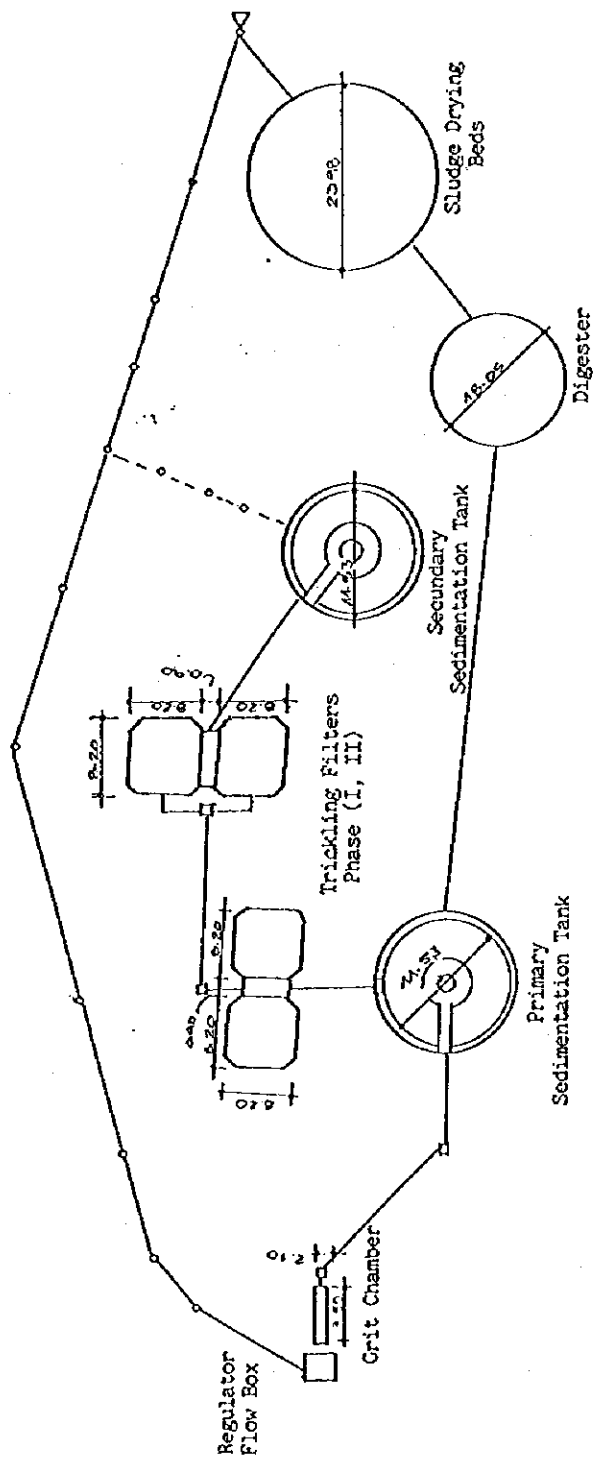


Sketch Treatment Plant  
VILLA LOBOS I  
SIN ESCALA

<p>THE REPUBLIC OF GUATEMALA</p> <p>GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)</p>	<p>THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA</p> <p>JAPAN INTERNATIONAL COOPERATION AGENCY</p>	<p>TITLE</p> <p>Villalobos I - Layout Plan</p>
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SKETCH TREATMENT PLANT  
VILLA LOBOS II  
SIN ESCALA

THE REPUBLIC OF GUATEMALA

GUATEMALA MUNICIPAL WATER  
SUPPLY PUBLIC CORPORATION  
(EMPAGUA)

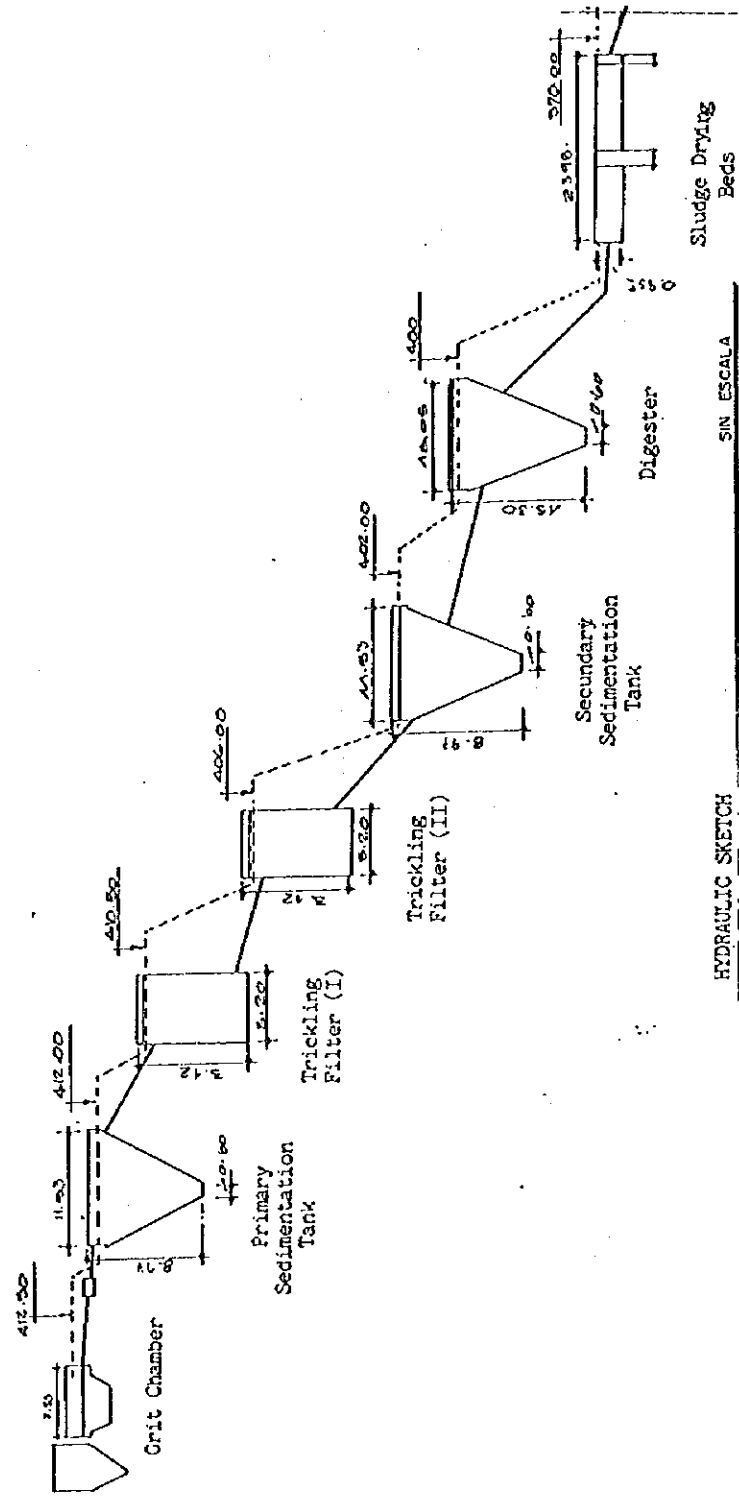
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METROPOLITAN AREA

JAPAN INTERNATIONAL COOPERATION AGENCY

TITLE

Villalobos II - Layout Plan

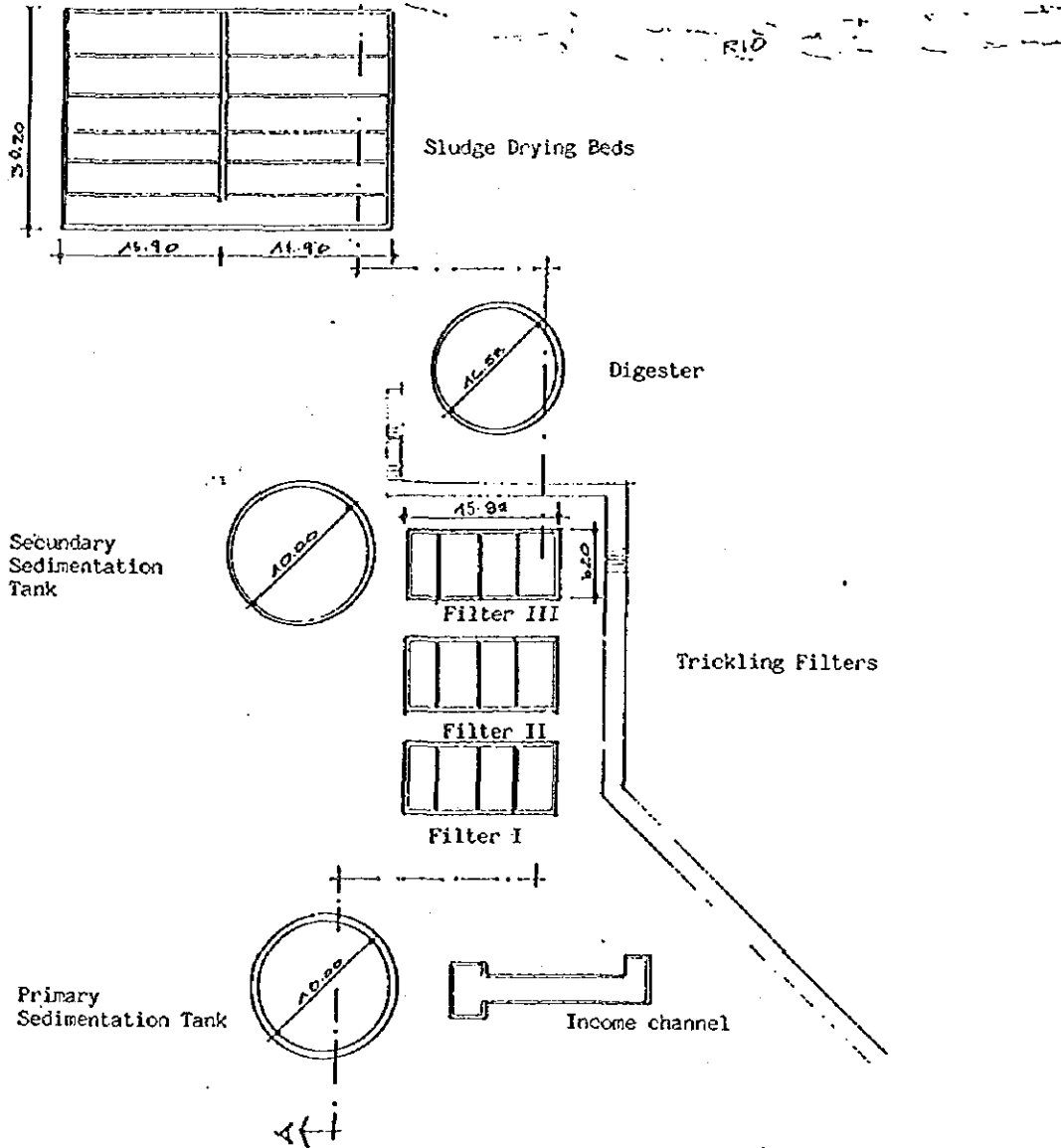
Fig. G - 6



HYDRAULIC SKETCH  
VILLA LOBOS II  
SIN ESCALA

<p>THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)</p>	<p>THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY</p>	<p>TITLE Villalobos II - Vertical Profile</p>
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Fig. G-7

