It can be said that EMPAGUA's employees are older than the Guatemala Metropolitan average. EMPAGUA's biggest age group is 31-40 years old, while the Guatemalan average is 20-29. Furthermore, at EMPAGUA, the age group of 41-60 years old forms more than 40% of the total, while at Metropolitan area, the age group of 40-59 years old occupies about 20%. In terms of years of experience, those who have 11-15 years of experience at EMPAGUA are relatively scarce compared with the bracket behind. For example, at the age group of 31-40, 155 employees have 16-20 years experience but as few as 72 people have 11-15 years experience. The same phenomenon can be observed also in the age group of 41-50 years old and 51-60 years old. One of the reasons for this is that in the first half of 1980's, there was a period when the Guatemala Municipality took a stringent employment policy and EMPAGUA did likewise.

Table H-4 displays how many employees have entered to and left EMPAGUA over the period of 1991 through 1994. Taking into consideration that EMPAGUA's total employees is some 1700 or 1800, the number of recruits between 1992 and 1994 are some 200 each year which is relatively high. Meanwhile the number of dismissed or retired employees seems normal or slightly high. It is said that some employees, especially unskilled workers are idle and that EMPAGUA can not easily dismiss them due to the time consuming legal procedures.

Table H-4 Employees Turnover

(unit: person)

	Beginning	In	Out	End
Year 1991	1752	50	91	1711
Year 1992	1711	191	283	1619
Year 1993	1619	214	86	1747
Year 1994	1747	186	77	1856

H4 SALARY

The monthly salary of EMPAGUA's employees ranges from 835 to 7,080 quetzals as presented in Table H-5. In addition to this ordinary salary, there are following salaries:

- Overwork allowance - Operative workers in the field and staff of certain administrative area like treasury section are paid about double amount of usual hourly rate according to their overtime working hours.

- Easter vacation bonus - Once a year before Easter, all employees are paid even amount which was Q250 in 1995.
- Summer bonus - Once a year in July, all employees are paid at the same rate which was equivalent to one month salary in 1995.
- Christmas bonus - Once a year before Christmas, all employees are paid at the same rate which was equivalent to one month salary in 1995.

The actual salary structure including additional salaries almost follows the standard of Guatemala Municipality. The raise of salary base is not necessarily approved every year but when it is made, the incremental amount is same to all employees. For example, at the beginning of 1996, the base was evenly raised by Q260.

Table H-5 Employees Salary

(As of March 1996)

Job category	Position	Monthly salary (unit: Quetzal)
Senior management	General manager	7080
	Sub-general manager	5715
	Director	5400
	Project delegate	5400
Skilled specialist	Advisor	4140 - 5400
	Internal auditor	3615 - 6400
	Specialist	1710 - 5400
Administrative staff	General affair staff	1725 - 2355
	Unit chief	2210 - 4350
	Auditing staff	1250 - 1775
	Administrative assistant	1620 - 2730
	Clerk	890 - 1250
	Secretary	1005 - 2040
	Warehouse worker	1100 - 1200
Technical staff	Technician	990 - 2060
	Programmer	1110 - 2100
	Assistant unit chief	1625 - 2355
	Circuit inspector	1490 - 1720
	Financial specialist	2730
	Specialized worker	890 - 1515
	Watchman	1085 - 1185
	Operator	1115 - 1460
Unskilled worker	Forest Guard	1125
	Chief worker	890 - 1250
	Operative worker	835 - 1155

H5 TRAINING

The training scheduling of EMPAGUA is based on annual requirements that each section head submits to the Training Section before starting a fiscal year. As shown in Table H-6, however, actual programs have not been executed as planned and the scale of annual training varies considerably from year to year. In 1994 for example, 100 courses were planned and 988 people were to be trained. But actually, as few as 31 courses were organized and 277 people participated in them. The number of courses related to wastewater management is minimal and most of the courses are for water supply operation.

