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No. 42

JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)

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

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

FINAL REPORT

VOLUME I
EXECUTIVE SUMMARY

AUGUST 1996

NIHON SUIDO CONSULTANTS CO., LTD.
PACIFIC CONSULTANTS INTERNATIONAL

VOLUME I EXECUTIVE SUMMARY AUGUST 1996 NIHON SUIDO CONSULTANTS CO., LTD. PACIFIC CONSULTANTS INTERNATIONAL

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EXCHANGE RATES USED IN THIS STUDY

1. Selection of Priority Regions (Master Plan)
   1US$ = Q5.71 = Yen 100.75(average of May '94 ~ April '95)
2. First Stage Project
   1US$ = Q5.88 = Yen 99.12(average of July '95 ~ December '95)

PREFACE

In response to a request from the Government of the Republic of Guatemala, the Government of Japan decided to conduct The Study on the Improvement of Wastewater Management in the Guatemala Metropolitan Area and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Guatemala a study team headed by Dr. Harutoshi Uchida, Nihon Suido Consultants Co., Ltd., and composed of staff members of Nihon Suido Consultants Co., Ltd., and Pacific Consultants International (five times between March 1995 and June 1996).

The team held discussions with the officials concerned of the Government of Guatemala, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Guatemala for their close cooperation extended to the team.

August, 1996

Kimio Fujita
President
Japan International Cooperation Agency

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

August, 1996

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo

Dear Sir,

LETTER OF TRANSMITTAL

We are pleased to submit herewith the Final Report of " The Study on the Improvement of Wastewater Management in the Guatemala Metropolitan Area" . This report describes results of the study conducted under the contract between JICA and Nihon Suido Consultants Co., LTD. in association with Pacific Consultants International during a period of seventeen months between March 1995 and August 1996.

This report describes existing conditions of the Study Area, Sewerage/Sanitation Master Plan and Results of Feasibility Study on Priority Project (First Stage Project).

This report consists of Executive Summary both in English and Spanish, Main Report both in English and Spanish, and Supporting Reports and Data Book in English. The Executive Summary describes the results of the Study briefly, and Main Report describes background of the Study, existing conditions of the Study Area, Sewerage/Sanitation Master Plan, Selection of Priority Regions, and Feasibility Study on the First Stage Project. The Supporting Reports describe results of detailed study, design calculations, drawings and data.

All members of the Study Team wish to express grateful acknowledgment to the personnel from your Agency, Advisory Committee, the Ministry of Foreign Affairs, the Ministry of Construction, Japan Sewage Works Agency and the Embassy of Japan in Guatemala as well as the officials and individuals from Guatemala for the kind assistance extended to the Study Team. The Study Team sincerely hopes that the proposed plans will help to improve water environment and social development in the Guatemala Metropolitan Area.

yours sincerely,

内田晴敏

Harutoshi Uchida
Team Leader

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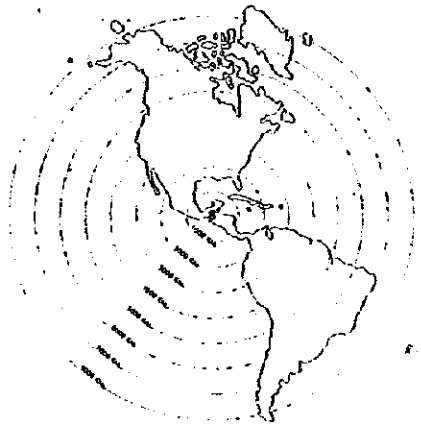

LOCATION OF THE REPUBLIC OF GUATEMALA

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SUMMARY

1. Introduction

This Final Report presents the results of the Study on the Improvement of Wastewater Management in the Guatemala Metropolitan Area. It consists of the Sewerage/sanitation Master Plan up to the target year 2015 and Feasibility Study on the First Stage Project. Fig. 1 shows the flow chart of the Study.

2. Contents

The Report consists of the following nine volumes :

Volume	I	:	Executive Summary (English)
Volume	II	:	Main Report (English)
Volume	III	:	Supporting Reports (I) (English)
Volume	IV	:	Supporting Reports (II) (English)
Volume	V	:	Supporting Reports (III) (English)
Volume	VI	:	Main Report (Spanish)
Volume	VII	:	Executive Summary (Spanish)
Volume	VIII	:	Drawings
Volume	IX	:	Data Book (English)

WASTEWATER MANAGEMENT MASTER PLAN

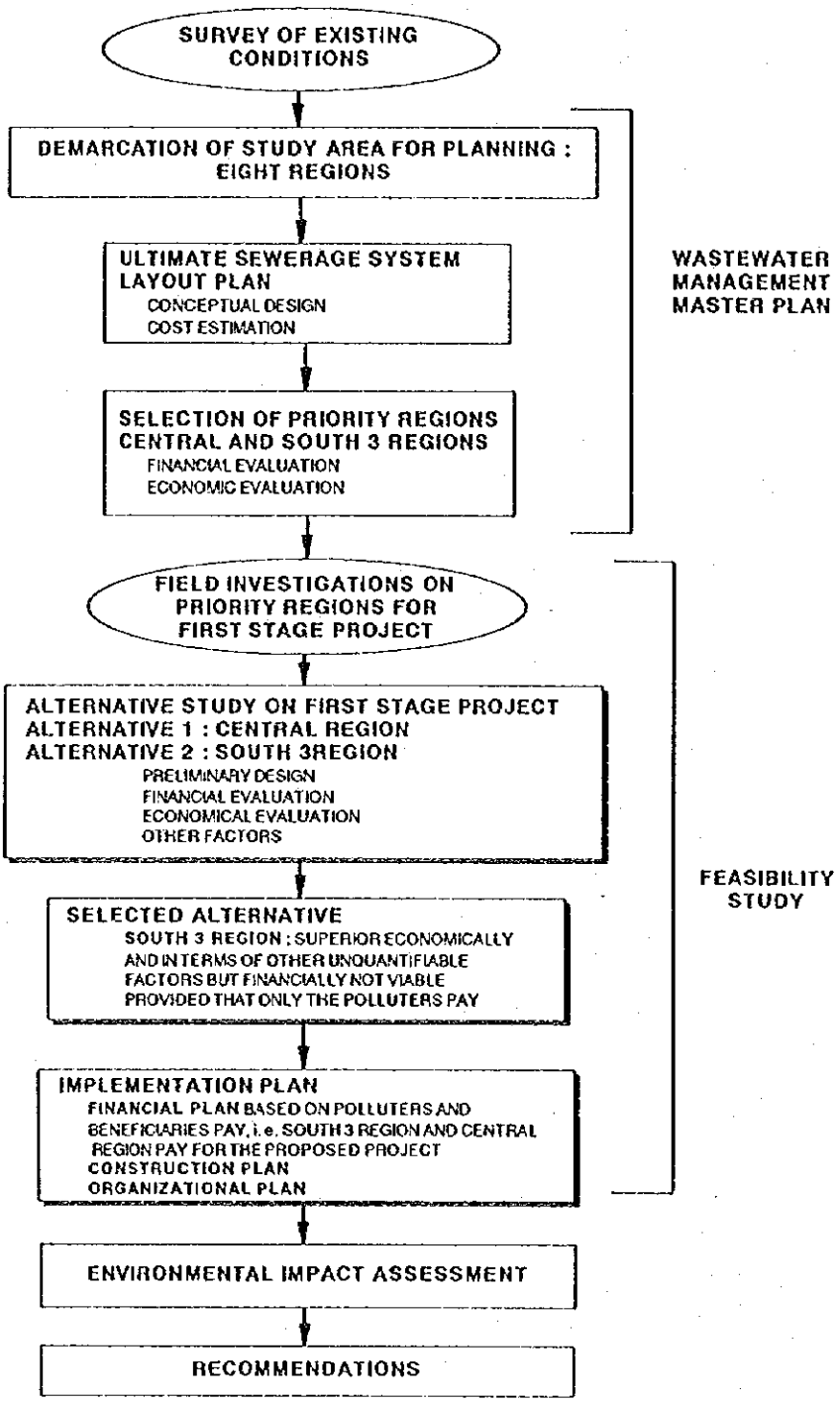
3. Water Environmental Conditions

To investigate the pollution levels in public water bodies, a water quality survey was conducted. The results showed that water quality in the rivers was almost the same as that of raw sewage. BOD_5 levels were from 100 to 300 mg/L most of the time and flow levels in the river varied during the daytime due to changing sewage flows. The rivers function as open sewage channels.

4. Regions

The Study Area is separated into north, south and east catchments by three major watersheds. The northern catchment is divided into Central, North 1 and North 2 Regions,

Fig. 1



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the southern catchment into South 1, South 2 and South 3 Regions and the eastern catchment into East 1 and East 2 Regions. The total area of all Regions for sewerage and sanitation implementation excluding green areas and valley's is 20,470 ha, out of the total Study Area of 34,500 ha.

5. Planned Population

The total area and estimated current (1994 census) and projected future (2015) population to be served by sewerage/sanitation for each Region are shown in Table 1.

Table 1 Population to be Served by Sewerage/Sanitation M/P by Regions

Regions	Area (ha)	Population				
		Total		Sewerage	Sanitation	
		1994	2015	2015	1994	2015
Central	6,460	508,500	861,400	751,800	109,600	109,600
North 1	2,190	180,000	392,000	379,100	12,900	12,900
North 2	740	72,000	150,000	-	72,000	150,000
South 1	1,640	40,000	280,000	277,500	2,500	2,500
South 2	2,220	83,000	191,600	183,600	8,000	8,000
South 3	2,360	134,000	279,000	276,100	2,900	2,900
East 1	3,705	251,000	521,000	500,800	20,200	20,200
East 2	1,155	25,800	40,000	-	25,800	40,000
Total	20,470	1,294,300	2,715,000	2,368,900	253,900	346,100

Note: Only a sanitation system is to be provided in North 2 and East 2 Regions.
Source : Study Team

6. Strategy for Wastewater Management System in M/P

(1) Bypassing Lake Amatitlan

At this stage, the provision of secondary treatment and disposal of treated effluent to the Lake would be the most appropriate solution and would significantly contribute to reducing waste inflows and improving the Lake water quality.

At a later stage, the water quality improvement of the lake environment should be carefully monitored to obtain conclusive results, based on which the necessity for bypassing could be accurately assessed.

(2) Strategy for Stormwater Drainage System

The stormwater management strategy in this Study is shown in Table 2:

Table 2 Stormwater Management Strategy in Each Region

Region	Sewerage System	Stormwater Management
Central	Combined	Stormwater intercepted will be treated at the wastewater treatment plant with sedimentation process
Other Regions	Separate	Existing stormwater drainage facilities are used. No treatment of stormwater is planned under this Study. Wastewater treatment should be given top priority.

Source : Study Team

(3) Scenario's of Effluent Standards

Scenario's of effluent standards are proposed as follows:

Case I Comply with the existing effluent standards

- Do not accept industrial wastewater
- Apply existing standards (60-89)
- Industries discharging to public sewers at present shall pay sewerage charges

Case II Revise Existing Standards

- Accept industrial wastewater
- Revise existing standards (60-89)
- The same effluent standards are set for discharging municipal wastewater and industrial wastewater into public water bodies
- Standards for industrial wastewater discharged into public sewers remain at the same level as Standard IS2

Case III Improved (stricter) Standards

- Set more stringent standards than Case II
- Accept industrial wastewater
- The same effluent standards are set for discharging municipal wastewater and industrial wastewater into public water bodies
- Standards for discharging industrial wastewater into public sewer remain at the same level as Standard IS2

Table 3 shows a summary of effluent standards for Cases I, II, and III and Table 4 shows the recommended standards for BOD concentration.

Table 3 Scenario of Effluent Standards

Source	Case I	Case II	Case III
Effluent Standards for Municipal Wastewater Discharged into Public Water Body	Standard MP	Standard P2	Standard P3
Effluent Standards for Industrial Wastewater Discharged into Public Water Body	Standard IP		
Standards for Industrial Wastewater Discharged into Public Sewers	_*	Standard IS2	

Note: discharge is only permitted for those industries with existing discharges.
Source : Study Team

Table 4 Example of Effluent Standards (BOD)

Case	Standard	BOD Concentration mg/L
Case I	Standard MP	200
	Standard IP (e. g. brewery)	900
Case II	Standard P2	200
	Standard IS2 (e. g. brewery)	900
Case III	Standard P3	< 200

Source : Study Team

7. Proposed Wastewater Management System

(1) Sewerage System

a) Wastewater Collection Facilities

The main collectors and interceptors to be built under the Master Plan range in diameter from 200 mm to 3,000 mm with an estimated total length of 169,200 meters. The ultimate sewerage system layout plan for the Study Area is shown in Fig. 2. The wastewater is conveyed by gravity flow to the point of discharge. The interceptors and main collector profiles were carefully determined so that no lift pumping stations will be required.

b) Wastewater and Sludge Treatment Process

The High-rate Trickling Filter Process is proposed for wastewater treatment. Existing sewers in Central Region are combined and some storm-water intercepted will enter the wastewater treatment plant. During wet weather, only primary treatment will be provided for flow exceeding the maximum hourly flow rate, before it is discharged to receiving water.

Unheated Anaerobic Digesters with Sludge Drying Beds are proposed for sludge treatment.

Fig. 2

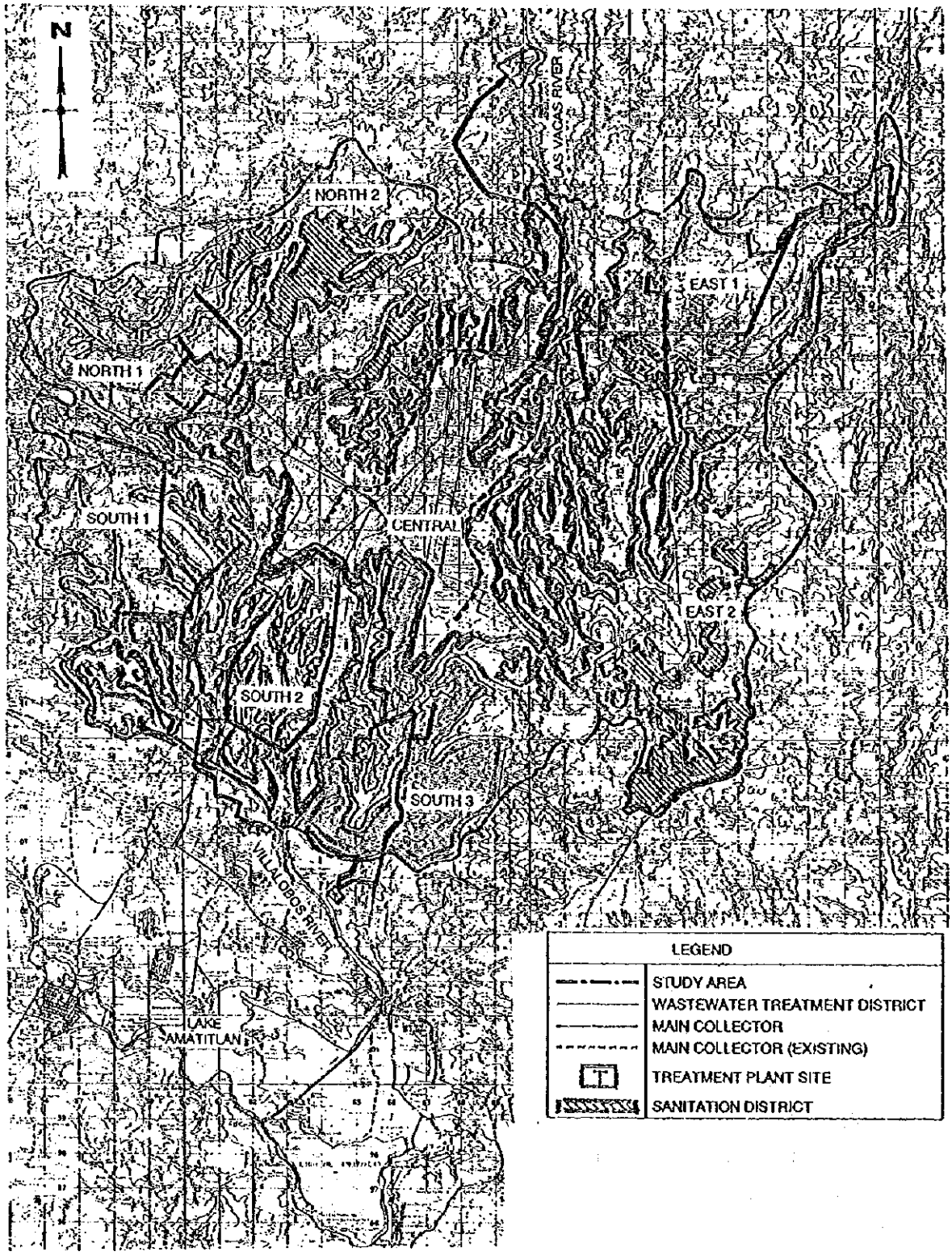

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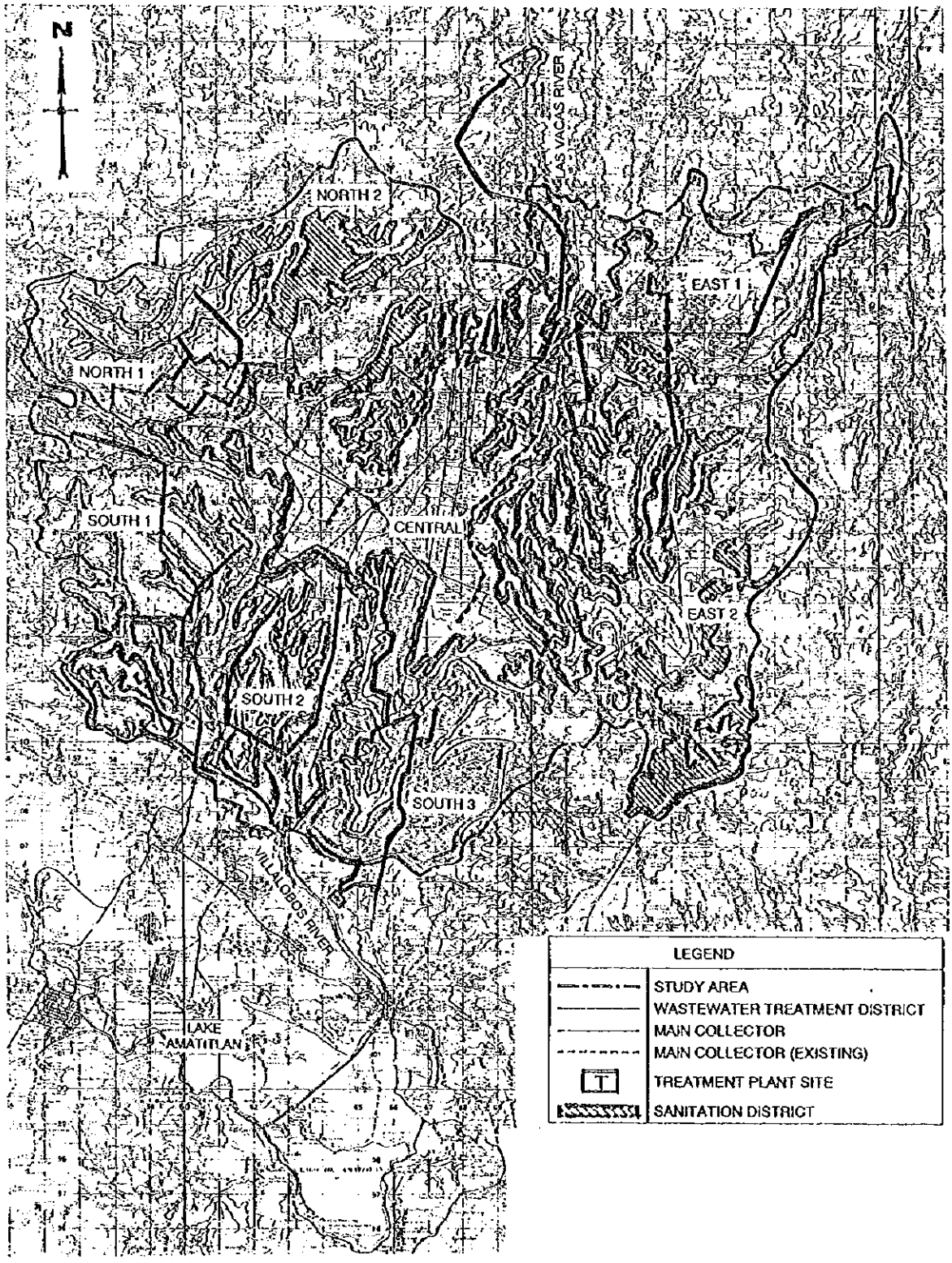
Fig. 2