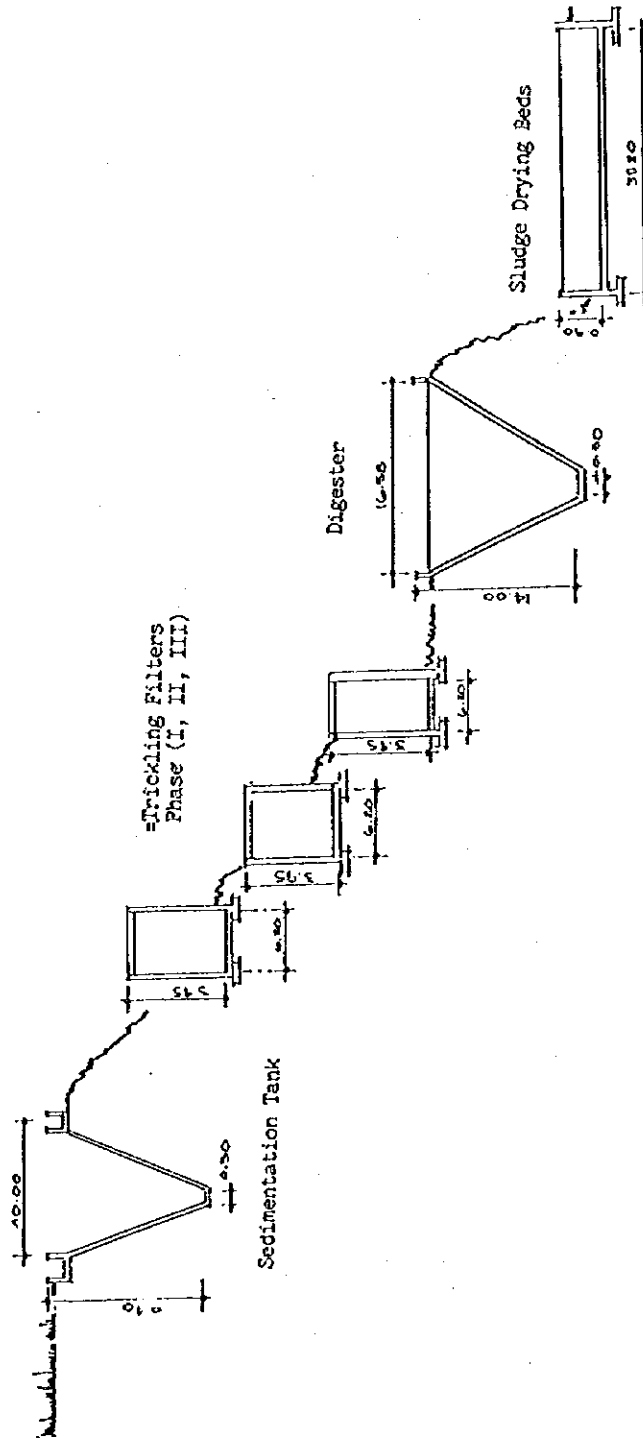


SKETCH TREATMENT PLANT

SIN ESCALA

EL. MEZQUITAL

<p>THE REPUBLIC OF GUATEMALA</p> <p>GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)</p>	<p>THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA</p> <p>JAPAN INTERNATIONAL COOPERATION AGENCY</p>	<p>TITLE</p> <p>El Mexquital - Layout Plan</p>
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HYDRAULIC SKETCH (Section A-A)

EL MEZQUITAL

SIN ESCALA

THE REPUBLIC OF GUATEMALA

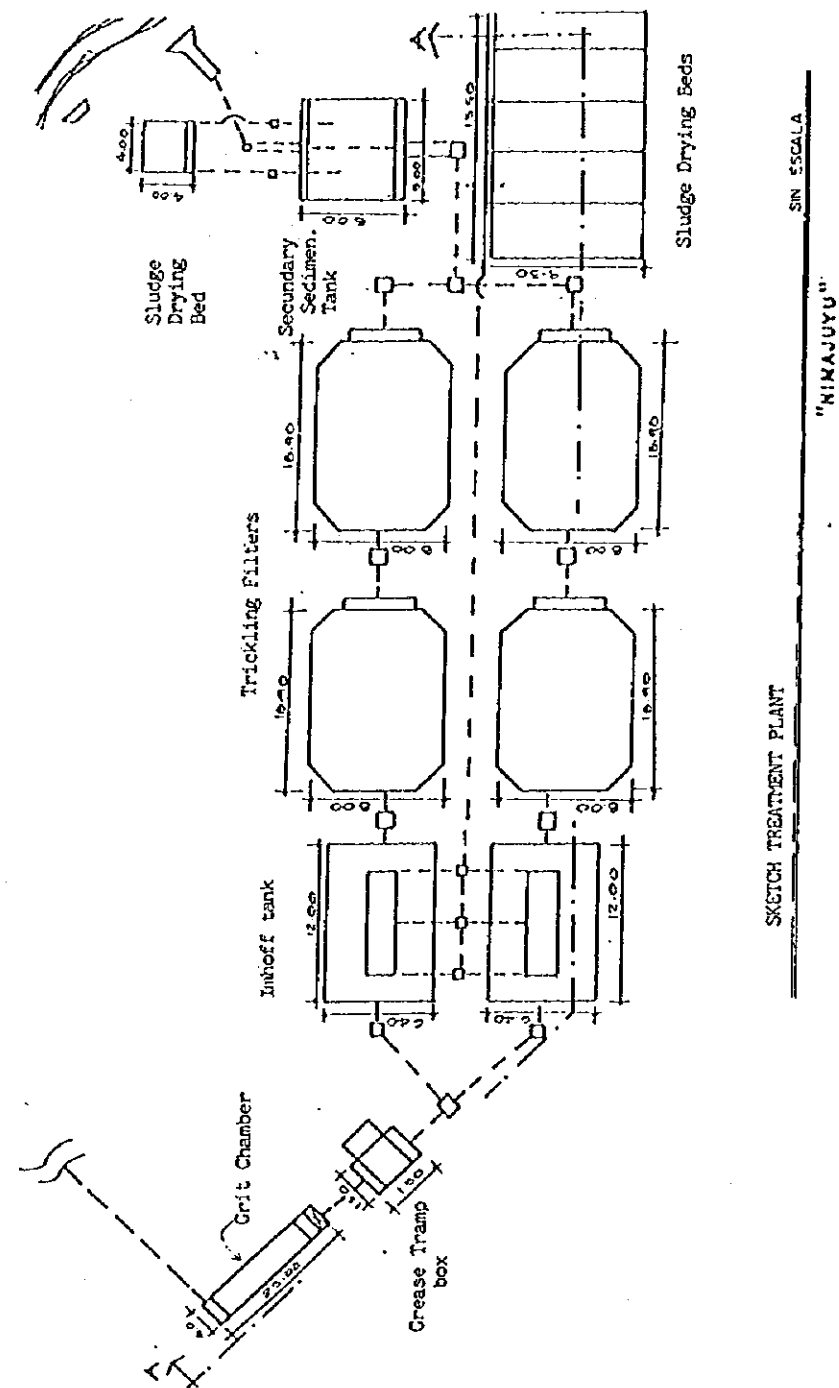
GUATEMALA MUNICIPAL WATER  
SUPPLY PUBLIC CORPORATION  
(EMPAGUA)

THE STUDY ON  
THE IMPROVEMENT OF WASTEWATER  
MANAGEMENT IN THE GUATEMALA  
METROPOLITAN AREA

JAPAN INTERNATIONAL COOPERATION AGENCY

TITLE

El Mexquital - Vertical Profile

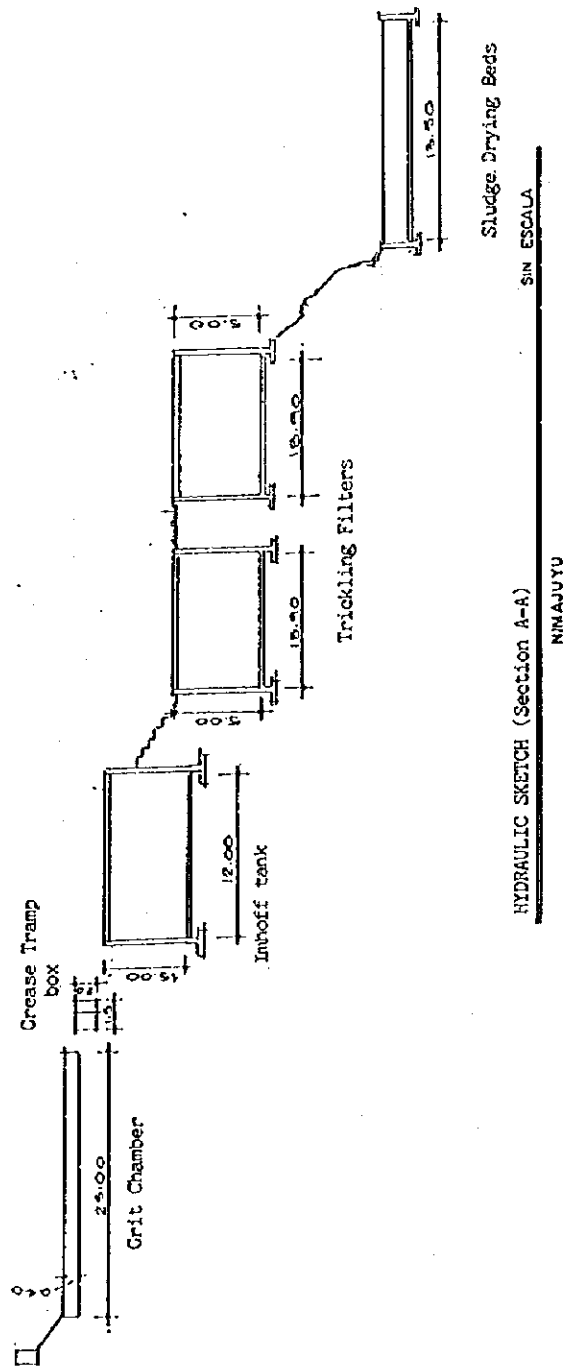


SKETCH TREATMENT PLANT

SIN ESCALA

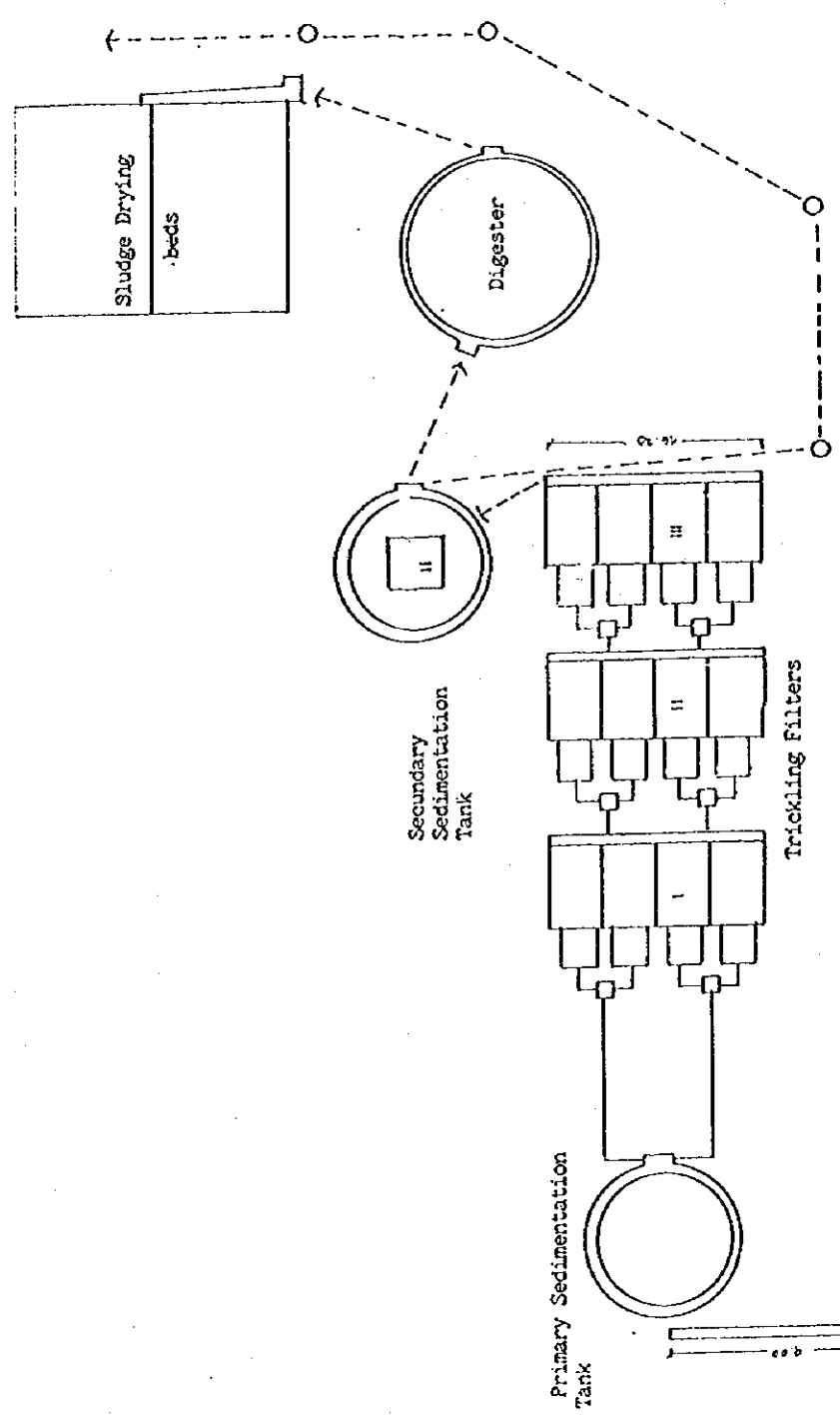
"NIMAJUYU"