Table H-6 Training Program (Planned and Actual)

Target & Scale	1991		1992		1993		1994		1995 * 3	
	Planned	Actual	Planned	Actual	Planned	Actual	Planned	Actual	Planned	Actual
For Senior Management										
# of courses	5	9	n.a.*4	3	11	9	18	9	23	5
# of trainees	24	100		52	65	86	108	119	45	58
For Middle Level *1										
# of courses	22	9	n.a.*4	7	34	25	61	19	55	9
# of trainees	233	301		134	400	450	543	133	577	87
For Operative Level *2										
# of courses	12	14	n.a.*4	5	11	9	21	3	21	5
# of trainees	343	148		55	423	367	337	25	228	52
All Levels										
# of courses	39	32	n.a.	15	56	43	100	31	99	19
# of trainees	600	549		241	888	903	988	277	850	197

*1 Speciality training for middle level staff such as computing courses
*2 Speciality training for operator level staff such as electric or mechanic courses
*3 The actual numbers for 1995 are as of end May
*4 Training Unit did not receive the planning from each unit

H6 INFORMATION SYSTEM

A good management information system is to show actual operational activities to the management group including division heads who, in turn, will make necessary countermeasures and decision based on the contents of the information. Table 5-6 shows major information currently produced and distributed in EMPAGUA.

It is said that there are considerable number of reports and information produced and that those information contain sufficient data which reflect the status of EMPAGUA's operation. However, most of information are reported only up to the division head and their contents look too raw for other senior management to digest easily. A few information are distributed to all senior management. The function of the Information Section seems still limited and no information center exists where information processing and distribution are centralized.

Table H-7 Major Management Reports

Section of origin	Title and frequency a(annual) q(quarterly) m(monthly) f(fortnightly) w(weekly) d(daily) i(irregular)	Destination
Finance Division (Budgeting Sec.)	General budget report(a)	State Fiscal Authority, Central Bank, General Manager, Auditor
	Budget opening(a)	State Fiscal Authority, Central Bank, General Manager, Auditor, Division Heads
	Budget execution(m)	State Fiscal Authority, Central Bank, General Manager, Auditor, Division Heads
	Budget execution(q)	State Fiscal Authority, Central Bank, General Manager, Auditor, Division Heads
	Budget settlement(a)	State Fiscal Authority, Central Bank, General Manager, Auditor, Division Heads
	Salary payment record(a)	Information System Division, Personnel Section
Finance Division (Accounting Sec.)	Financial state(m)	State Fiscal Authority, General Manager, Auditor
Finance Division (Treasury Sec.)	Cashier's report(d)	State Fiscal Authority, General Manager, Auditor
Administration Div. (Personnel Sec.)	Salary payment record of non operative workers(m)	Accounting Section, General Manager, Auditor
	Salary payment record of operative workers(f)	*idem*
	Check issuance(d)	*idem*
O/M Division (Hydroelectrometry Sec.)	Water Quality Report of USAC Laboratory (d)	General Manager, Sub General Manager-Technical area
	Production report by water system (d)	Sub General Manager-Technical area
	Production report by water system (m)	Sub General Manager-Technical area
O/M Division (Each treatment plant)	Consumption of chemical (m)	Sub General Manager-Technical area
User Service Division (Billing Section)	Billing Statistics (m)	Sub General Manager-adm. finance, Finance Division
Works Division	Works execution report (a)	General Manager, Accounting Section
	Drainage maintenance report (a)	IDB
Underground Water Development Section	Progress report (q)	General manager, Ministry of finance, OECF

H7 TARIFF STRUCTURE

EMPAGUA carries out regulation of public water services for consumers within the service area of EMPAGUA. The relevant regulation was revised in August 1992 and again in September 1994. However, the proposed tariff in 1994 was not completely approved by the authority. The present tariff is given in Table H-8.