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(2) Sanitation System

In areas, where wastewater cannot be collected by the proposed sewerage system due to topography, a sanitation system will be provided.
A sanitation system only is proposed for North 2 and East 2 Regions.

a) Wastewater Collection System
A gravity system is proposed for collecting and transporting wastewater to the community sanitation treatment facility.
It is planned to install a minimum size of 200 mm sewers.

b) Wastewater Treatment System and Sludge Management

The sanitation treatment system proposed consists of a septic tank followed by soil absorption well or upflow anaerobic filter. A two compartment septic tank is proposed to limit discharge of solids with the effluent. In cases where the effluent disposal is by soil absorption well, it is recommended that two wells are provided to ensure a sufficient resting period for the soil strata.

It is proposed that septage should be treated at the nearest Wastewater Treatment Plant.

8. Priority Regions up to the Year 2015

A study conducted to select a priority regions took into account the following parameters:

- Level of pollutant load reduction;
- Investment efficiency;
- Willingness to pay;
- Contribution to drinking water source protection;
- Availability of wastewater treatment plant sites;
- Public appeal

Construction of sewerage/sanitation systems in Priority Regions, namely **Central Region** and **South 3 Region**, is recommended in the Wastewater Management Master Plan.

The main reasons for selection of these Regions are:

- Central Region is identified as being the highest priority Region for pollutant load reduction, investment efficiency, contribution to drinking water source protection (second only to South 3 Region) and earlier realization of benefits due to availability of existing sewerage.

- South 3 Region is identified as the high priority region in Lake Amatitlan Basin for being effective in the pollutant load reduction to the downstream, the highest contribution to drinking water source protection, and for its public appeal towards pollution control of Lake Amatitlan.
- Projects in both Central and South 3 Regions will benefit both regions and will demonstrate the Governments eagerness for environmental improvement.

After implementing projects in Central and South 3 Regions, the BOD pollutant load reduction is estimated to be 41% in the Motagua River Basin and 29% in Lake Amatitlan Basin, respectively.

9. Development Plan of Priority Regions

Implementation is divided into three consecutive stages; the first stage program being from 1999 to 2001, the second stage from 2002 to 2006, and the third stage from 2007 to 2011. Construction program for each stage is described below and summarized in Table 5.

Table 5 Summary of Staged Implementation for the Priority Regions

Item	Stage	Central		South 3		Total Invetsment Cost
		Sewerage	Sanitation	Sewerage	Sanitation	
Collector Sewers	1	ϕ 3,000 L= 10.1 km	ϕ 200 main L=56 km	ϕ 1,500 L=7.76 km ϕ 600 L=2.34 km ϕ 500 L=1.72 km etc.	ϕ 200 main L=13 km	
	2	Branch Sewers	ϕ 200 main L=56 km	ϕ 1,500 L=0.23 km ϕ 700 L=1.58 km ϕ 600 L=2.31 km etc.	-	
	3	Branch Sewers	ϕ 200 main L=65 km	Branch Sewers	-	
Wastewater Treatment Plant Sewerage : (Daily Max.), m3/day Sanitation : No. of Community Plant Constructed	1	Primary : 196,000	35	Secondary : 36,000	3	
	2	Primary : 235,000 Secondary : 130,500	35	Secondary : 48,000	-	
	3	Secondary : 261,000	40	Secondary : 72,000	-	
Total Investment Cost (Million Quetzal)	1	162	30	104	4	300
	2	154	30	98	0	282
	3	149	35	114	0	298
Grand Total		465	95	316	4	880

Source : Study Team

a) First Stage Construction Program (1999 to 2001)

The components of sewerage works include about 25 km of main collector sewers, branch lateral sewers and some treatment capacity. Primary treatment and common facilities, (such as the control room, access road etc.), with a daily maximum treatment capacity of 196,000 m^3/day will be provided for Central Region, and secondary treatment and common facilities with a daily maximum treatment capacity of 36,000 m^3/day for South 3 Region. The sanitation system program will comprise the construction of 35 community treatment plants in Central Region and 3 in South 3 Region, each rated at 1,000 persons capacity, with small sewer reticulations to transport the wastewater to the plants.

b) Second Stage Construction Program (2002 to 2006)

During this construction stage, main collector sewers, part of the secondary treatment facilities and additional primary treatment facilities will be provided in Central Region and an additional train in South 3 Region. For the sanitation system, 35 community treatment plants and connecting small sewer reticulations will be built.

c) Third Stage Construction Program (From 2007 to 2011)

During this stage, the remaining main, branch and lateral sewers, and wastewater treatment plant trains will be constructed. When the third stage is completed, a total of 1,140,400 people within Central and South 3 Regions will have access to the sewerage and sanitation systems by the year 2015.

10. Project Evaluation

a) Technical Evaluation

The sewerage/sanitation systems proposed are easy to construct using locally available materials and technology and do not require imported mechanical and electrical equipment. The O/M of the proposed systems is easy, and low cost, and there is local practical experience and accumulated knowledge available from the existing facilities. Thus, it can be evaluated that the proposed wastewater treatment facilities are technically sound.

b) Financial Evaluation

Table 6 shows the results of the financial evaluation for three cases and the project is viable if Case 3 is applied. Sewage service Charge II, based on the results of willingness-to-pay,

was applied to the beneficiaries in the service areas and 40% of the capital investment cost is subsidized by the government or contributed by beneficiaries.

Table 6 Summary of the Results of Financial Evaluation of Priority Regions

Case	Charge, Q/connection/ month	Revenue for the Project		Contribution from Government or beneficiaries	FIRR	Remarks
		Central Region	South 3 Region			
1	20 (Charge I)	10	20	nil	-1.1%	
2	30 (Charge II)	20	30	nil	4.1%	
3	30 (Charge II)	20	30	40% of Total Investment Cost	8.4%	IBRD(7.2%) IDB(8.1%)

Note : 1. Evaluation period is 30 years.
2 Average charge per connection is Q10/month, based on the revenue records of EMPAGUA.
Source : Study Team

It became clear that for the undertaker EMPAGUA to accomplish the sound management of the proposed project for Case 3, 66% of the interest of the long-term loan has to be subsidized by the governments.

c) Economic Evaluation

Economic efficiency was evaluated in terms of the following parameters:

Net Present Value(NPV) - -102.1 million Quetzal
Benefit-Cost Ratio (B/C) - 0.79
Economic Internal Rate of Return (EIRR) - 7.9%

EIRR of 7.9% is lower than the opportunity cost of capital (10%) and B/C below 1. However, the Projects in Priority Regions can be said to be economically viable because the EIRR is high compared similar sewage projects and due to the fulfillment basic human needs to improve living environment.

11. Organizational Reform

To implement the Wastewater Management Plan, it is proposed to establish a Wastewater Management Division within EMPAGUA.

12. Alternatives

To supplement the information available for the Priority Regions topographic, geotechnic and environment surveys were conducted. Preliminary designs showed that the scale of investment costs required makes it difficult to implement projects in both Central and South 3 Region. Therefore, two alternatives namely **Alternative 1: Central Region** and **Alternative 2: South 3 Region** were evaluated.

13. Costs

Estimated cost for the alternatives are as follows:

Table 7 Summary of Investment Costs

Item		Unit	Central	South 3
Total Investment Cost (sum of 1 and 2)		million Quetzal	480.9	228.4
1. Direct Construction Cost	:Total	million Quetzal	379.5	173.8
	: Sewerage	million Quetzal	331.5	168.0
	: Sanitation	million Quetzal	48.0	5.8
2. Land Acquisition, engineering fee etc.	: Total	million Quetzal	101.4	54.6
3. Operation and Maintenance Cost	: sewerage	thousand Quetzal/year	3,265~3,401	1,627~1,713
	: sanitation	thousand Quetzal/year	381~415	96~99

Source : Study Team

14. Results of Evaluation

Table 8 shows the results of financial and economic evaluation.

Table 8 Results of Evaluation of Alternatives for First Stage Project

Item	Central Region	South 3 Region
1 Financial Evaluation		
1.1 Financial Viability (FIRR)		
a. Charge I (Q20/CONNECTION/M)	-1.7 %	- 5.5 %
b. Charge II (Q30/CONNECTION/M)	3.5%	-2.7%
c. Charge III (Q40/CONNECTION/M)	7.1%	-0.8%
2 Economic Evaluation		
2.1 Evaluation Parameters		
a. Net Present Value (NPV:Q1000)	-246,412	-64,986
b. Benefit-Cost Ratio (B/C)	0.27	0.58
c. Economic Internal Rate of Return (EIRR)	0.5%	5.4%

Source : Study Team

In addition to financial and economic evaluation, the following unquantifiable factors are also considered. They are:

- Contribution to the protection of potential water resources
- Benefit to the downstream population
- Public appeal
- Ease of implementation.

South 3 Region is superior in terms of economic efficiency and other unquantifiable factors. The only drawback is financial. Moreover, it will contribute to the protection of water resources in South 3 Region.

15. Selected Alternative

South 3 Region is selected as the First Stage Project excluding the construction of sanitation system. Sanitation System is deferred to subsequent stages to improve financial viability and considering EMPAGUA's ongoing projects etc. Table 9 shows the outline of First Stage Project.

16. Financial Plan

Financial plan is devised to implement the selected alternative. Financial Plan is based on the premise that the project in South 3 Region is paid by both South 3 Region and Central Region, because population in Central Region enjoy the benefits of protecting water supply sources in South 3 Region.

As shown in Table 10, Plan 1 requires that EMPAGUA establish a Wastewater Management Fund by mark-up of sewage service charges in its existing service area, i. e. in Central Region starting from 1998. Fund saved from the increase could then be utilized together with foreign loan to implement the proposed project. Derivative of Plan 1 proposes to reschedule the construction of sub-main and lateral sewers for two more years to smoothen the burden of EMPAGUA. Plan 2 requires foreign loans from two sources in addition to mark-up of sewage service charge. Based on the results shown in Table 10, Derivative of Plan 1 is recommended.

The following conditions are necessary for the proposed financial plan. They are:

- mark-up of sewage service charges from 1998
- establishment of Wastewater Management Fund using the excess revenue due to mark-up
- procurement of foreign loan with a low interest and good terms

Table 9 Selected Alternative for the First Stage Project

ITEM		SOUTH 3 REGION
1	FUNDAMENTALS	
1.1	CONSTRUCTION PERIOD	1999 ~ 2001
1.2	SEWERAGE	
1.2.1	Served Area, ha	896
1.2.2	Served Population (As of 2002)	53,200
2	FACILITY DESIGN	
2.1	SEWER	
2.1.1	Collection system	Separate
2.1.2	Main Collector	
	a) diameter and Length	1,500 mm x 10.0 km (Tunnel, soft) 1,200 mm x 1.2 km (Open Cut, soft) 300~700mm x 6.0 km (Open Cut, soft) 400~700mm x 0.12 km (Pipe Bridge, 2 Locations)
	b) Total Length	17.32 km
2.1.3	Collector	
	a) diameter and Length	200mm x 86.1 km (Open cut, soft)
2.2	WASTEWATER TREATMENT PLANT	
2.2.1	Treatment Capacity, m3/d (daily maximum)	36,000
2.2.2	Raw Wastewater Quality	
	a) BOD, mg/L	280
	b) SS, mg/L	280
2.2.3	Treatment Level	Secondary
2.2.4	Treatment Process	Trickling Filter Process
2.2.5	Final Effluent Quality a) BOD, mg/L	56
	b) SS, mg/L	56
2.2.6	Receiving Water Body	Villalobos River (Pinula River)
3	COSTS	
3.1	Total Investment Cost, million Quetzal	221.3
3.2	Total O/M Cost, million Quetzal/year (for the year 2002)	1.63

Note : All costs are in 1996 Prices (February 1996)
Source : Study Team

Table 10 Financially Feasible Conditions for Proposed Project

(Unit: Million Quetzal)

Item		Plan 1	Plan 2	Derivative of Plan 1
Financial Sources	Financial Source A	173.5	173.5	173.5
	Financial Source B	-	26.5	-
	Fund Saved by EMPAGUA*1	52.0	25.5	52.0
Total Revenue *2	Revenue of Sewage Services	131.0	93.6	106.2
	• Domestic	105.4	75.3	84.0
	• Industrial	25.6	18.3	22.2
	Transfer from General Account	611.7	276.1	371.0
Average Service Charge (Q/connection/Month)		21.0	15.0	17.0
Nominal FIRR (%) *3		8.0	3.2	5.8

Note: *1 Average service charge in this table has to be applied to Central Region area after the year 1998.
*2 Accumulation for the economic life of the sewerage facilities.
*3 An internal rate of return of total revenue from sewage treatment services including transfer from EMPAGUA's general accounts against the total amount from loans.

Source : Study Team

17. Impact of Mark-up of Sewage Service Charge

Mark-up of sewage service charge will be 0.14 to 0.34% of the total income for middle-income users and less than 0.22% of the high-income users. Both are within the reference level of 3% and are considered reasonable.

18. Environmental Impact Assessment

Proposed Project is an environmental improvement project. Environmental impact assessment of the proposed First Stage Project, showed the benefits of the project and consequences of no action. Mitigation measures are proposed for significant impacts identified . With those measures, the project is environmentally sound.

19. Conclusion

The Project in South 3 Region is identified and is proposed as the First Stage Project through the Study on the Improvement of Wastewater Management in Guatemala Metropolitan Area.

Discussion in the preceding sections showed that the First Stage Project in the South 3 Region is financially feasible provided that a Wastewater Management Fund by EMPAGUA is established to cover the local portion required for implementation.

Generally, sewerage projects are implemented with subsidies from the Central Government or local government because initial investment required is high. However, in this case the possibility of obtaining subsidy is rather limited and the only way of generating capital for investment will be to obtain foreign with a low interest rate and good terms loan and to establish the Wastewater Management Fund from the mark-up of sewage service charges in the existing sewer-served areas in Central Region.

It is concluded that the proposed First Stage Project in South 3 Region is the most feasible alternative in the process of improving the wastewater management in the Guatemala Metropolitan Area. The proposed mitigation management and monitoring plan described in EIA should be carefully examined and implemented.