<p>THE REPUBLIC OF GUATEMALA</p> <p>GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)</p>	<p>THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA</p> <p>JAPAN INTERNATIONAL COOPERATION AGENCY</p>	<p>TITLE</p> <p>Nimajuyu - Layout Plan</p>
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<p>THE REPUBLIC OF GUATEMALA</p> <p>GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)</p>	<p>THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA</p> <p>JAPAN INTERNATIONAL COOPERATION AGENCY</p>	<p>TITLE</p> <p>Nimajuyu - Vertical Profile</p>
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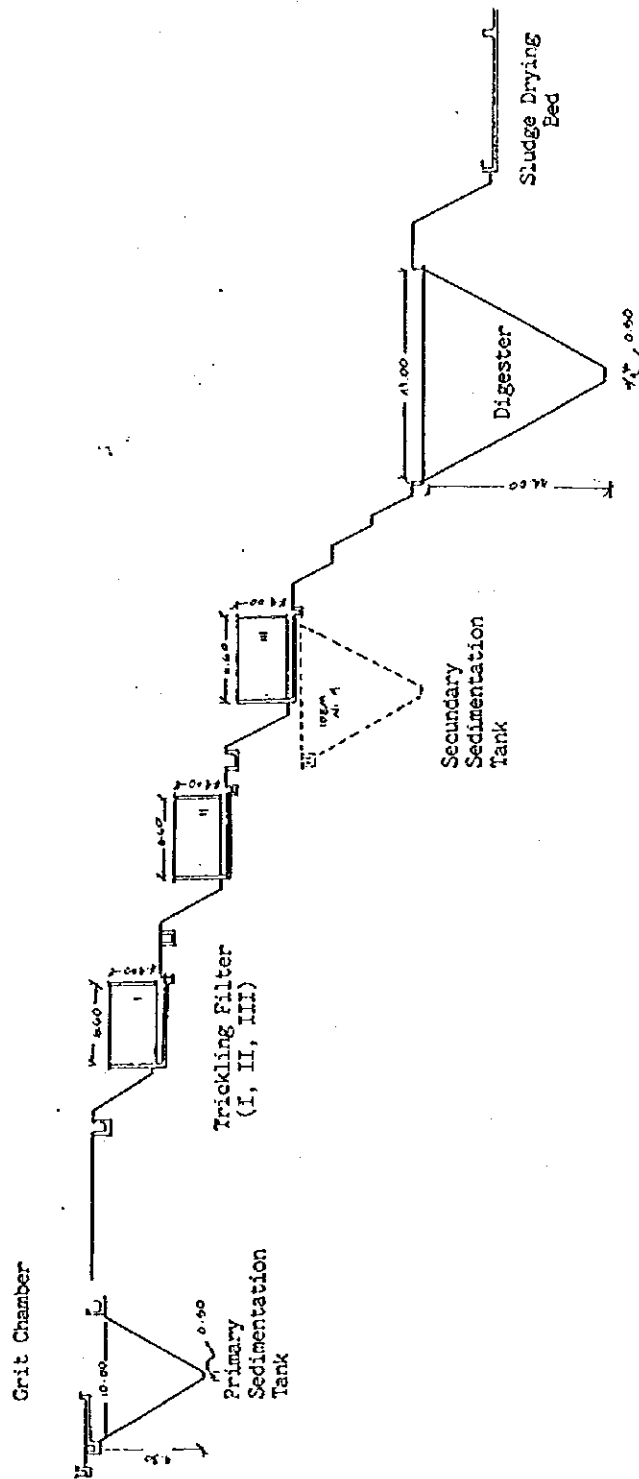
Fig. G - 11



USAC  
SKETCH TREATMENT PLANT

<p>THE REPUBLIC OF GUATEMALA</p> <p>GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)</p>	<p>THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA</p> <p>JAPAN INTERNATIONAL COOPERATION AGENCY</p>	<p>TITLE</p> <p>USAC - Layout Plan</p>
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HYDRAULIC SKETCH  
**USAC**

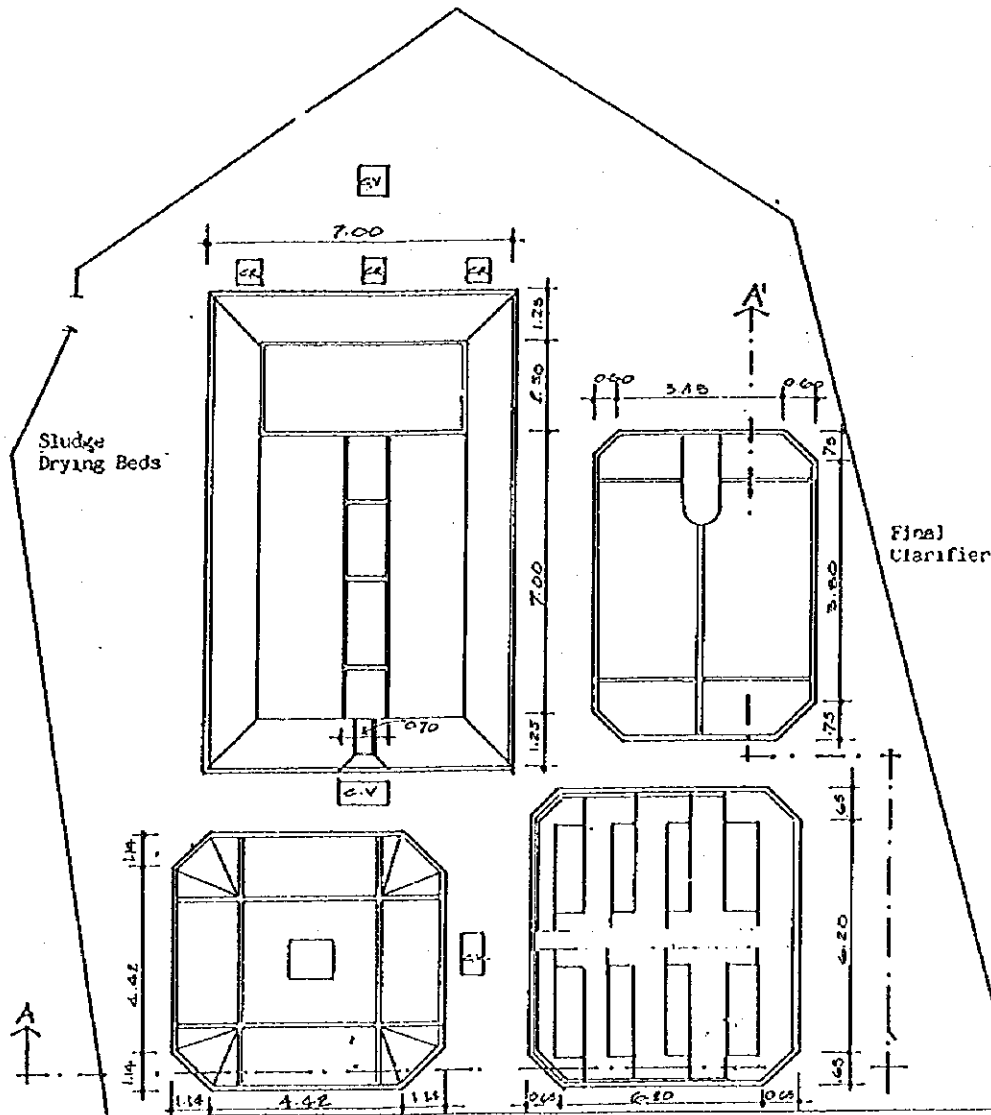
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GUATEMALA MUNICIPAL WATER  
SUPPLY PUBLIC CORPORATION  
(EMPAGUA)