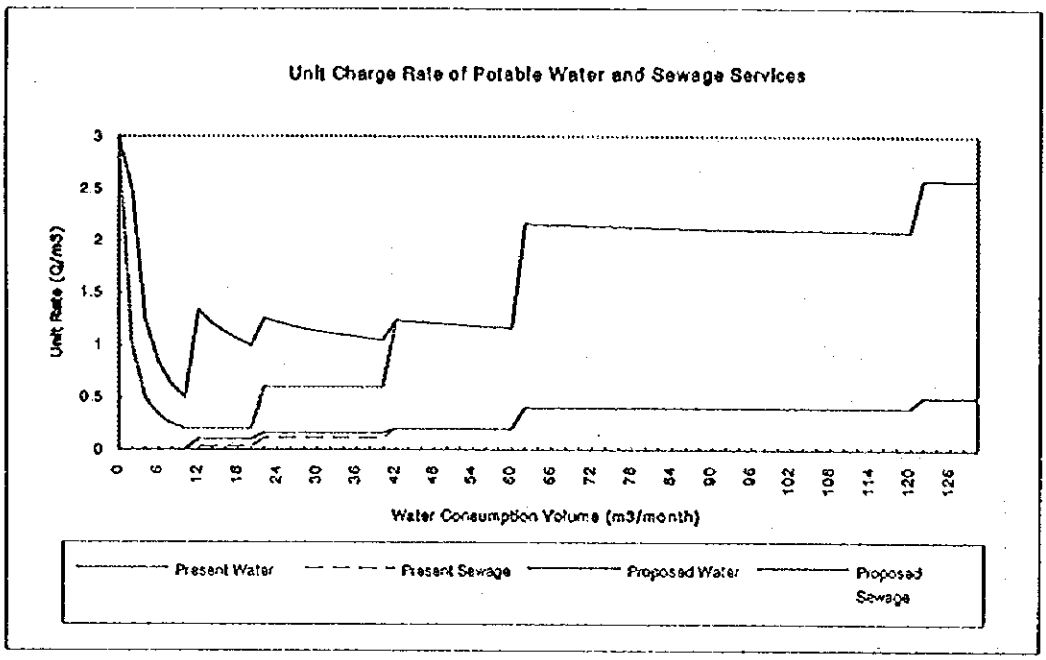
Table II-8 Charges for Potable Water and Sewage Services

1. Potable Water Tariff

Water Consumption Volume (m3/month/Household)	Existing Tariff		Proposed Tariff	
	Standing Charge (Quetzals)	Specific Charge (Quetzals/m3)	Standing Charge (Quetzals)	Specific Charge (Quetzals/m3)
0 ~ 10	2	-	5	-
11 ~ 20	-	0.20	10	0.50
21 ~ 40	-	0.60	10	0.80
41 ~ 60	10	1.00	10	1.00
61 ~ 120	10	2.00	10	2.00
More than 120	10	2.50	10	2.50

2. Sewage Service Tariff

20% of Specific Charges in proportion to Potable Water Consumed



EMPAGUA is still expecting to apply the proposed tariff to customers, but at present it is unpredictable when the new tariff will become effective. The graph in Table H-8 illustrates the unit rate of potable water and sewage services for both the present tariff and the proposed tariff. According to the present tariff structure of EMPAGUA, typical users of the services are monthly charged the amounts as shown in Table H-9.

Table H-9 Representative Monthly Charge

(Unit: Quetzals/Household)

Water Consumption Volume (m^3/month)	Water Charge	Sewage Charge	Total Charge
10	2.00	0.00	2.00
20	4.00	0.90	4.80
30	18.00	3.60	21.60
40	24.00	4.80	28.80
50	60.00	10.00	70.00
60	70.00	12.00	82.00

For small users consuming less than 40 m^3/month, the old tariff is still applied from the point of social welfare view. Once the proposed tariff is applied, their total charges would become double to triple of the present ones. For medium and large consumers, the total charges will be the same as the present ones. These conditions are shown in the figure of Table H-8.

To derive the monthly average charge of potable water and sewage services that EMPAGUA actually collected from the users, the following formulas can be applied:

$$C_{wt} = S_{wt} \div (N_j + N_d)/2 \div 12$$

$$C_{st} = S_{st} \div (N_j + N_d)/2 \div 12$$

where

C_{wt} = monthly average charge of potable water that EMPAGUA collected in year t

C_{st} = monthly average charge of sewage services that EMPAGUA collected in year t

S_{wt} = sales revenue of potable water for year t

S_{st} = sales revenue of sewage services for year t

N_j = service connection for January year t

N_d = service connection for December year t

The following data are available at EMPAGUA:

S_{w1994} = 74,767 thousand quetzals

S_{s1994} = 17,547 thousand quetzals

N_j = 139,673

N_d = 141,861

Accordingly, monthly average charge of potable water (C_{w1994}) and that of sewage services (C_{s1994}) turn out to be 44.3 quetzals and 10.4 quetzals respectively.

H8 MAIN COMMERCIAL PROCEDURE

The billing and collection system employed at EMPAGUA mainly consists of (i) connection, (ii) meter installation, (iii) meter reading, (iv) billing, (v) handling of customer complaints, (vi) collection, and (vii) control of arrears. Each step and relevant tasks are described in subsequent subsections.