20. Recommendations

To implement the proposed First Stage Project and Wastewater Management Master Plan smoothly the following measures are recommended.

a) First Stage Project

1) Establishment of Wastewater Management Fund
2) Procurement of Land for WWTP
3) Strengthening of Legal Powers of EMPAGUA

b) Wastewater Management Master Plan

1) Rehabilitation and management of existing small-scale sewage treatment plants under EMPAGUA
2) Disposal of septage collected by private desludging over the entire area at wastewater treatment plants
3) Improvement of the management of information and records of sewerage facilities in EMPAGUA
4) Enforcement and improvement of effluent standards
5) Enactment and enforcement of laws for ground water protection

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ABBREVIATIONS

ABBREVIATIONS OF ORGANIZATION / SIGLAS DE ORGANIZACION

AID	=	Agency for International Development Agencia Internacional para el desarrollo
ANAM	=	National Association of Municipalities Asociacion Nacional de Municipalidades
BANVI	=	National Housing Bank Banco Nacional de Vivienda
BANGUAT	=	Central Bank of Guatmala Banco de Guatemala
BCIE	=	Central American Economic Integration Bank Banco Centroamericano de Integracion Economica
CIDA	=	Canadian International Development Agency
	=	Agencia Canadiense de Desarrollo Internacional
CACIF	=	Coordinator Committee of Agricultural, Industrial and Financial Associations Comite Coordinador de Asociaciones Agricolas, Industriales y Financieras
CAPRE	=	Regional Coorinating Committee of Drinking Water and Sanitation of Central America, Panama and Dominican Republic Comite Coordinador Regional de Instituciones de Agua Potable y Saneamiento de Cetroamerica, Panama y Rupublica Dominicana
CIEN	=	National Economic Research Center Centro de Investigaciones Economicas Nacionales
CNPE	=	National Council of Economic Planning Consejo Nacional de Planificacion Economica
CONAMA	=	National Environmental Commission Comision Nacional del Medio Ambiente
CONAP	=	National Council of Protected Area Consejo Nacional de Areas Protegidas
COPECAS	=	Permanent Committee of Coordination of Water and Sanitation Comite Permanente de Coordinacion de Agua y Saneamiento
EDOM	=	Study of Metropolitan Orderliness Estudio de Ordenamiento Metropolitana
DGSS	=	General Bureau of Health Services Direction General de Servicios de Salud
DST	=	Environmental Sanitation Department Division de Saneamiento del Medio
EMPAGUA	=	Guatemala Municipal Water Supply Corporation Empresa Municipal de Agua de la Ciudad de Guatemala
ERIS	=	Regional School of Sanitary Engineering Escuela Regional de Ingeneria Sanitaria
FAO	=	Food and Agricultural Organization Organizacion de Comidas y Agricultura
GOG	=	Government of Guatemala Gobierno de Guatemala
GOJ	=	Government of Japan Gobierno de Japon
GTZ	=	German Cooperation Agency Sociedad Alemana de Cooperacion
IBRD	=	See "WB" Vease "WB"
IDA	=	International Development Association Asociacion Internacional de Desarrollo
IDB	=	Inter-American Development Bank Banco Interamericano de Desarrollo
IGM	=	Military Geographic Institute Instituto Geografico Militar

IGSS	=	Guatemalan Institute of Social Security
		Instituto Guatemala de Seguridad Social
INAFOR	=	National Institute of Forestation
		Instituto Nacional de Forestacion
INDE	=	National Institute of Electrification
		Instituto Nacional de Electrificacion
INE	=	National Institute of Statistics
		Instituto Nacional de Estadistica
INFOM	=	National Institute of Municipal Development
		Instituto Nacional de Fomento Municipal
INSIVUMEH	=	National Institute of Seismology, Vulcanology, Meteorology and Hydrology
		Instituto Nacional de Sismologia, Vulcanologia, Meteorologia e Hidrologia
INTECAP	=	Technical Institute of Training and Productivity
		Instituto Tecnico de Capacitacion y Productividad
JICA	=	Japan International Cooperation Agency
	=	Agencia de Cooperacion Internacional del Japon
MCTyOP	=	Ministry of Communications, Transportation and Public Works
	=	Ministerio de Comunicacion, Transportacion y Obras Publicas
MINFIN	=	Misnistry of Public Finance
		Ministerio de Finanzas Publicas
MSPyAS	=	Ministry of Public Health and Social Assistance
		Ministerio de Salud Publica y Asistencia Social
MUNI	=	Municipality of Guatemala
		Municipalidad de Guatemala
OECF	=	Overseas Economic Cooperation Fund of Japan
		Fondo Japones de Cooperacion Economica Ultramar
PAHO	=	Panamerican Health Organization
		Organizacion Panamericana de Salud
PLAMABAG	=	Guatemala City Water Supply Master Plan
		Plan Maestro de Abastecimiento de Agua a la Ciudad de Guatemala
SEGEPLAN	=	General Secretariat of Economic Planning
		Secretaria General de Planificacion Economica
SRH	=	Secretariat of Hydraulic Resources
		Secretaria de Recursos Hidraulicos
UEA	=	Emergency Water Unit
		Unidad de Emergencia de Agua
UENIA	=	Study Unit of New Water Introduction
		Unidad de Estudios de Nuevas Introducciones de Agua
UN	=	United Nations
		Organicacion de Naciones Unidas
UNDP	=	United Nations Development Program
		Programa de Naciones Unidas para el Desarrollo
UNEHIVAGUA	=	Executant Unit of Hydrological Study of Guatemalan Valley
		Unidad Ejecutora del Estudio Hidrologico del Valle de Guatemala
UNEPAR	=	Executant Unit of Rural Aqueduct Program
		Unidad Ejecutora del Programa de Acueductos Rurales
UNESCO	=	United Nations Educational Scientific and Cultural Organization
		Organizacion Educacional, Sientifica y Cultural de Naciones Unidas
UNICEF	=	United Nations International Children's Emergency Fund
		Fondo de Nacioned Unidas para la Infancia
USAC	=	University of San Carlos of Guatemala
		Universidad San Carlos de Guatemala
USAID	=	United States Agency for International Development
		Agencia Internacional de Desarrollo de Estados Unidos
WB	=	World Bank
		Banco Mundial
WHO	=	World Health Organization
		Organizacion Mundial de Salud

ABBREVIATIONS OF TERMS USED IN THIS REPORT

B/C	-	Benefit Cost Ratio
BOD	-	Biochemical Oxygen Demand
CCTV	-	Closed Circuit Television
COD	-	Chemical Oxygen Demand
DSR	-	Debt Service Ratio
EIA	-	Environmental Impact Assessment
EIRR	-	Economic Internal Rate of Return
FIRR	-	Financial Internal Rate of Return
GDP	-	Gross Domestic Product
GDE	-	Gross Domestic Expenditure
GFCF	-	Gross Fixed Capital Formation
HWL	-	High Water Level
IC	-	Intermediate Clarifier
IEE	-	Initial Environmental Examination
MSL	-	Above Mean Sea Level
NPV	-	Net Present Value
O/M	-	Operation and Management
PDWF	-	Peak Dry Weather Flow
PST	-	Primary Sedimentation Tank
RCP	-	Reinforced Concrete Pipe
SCF	-	Standard Conversion Factor
SDB	-	Sludge Drying Bed
SDT	-	Sludge Digester Tank
SGC	-	Screen • Grit Chamber
SS	-	Suspended Solids
TF	-	Trickling Filter
T-N	-	Total Nitrogen
TOR	-	Terms of Reference
T-P	-	Total Phosphorous
TS	-	Total Solids
VA	-	Value Added
VAT	-	Value Added Tax
WWTP	-	Wastewater Treatment Plant

ABBREVIATIONS OF MEASURES

1 Length

mm	=	millimeter
cm	=	centimeter
m	=	meter
km	=	kilometer
"	=	inch

2 Area

m2, sq.m	=	square meter
ha	=	hectare
km2, sq.km	=	square kilometer

3 Volume

cc	=	cubic centimeter
lit, l,L	=	liter
lcd	=	liter per capita per day
m3, cu.m	=	cubic meter
Gal, Gallon (US)	=	3.785 liter

4 Weight

mg	=	milligram
g	=	gram
kg	=	kilogram
t	=	ton

5 Time

s, sec	=	second
mim	=	minute
h, hr	=	hour
d	=	day
yr	=	year

6 Money

Q	=	Quetzales (unit of Guatemalan currency)
US$, $	=	US Dollar
¥	=	Japanese Yen

7 Electric Measures

A	=	ampere
V	=	volt
kV	=	kilovolt
kW	=	kilowatt

	kWh	=	kilowatt hour
	kVA	=	kilovolt ampere
	Hz	=	hertz

8 Other Measures

mS	=	milli Siemens
μmho	=	micromho = conductivity
ppb	=	parts per billion
ppm	=	parts per million
MPN	=	most probable number
‰	=	per thousand
%	=	percent
PS	=	0.736 kW
°	=	degree
'	=	minute
"	=	second
°C	=	degree centigrade

9 Derived Measures Based on the Same Symbols

cm/sec	=	centimeter per second
m/s, m/sec	=	meter per second
cm3/min	=	cubic centimeter per minute
m3/sec, cu.m/sec	=	cubic meter per second
m3/s, cu.m/s	=	cubic meter per second
m3/min, cu.m/min	=	cubic meter per minute
m3/h, cu.m/h	=	cubic meter per hour
m3/day, cu.m/day	=	cubic meter per day
m3/d, cu.m/d	=	cubic meter per day
lpcd	=	liter per capita per day
m3/m2/day	=	cubic meter per square meter per day
m3/sec/km2	=	specific discharge
kg/day	=	pollutant load
ton/m2	=	ton per square meter
kg/day/km2	=	unit areal pollutant load
kg/(ha•mm)	=	areal pollutant load per unit rainfall
mg/kg	=	milligram per kilogram
mS/cm	=	milli Siemens per centimeter
mg/L	=	milligram per litre
g/cm3	=	gram per cubic centimeter
GPM	=	Gallon per minute

1 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Government of Guatemala (GOG) has placed much importance on the improvement of urban infrastructure and living conditions of Guatemala Metropolitan Area. In this respect, to improve the wastewater management in the Guatemala Metropolitan Area, the GOG has requested Government of Japan (GOJ) for technical assistance.

In response to the request of the GOG, Japan International Cooperation Agency (JICA) has dispatched the Preparatory Study Team headed by Mr. Katsuhiko Kitai, to Guatemala from December 4 to 13, 1994 to decide the Scope of Work for the Study on the Improvement of Wastewater Management in the Guatemala Metropolitan Area with the GOG.

The Study on the Improvement of Wastewater Management in the Guatemala Metropolitan Area has been conducted according to the Scope of Work.

1.2 OBJECTIVES OF THE STUDY

The Objectives of the Study are as follows:

a) to formulate a master plan for the improvement of wastewater management that contributes to the upgrading of sanitary and environmental conditions in the Guatemala Metropolitan Area to the year 2015; and

b) to conduct a feasibility study to select the first stage project from the master plan; and

c) to transfer technology in planning skills to the Guatemala counterpart personnel through the Study.

1.3 STUDY AREA

The Study Area is limited to Guatemala City and part of seven municipal areas which are: Chinautla, Mixco, Villa Nueva, San Miguel Petapa, Santa Catarina Pinula, Villa Canales and San Pedro Ayampuc, as specified in the Scope Work agreed by EMPAGUA (The Municipal Water Supply Public Corporation) and JICA (Japan International Cooperation Agency) on December 13, 1994.

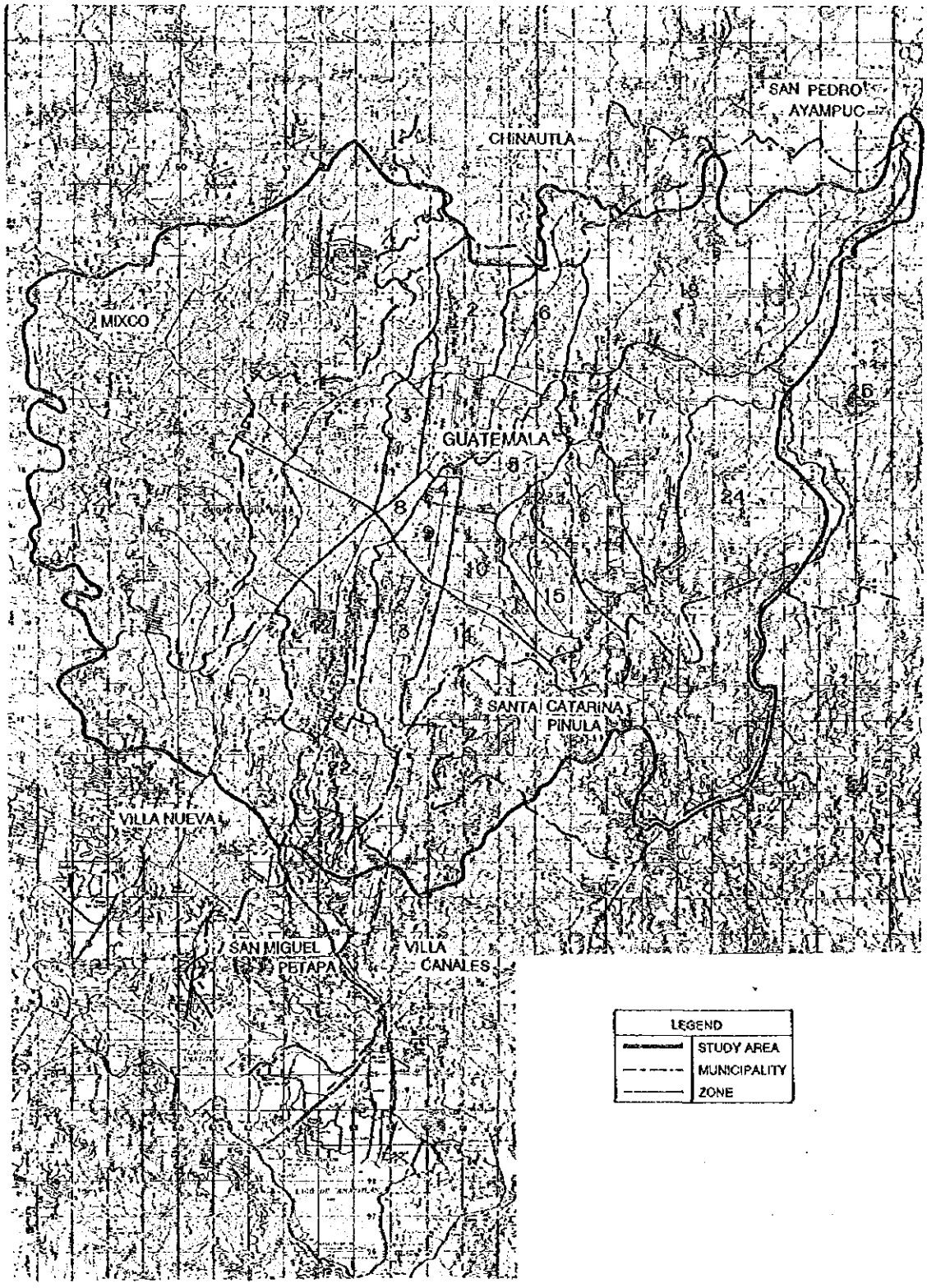
The Study Area, specified on a 1:50,000 scale topographical map, agreed in the Minutes of the Meeting on the Inception Report held on April 6 , 1995, was modified and confirmed as

shown in Fig. 1-1. This modification was agreed upon between EMPAGUA and the Study Team as per the letter dated May 19, 1995. The modification was based on information stating boundaries of the municipalities to fulfill the Study Area specified in the Scope of Work. Total area of the Study Area is 34,500 ha.

1.4 STUDY ORGANIZATION

The Study was carried out by the JICA Study Team and Guatemalan Counterpart Team. Technical direction was made by the JICA Advisory Committee. Steering Committee consisting of EMPAGUA, SEGEPLAN (General Secretariat of Economic Planning), CONAMA (National Environment Commission) and ANAM (National Association of Municipalities) was formed and regular meetings were held to inform the results of the Study and for confirmation of major decisions.

Fig. 1 - 1



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2 NATURAL, SOCIAL AND ECONOMIC CONDITIONS OF THE STUDY AREA

2.1 NATURAL CONDITIONS

2.1.1 Topography

The Study Area consists of most of the Guatemala Valley and the eastern part of the area surrounded by the Catarina and Teocinte/Palencia Faults. South and east along the Inter-American Highway the altitude decreases to about 1,500 m at Guatemala City. North of Guatemala City the highlands of Alta Verapaz gradually decline to the lowlands of El Peten. The altitude ranges between 1,500 and 1,600 m in the central part of the Study Area but to the east and west, in the hilly areas, the range is between 1,900 m and 2,000 m. The ground surface south of the Continental Divide slopes at 1/50 to 1/60 towards Lake Amatitlan, whereas the terrain north of the Divide declines slowly.

2.1.2 Geology

Most of the ground surface is of the Quaternary period and consists of alluvial sediment, solidified pumice sediment, ash flow and pyroclastics, with an average depth of about 250m. These volcanic sediments form deep V-shaped valleys and separate the Area. The depth of valleys ranges between 150 m and 250 m. Below the surface layer is Pliomiocene, consisting of andesite, tuff, basalt mud flow, vesicular rhyolite, glassy quartz, welded tuff, latite-dacite tuff, welded glassy tuff, etc. Rivers in the Study Area have formed following the faults. The gradient of river beds ranges from 0.9 % in the south to 1.5 % in the north of the Area.

2.1.3 Climate

a) Air Temperature and Humidity

The average daily temperature variation is between 16°C and 20°C throughout the year. The annual average relative humidity is 73 %.

b) Precipitation

The average annual rainfall for Guatemala City is 1,234.4 mm. The driest month of the year is January with an average precipitation of 3.6 mm. The wettest month is June with an

average precipitation of 257.2 mm. There are two well defined seasons, the wet season from May to October and the dry season from November to April.

2.1.4 Rivers and Lake Amatitlan

a) Rivers

The Study Area is separated into north, east and south catchments by three major watersheds. North and east catchments are part of Motagua River Basin while south catchment is part of Michatoya River Basin. The Motagua River Basin drained by Las Vacas River in the north and the Michatoya River Basin drained by Villalobos River in the south, are the main river systems in the Study Area.

b) Lake Amatitlan

Lake Amatitlan is situated at the southern end of the Study Area, about 20 km from the center of Guatemala City. The lake has a surface area of 15.35 km^2 and a storage capacity of 286 x 10^6 m^3 with a depth ranging from 24 to 33m. About 0.75 m^3/s (Data of year 1976 measured at El Cementerio, source: INSUVIMEH) of water flows into the lake through the Villalobos a River, while 3.03 m^3/s (Average of 1953~1994, source:INDE) of water is out flowing through the Michatoya River. The balance of the inflow is considered to be supplemented with groundwater flowing into the lake.

2.2 SOCIO-ECONOMIC CONDITIONS

2.2.1 Population

According to the latest census data as of 1994, as shown in Table 2-1, the population of the Republic of Guatemala is about 8.3 million of which the Department of Guatemala and Guatemala City represent about 1.8 million and 0.82 million, respectively.

Guatemala City's population of 0.82 million, as of 1994, accounted for 45% of the total population of the Department of Guatemala and its share decreased. Its growth rate of 0.7% was lower than those of surrounding municipalities and was also lower than those of the Department of Guatemala and the Republic of Guatemala while the municipalities of Villa Nueva and Santa Catarina Pinula showed a particularly sharp increase at annual rates of 13% and 9%, respectively.

Table 2 -1 Population and Annual Growth Rate based on Census Data

Area	1981 *1)		1994 *2)		Annual
	Population	Share (%)	Population	Share (%)	Growth Rate (%)
Republic of Guatemala	6,054,227	-	8,322,051	-	2.9
Guatemala Department	1,311,192	100.0	1,812,411	100.0	2.9
Guatemala City	754,243	57.5	822,587	45.40	0.7
Mixco	197,741	15.1	304,954	16.83	4.2
Villa Nueva	71,069	5.4	191,985	10.59	13.1
Villa Canales	39,309	3.0	62,284	3.44	4.5
Santa Catarina Pinula	17,387	1.3	38,609	2.13	9.4
Chinautla	41,682	3.2	63,431	3.50	4.0
Other Municipalities	189,761	14.5	328,561	18.13	5.6

Source: *1) INE, 1985, Censos nacionales de 1981
*2) INE, 1995, Censos nacionales de 1994
Note: The census data has some omissions.