THE STUDY ON  
THE IMPROVEMENT OF WASTEWATER  
MANAGEMENT IN THE GUATEMALA  
METROPOLITAN AREA

JAPAN INTERNATIONAL COOPERATION AGENCY

TITLE

USAC - Vertical Profile



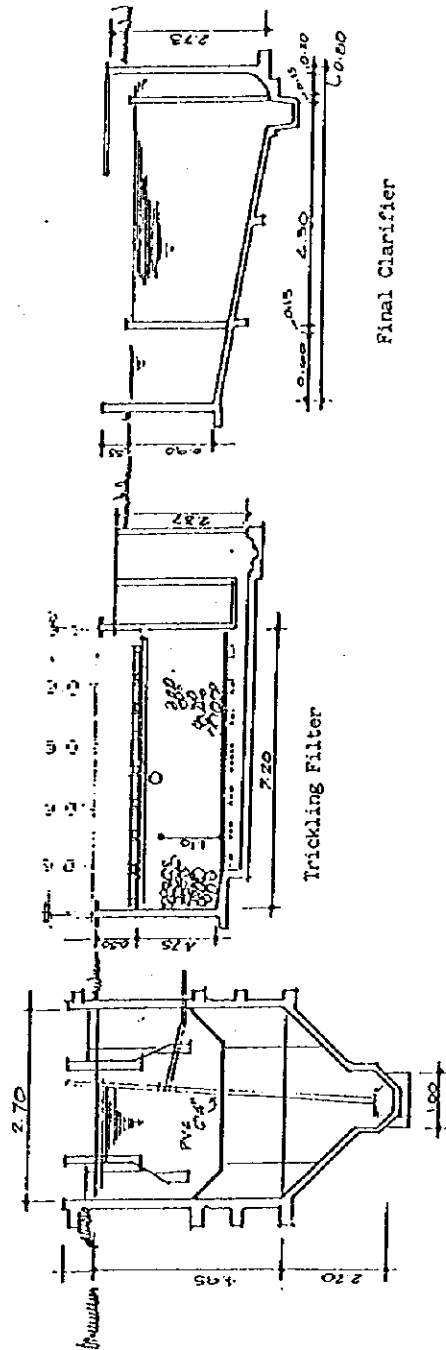
Sedimentation Tank  
Dortmund

Trickling Filter

Sketch Treatment Plant  
EUREKA - MORSE

SIN ESCALA

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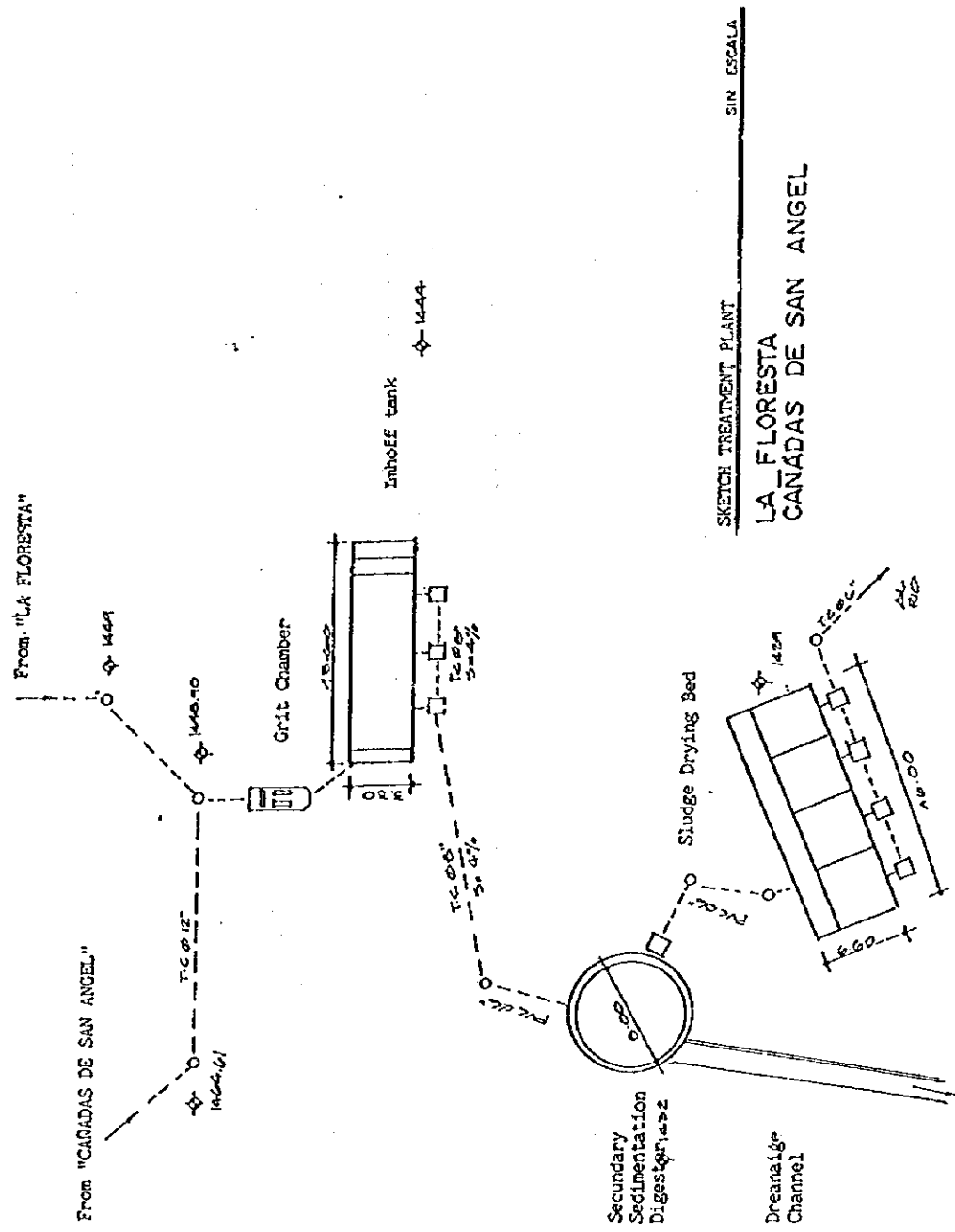
HYDRAULIC SKETCH  
EUREKA - MORSE  
SIN ESCALA

Sedimentation Tank  
Dortmund

Trickling Filter

Final Clarifier

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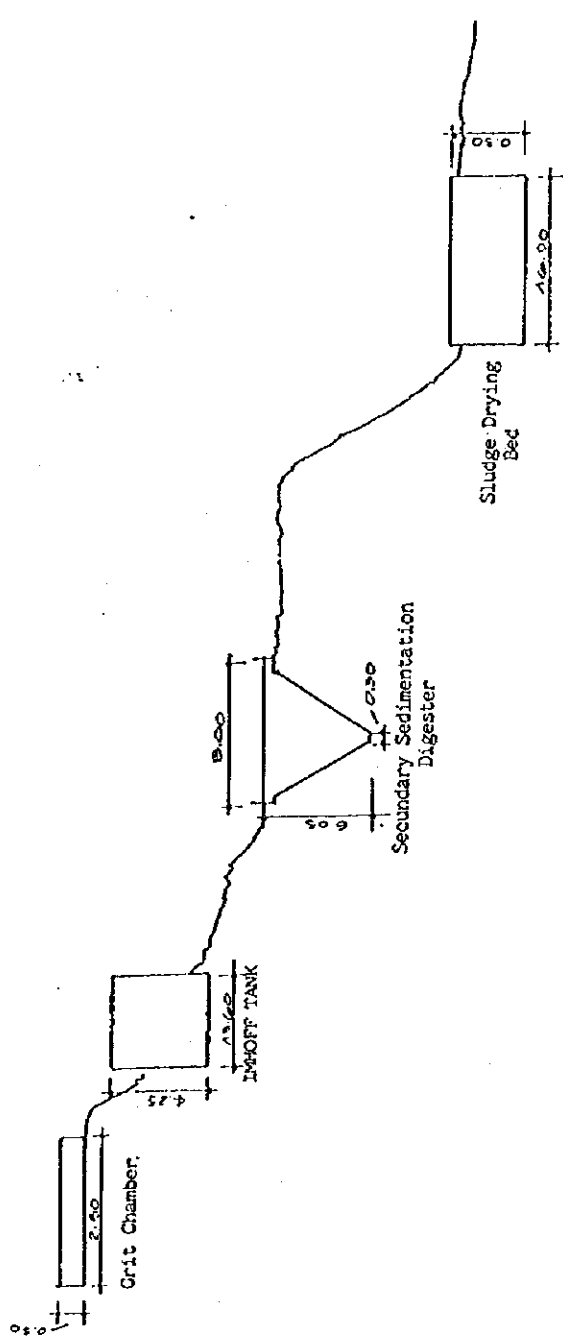


SKETCH TREATMENT PLANT  
 LA FLORESTA  
 CANADAS DE SAN ANGEL  
 SIN ESCALA

THE REPUBLIC OF GUATEMALA  
 GUATEMALA MUNICIPAL WATER  
 SUPPLY PUBLIC CORPORATION  
 (EMPAGUA)

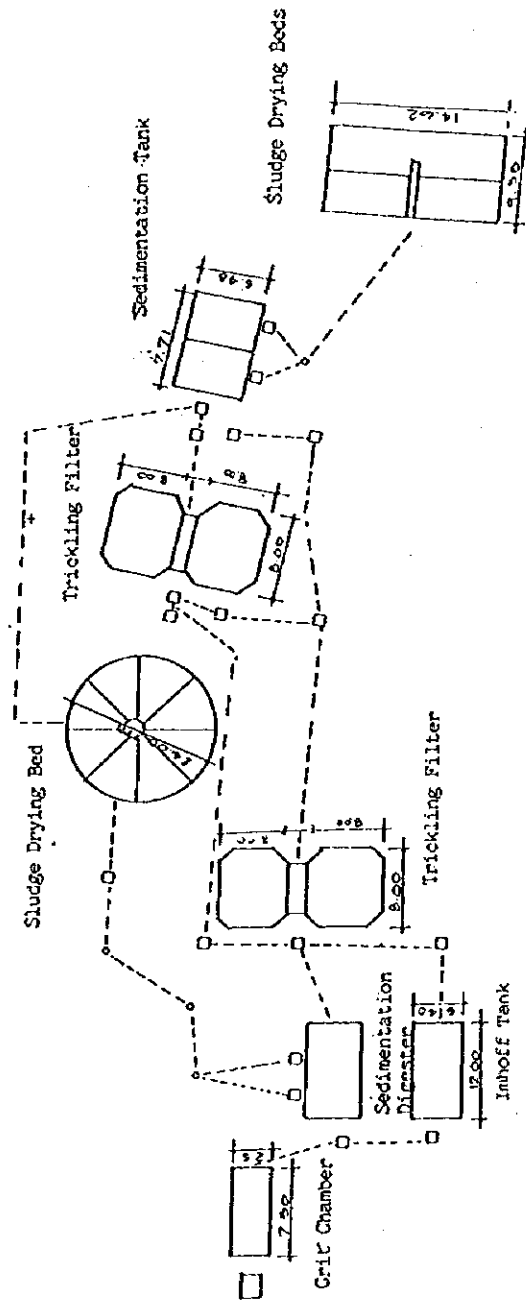
THE STUDY ON  
 THE IMPROVEMENT OF WASTEWATER  
 MANAGEMENT IN THE GUATEMALA  
 METROPOLITAN AREA  
 JAPAN INTERNATIONAL COOPERATION AGENCY

TITLE  
 Canada de San Angel-  
 Layout Plan



HYDRAULIC SKETCH  
LA FLORESTA  
CAÑADAS DE SAN ANGEL

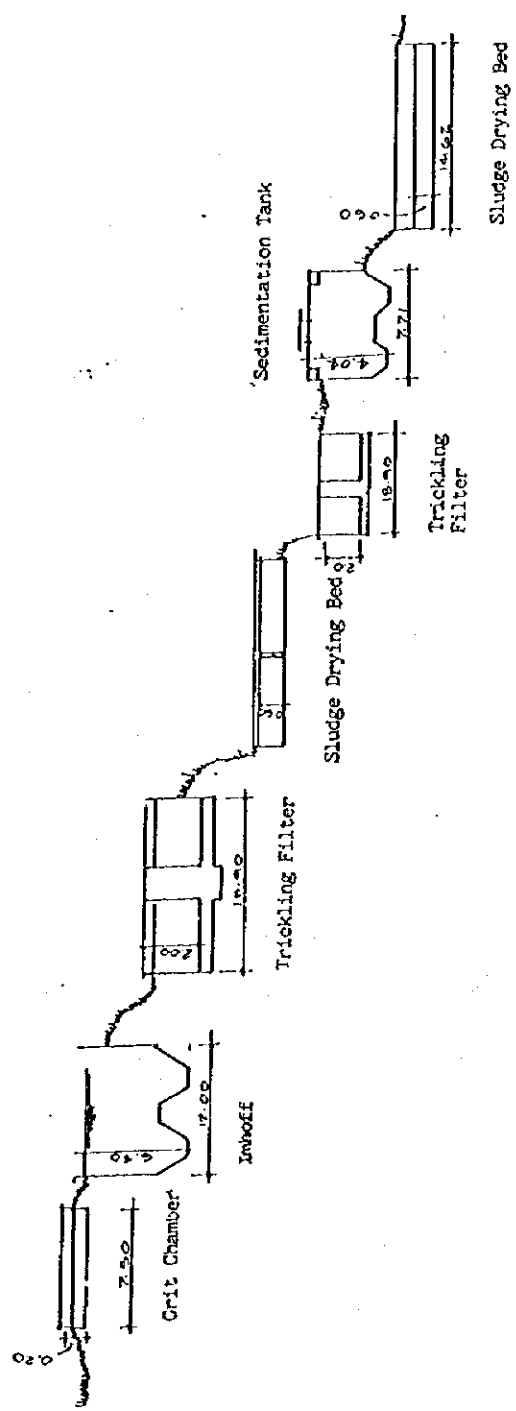
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<p>JAPAN INTERNATIONAL COOPERATION AGENCY</p>		



SKETCH TREATMENT PLANT  
**BELLO HORIZONTE**  
 SIN ESCALA

<p>THE REPUBLIC OF GUATEMALA</p> <p>GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)</p>	<p>THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA</p> <p>JAPAN INTERNATIONAL COOPERATION AGENCY</p>	<p>TITLE</p> <p>Bello Horizonte - Layout Plan</p>
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Fig. G - 18

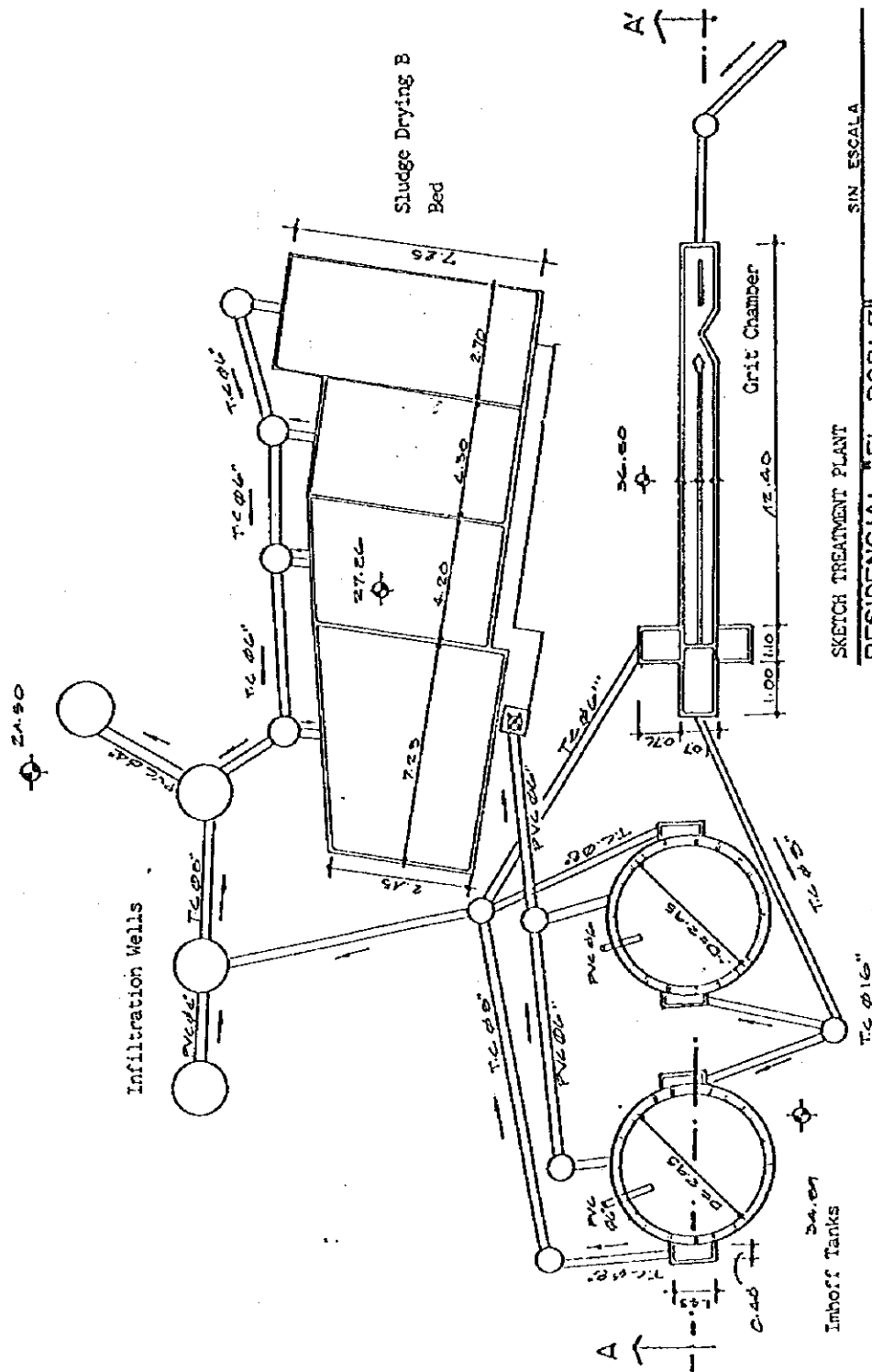


HYDRAULIC SKETCH:  
**BELLO HORIZONTE**  
 SIN ESCALA

THE REPUBLIC OF GUATEMALA  
 GUATEMALA MUNICIPAL WATER  
 SUPPLY PUBLIC CORPORATION  
 (EMPAGUA)

THE STUDY ON  
 THE IMPROVEMENT OF WASTEWATER  
 MANAGEMENT IN THE GUATEMALA  
 METROPOLITAN AREA  
 JAPAN INTERNATIONAL COOPERATION AGENCY

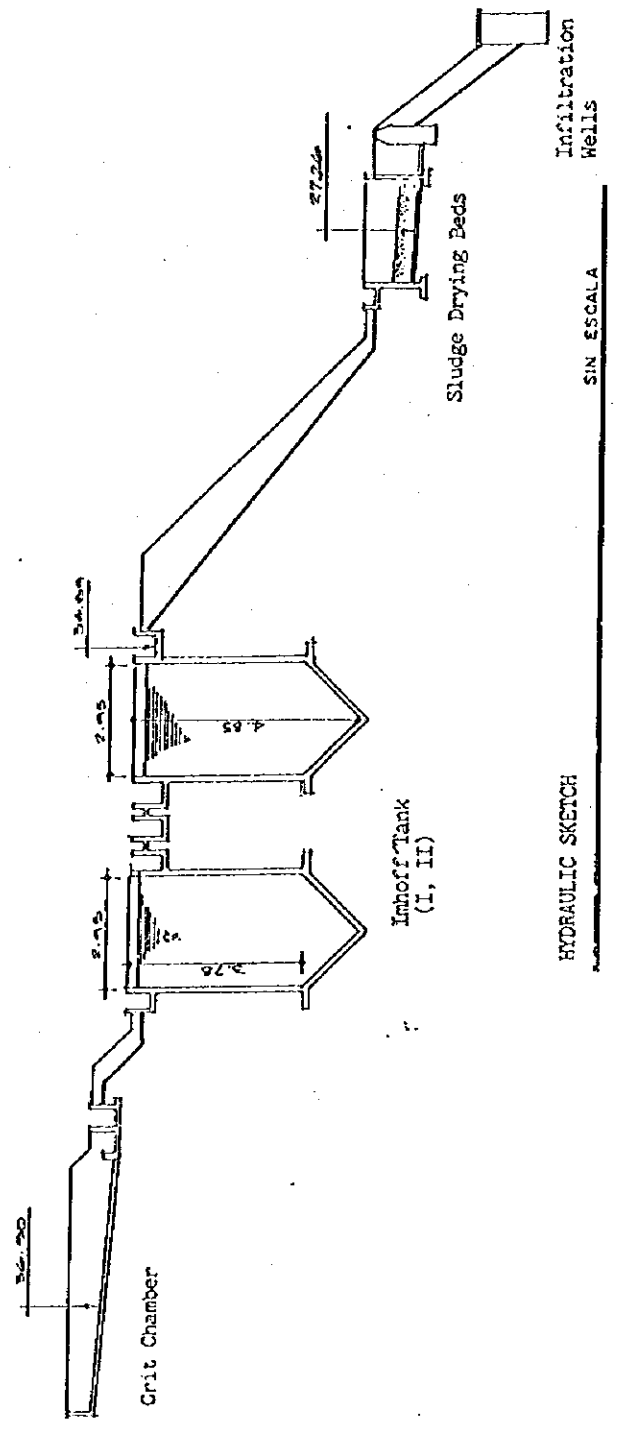
TITLE  
**Bello Horizonte - Vertical  
 Profile**



SKETCH TREATMENT PLANT  
RESIDENCIAL "EL ROBLE"  
SIN ESCALA

<p>THE REPUBLIC OF GUATEMALA</p> <p>GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)</p>	<p>THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA</p> <p>JAPAN INTERNATIONAL COOPERATION AGENCY</p>	<p>TITLE</p> <p>El Roble - Layout Plan</p>
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HYDRAULIC SKETCH

RESIDENCIAL "EL ROBLE"

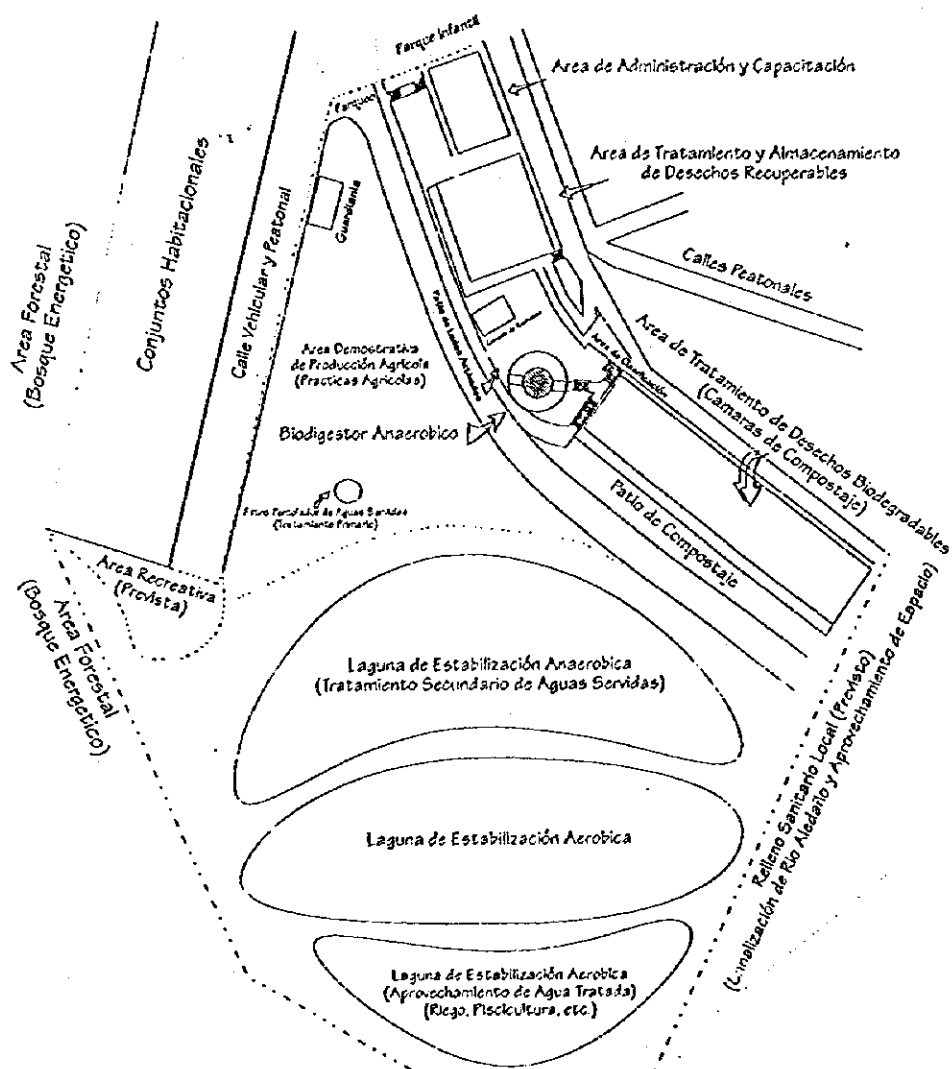
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# ASOCIACION PARA LA RECUPERACION, MANEJO Y SANEAMIENTO AMBIENTAL