2.2.2 Foreign Assistance and Debt

As can be seen in Table 2-2, over the period of 1988 through 1994, Guatemala received US$1,537 million in development aid, whose annual average is calculated as about US$220 million. The primary source of bilateral aid to Guatemala is the US Agency for International Development, (USAID). Bilateral aid from USAID accounted for almost half of the total figure.

As shown in Table 2-2, Guatemala's external debt gradually increased from some US$2,600 million to US$3,000 million over the period of 1988 through 1994. Although it still stayed at a low level compared with other Central American countries such as Honduras and El Salvador, the debt outstanding was not small compared with the current-account balance in the balance of payment. Most of Guatemala's debt is owned by the Government. In 1994, total debt service decreased from 1992's US$517 million to US$283 million, thus, the debt-service ratio (DSR) was lowered to 10.9% in 1994 which is almost the level of the early 80s and safely below the critical 20%.

Table 2-2 Foreign Development Assistance and External Debt: 1988-1994

(Unit: US$ Million)

Item	1988	1989	1990	1991	1992	1993	1994
Foreign Assistance	235	262	204	199	198	215	224
Bilateral	193	211	150	155	177	180	157
Multilateral	42	51	54	44	21	35	67
External Debt							
External Debt	2,639	2,637	2,840	2,825	2,753	2,891	3,017
Long-term Debt	2,255	2,243	2,368	2,362	2,250	2,420	2,529
Short-term-Debt	296	321	406	399	473	471	488
Use of IMF Credit	88	73	67	64	31	0	0
Total Debt Service	374	304	212	289	517	302	283
Principal	247	172	102	157	346	190	166
Interest	126	132	111	132	171	112	117
Debt-Service Ratio (%)	27.5	19.6	12.3	15.3	24.2	14.5	10.9

Source: Geographical Distribution of Financial Flows to Aid Recipient, OECD
World Debt Tables, World Bank

2.2.3 Land Use

For planning the wastewater management plan, the land use pattern in the year 2015 has been elaborated in principle based on the 2010 land use plan established in the Transportation System Study, as summarized in Fig. 2-1.

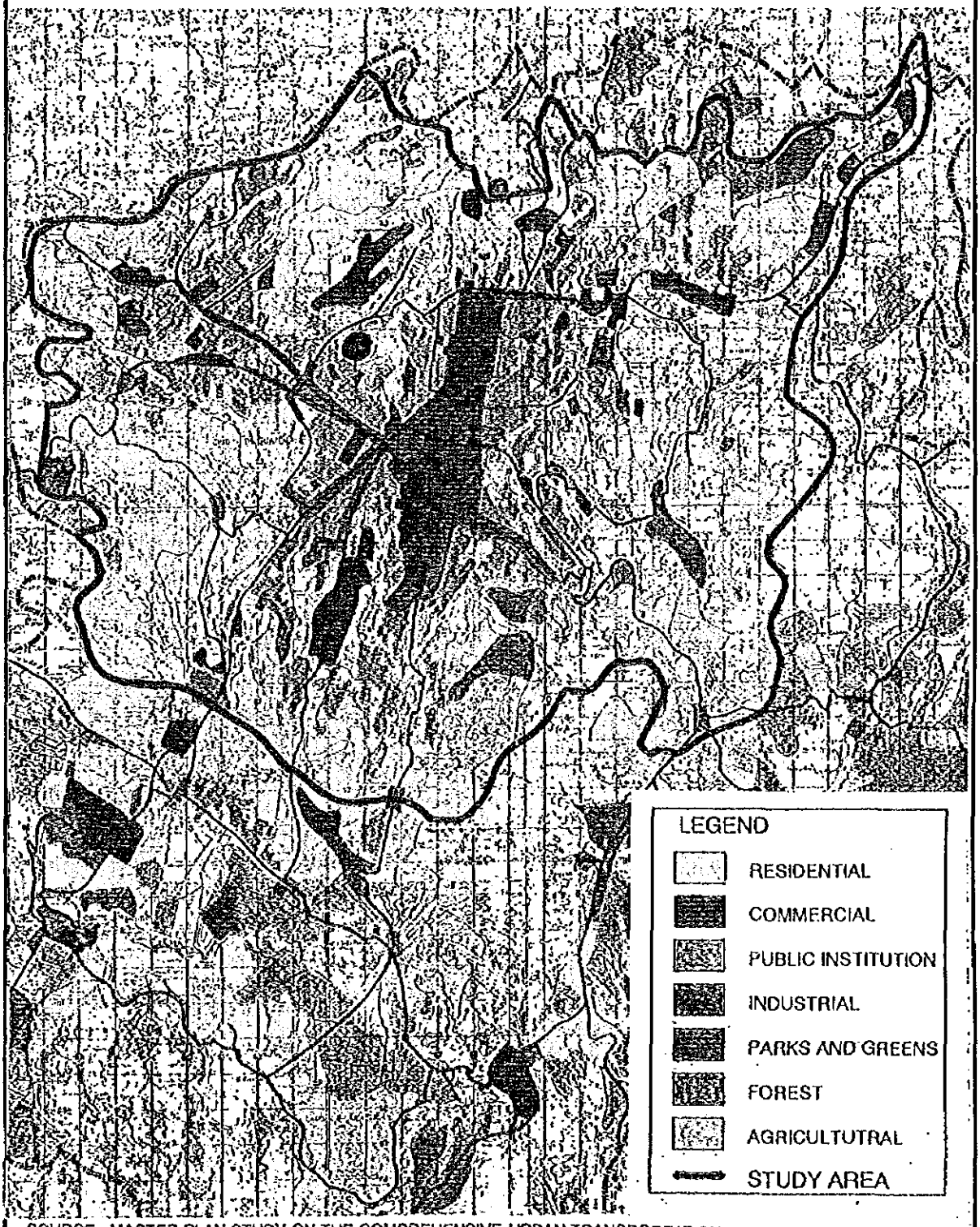
2.3 ENVIRONMENTAL CONDITIONS

2.3.1 Water Environmental Conditions

a) Rivers and Channels

Water quality of the rivers was almost similar to that of sewage. BOD concentrations were from 100 to 300 mg/L most of the time. Due to sewage flow into the rivers, the river flow varied during the daytime. Rivers function as open sewage channels.

Fig. 2 - 1



SOURCE: MASTER PLAN STUDY ON THE COMPREHENSIVE URBAN TRANSPORTATION SYSTEM IN GUATEMALA METROPOLITAN AREA, MARCH 1992, JICA

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 LAND USE IN THE STUDY AREA (2015)

Based on the measurements upstream and downstream of the Las Vacas River near Gran Collector, wastewater quality (BOD) and flowrate of Gran Collector were estimated and are shown in Table 2-3. Average day-time BOD concentrations were 277 and 242 mg/L and SS concentrations were 264 and 318 mg/L, for the first and second samplings in May and June '95.

For the Villalobos River, the average T-N (total nitrogen) concentration was 0.51 mg/L (0.20~1.88) in 1969~1970, compared to 10~32.9 mg/L in 1995, indicating a drastic increase in pollution of Lake Amatitlan. The average nitrate nitrogen concentration in the Villalobos River in 1970 was 0.1 mg/L, (Guatemalan Rivers, 1969~1970, Charles Weiss), compared to 27.26~33.44 mg/L in January and February 1995, again indicating a drastic increase in pollutant load to the lake.

Table 2-3 Calculated Water Quality and Flowrate of Gran Collector North

Date	Time	Flowrate, m³/s	BOD_5, mg/L	SS mg/L	COD mg/L	T-N mg/L	T-P mg/L
03-05-95	7:45~	1.121	308	119	316	91	7.6
	12:30~	0.818	188	513	331	37	7.8
	15:10~	0.815	324	215	337	43	6.5
	Day-time Average	0.912	277	264	327	61	7.3
07-06-95	7:15~	1.069	271	358	296	43	7.8
	12:30~	0.638	339	249	421	18	6.5
	15:30~	1.118	159	1689	256	10	6.1
	Day-time Average	0.863	242	860 (318)	308	24	6.8

Note : Daytime average SS concentration shown in brackets (318) excludes the SS concentration of 1,689 mg/L on 7 June 95.

Source : Study Team

b) Lake Amatitlan

The water quality of Lake Amatitlan shows a difference 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 western part while those in the eastern part were 23.2~25.2 mg/L. However, the range of concentrations is similar to the values measured in 1970 for west and east stations which were in the range 147~170 mg/L for west and 83~90 mg/L in the east. Sulfate concentrations did not show much variation 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 mg/L in 1950,

0.035~0.046 mg/L in 1970 and 0.028~0.042 mg/L in this survey. A previous study by Charles Weiss, (1970), pointed out this characteristic, noting that this may be the limiting factor preventing large-scale eutrophication from taking place even though the pollutant load to the lake is increasing.

COD concentrations for the west part 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 comparisons could not be made.

c) Ground Water

Ground water is exploited for water supply while wastewater disposal by infiltration is also widely practiced for domestic and industrial wastewater disposal. Wells closer to Villalobos River near Ojo de Agua (Pozo Anexo and Pozo Diamante) are gradually becoming polluted by infiltration of raw wastewater flowing in the river.

2.3.2 Public Health Conditions

Fig. 2-2 shows the incidence of cholera in Guatemala Metropolitan Area according to zones and municipalities in the year 1993. Out of the municipalities, Amatitlan had the high incidence per population followed by Chinautla. Both are at the downstream of Guatemala City affected by raw wastewater discharge to Villalobos River and Las Vacas River.

2.4 ADMINISTRATIVE AND FINANCIAL SITUATION

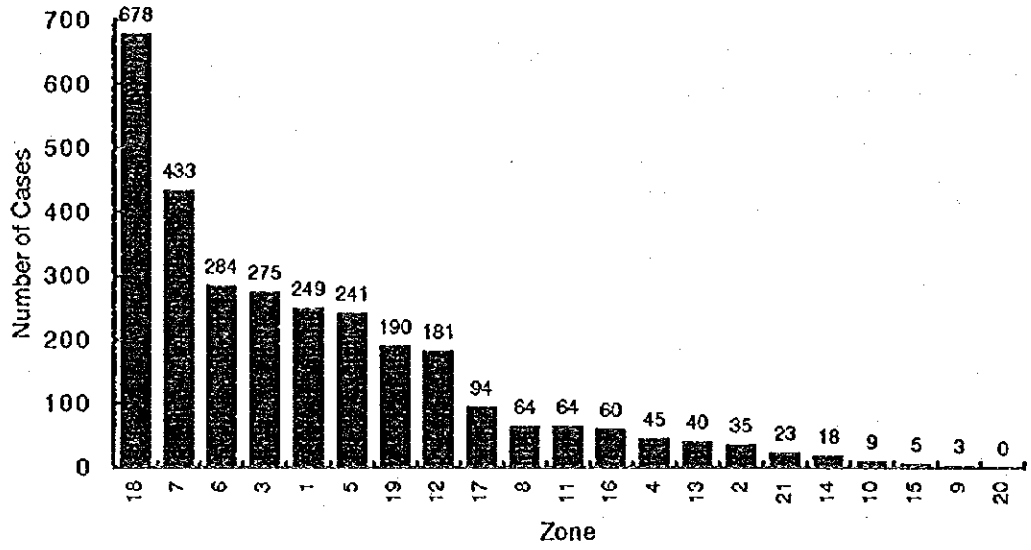
2.4.1 Organization

a) Organizations Related to Wastewater Management

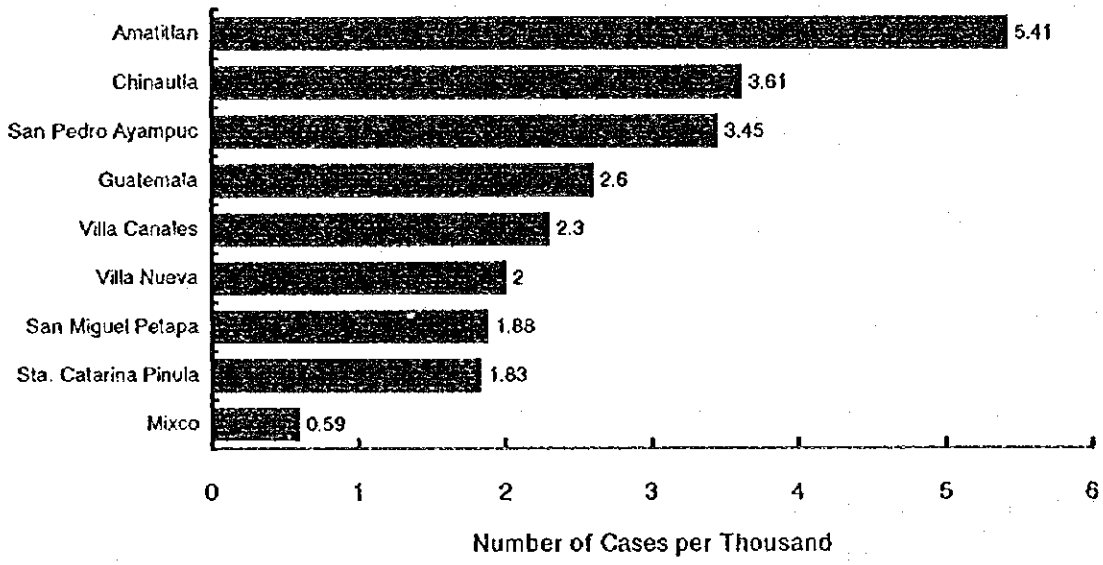
Numerous organizations are involved in one way or another in wastewater management in the Guatemala Metropolitan Area. Fig. 2-3 illustrates those which are principally involved. Apparently there are many organizations which are capacitated as coordinator but at present there seems to be no single organization which can strongly manage a large scale wastewater project.

Fig. 2 - 2

Reported Cases of Cholera by Zones in 1993 (both confirmed and unconfirmed cases)



Reported Cases of Cholera by Municipality in 1993 (both confirmed and unconfirmed)



Source : Centro de Salud, Area Norte, Guatemala

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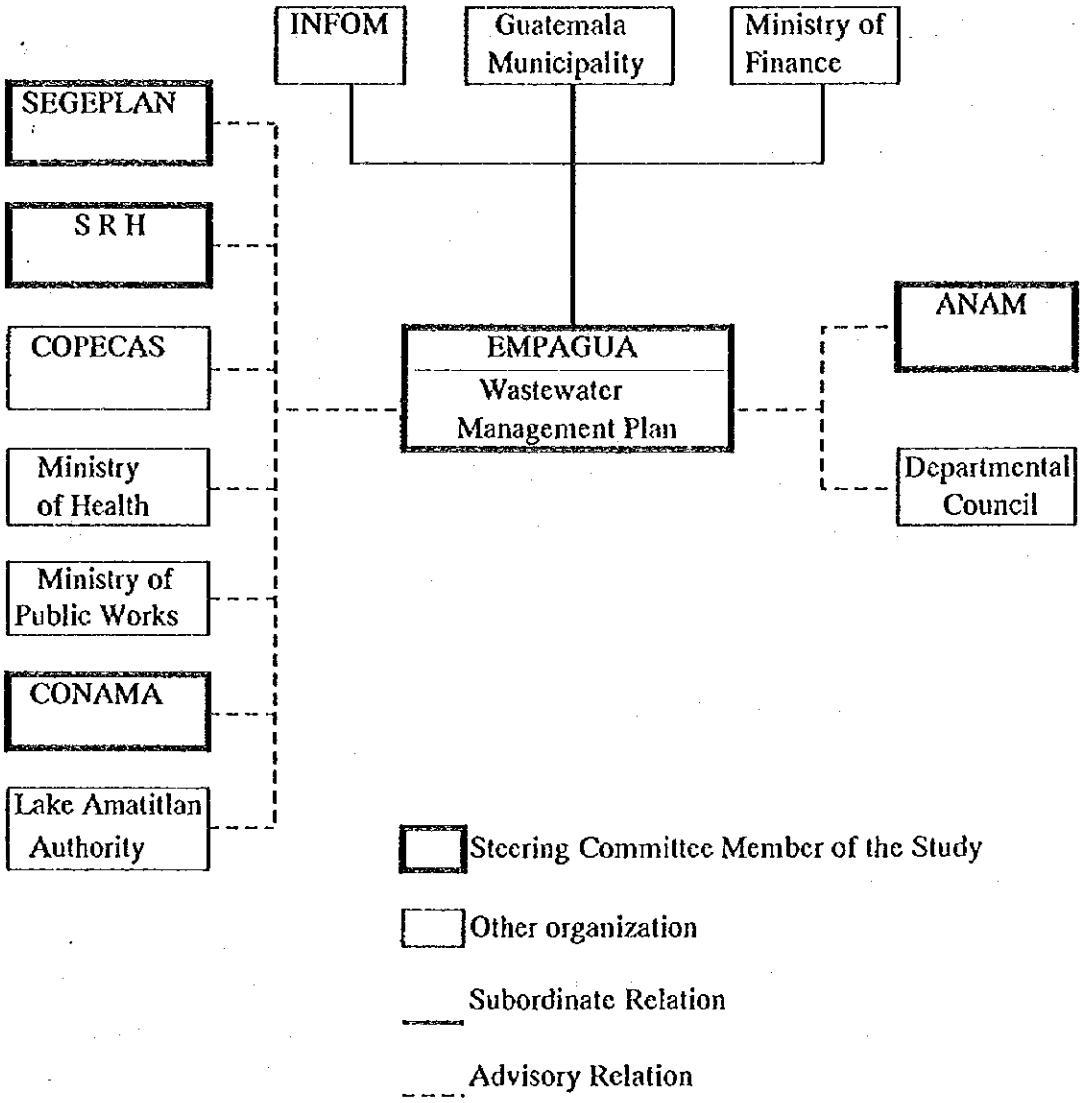
Fig. 2 - 3



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 RELATIONSHIP OF OGRANIZATIONS RELATED TO WASTEWATER MANAGEMENT

EMPAGUA is a leading public body which covers most parts of the study area in terms of water supply, sewage treatment and sanitation services. It is responsible for water supply and sewage services, but does not cover individual sanitation facilities and small sewerage treatment plants in collective estates.

b) EMPAGUA

EMPAGUA's organization chart as of February 1996 is presented in Fig. 2-4, wherein the dependency of EMPAGUA on Guatemala Municipality is notable. The Municipality's Council and Managing Board has jurisdiction over the General Manager's Office. The former consists of the Mayor of Guatemala, syndics and counselors. The latter consists of the Mayor of Guatemala, counselors, delegates from the Ministry of Finance and INFOM, and EMPAGUA's directors. These two units play an important role in deciding key issues such as change of tariff.