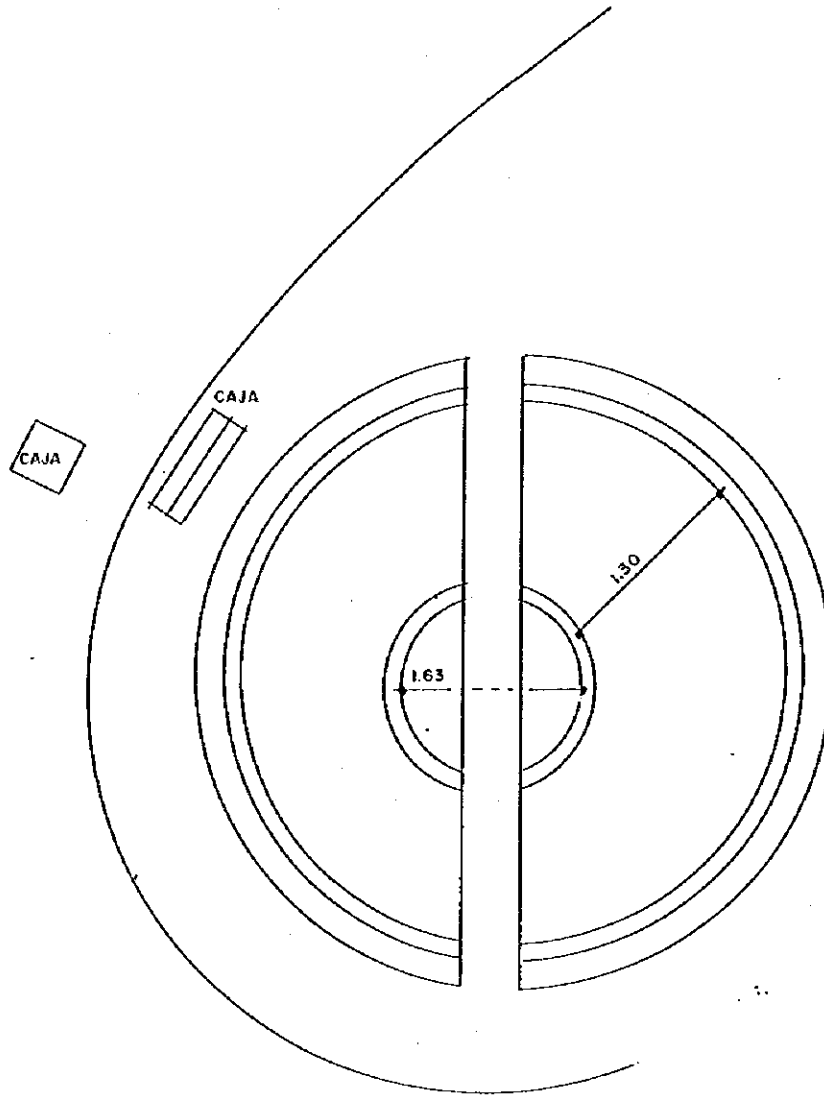


## SISTEMA INTEGRADO ALTERNATIVO ALAMEDA NORTE

DIAGRAMA 1: Disposición de Areas a Nivel de Diseño

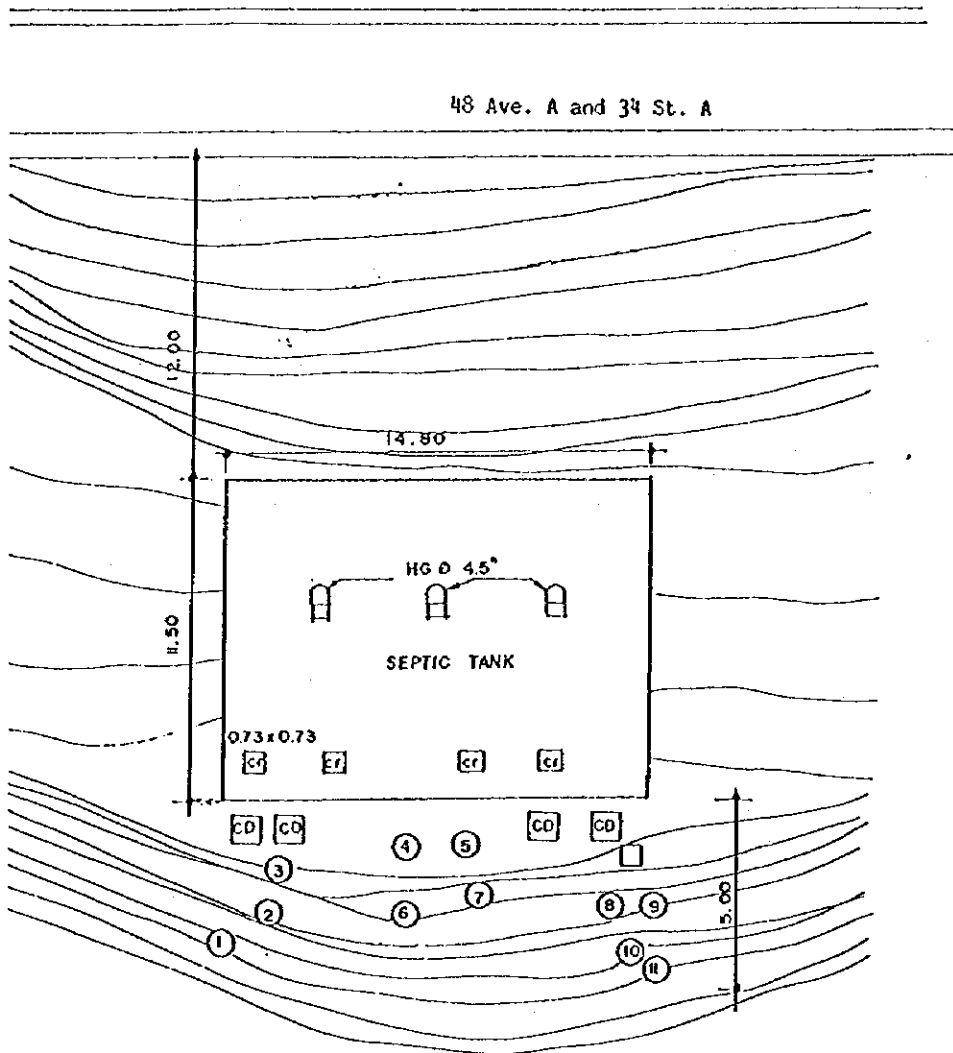


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	<p>JAPAN INTERNATIONAL COOPERATION AGENCY</p>	



PLANTA: BIODIGESTOR ANAEROBICO  
COLONIA "ALAMEDA NORTE "

<p>THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)</p>	<p>THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA</p> <hr/> <p>JAPAN INTERNATIONAL COOPERATION AGENCY</p>	<p>TITLE Alameda Norte - Existing Facility</p>
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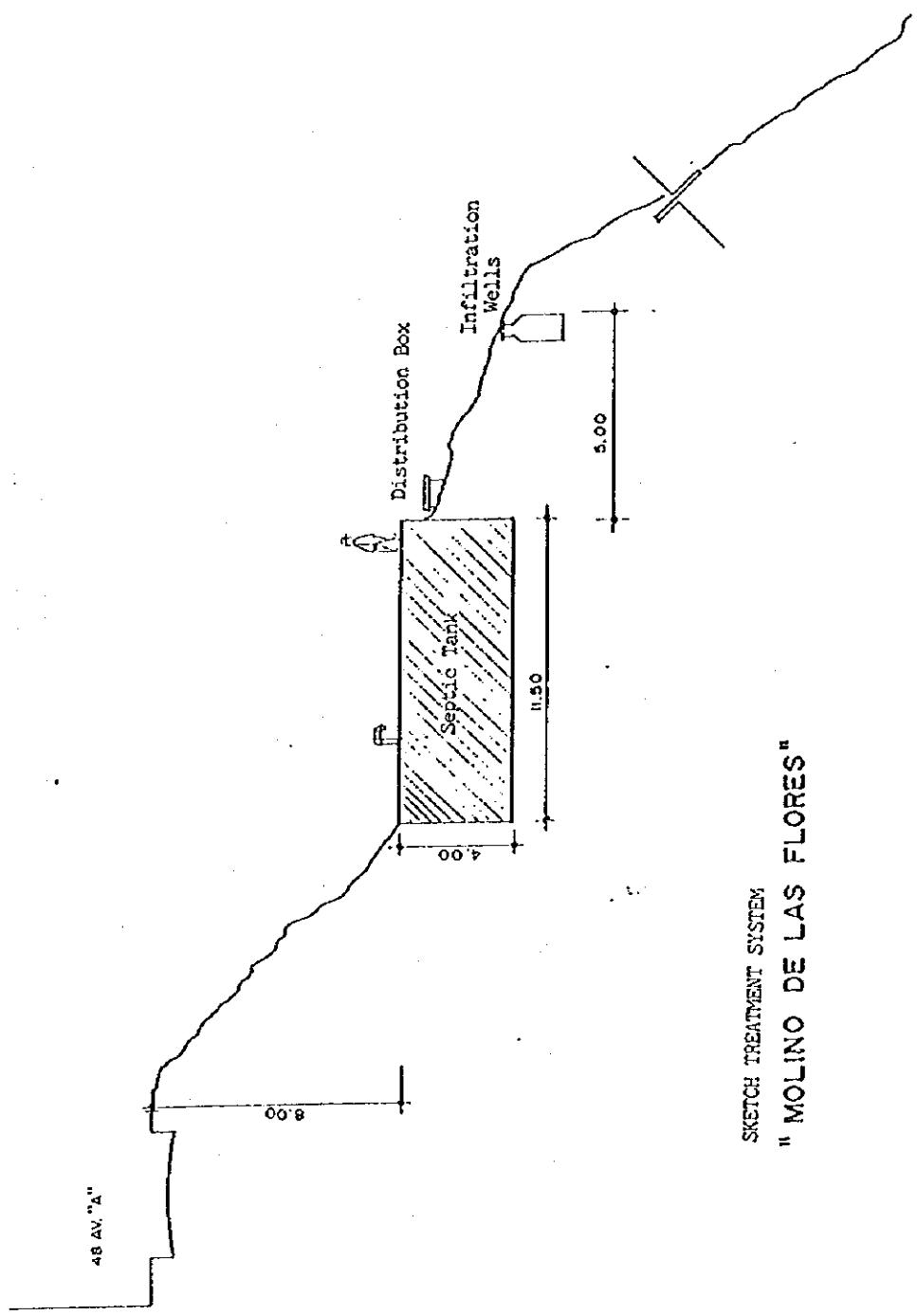


SKETCH TREATMENT SYSTEM

SCALE 1/200

\*MOLINO DE LAS FLORES\*

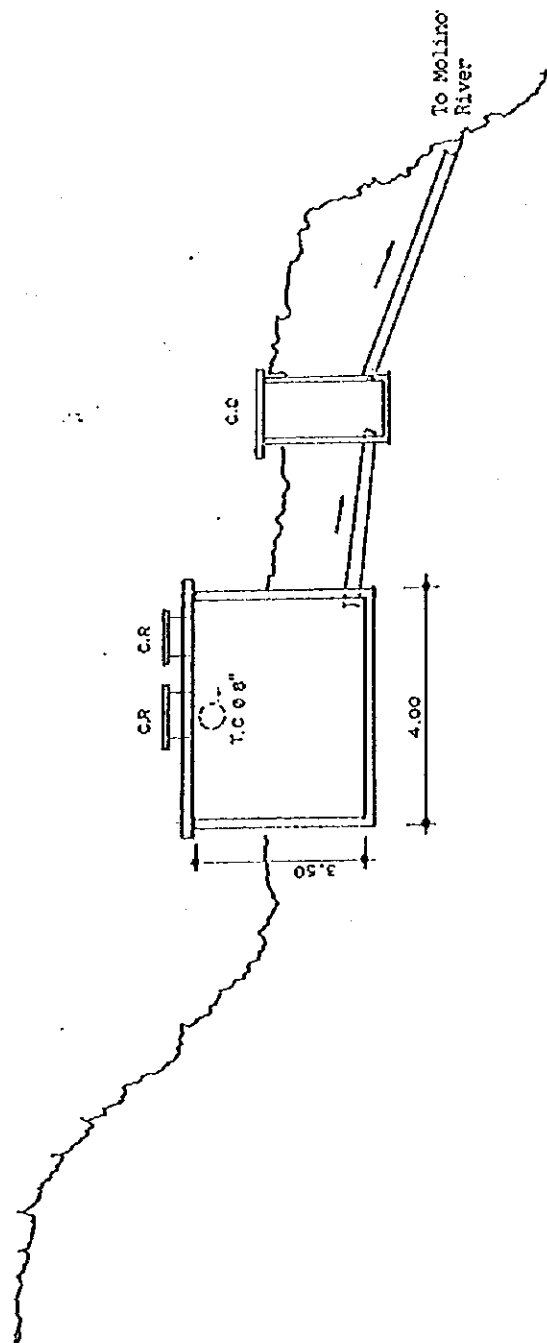
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SKETCH TREATMENT SYSTEM  
" MOLINO DE LAS FLORES "

<p>THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)</p>	<p>THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA</p> <hr/> <p>JAPAN INTERNATIONAL COOPERATION AGENCY</p>	<p>TITLE Molino de Las Flores - Vertical Profile</p>
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SKETCH TREATMENT PLANT (Section A-A)  
 " LOMAS DE PORTUGAL "

ESC. 1:100

<p>THE REPUBLIC OF GUATEMALA                  GUATEMALA MUNICIPAL WATER                  SUPPLY PUBLIC CORPORATION                  (EMPAGUA)</p>	<p>THE STUDY ON                  THE IMPROVEMENT OF WASTEWATER                  MANAGEMENT IN THE GUATEMALA                  METROPOLITAN AREA</p> <hr/> <p>JAPAN INTERNATIONAL COOPERATION AGENCY</p>	<p>TITLE                  Lomas de Portugal -                  Vertical Profile</p>
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**SUPPORTING REPORT H**  
**EMPAGUA'S ORGANIZATION**



**SUPPORTING REPORT II  
EMPAGUA'S ADMINISTRATION  
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H3	Characteristics of Employees.....	H - 7
H4	Salary .....	H - 8
H5	Training .....	H -10
H6	Information System .....	H -10
H7	Tariff Structure.....	H -11
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# H EMPAGUA'S ADMINISTRATION

## H1 INTRODUCTION

The purpose of this supporting report is to supplement the Chapter 5 of Main Report. Together with the chapter, this report concentrates on the administrative areas of EMPAGUA such as organization, employees and managerial systems.

## H2 ORGANIZATIONAL STRUCTURE

EMPAGUA's organization chart as of February 1996 is presented in Fig. 5-2 of Main Report, wherein the dependency of EMPAGUA on Guatemala Municipality is notable. Table H-1 describes the function of each unit appeared in the organization chart.

**Table H-1 Unit Classification**

Unit	Function
Municipality Council	<ul style="list-style-type: none"> <li>Check the management of EMPAGUA and approve important matters decided by EMPAGUA as its founding body.</li> </ul>
Managing Board	<ul style="list-style-type: none"> <li>Deliberate on and decide company strategy.</li> </ul>
General Manager's Office	<ul style="list-style-type: none"> <li>Lead, direct and coordinate administrative, technical and operational activities.</li> </ul>
Institutional Modernization Section	<ul style="list-style-type: none"> <li>Coordinate activities of outside consultants contracted by the company;</li> <li>Study and propose methods and procedures for administrative improvement; and</li> <li>Participate in discussions with consultants and directors of the company on the methods and systems proposed by consultants.</li> </ul>
Audit Division	<ul style="list-style-type: none"> <li>Audit the Company's financial and administrative activities; and</li> <li>Intervene in authorization and approval of transactions and operations carried out by the company.</li> </ul>
Legal Division	<ul style="list-style-type: none"> <li>Provide an opinion on legal issues; and</li> <li>Defend interests of the company through the courts.</li> </ul>
Sub General Manager's Office - Administration and Finance Administration Division	<ul style="list-style-type: none"> <li>Execute administrative and financial policies of the company.</li> </ul>
Personnel Section	<ul style="list-style-type: none"> <li>Monitor compliance with the resolutions dispositions and ordinances issued by superior organs of the company.</li> </ul>
Auxiliary Service Section	<ul style="list-style-type: none"> <li>Regulate labor relationships between the company and employees.</li> </ul>
Vehicle and Repair Section	<ul style="list-style-type: none"> <li>Furnish all sections with the services for the maintenance of office facilities such as computers, electronic services and cleaning.</li> </ul>
Medical Section	<ul style="list-style-type: none"> <li>Plan, organize, control and execute all activities related with the vehicles;</li> <li>Effect maintenance of the vehicles; and</li> <li>Ensure the good use and conservation of the same.</li> </ul>
Training Section	<ul style="list-style-type: none"> <li>Furnish the employees and their families with medical services.</li> </ul>
Document Section	<ul style="list-style-type: none"> <li>Foster the training program of the company at executive, intermediate and operative levels.</li> </ul>
	<ul style="list-style-type: none"> <li>Keep documents of all sections of the company for supply of necessary information.</li> </ul>

User Service Division	<ul style="list-style-type: none"> <li>Coordinate and execute policies established by the superior organs of the company; and</li> <li>Plan and formulate commercial policies in coordination with the units in charge.</li> </ul>
Installation Section	<ul style="list-style-type: none"> <li>Study, research, promote, commercial registration and checking of both existing and potential customers.</li> </ul>
Public Information Section	<ul style="list-style-type: none"> <li>Attend, analyze and solve customers' claims by telephone and direct counseling.</li> </ul>
Billing Section	<ul style="list-style-type: none"> <li>Effect meter readings and distribution of bills;</li> <li>Issue meter reading cards and bills.</li> </ul>
Supply Division	<ul style="list-style-type: none"> <li>Plan, check and carry out the purchase, storage and distribution of necessary goods for the execution of operational works and investments.</li> </ul>
Purchasing Section	<ul style="list-style-type: none"> <li>Execute applications for the purchase of goods and services necessary for operation and investment by various sections;</li> <li>Obtain price estimates in order to know the best offers.</li> </ul>
Information System Division	<ul style="list-style-type: none"> <li>Assign resources for the realization of activities of analysis and design of new systems, programming, operation and processing of data;</li> <li>Provide each unit with required information and reports.</li> </ul>
Finance Division	<ul style="list-style-type: none"> <li>Program, manage and check the company's income and all financial operation.</li> </ul>
Budgeting Section	<ul style="list-style-type: none"> <li>Elaborate, check, execute and program the general budget of revenue and expenses of the company;</li> </ul>
Accounting Section	<ul style="list-style-type: none"> <li>Effect the accounting registry of the company activities;</li> <li>Determine managerial measures through financial statements.</li> </ul>
Treasury Section	<ul style="list-style-type: none"> <li>Collect funds from payments by various customers.</li> </ul>
Collection Section	<ul style="list-style-type: none"> <li>Handle, analyze and check customers payment arrears;</li> <li>Effect agreement of payment in accordance with effective regulations.</li> </ul>
Warehouse and Supply Section	<ul style="list-style-type: none"> <li>Maintain adequate minimum and maximum stocks of materials used for the company's activities.</li> </ul>
Sub General Manager's Office - Technical Area	<ul style="list-style-type: none"> <li>Collaborate closely with management in the definition of policy planning and execution of technical programs by the company.</li> </ul>
Works Division	<ul style="list-style-type: none"> <li>Attend to the necessities of construction and supervision of the works of potable water and sewerage;</li> <li>Supervise the works carried out by contractors so that they are in accordance with the specifications and recommended plans;</li> </ul>
Civil Works Section	<ul style="list-style-type: none"> <li>Install pressure pipes, conduction pipes and distribution pipes;</li> <li>Responsible for the maintenance and good operation of water treatment plants, repair of pavements in the city.</li> </ul>
Sewerage Construction and Supervision Section	<ul style="list-style-type: none"> <li>Responsible for the preventive and corrective maintenance of drainage;</li> <li>Create projects in populated areas;</li> <li>Prevent contamination of rivers.</li> </ul>
Sewerage Maintenance Section	<ul style="list-style-type: none"> <li>Clean up and rehabilitate sewers ;</li> <li>Maintain the sewerage system.</li> </ul>
IDB-540 Program Section	<ul style="list-style-type: none"> <li>Maintain the drainage system constructed by IDB-540 loan;</li> <li>Maintain other drainage systems.</li> </ul>
Pipe Factory	<ul style="list-style-type: none"> <li>Produce concrete pipes and other articles required for the several works to extend the service.</li> </ul>
Operation and Maintenance Division	<ul style="list-style-type: none"> <li>Execute all activities to operate the installations and the equipment which constitute the production and distribution system of potable water;</li> <li>Organize the efficient operation of systems to optimize continuity of programmed service;</li> <li>Optimize the quality and pressure of water supply.</li> </ul>
Water Basin Conservation and Management Section	<ul style="list-style-type: none"> <li>Clean up and maintain dams, conduction lines and river banks that provide water to the company.</li> </ul>

Wells and Electric System Maintenance Section	<ul style="list-style-type: none"> <li>Responsible for preventive and corrective maintenance of electrical equipment and installations in all wells and plants.</li> </ul>
Santa Luisa - Cambray - Ilusiones Water System Section	<ul style="list-style-type: none"> <li>Responsible for harnessing, treatment, conduction and distribution of ground and underground waters from the Santa Luis - Cambray - Ilusiones Water System, in order to provide an efficient water supply service.</li> </ul>
Lo de Coy - Brigada Water System Section	<ul style="list-style-type: none"> <li>Responsible for harnessing, treatment, conduction and distribution of surface and underground waters from the Lo de Coy - Brigada Water System, in order to provide an efficient water supply service.</li> </ul>
Distribution Section	<ul style="list-style-type: none"> <li>Maintain the conduction and distribution network of potable water.</li> </ul>
Chemical - Bacteriological Laboratory	<ul style="list-style-type: none"> <li>Take and analyze water samples at key points in the distribution network;</li> <li>Carry out physical-chemical partial analysis and bacteriological tests to determine efficiency of the treatment is shown.</li> </ul>
Hydroelectrometry Section	<ul style="list-style-type: none"> <li>Check water flow, pressures, levels of tanks.</li> </ul>
Meter and Housing Installation Section	<ul style="list-style-type: none"> <li>Charged with the preventive and corrective maintenance of water meters for users.</li> </ul>
Planning Division	<ul style="list-style-type: none"> <li>Responsible for guiding the planning of water supply and drainage system in the Guatemala City for better use of hydraulic and economic resources;</li> <li>Represent to the company on the diverse commissions and committees of institutions related with the potable water supply and sewerage services;</li> <li>Program and monitor to achieve better use of the resources of underground water;</li> <li>Promote projects for potable water, according to the necessities of an integral plan;</li> <li>Develop technical activities related to projects of housing and building developments.</li> </ul>
Basic Study Section	<ul style="list-style-type: none"> <li>Develop studies related to the hydraulic resource in order to satisfy the water demand of Guatemala City.</li> </ul>
Hydrology and Underground Water Section	<ul style="list-style-type: none"> <li>Plan, program, supervise and control the use of the underground water resources in the capital city and areas of influence in order to optimize its use and establish designs for new exploitation of water.</li> </ul>
Design Section	<ul style="list-style-type: none"> <li>Responsible for technical-normative activities related to the water network for housing development, condominiums and branch line extensions;</li> <li>Elaborate projects of potable water according to the necessities of the company.</li> </ul>
Marginal Area Improvement Contribution Section	<ul style="list-style-type: none"> <li>Carry out a study of the land register and to calculate and formulate of applications for approval for contributions to the cost of improvement through the water supply and sewerage projects already executed or in process.</li> </ul>

EMPAGUA's staff can be classified into four types of job category, namely (i) senior management, (ii) skilled specialist, (iii) administrative staff, (iv) technical staff, and (v) unskilled worker. These job categories are further divided by job position. Table II-2 shows the classification, job duties and required qualification.