As of February 1996, EMPAGUA has 1,798 employees of whom 13 are considered to be in senior management positions, 17 are skilled specialists, 302 hold administrative posts, 518 are working in technical area and 948 are unskilled workers.

2.4.2 EMPAGUA's Financial Situation

a) General Balance

Table 2-4 shows a balance between revenue and expenditure for EMPAGUA during 1991-1994. In each four year, the overall balance of EMPAGUA recorded a surplus except in 1992. In 1994 EMPAGUA dissolved an accumulated deficit and went into the black. Main sources of the revenue were potable water and sewage services which accounted for Q96 million or 86% of the total revenue in 1994. These revenues were divided into three parts: Q75 million (67% of the total revenue) for water supply services; Q18 million (16%) for sewage services; and Q3 million (3%) of premium allotment from beneficiaries. Besides these main sources, EMPAGUA gets some revenues from: sales of accessories for water supply system such as water meters and boxes; and subsidy from the governments. Although subsidy has been provided by both central government and Guatemala Municipality, after 1995, it is unified into the subsidy by Guatemala Municipality only.

Fig. 2 - 4

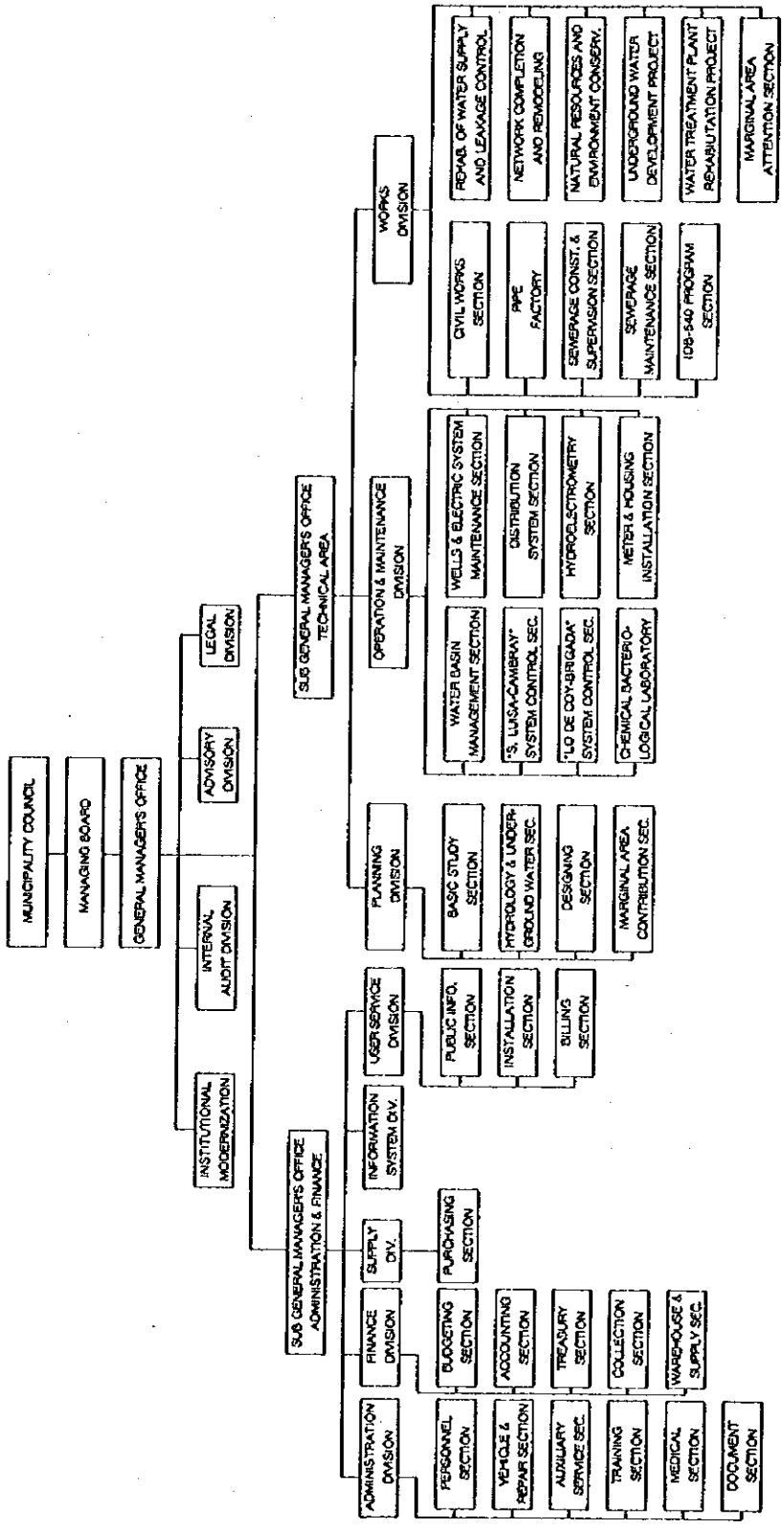


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Table 2-4 Revenue and Expenditure of EMPAGUA: 1991-1994

(Unit: 1000 Quetzals)

Item	1991	1992	1993	1994
Revenue				
1. Services to Consumers	36,400	44,407	70,107	95,849
-1 Water Supply Services	36,390	43,327	59,954	74,764
-2 Sewage Services	10	1,080	10,153	17,547
-3 Allotment to Beneficiaries *1	0	0	0	3,537
2. Water Meters and Accessories	1,342	4,769	4,500	4,462
-1 Installation of Water Meters	198	1,386	1,795	2,052
-2 Sales of Water Meters	11	2,027	1,668	1,449
-3 Accessories & Others	1,133	1,356	1,036	961
3. Sundry Receipts	2,104	1,758	3,642	4,027
4. Subsidy and Contribution	6,144	6,873	40,657	7,698
-1 Subsidy of Government *2	5,809	6,021	39,615	7,019
-2 Contribution of Drainage	335	852	1,043	679
5 Bond Issuing *1	4,850	449	921	-2
Total	50,841	58,257	119,826	112,034
Expenditure				
1. Operation Expenditure	47,286	72,119	98,752	90,676
-1 Managing Board	1,721	1,978	2,298	2,960
-2 Planning	493	1,250	1,615	1,445
-3 Water & Sanitation Works	2,853	5,533	8,222	2,987
-4 Operation & Maintenance	19,284	41,258	59,617	54,727
-5 Administration *3	14,958	12,781	15,894	18,227
-6 Depreciation	7,374	8,586	10,398	9,841
-7 Bad Debt Loss	603	731	706	488
2. Rehabilitation & Maintenance	840	1,802	1,404	4,597
-1 Water & Sanitation Facilities	677	1,537	926	3,896
-2 Operation & Maintenance	163	265	478	382
-3 Others	0	0	0	319
3. Non-operating Expenditure	1,485	1,496	1,536	1,637
-1 Interest on Loans	924	787	686	2,113
-2 Others	561	709	850	-476
Total	49,611	75,416	101,692	96,910
Surplus/Deficit	1,229	-17,159	18,134	15,124

Source: Estados Financieros, Al 31 de Diciembre de 1994, 1993, 1992 y 1991, EMPAGUA
Liquidacion del Presupuesto General de Ingresos y Egresos Ejercicio Fiscal 1994, EMPAGUA
Presupuesto General de Ingresos y Egresos Ejercicio Fiscal 1995, EMPAGUA

Note: *1 Bond is transferred to allotment contribution from beneficiaries.
*2 After 1995 subsidies come from Guatemala Municipality only, although until 1994 they had come from both Central Government and Guatemala Municipality
*3 Including other functions

Table 2-5 Balance Sheet of EMPAGUA: 1991-1994

(Unit: 1000 Quetzals)

Item	1991	1992	1993	1994
Assets				
1. Current Assets	33,533	29,898	47,435	54,234
-1 Cash	119	153	94	175
-2 Savings	12,244	11,744	13,917	10,239
-3 Accounts Receivable	21,024	17,701	33,575	43,200
-4 Estimation of Uncollected Charges	-603	-1,172	-2,095	-2,583
-5 Premium of Water Services	750	1,472	1,944	410
-6 Advance Payment, etc.	0	0	0	2,793
2. Fixed Assets	271,698	278,748	307,029	318,948
-1 Intake Facility	3,655	3,591	5,922	5,731
-2 Conveying Pipe Line	1,821	4,852	5,341	5,071
-3 Pumping Stations	7,799	7,051	7,818	8,739
-4 Treatment Plants	2,317	1,770	1,777	1,669
-5 Distribution System	79,992	81,691	82,491	83,939
-6 Sewerage & Drainage Works	171,271	174,056	193,829	197,493
-7 Land	183	183	183	183
-8 Buildings & Structures	75	70	64	59
-9 Construction Equipment	131	-125	-88	41
-10 Transportation Equipment	-126	403	612	896
-11 Other Fixed Assets	4,579	5,205	9,078	15,127
3. Differed Assets	70,113	83,226	70,296	60,241
-1 Research & Studies	6,974	7,689	4,691	4,848
-2 Rehabilitation of Water System	21,138	25,644	29,118	18,984
-3 Works in Progress	18,845	21,867	13,357	11,658
-4 Inventory Stock of Materials	10,290	13,306	8,657	14,610
-5 Others	12,866	14,720	14,473	10,141
Total	375,344	391,871	424,761	433,422
Capital and Liability				
1. Liability	303,142	319,673	344,648	304,523
-1 Current Liability	64,314	73,215	72,164	42,337
- Accounts Payable	62,493	69,953	67,517	37,201
- Accrued Payroll	209	1,013	1,471	2,614
- Reserve for Accumulated E	1,612	2,249	3,176	2,522
-2 Fixed Liability	237,402	245,117	272,049	261,163
-3 Deferred Liability	1,425	1,341	435	1,023
2 Capital	72,202	72,299	80,113	128,900
-1 EMPAGUA Capital	104,698	124,251	107,414	107,598
-2 Accumulated Surplus/Deficit	-32,495	-51,953	-27,301	21,302
Total	375,344	391,971	424,761	433,422

Source: Estados Financieros, Al 31 de Diciembre de 1994, 1993, 1992 y 1991, EMPAGUA
Liquidacion del Presupuesto General de Ingresos y Egresos Ejercicio Fiscal 1994, EMPAGUA
Presupuesto General de Ingresos y Egresos Ejercicio Fiscal 1995, EMPAGUA

b) Assets

Assets of EMPAGUA consist of current assets, which include not only general assets such as cash but also estimation of uncollected charges; fixed assets, which include water supply and sewerage facilities and equipment for O/M; and deferred assets, which include research, rehabilitation and works in progress. As shown in Table 2-5, the total amount of the assets was reported as Q433 million in 1994. It increased Q58 million or 15% of the 1991's total assets during the latest four years.

Table 2-6 gives financial indices indicating the status of EMPAGUA's management conditions. In 1994, the current ratio was 1.3, so EMPAGUA seems to has good solvency. In other years, however, the ratios were less than 1.0, the solvency was not in good conditions. Acid ratios were kept at less than 0.2, so EMPAGUA has little solvency from the short term view point. Since EMPAGUA should be considered to have little opportunity to liquidate liabilities abruptly the same as the municipal government, the ratio might not be always more than 0.4.

Table 2-6 Financial Indices of EMPAGUA

Item	1990	1991	1992	1993
Current Ratio	0.5	0.4	0.7	1.3
Acid Ratio	0.2	0.2	0.2	0.2
Worth Debt Ratio	0.2	0.2	0.2	0.4
Ratio of Fixed Assets to Long-term Capital	0.9	0.9	0.9	0.8

Source : Study Team

The worth debt ratio has been improved from 0.2 in 1991 to 0.4 in 1994, although EMPAGUA increased external liabilities for four years. The conditions of the capital fund are not good because its funds rely on debts excessively. The fixed assets to long-term capital ratios in the above table were 0.9 in the former three years and went down to 0.8 in 1994, so the invulnerability might move to worsen slightly.

2.5 EXISTING WASTEWATER MANAGEMENT

2.5.1 Existing Sewers

In the Guatemala Metropolitan Area, since construction began about 55 years ago, the sewerage system has been introduced gradually and extended on various subsequent occasions. It may be assumed that at present about 82% of Guatemala City is covered either by public or private sewerage. Due mainly to the topography of the City area, the sewerage system is divided by the Continental Divide into two sewerage districts, i.e. North and South districts.

Most of the northern portion of the City is provided with a combined system with stormwater outfalls upstream of the final disposal points at public watercourses (Fig. 2-5).

The areas south of the Continental Divide are less sewered than those in northern areas. Most wastewater is treated either by individuals or communities or, in some cases directly disposed of to nearby waterways or into the ground.

2.5.2 Functioning of Existing Small-scale Sewage Treatment Plants

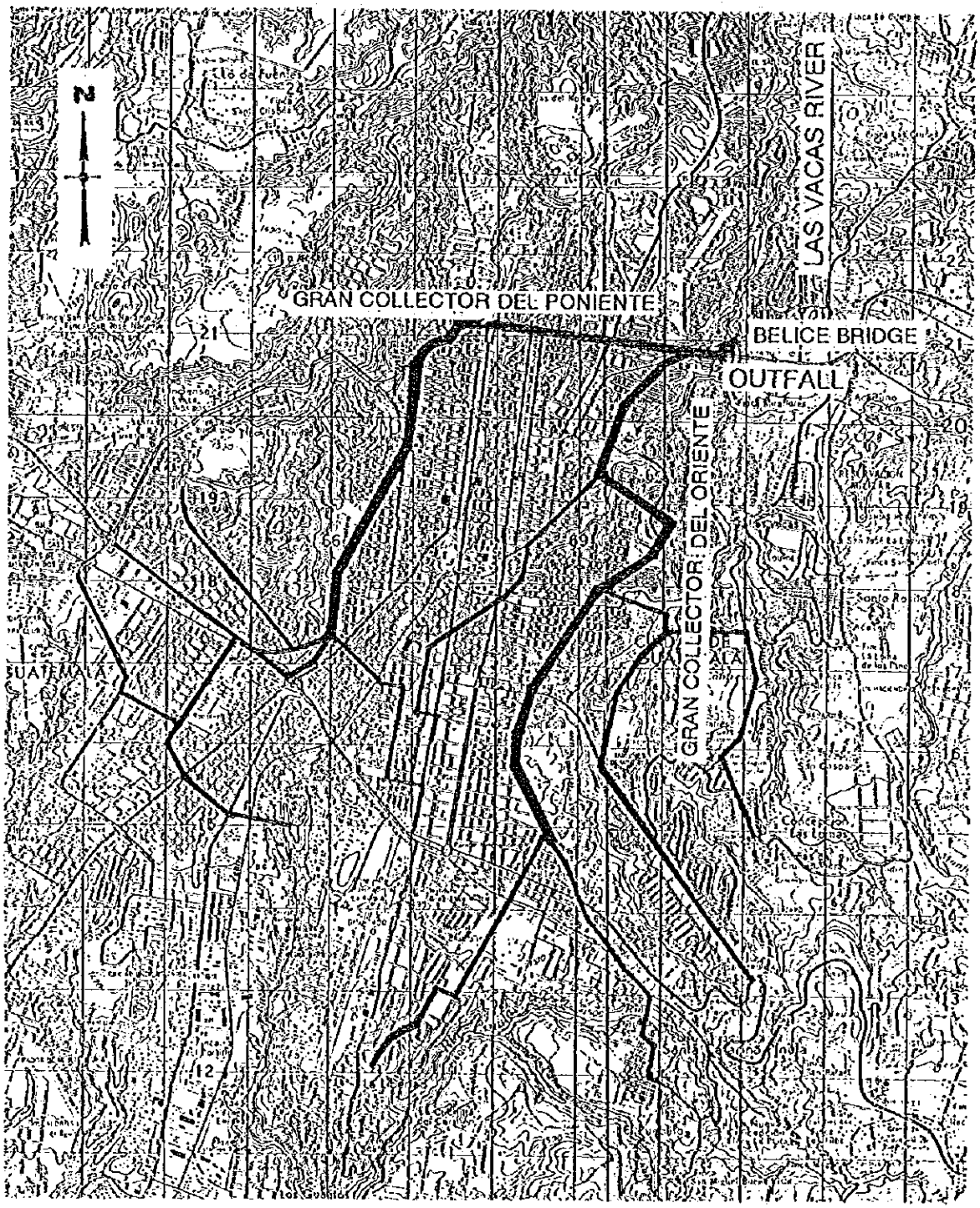
In the Study Area, there are about ten (10) small-scale sewage treatment plants (Fig. 2-6) and many septic tanks treating domestic wastewater from colonies (settlements).

These small-scale plants are owned by many different institutions including private companies and their functioning / operational conditions were unknown. In this Study these sewage treatment plants were surveyed and the following conclusions and recommendations are reached:

1) Possible Further Use If Rehabilitated
   Out of those facilities surveyed nine (9) facilities can be used further if rehabilitated.
2) Rehabilitation Cost
   The total estimated rehabilitation cost for the nine plants is Q 6.6 million at 1995 prices.
3) Necessary Conditions for Rehabilitation
   The following are the necessary preconditions, in terms of technical and O/M aspects, for implementing a rehabilitation program.
   A) Technical Aspects
   - Preparation of drawings and estimation of the capacity of facilities is necessary.
   - Final selection of facilities for rehabilitation should be carried out.
   - A rehabilitation plan should be prepared.