**Table II-2 Job Classification**

<b>Position *</b>	<b>Qualification</b>	<b>Job duties</b>
<b>Senior Management</b>		
General manager (Gerente)	University graduate	<ul style="list-style-type: none"> <li>Nominate the appropriate administrative personnel;</li> <li>Issue circular orders and instructions for the good functioning of the company;</li> <li>Authorize viable proposals submitted by the directors;</li> <li>Organize, manage, check and evaluate the technical and administrative work of the company.</li> </ul>
Sub-General Manager (Sub-Gerente Administrativo)	Recognized administrative competence, preferably university graduate	<ul style="list-style-type: none"> <li>Propose organization manuals and administrative forms to the manager for his approval;</li> <li>Supervise the activities of departments under his charge;</li> <li>Collaborate in preparation of the company annual report.</li> </ul>
Sub-General Manager (Sub-Gerente Tecnico)	University graduate with major of civil engineering, preferably specialized in hydraulics	<ul style="list-style-type: none"> <li>Collaborate closely with the General Manager's Office in the definition of policy planning and execution of technical programs of the company;</li> <li>Manage and watch all technical activities of the company;</li> <li>Propose technical manuals and standards to the General Manager;</li> <li>Recommend to the General Manager measures for the proper functioning of company's technical area.</li> </ul>
Division Head (Profesional Ejecutivo, Director)	University graduate with any major related to the activities of EMPAGUA and to his position	<ul style="list-style-type: none"> <li>Coordinate the management of the resources and activities carried out by the units of his department;</li> <li>Elaborate plans and work programs in the short, medium and long term;</li> <li>Submit work reports to the corresponding management;</li> <li>Submit to his superior management proposals of change and new process to contribute to the improvement of his area.</li> </ul>
Project Delegate (Delegado Residente)	University graduate, preferably civil engineering major	<ul style="list-style-type: none"> <li>Evaluate the execution of services contracted for the development of the projects;</li> <li>Manage projects and coordinate between the consultants and EMPAGUA;</li> <li>Revise and decide on the approval of reports;</li> <li>Coordinate project staff and consultants.</li> </ul>
<b>Skilled Specialist</b>		
Advisor (Asesor de Gerencia)	University graduate with major study field of civil engineering or economics and finance	<ul style="list-style-type: none"> <li>Give orientation about technical, administrative and/or financial aspects;</li> <li>Propose solutions to problems of his relevant areas in EMPAGUA;</li> <li>Give opinions in reply to questions of various directors;</li> <li>Attend the consulting firms by request of General Manager's office.</li> </ul>
Internal Auditor (Auditor Interno)	Accounting specialist with experience in auditing (secondary education level) or university graduate with major of accounting and public auditing	<ul style="list-style-type: none"> <li>Coordinate the internal audit of the company;</li> <li>Report on aspects of financial inspection and audit;</li> <li>Recommend corrective measures to strengthen the internal checking;</li> <li>Submit periodical activity reports to the board of directors.</li> </ul>
Specialist (Profesional)	University graduate	<ul style="list-style-type: none"> <li>Carry out various studies to solve problems;</li> <li>Coordinate and execute the works projected</li> </ul>

Administrative Area		
General Affairs Staff (Oficial Administrativo)	Secondary education, preferably university student	<ul style="list-style-type: none"> <li>• Receive field reports and administrative reports made by personnel;</li> <li>• Check the stock of office equipment;</li> <li>• Check overtime records and elaborate various tables.</li> </ul>
Clerk (Oficial)	Secondary education, preferably current university students	<ul style="list-style-type: none"> <li>• Attend clients for various problem solving;</li> <li>• Do various clerical work;</li> <li>• Diagnose the necessity of training for various units and personnel;</li> <li>• Coordinate and execute technical and/or administrative works.</li> </ul>
Section Head (Jefe Profesional)	University graduate	<ul style="list-style-type: none"> <li>• Elaborate activity programs;</li> <li>• Execute civil works and sewerage projects;</li> <li>• Supervise contracting works to meet the specification;</li> <li>• Manage the activities of production and maintenance of the water supply system.</li> </ul>
Section Head (Jefe Tecnico Profesional)	Secondary education with experience, preferably university graduate	<ul style="list-style-type: none"> <li>• Plan, design, coordinate and supervise jobs with medium complexity;</li> <li>• Attend periodical meetings with other management</li> </ul>
Administrative Assistant (Asistente)	Secondary education, preferably those who currently study at university	<ul style="list-style-type: none"> <li>• Elaborate reports and tables to be presented to his superior;</li> <li>• Carry out research requested by superiors;</li> <li>• Prepare detailed information about his activities;</li> <li>• Act as proxy for his superior in meetings of minor importance.</li> </ul>
Sub-Internal Auditor (Sub Auditor)	Accounting specialist with experience in auditing (secondary education level), preferably those who currently major in public accounting and auditing at university	<ul style="list-style-type: none"> <li>• Assist to the Internal Auditor during his absence;</li> <li>• Analyze inquiries which require opinions;</li> <li>• Elaborate report to the General Manager's Office when required.</li> </ul>
Auditing Staff (Auditor)	Accounting specialist with experience in auditing (secondary education level), preferably those who currently major in public accounting and auditing at university	<ul style="list-style-type: none"> <li>• Carry out fiscal operation and accounting registrations;</li> <li>• Sum up and cash up the cash account;</li> <li>• Check the process in which several units are involved;</li> <li>• Verify the adequate use of goods, materials and inputs.</li> </ul>
Secretary (Secretaria)	Commercial secretary	<ul style="list-style-type: none"> <li>• Do secretarial works;</li> <li>• Do receptionist works</li> </ul>
Executive Secretary (Secretaria Ejecutiva, Secretaria Junta Directiva)	Executive secretary, preferably bilingual (English-Spanish).	<ul style="list-style-type: none"> <li>• Do secretarial works for executives.</li> </ul>
Warehouse Worker (Bodeguero)	Completed primary education, preferably with basic secondary studies (third year of secondary education)	<ul style="list-style-type: none"> <li>• Keep the register of entry, exit and stock of materials, furniture, and office equipment;</li> <li>• Participate in receipt and delivery of merchandise;</li> <li>• Make daily, weekly, fortnightly and monthly movement reports</li> </ul>

Technical Area		
Technician (Tecnico)	Secondary education with study at university for civil engineering, architecture or computer	<ul style="list-style-type: none"> <li>• Draw maps of pipelines of water supply and sewage;</li> <li>• Program and operate computers to make reports;</li> <li>• Ensure the proper functioning of equipment and electrical installations;</li> <li>• Elaborate annual activity plans for the units.</li> </ul>
Assistant Section Head (Auxiliar Tecnico Profesional)	Secondary education, preferably those who currently study at university	<ul style="list-style-type: none"> <li>• Supervise the execution of activities done by the unit personnel;</li> <li>• Elaborate tables that show the execution of planned duties;</li> <li>• Resolve inquiries consulting with the Unit Chief;</li> <li>• Participate in the elaboration of work programs of the unit.</li> </ul>
Circuit Inspector for Pump Station and Water Intake (Jefe de Turno I)	Secondary education : expert, master, adept accountant with experience in drinking water	<ul style="list-style-type: none"> <li>• Watch over pumping equipment to keep a good water flow to the treatment plants;</li> <li>• Operate pumping system switch;</li> <li>• Report water flow by radiophone;</li> <li>• Monitor if water flow from the dam to the treatment plant is constant;</li> <li>• Operate the machinery, equipment and control system to initiate pre-treatment;</li> <li>• Report water quantity by radiophone.</li> </ul>
Circuit Inspector for Treatment Plant (Jefe de Turno II)	Secondary education : expert, master, adept accountant with experience in drinking water	<ul style="list-style-type: none"> <li>• Carry out laboratory tests to determine the optimal dose quantity;</li> <li>• Check the water treatment stages;</li> <li>• Supervise and operate electronic equipment and energy systems of the plant;</li> <li>• Assign and supervise the functions of operators.</li> </ul>
Operator (Operador)	Secondary education with experience in water and basic knowledge of electricity	<ul style="list-style-type: none"> <li>• Operate dam facilities;</li> <li>• Operate distribution tank facilities;</li> <li>• Operate well facilities;</li> <li>• Operate pumping station facilities;</li> <li>• Operate treatment plant facilities;</li> <li>• Take samples for water quality analysis.</li> </ul>
Financial Specialist (Especialista Financiera)	University graduate with experience in finance and economics, domestic and foreign financing.	<ul style="list-style-type: none"> <li>• Elaborate accounting registration of the company's operation;</li> <li>• Coordinate elaboration of projects at budgetary level;</li> <li>• Analyze and interpret financial statements of project;</li> <li>• Elaborate reports and give specific recommendations about the interpretation and application of fiscal disposals.</li> </ul>
Specialized Worker (Trabajador Especializado)	Secondary education with proved experience	<ul style="list-style-type: none"> <li>• Repair and maintain vehicles;</li> <li>• Construct and repair metallic structures such as balconies, gates, handrailing and steel works;</li> <li>• Install, repair, maintain electric equipment, apparatus and systems;</li> <li>• Operate heavy machinery;</li> <li>• Elaborate programs of computerized system.</li> </ul>
Watchman (Guardian)	Primary education with good physical and mental condition	<ul style="list-style-type: none"> <li>• Watch over the installations constantly;</li> <li>• Guard the goods and valuables of the company;</li> <li>• Secure access to the installations;</li> <li>• Record the entry and exit of guarded goods.</li> </ul>



Unskilled Worker		
Water Body Inspector (Guarda Bosque)	Reading and writing ability without physical and mental problems	<ul style="list-style-type: none"> <li>• Travel through water basins and along rivers which supply water to the dams;</li> <li>• Maintain access roads to the basins and rivers;</li> <li>• Report anomalies and happenings in the forests and at dams;</li> <li>• Watch over the assigned forest area constantly.</li> </ul>
Chief Worker (Trabajador Jefe Operativo)	Primary education with experience in personnel management	<ul style="list-style-type: none"> <li>• Organize and allocate daily duties to his workers;</li> <li>• Supervise the assigned duties;</li> <li>• Provide workers with tools and materials to carry out duties;</li> <li>• Elaborate and submit job reports;</li> </ul>
Operative Worker (Trabajador Operativo)	Recognized experience with good health (Assistant) Primary education (Messenger) Primary education with driver license (Driver)	<ul style="list-style-type: none"> <li>• Do various construction work;</li> <li>• Do miscellaneous work;</li> <li>• Drive vehicles and transport people and materials.</li> </ul>

\* The titles in parenthesis are corresponding Spanish titles actually used in EMPAGUA

### H3 CHARACTERISTICS OF EMPLOYEES

Fig. 5-4 of Main Report and the following Table H-3 illustrates how the employees of EMPAGUA are classified by age and experience. The composition by age bracket is compared with the labor force in Guatemalan Metropolitan area.

**Table H-3 Employees Composition by Age and Experience**  
(as of June 1995, unit: person)

Years of Service	Age						Total
	20 or less	21-30	31-40	41-50	51-60	61 or more	
0-2	15	93	55	41	9	2	215
3-5	6	164	83	24	3	1	281
6-10	0	131	173	87	29	17	437
11-15	0	7	72	21	21	4	125
16-20	1	1	155	133	74	12	376
21-25	0	0	22	80	44	9	155
26-30	0	3	1	59	42	11	116
31-35	0	0	0	8	43	15	66
36-40	0	0	0	0	11	10	21
41-	0	0	0	0	21	3	24
Total	22	399	561	453	297	84	1816
%	1.2%	22.0%	30.9%	24.9%	16.4%	4.6%	100%
Guatemalan average *	10-19 (age)	20-29	30-39	40-49	50-59	60 or more	
	16.2%	34.8%	23.1%	14.7%	6.9%	4.3%	100%

\* Source: Poblacion economicamente activa y ocupada en la Region Metropolitana, obrero o empleado de ambos sexos, encuesta empleo y desempleo, INE, agosto 1993