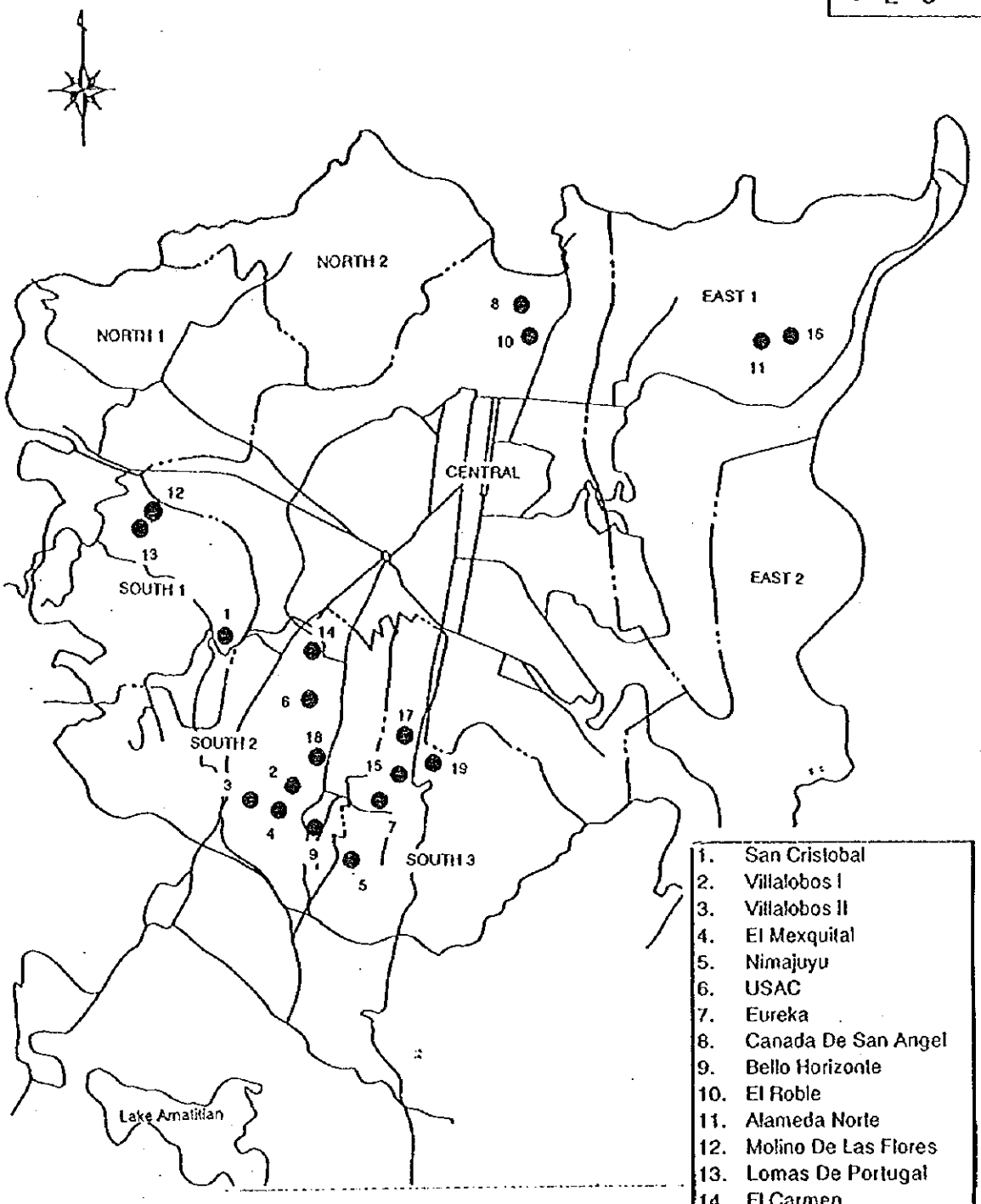
   B) Operation and Maintenance Aspects
   - The existing O/M structure and responsibilities should be clarified.
   - An institutional structure should be established to be responsible for O/M of the facilities after rehabilitation (eg take-over by EMPAGUA or by another single institution i. e. ANAM).
   - The O/M technology (treatment, water quality, structural aspects etc.) should be established.
   - A sewage service charge collection system should be established.

Fig. 2 - 5



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 EXISTING MAIN COLLECTORS

Fig. 2 - 6



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 EXISTING SMALL SCALE SEWAGE TREATMENT PLANTS

3 FUNDAMENTALS OF PLANNING FRAMEWORK

3.1 TARGET YEAR

To carry out the master planning for the development of an economically viable sewerage and sanitation system, the elements of work necessary are forecast and generally defined in successive stages to meet the present and future needs of the Study Area up to the year 2015.

3.2 REGIONS/DISTRICTS

The Study Area is separated into north, south and east catchments by three major watersheds. For the purpose of planning the staged implementation of sewerage and sanitation works, these three catchments are subdivided into smaller Regions for further consideration. The eastern catchment is divided into East 1 and East 2 Regions, the northern catchment into Central, North 1 and North 2 Regions and the southern catchment into South 1, South 2 and South 3 as shown in Fig 3-1. The boundaries of these Regions were defined taking into account of topography (including possiblity of wastewater collection by gravity system), existing sewerd area and population density. The total area for all Regions for sewerage and sanitation implementation is 20,430 ha, excluding green areas and valley's, out of the total Study Area of 34,500 ha.

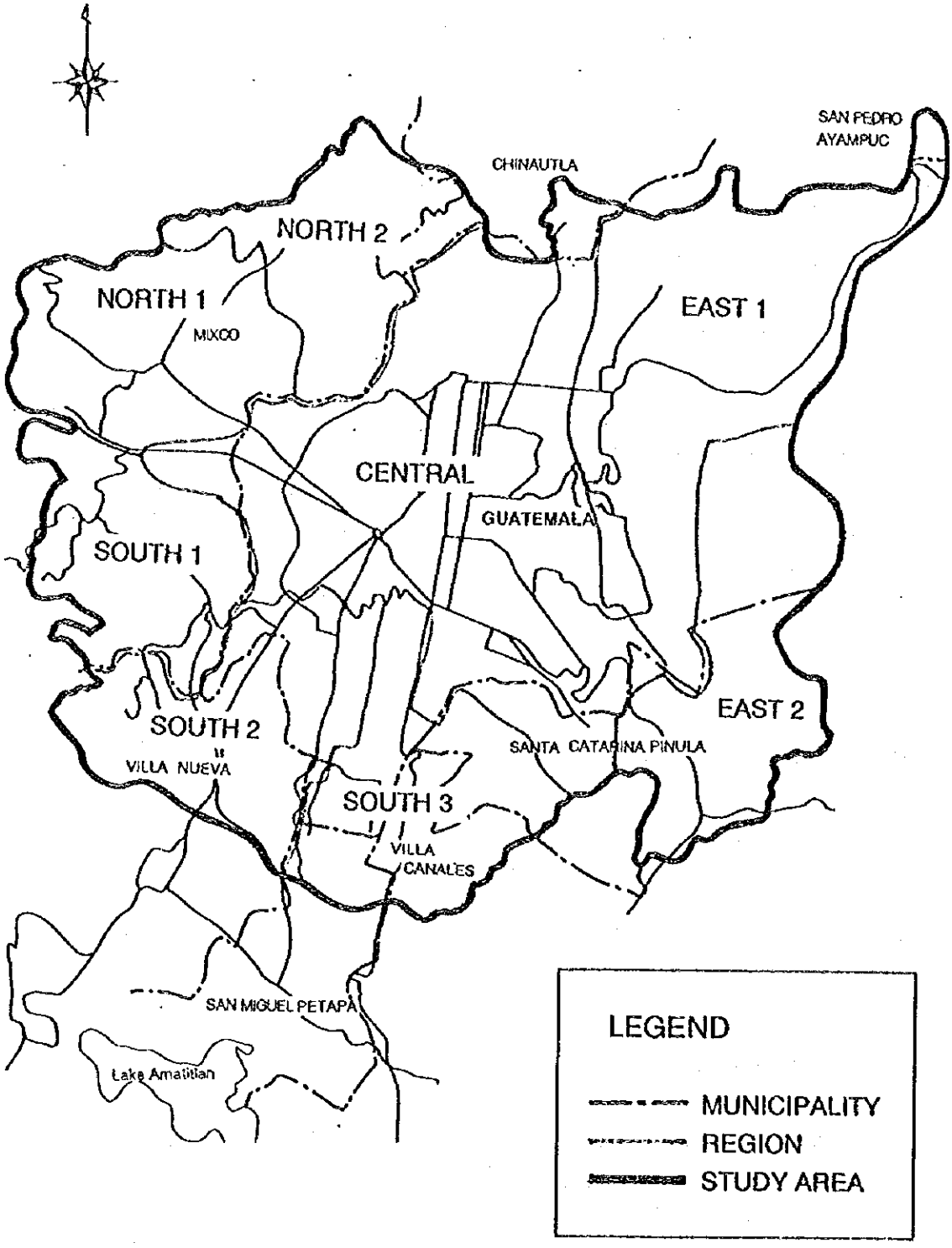
Each Region is further divided into Wastewater Treatment District and Sanitation Districts. A Wastewater Treatment District is covered by a sewerage system, composed of wastewater collection facilities and a wastewater treatment plant. Sanitation Districts are covered by sanitation system, composed of wastewater collection facilities and community treatment plants.

3.3 PLANNED POPULATION AND WASTEWATER GENERATION

3.3.1 Planned Population

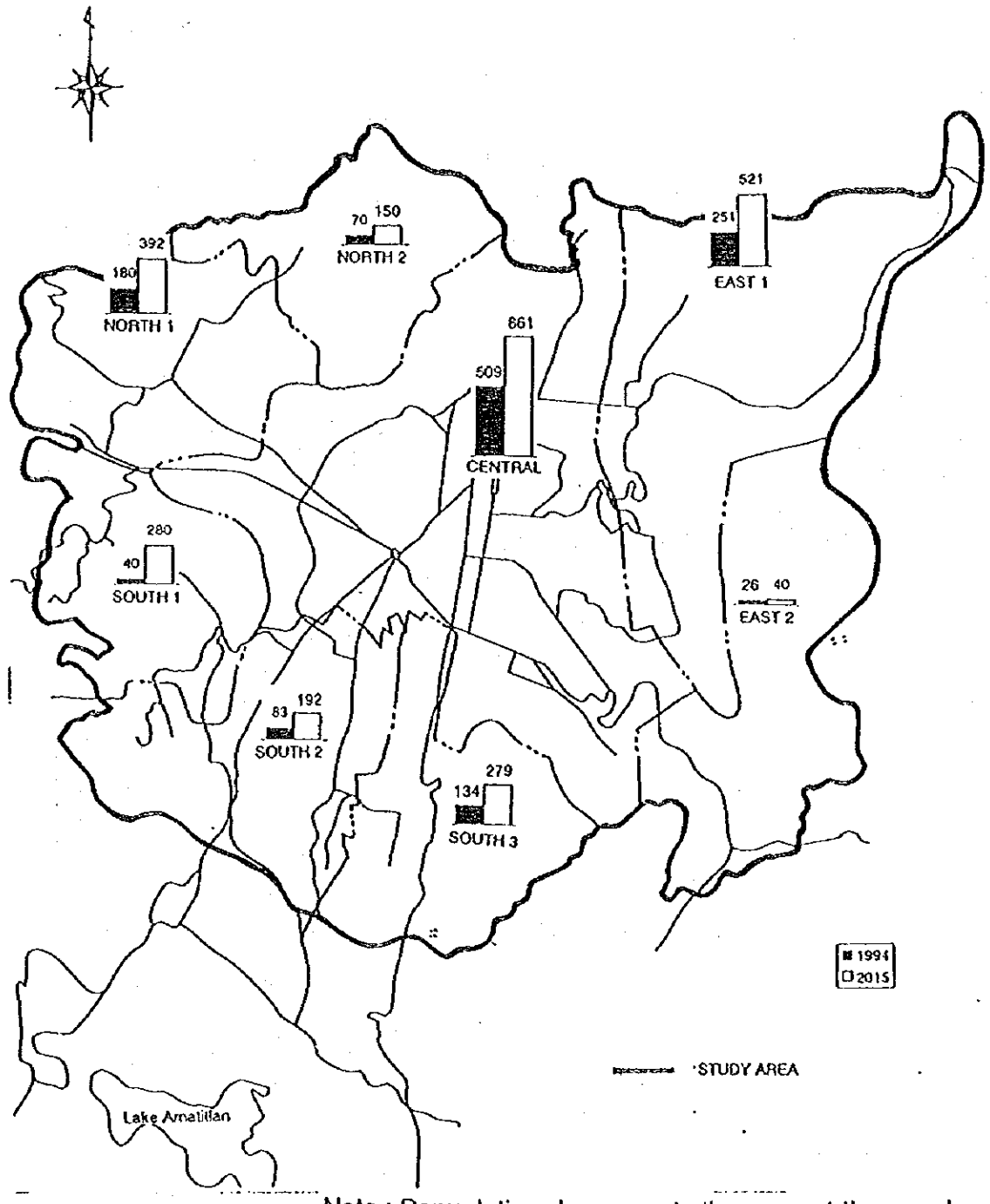
The total area and estimated current (1994 census) and projected future (2015) population to be served by sewerage/sanitation for each Region are shown in Table 3-1 and in Fig. 3-2. Table 3-2 shows the planned population in 2015 within the Study Area by municipality.

Fig. 3 - 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 LAYOUT OF SEWERAGE / SANITATION REGIONS

Fig. 3 - 2



Note : Popuplation shown are to the nearest thousand

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 POPULATION TO BE SERVED BY SEWERAGE / SANITATION IN EACH REGION

Table 3-1 Population to be Served by Sewerage/Sanitation M/P by Regions

Regions	Area ha	Population				
		Total		Sewerage	Sanitation	
		1994	2015	2015	1994	2015
Central	6,460	508,500	861,400	751,800	109,600	109,600
North 1	2,190	180,000	392,000	379,100	12,900	12,900
North 2	740	72,000	150,000	-	72,000	150,000
South 1	1,640	40,000	280,000	277,500	2,500	2,500
South 2	2,220	83,000	191,600	183,600	8,000	8,000
South 3	2,360	134,000	279,000	276,100	2,900	2,900
East 1	3,705	251,000	521,000	500,800	20,200	20,200
East 2	1,155	25,800	40,000	-	25,800	40,000
Total	20,470	1,294,300	2,715,000	2,368,900	253,900	346,100

Note: (*) Only a sanitation system is to be provided.
Source : Study Team

Table 3-2 Planned Population by Municipalities Within Study Area in 2015

Municipality	Population in the Study Area			Others	Total
	Sewerage	Sanitation	Total		
Guatemala City	1,391,200	141,800	1,533,000	9,000	1,542,000
Mixco	662,600	153,400	816,000	25,000	841,000
Villa Nueva	120,400	5,200	125,600	337,400	463,000
San Miguel Petapa	36,600	400	37,000	61,000	98,000
Villa Canales	95,100	900	96,000	81,000	177,000
Santa Catarina Pinula	28,000	30,400	58,400	4,600	63,000
Chinautla	35,000	12,000	47,000	102,000	149,000
San Pedro Ayampuc**		2,000	2,000	18,000	20,000
Total	2,368,900	346,100	2,715,000	638,000	3,353,000

Note: Planned population for San Pedro Ayampuc falling within the Study Area (50 ha) was estimated with a population density of 40 person/ha.

Source: Study Team

3.3.2 Wastewater Generation

Table 3-3 shows the planned wastewater quantity generated for sewerage system for each Region in 2015.

3.4 WASTEWATER QUALITY

Wastewater quality, in terms of BOD_5 and SS, for planning of wastewater treatment facilities and sanitation systems, has been estimated based on the water quality survey results and reported unit pollutant load generation. The BOD_5 and SS wastewater concentrations are as follows:

(1) Sewerage system 280 mg/L
(2) Sanitation system 330 mg/L

3.5 PRELIMINARY ENGINEERING CONSIDERATIONS

3.5.1 Bypassing Lake Amatitlan

Bypassing of Lake Amatitlan is not considered as an option in the wastewater management plan for the following reasons

(1) For bypassing, large initial investment for a large size outfall of more than 10 km long will be required.

(2) Ecological impacts due to bypassing is complex and cannot be appraised within the time frame of this Study.

(3) Water Quality of Michatoya River, which outflows from Lake Amatitlan, is much better than that of Villalobos River. Michatoya River Water is used directly for bathing and washing by people. For bypassing, an advanced wastewater treatment would be required from the first stage project.

(4) If necessary bypassing could be done at a later stage augmenting the proposed system.

Table 3-3 Planned Wastewater Quantity for Sewerage System in 2015

Region		Planned Population	Domestic and Commercial Wastewater			Industrial Wastewater		Ground Water	Total			Wet Weather Flow
			Daily Average	Daily Maximum	Hourly Maximum	Daily Average	Hourly Maximum		Daily Average	Daily Maximum	Hourly Maximum	
Central	Separate	80,100	23,630	26,033	39,249			1,202	24,832	27,235	40,451	40,451
	Combined	671,700	198,151	218,302	329,133	4,699	9,398	10,075	212,925	233,076	348,606	1,045,818
	Sub Total	751,800	221,781	244,335	368,382	4,699	9,398	11,277	237,757	260,311	389,057	1,086,269
North 1		379,100	83,402	90,984	136,476	1,706	3,412	3,791	88,899	96,481	143,679	
South 1		277,500	61,050	66,600	99,900	158	316	2,775	63,983	69,533	102,991	
South 2		183,600	40,392	44,064	66,096	8,741	17,482	1,836	50,969	54,641	85,414	
South 3		276,100	60,742	66,264	99,396	2,231	4,462	2,761	65,734	71,256	106,619	
East 1		500,800	110,176	120,192	180,288	5,198	10,396	5,008	120,382	130,398	195,692	
Total		2,368,900	577,543	632,439	950,538	22,733	45,466	27,448	627,724	682,620	1,023,452	

Note: For industrial Wastewater daily average and daily maximum are assumed to be equal. All flows are in m3/d.

Source: Study Team

3.5.2 Storm Water Drainage

The stormwater drainage network in Metropolitan Guatemala has been gradually expanded to cope with the rapidly expanding Metropolitan Area. Due to the generally steep slopes, stormwater discharge is relatively easy and so far no serious flooding problems have occurred except in limited low lying areas. The stormwater management strategy in this Study is shown in Table 3-4.

Table 3-4 Stormwater Management Strategy in Each Region

Region	Sewerage System	Stormwater Management
Central	Combined	Stormwater intercepted will be treated at the wastewater treatment plant with sedimentation process
Other Regions	Separate	Existing stormwater drainage facilities are used. No treatment of stormwater is planned under this Study. Wastewater treatment should be given top priority.

Source : Study Team

3.5.3 Treatment Level and Effluent Standards

Existing effluent standards for municipal wastewater discharges (Government Agreement No. 60-89) can be satisfied by primary treatment. This type of standard is called a treatment-based standard.

The development and implementation of effluent standards from treatment-based standards towards water quality-based standards is increasingly complex and requires a long time span. Considering the existing condition of virtually no wastewater treatment, only treatment-based standards are considered in the Master Plan for wastewater management up to 2015.

a) Scenarios of Effluent Standards

Scenarios of effluent standards are proposed as follows:

Case I To comply with the existing effluent standards (Fig. 3 - 3).

Case II Revise Existing Standards (Fig. 3 - 4).

Case III Improved (stricter) Standards (Fig. 3 - 5).

Table 3 - 5 shows a summary of effluent standards for Cases I, II, and III and Table 3 - 6 shows the example of BOD concentration.

Table 3 - 5 Scenario of Effluent Standards

Source	Case I	Case II	Case III
Effluent Standards for Municipal Wastewater into Public Water Body	Standard MP	Standard P2	Standard P3
Effluent Standards for Industrial Wastewater into Public Water Body	Standard IP		
Discharge Standards for Industrial Wastewater into Public Sewers	_*	Standard IS2	

Note: *Only permitted for those industries with existing discharges.
Source : Study Team

Table 3 - 6 Example of Effluent Standards (BOD)

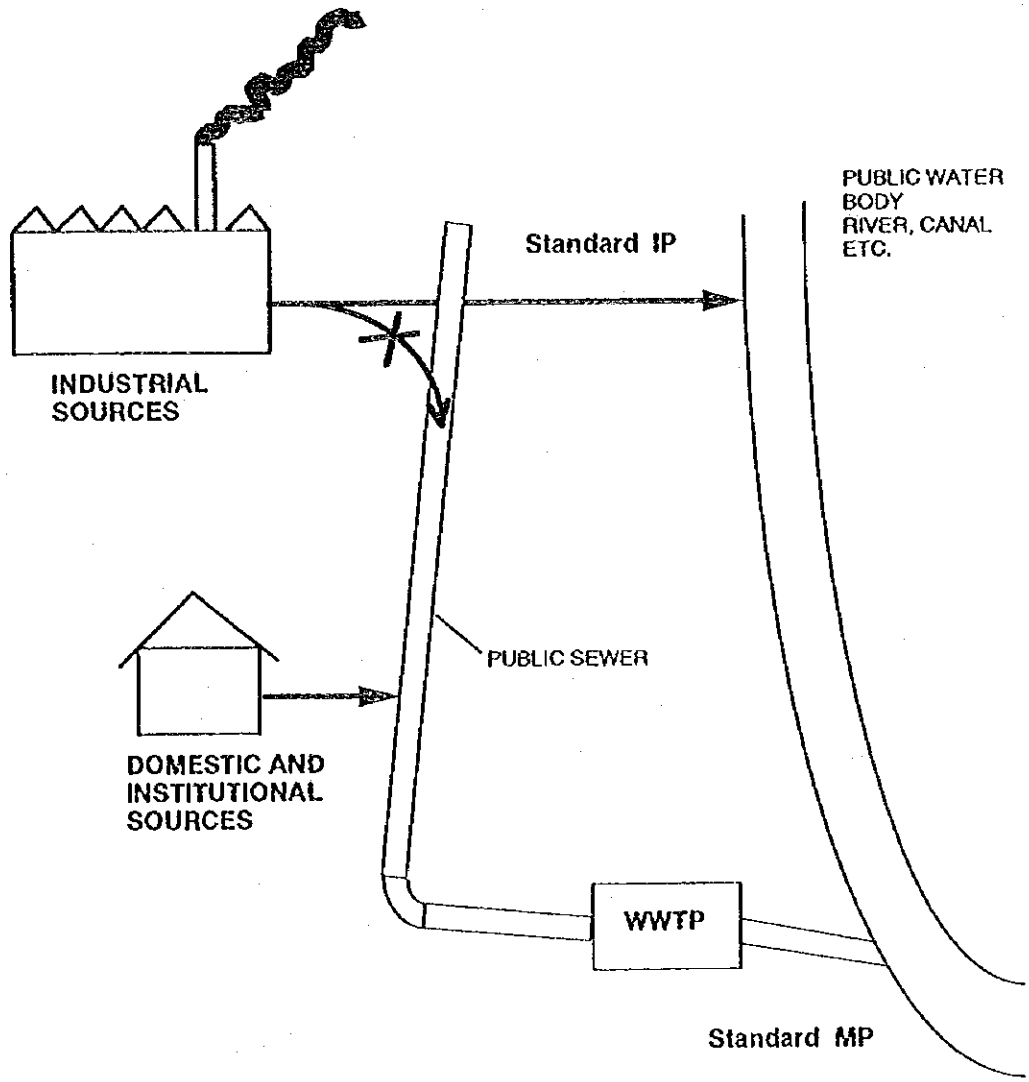
Case	Standard	BOD Concentration mg/L
Case I	Standard MP	200
	Standard IP (e. g. brewery)	900
Case II	Standard P2	200
	Standard IS2 (e. g. brewery)	900
Case III	Standard P3	< 200

Source : Study Team

b) Enactment and Implementation of Effluent Standards

Enactment and implementation of effluent standards and discharge standards, (for industrial wastewater), shall be conducted by the respective implementing authorities. As for industrial effluents, necessary procedures shall be taken to provide necessary legal authority for EMPAGUA (or Municipality) to set standards/regulations for accepting industrial wastewater. To ensure safe and reliable functioning of the sewerage system, industries shall provide data on a) flow rate of wastewater and b) characteristics and composition of wastewater to EMPAGUA, to enable EMPAGUA to decide whether or not to accept industrial wastewater into its sewerage system.

Fig. 3 - 3

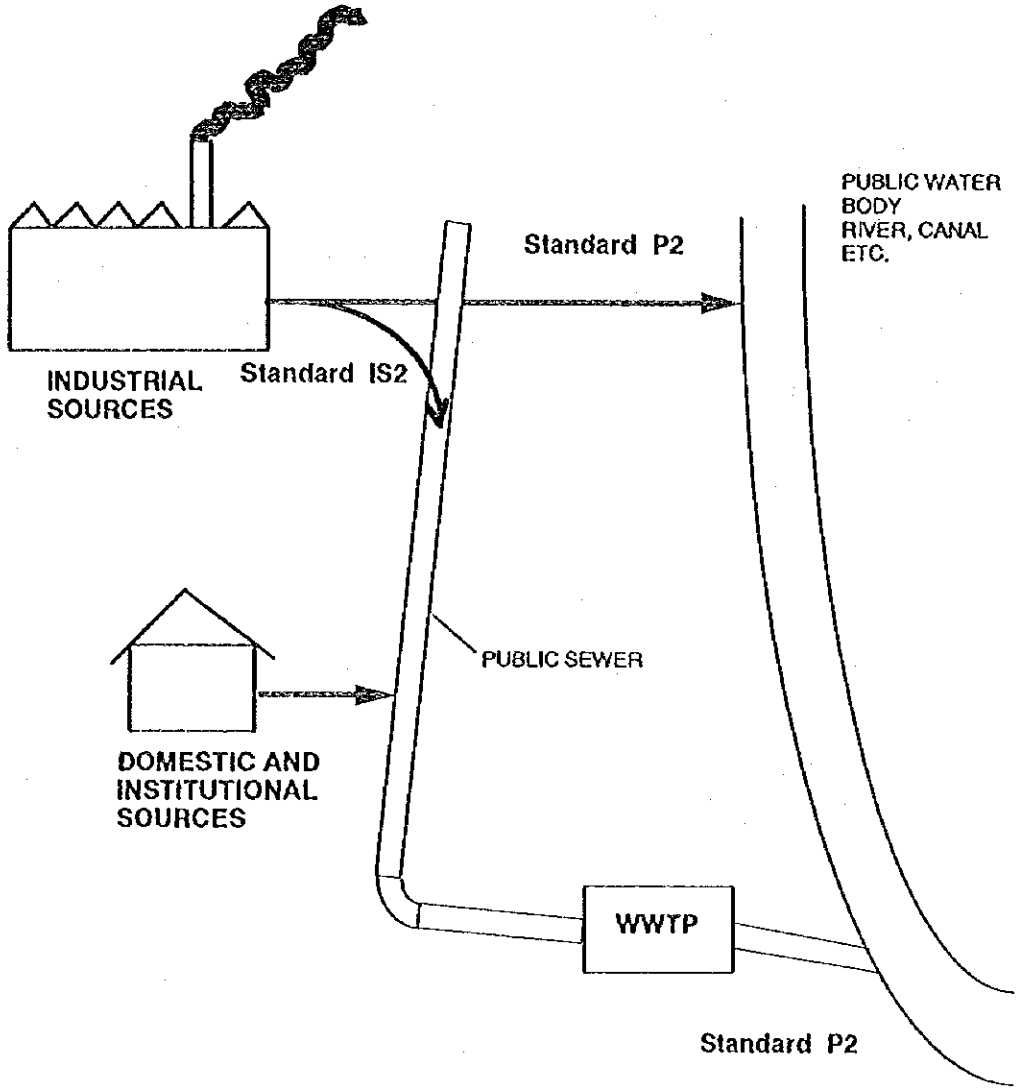


Note WWTP - Public Wastewater Treatment Plant
Standard IP - Effluent Standards for Industrial Wastewater into Public Waterbody
Standard MP - Effluent Standards for Municipal Wastewater into Public Waterbody

CASE I
- **NOT ACCEPT INDUSTRIAL WASTEWATERS**
- **EXISTING STANDARDS (60-89)**
- **INDUSTRIES DISCHARGING TO PUBLIC SEWERS AT PRESENT SHALL PAY SEWERAGE CHARGES**

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 SCENARIOS OF EFFLUENT STANDARDS - CASE I

Fig. 3 - 4



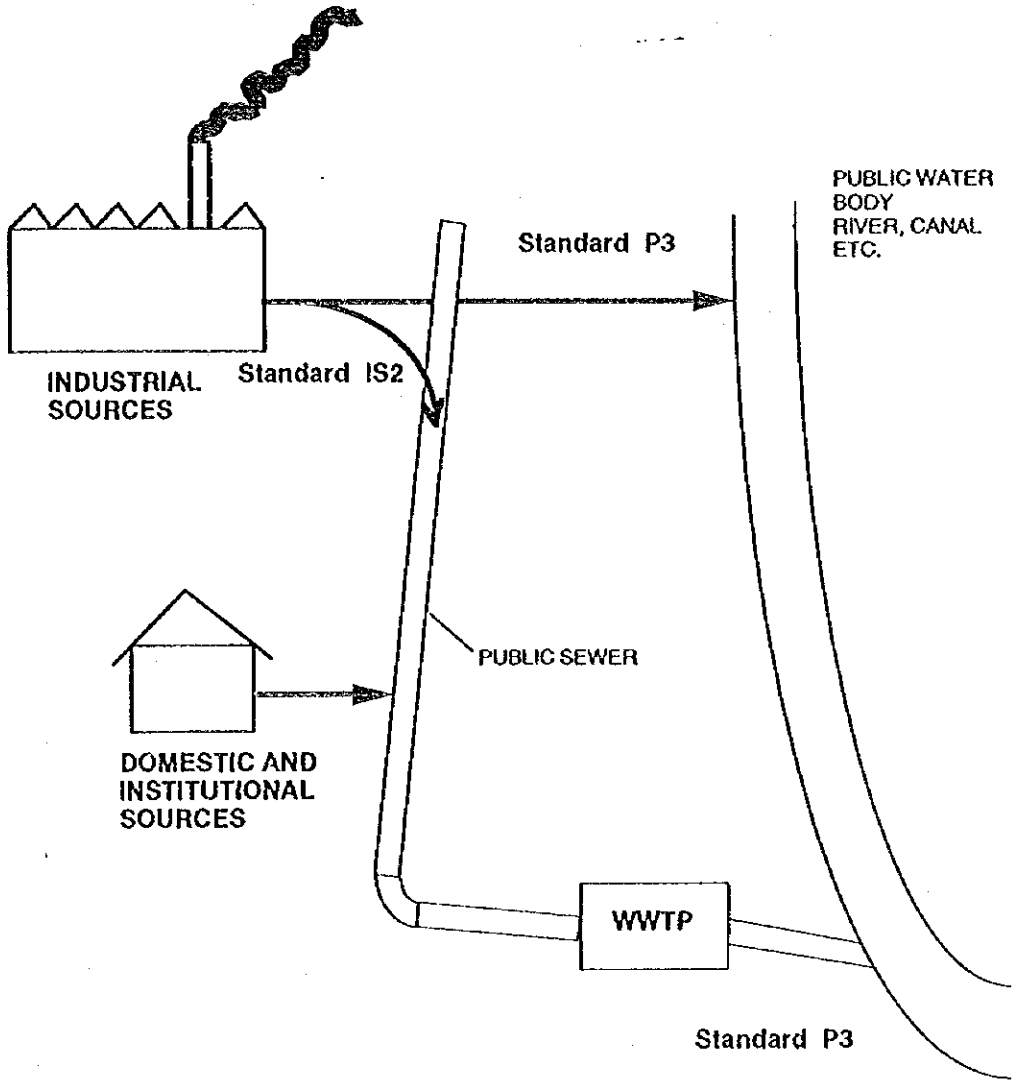
Note
- WWTP - Public Wastewater Treatment Plant
- Standard P2 - Effluent Standards for Industrial Wastewater into Public Waterbody
- Standard IS2 - Discharge Standards for Industrial Wastewater into Public Sewers
- Standard P2 - Effluent Standards for Municipal Wastewater into Public Waterbody

CASE 2

- **ACCEPT INDUSTRIAL WASTEWATERS**
- **REVISE EXISTING STANDARDS (60-89)**
- **EFFLUENT STANDARDS FOR MUNICIPAL WASTEWATER AND INDUSTRIAL WASTEWATER INTO PUBLIC WATER BODY ARE THE SAME**
- **DISCHARGE STANDARDS FOR INDUSTRIAL WASTEWATER INTO PUBLIC SEWER REMAINS AT THE SAME LEVEL AS Standard IS2**

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 SCENARIOS OF EFFLUENT STANDARDS - CASE II

Fig. 3 - 5



Note
- WWTP - Public Wastewater Treatment Plant
- Standard P3 - Effluent Standards for Industrial Wastewater into Public Waterbody
- Standard IS2 - Discharge Standards for Industrial Wastewater into Public Sewers
- Standard P3 - Effluent Standards for Municipal Wastewater into Public Waterbody

CASE 3

- **MORE STRINGENT STANDARDS THAN CASE 2**
- **ACCEPT INDUSTRIAL WASTEWATERS**
- **EFFLUENT STANDARDS FOR MUNICIPAL WASTEWATER AND INDUSTRIAL WASTEWATER INTO PUBLIC WATER BODY ARE THE SAME**
- **DISCHARGE STANDARDS FOR INDUSTRIAL WASTEWATER INTO PUBLIC SEWER REMAINS AT THE SAME LEVEL AS Standard IS2**

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 SCENARIOS OF EFFLUENT STANDARDS - CASE III

4 WASTEWATER MANAGEMENT PLAN

4.1 WASTEWATER MANAGEMENT FACILITIES

4.1.1 Wastewater Collection System

a) Main Collectors

The main collectors and interceptors to be built under the Master Plan, range in diameter from 200 mm to 3,000 mm with an estimated total length of 169,200 meters, covering six sewerage Regions; namely, Central, North 1, South 1, South 2, South 3 and East 1.

The ultimate sewerage system layout plan for the Study Area is shown in Fig. 4-1.

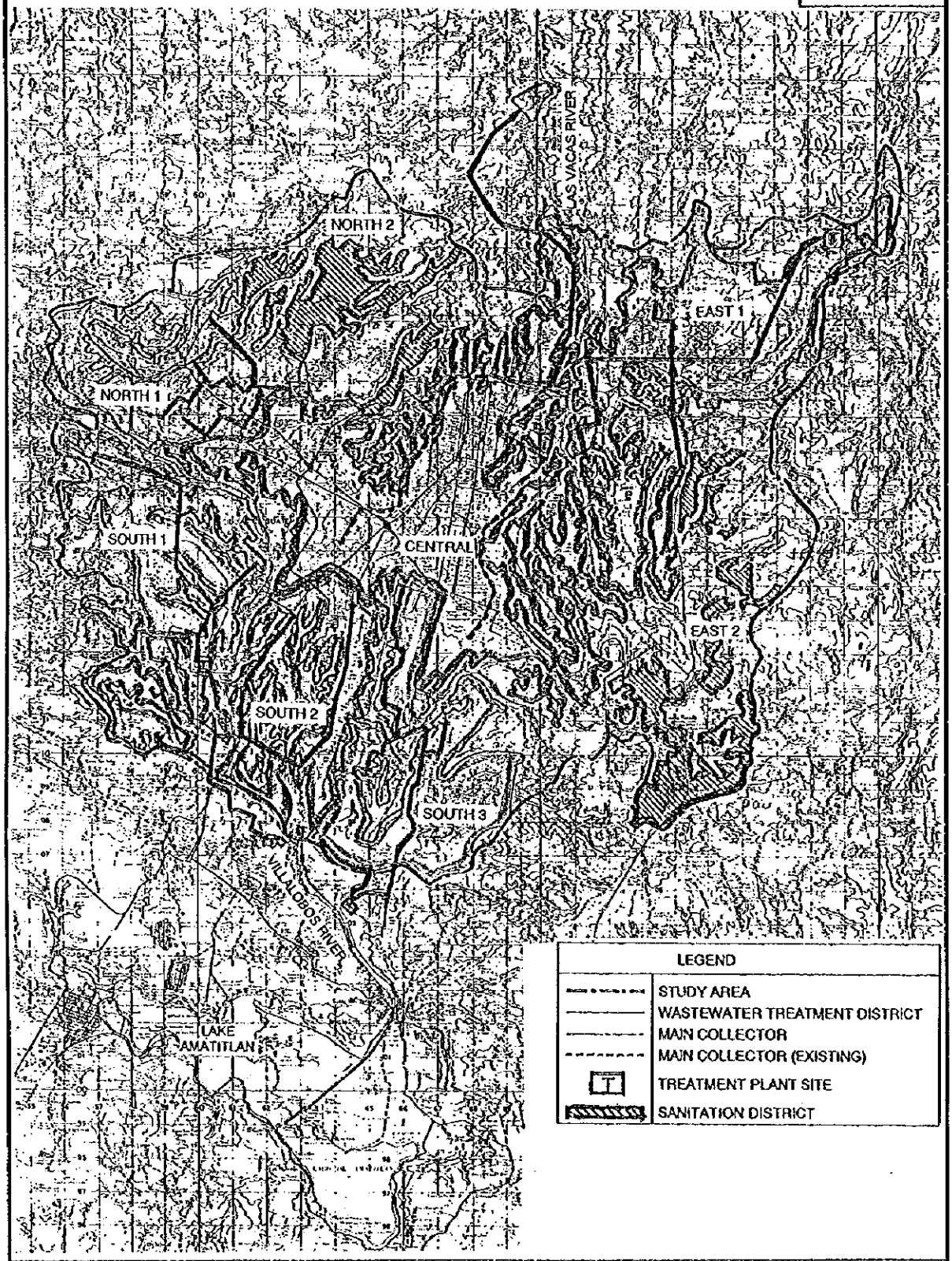
A break down of the component sewers of the major collectors by wastewater treatment district is shown in Table 4-1:

Table 4-1 Size and Length of Collectors for Wastewater Treatment Districts

Sewer Size (mm)	Length of Main Collector (m)					
	Central	North 1	South 1	South 2	South 3	East 1
200	-	-	-	-	1,350	-
250	-	560	1,770	6,900	-	2,430
300	-	1,060	6,780	5,060	6,230	1,540
350	-	-	2,400	6,750	7,250	4,450
400	-	1,050	-	1,050	4,790	-
450	-	260	6,060	1,670	-	1,560
500	-	4,030	1,400	4,540	2,090	1,400
600	-	2,190	-	-	4,650	1,440
700	-	930	-	-	1,580	-
800	-	1,970	-	-	-	-
1,500	-	11,890	9,350	13,870	7,990	18,850
3,000	10,060	-	-	-	-	-
Total	10,060	23,940	27,760	39,840	35,930	31,670

Source: Study Team

Fig. 4 - 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 ULTIMATE SEWER SYSTEM LAYOUT IN STUDY AREA

b) Sub-main, Branch and Lateral Sewers

The proposed sewerage system includes the provision of new sewer reticulations consisting of I) sub-mains, ii) branches, and iii) laterals for the areas wherein no sewer reticulations have been provided yet for master planning purposes. The wastewater collected from households, industries, the commercial sector, etc. through house connections, flows by gravity to lateral or branch sewers, and then is led to sub-main sewers.

4.1.2 Wastewater Treatment System

a) Proposed Wastewater Treatment Facilities

Proposed locations of Wastewater Treatment Plants are as shown in Fig. 4-1. Schematic of wastewater and sludge treatment processes are shown in Fig. 4-2.

Wastewater flowrates used for the design are as shown in Table 4-2.

Table 4-2 Design Flow Rates for Wastewater Treatment Plants

Region	Wastewater Flow Rate (m3/d)			Wet Weather Flow Rate (m³/d)
	Daily Average	Daily Maximum	Hourly Maximum	
Central	238,000	261,000	390,000	1,087,000
North 1	89,000	97,000	144,000	—
South 1	64,000	70,000	103,000	—
South 2	51,000	55,000	86,000	—
South 3	66,000	72,000	107,000	—
East 1	121,000	131,000	196,000	—

Source : Study Team

Table 4-3 shows the influent and effluent water quality in terms of BOD and SS.

Table 4-3 Treated Water Quality

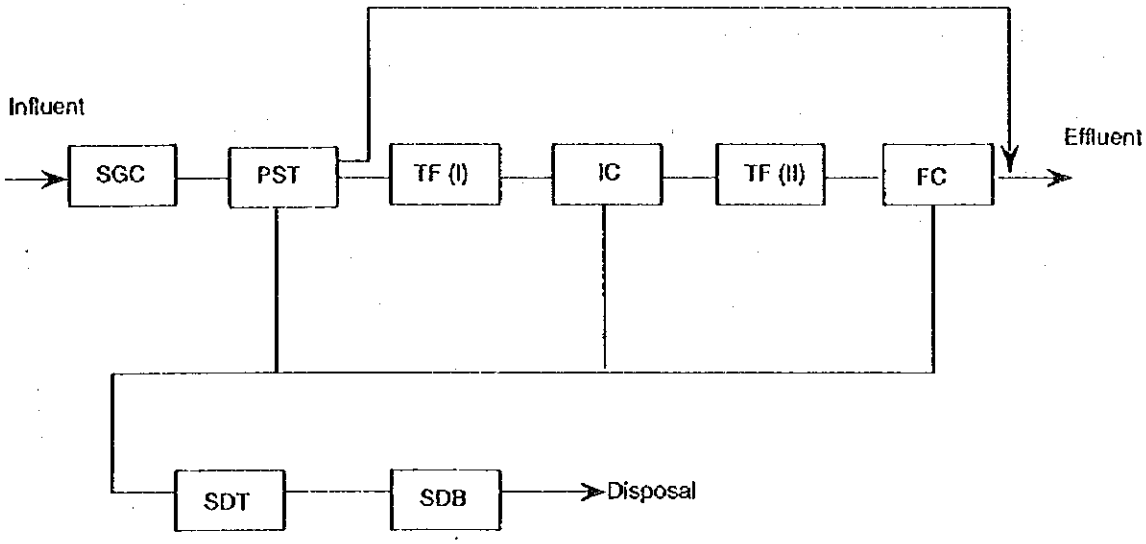
Parameter	Concentration (mg/L)		
	Influent	Effluent	
		Primary	Secondary
BOD_5	280	182	56
SS	280	126	56

Source: Study Team

Fig. 4 - 2

ONLY FOR CENTRAL REGION

Primary Treated ExcessWet weather Flow
(3 x Maximum Hourly Flow - 1 x Maximum Hourly Flow)



Legend
SGC - Screen Grit Chamber
PST - Primary Sedimentation Tank
TF - Trickling Filter
IC - Intermediate Clarifier
FC - Final Clarifier
SDT - Sludge Digester Tank
SDB - Sludge Drying Bed

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b) Sludge Disposal and Reuse

Because the magnitude of this project is large and it is the first time that construction of these type of facilities has been carried out in Guatemala, reuse of wastewater effluent and sludge is not considered in the initial program. The treated wastewater effluent will be discharged directly into public waterways and the sludge will be disposed of by land filling. At a later stage, this issue could be re-evaluated. Table 4-4 shows a summary of the issues involved when effluent and sludge reuse are considered:

Table 4-4 Consideration of Treated Wastewater and Sludge Reuse

Item	Treated Wastewater	Sludge (Dried)
Use	Irrigation	Fertilizer
Quantity	As constantly produced throughout the year, it is difficult to adjust production quantity to meet users varied demand.	As constantly produced throughout years, sludge stock facility is needed to meet users varied demand.
Quality	As effluent is either from primary or secondary treatment without chlorination, guarantee's of quality and legal responsibility for consequences of reuse need to be considered.	As industrial wastewater's may contain hazardous heavy metals, guarantee's of quality and legal responsibility for sludge use need to be examined.
Transportation, Supply and Marketing	Energy for pumping will be required to transport effluent, except for gravity supply to areas downstream of treatment plant.	Transportation costs will be incurred. For promotion and marketing of products, new distribution routes should be established.

Source : Study Team

4.1.3 Sanitation System

Since individual facilities are difficult to control from an O/M point of view, only sanitation facilities at a community level are considered in this Study.

a) Wastewater Collection System

A conventional gravity system is proposed for collecting and transporting the wastewater to the community sanitation treatment facility. The size of sewer required for a colony of 1,000 people is less than 200 mm however a minimum size of 200 mm is assumed. The length of sewer required in each Region is shown in Table 4-5.

Table 4-5 Length of Sewers Required for Sanitation

Region	Length (km)
Central	177
North 1	10
North 2	111
South 1	2
South 2	17
South 3	10
East 1	53
East 2	324
Total	704

Source : Study Team

b) Sanitation Treatment System

A septic tank followed by soil absorption well or upflow anaerobic filter is proposed. The number of septic tanks required in each Region is shown in Table 4 -6 and was estimated assuming that each community has a population of 1,000.

Table 4 - 6 Number of Septic Tanks Required

Region	Number of Units Required
Central	110
North 1	13
North 2	150
South 1	3
South 2	8
South 3	3
East 1	21
East 2	40
Total	348

Source : Study Team

Dimensions of a septic tank and aerobic filter for a community of 1,000 are given below as an example.

Septic Tank: = 23.0 m x 12.0 m x 2.0 m

Upflow Anaerobic Filter: = 10.0 m x 12.0 m x 1.2 m

c) Septage Management

The volume of septage to be desludged from the sanitation system in the year 2015 for each Region is shown in Table 4-7. The septage will be treated at the sludge treatment facility of the wastewater treatment plant to be constructed in the respective Region, except North 2 and East 2 Regions. Septage from North 2 and East 2 Regions will be treated at the wastewater treatment plants in North 1 and East 1 Regions respectively.

Table 4 - 7 Quantity of Septage to be Desludged in the Year 2015

Region	Quantity of Septage to be Desludged from Septic Tanks (m^3/year)	Location of Treatment Plants for Treating Septage
Central	4,384	Central
North 1	516	North 1
North 2	6,000	North 1
South 1	100	South 1
South 2	320	South 2
South 3	116	South 3
East 1	808	East 1
East 2	1,600	East 1
Total	13,844	--

Source : Study Team

4.1.4 Operation and Maintenance

From the commencement of operation, daily O/M is essential. Further, information and data obtained through O/M is very useful and would be important for planning the expansion of facilities etc. and for planning facilities for other regions in Guatemala. O/M Guidelines for the proposed facilities are described in the Main Report.

4.2 COST ESTIMATION

4.2.1 Total Investment Cost

a) Sewerage System

The total investment cost is composed of direct construction cost, land acquisition cost, engineering fee, administration fee and contingency. Of these, only the engineering fee is considered to be a foreign currency element; other items are considered in the local currency.

The direct construction cost of the sewerage system is estimated based on the preliminary design for Master Plan and unit construction costs obtained from a survey conducted in Guatemala from April 1995 to July 1995.

The direct construction costs are estimated as total costs including materials, labor (including some benefits), but excluding consumption tax (IVA).

The investment required to construct main collectors and wastewater treatment plants is summarized in Table 4 - 8.

Table 4 - 8 Summary of Total Investment Cost for Sewerage System

[Unit : Million Quetzal]

Region	Direct Construction	Land Acquisition	Engineering Fee	Administration Fee	Contingency	Total
Central	368.7	26.8	22.1	11.1	36.9	465.5
North 1	265.9	9.7	16.0	8.0	26.6	326.2
North 2	0.0	0.0	0.0	0.0	0.0	0.0
South 1	171.5	11.5	10.3	5.1	17.2	215.6
South 2	143.0	9.4	8.6	4.3	14.3	179.5
South 3	254.1	12.4	15.2	7.6	25.4	314.8
East 1	317.0	20.9	19.0	9.5	31.7	398.2
East 2	0.0	0.0	0.0	0.0	0.0	0.0
Total	1,520.2	90.7	91.2	45.6	152.0	1,899.7

Note 1. Engineering Fee = (Direct Construction Cost) x 0.06
2 Administration Fee = (Direct Construction Cost) x 0.03
3. Contingency = (Direct Construction Cost) x 0.10
4. Cost : as of September 1995.
Source : Study Team

b) Sanitation System

The investment required to construct sewer pipelines and community plants for each Region, is summarized in Table 4 - 9.

Table 4 - 9 Summary of Total Investment Cost for Sanitation System

(Unit: Million Quetzal)

Region	Direct Construction	Land Acquisition	Engineering Fee	Admin Fee	Contingency	Total
Central	74.6	6.2	4.5	2.2	7.5	94.9
North 1	6.8	0.6	0.4	0.2	0.7	8.7
North 2	68.7	4.2	4.1	2.1	6.9	85.9
South 1	1.5	0.3	0.1	0.0	0.2	2.0
South 2	6.2	0.7	0.4	0.2	0.6	8.0
South 3	3.0	0.3	0.2	0.1	0.3	3.8
East 1	17.8	1.8	1.1	0.5	1.8	23.0
East 2	71.4	3.4	4.3	2.1	7.1	88.3
Total	249.9	17.3	15.0	7.5	25.0	314.7

Note: 1. Engineering Fee = Direct Construction Cost x 0.06
2. Administration Fee = Direct Construction Cost x 0.03
3. Contingency = Direct Construction Cost x 0.10
4. Costs are as of September 1995.

Source : Study Team

4.2.2 Operation and Maintenance Costs

a) Sewerage System

The required annual O/M costs at 1995 prices for the full operational capacity is shown in Table 4 - 10.

Table 4-10 *Summary of O/M Cost for Sewerage System*

(Unit : Thousand Quetzal/Year)

Item	Central	North 1	South 1	South 2	South 3	East 1
1 Wastewater Treatment Plant						
- Personnel Costs	1,200	480	300	240	360	600
- Transportation Cost of sludge	1,288	401	291	231	301	549
- Repair Costs (0.5% of C/C)	1,161	469	296	237	353	584
Sub-Total	3,589	1,350	887	708	1,014	1,733
2 Sewer Pipelines						
- Personnel Costs	2,404	845	648	880	928	1,417
- Repair Costs (0.5% of C/C)	682	862	562	477	917	1,001
Sub-Total	3,086	1,707	1,210	1,357	1,845	2,418
Total O/M Cost	6,524	3,057	2,097	2,065	2,857	4,151

Note : Costs are as of September 1995.

Source : Study Team

b) Sanitation System

The summary of required annual O/M costs are shown below in the Table 4 - 11.

Table 4 - 11 Summary of O/M Cost for Sanitation System

(Unit: Thousand Quetzal/Year)

Item	Region							
	Central	North 1	North 2	South 1	South 2	South 3	East 1	East 2
1. Community Plant								
- Personnel Cost	220	30	300	30	30	30	42	80
- Transportation Cost of Sludge	140	17	192	3	10	4	26	51
- Repair Cost	208	24	284	6	15	5	39	75
Sub-total	568	71	776	39	55	39	107	206
2. Sewerage								
- Personnel Cost	175	30	109	30	30	30	52	320
- Repair Cost	165	10	60	2	16	10	50	282
Sub-total	340	40	169	32	46	40	102	602
Total O/M Cost	908	111	945	71	101	79	209	808

Note: Costs are as September 1995.
Source : Study Team

4.3 SELECTION OF PRIORITY REGIONS

4.3.1 Objectives and Procedures for Selection

a) Objectives

The provision of a complete sewerage and sanitation system for the Guatemala Metropolitan Area, with its large and expanding population, is a task of tremendous magnitude. It is prudent to build the required facilities in stages, according to the urgency of need and benefit to be derived.

This study has therefore been made to determine the desirable priority for sewerage/sanitation system construction, taking into account the various important elements which affect environmental and sanitary conditions in the eight Regions of the Study Area, based on reasonable assumptions and a rating procedure.

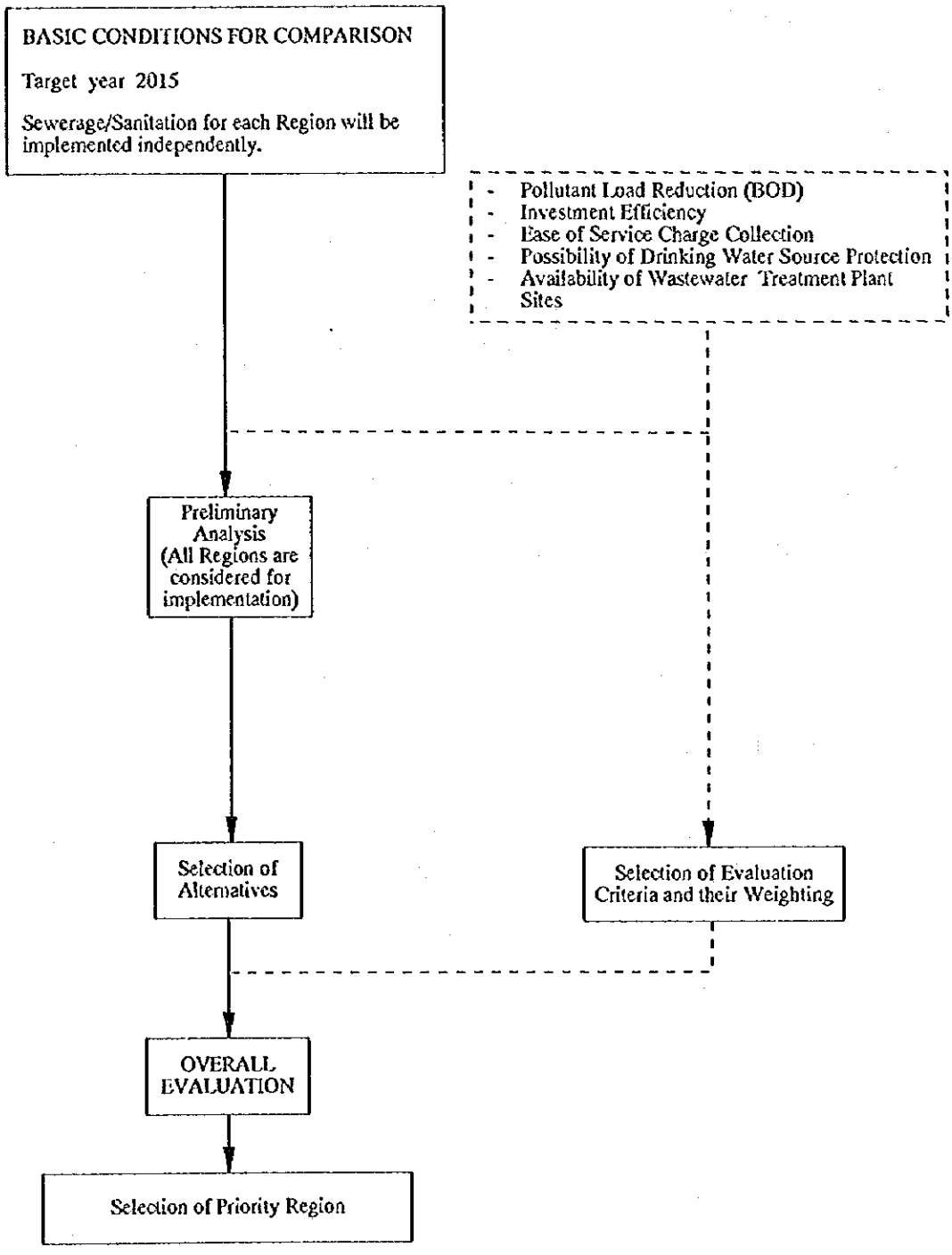
b) Procedure for Selection

The procedure for selecting Priority Regions is as shown in Fig. 4-3. There are two steps;

First Step : Selection of Alternatives

Second Step : Selection of Priority Regions

Fig. 4 - 3



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 FLOWCHART FOR SELECTION OF PRIORITY REGION