H8.1 Connection

The installation of service connection is handled by the User Services Division. A new customer in need of connection for EMPAGUA water supply, makes a request submitting an application by designated form. The new customer, after being approved for connection, is obliged to pay (i) water right fee of Q1,200 up to monthly $30m^3$ consumption or Q2,400 up to monthly $60m^3$ consumption, (ii) connection charge of Q602, and (iii) pipe use fee of Q25. These are all initial non-recurring fees. In addition to these fees, purchase of a water meter is required. EMPAGUA recommends and sells a few types of meter which are priced at Q200 approximately. However, customers are free to choose other meters in the market.

H8.2 Meter Installation

Installation works are done either by the Meter and Housing Installation Section or by registered outside plumbers. As stated in the previous paragraph, there are many brands and types of meter in the market, many of which are found low quality products. Customers are freely have those low grade meters installed. Those meters become quickly broken down or deliberately forged after the installation, contributing to the high rate of unaccounted-for water which is currently considered about 40 percent.

H8.3 Meter Reading

As of 1995, 68% of water sales are based on metering. Due to the frequent meter breakdown aforementioned, the remaining 32 percent are unmetered and their volume are estimated based on the past ten months' average. The meter reading task has been partially contracted out to a private company since 1987, and at present EMPAGUA is supervising meter reading done by the subcontractor. The meter reading task is carried out as follows:

(i) Meter readers are equipped with a customer book in which customer's names, addresses and meter gauge numbers are written. They visit all of the listed customers once a month, find the protection case of the meter located at the customer's property, lift up the cover and gauge each of the meters.

(ii) After reading the meter gauge, the meter reader fills in the results and other necessary information to his customer book and a proof voucher. This proof voucher is delivered to the customer on the spot or slipped under the customer's door.
(iii) The customers book is updated and submitted daily to the supervisor of the subcontractor company, who in turn, sums up all of the records of customers books and reports every day to EMPAGUA for data processing purposes.

II8.4 Billing

The Billing Section receives data from the subcontractor, and this data is processed and checked to identify whether there are abnormally high or low results, than previous month, and for omissions. After correction and verification of data, bills are printed in-house and passed to a subcontracted delivery company. Those bills are delivered to customers by delivery staff of the subcontractor by foot.

II8.5 Handling of Customer Complaints

The Public Attention Section receives customer's complaints, of which major items are shown below in order of frequency. The figures in parenthesis means the percentage of customers who made the complaints. The total number of EMPAGUA's customers as of December 1995 is 144,775. These complaints, after passing the Public Attention Section, are solved by respective relevant sections:

- Exaggerated billing amount (3%)
- Unsatisfactory water supply service: customer receives water only for limited hours in the night or early morning; water is shut down completely (1%)
- No meter reading : customer believes that meter reading has not been done because no proof voucher has been left; customer believe that the reading is invented (1%)
- No delivery of proof voucher (1%)
- Negligence of meter reading person : meter reader did not visit client for reading or did not inform a client of entrance to his house (1%)
- Malfunctioning of meter gauge and consequent exorbitant billing amount (1%)
- Inaccuracy of meter reading: customer considers it incorrect (0.3%)
- Damage of meter gauge (0.2%)
- No delivery of bill (0.1%)
- Rudeness of meter reader when asked by a client for the proof voucher (0.01%)

- Double billing (0.01%)
- Omission of delivery of bill: several bills were delivered to one client (0.01%)
- Delayed delivery of bill (0.01%)

H8.6 Collection

The customers pay their bills either at EMPAGUA or at banks. EMPAGUA has only one collection place located in the same building as the head office. Thus, those who opt for direct payment at EMPAGUA must visit there. Those who opt for bank payment can pay at almost any bank in the city. The payment commission at the bank is 2%, which is charged to EMPAGUA. During 1994, on average 33% of the customers paid at EMPAGUA and 67% opted for bank payment. In terms of the collected amount, about 60% of bills were collected through banks. It is planned that EMPAGUA opens several collection places in the city so that those who prefer to pay at EMPAGUA can go to a nearer collection place.

H8.7 Control of Arrears and Write-off of Bad Debts

Bad debts are recognized as billings outstanding for more than two months. However, there is no specific rule for these bad debts to be written off. They are only written off when they become considerably old or the debtors definitely become insolvent. The average number in arrears amounts to 15,000 per month which is rather large compared with the total number of 144,775 connections as of December 1995. One reason for this high number is that the present client information system can not immediately delete arrears records after they are cleared. As of June 1995, detection of arrears is done by a computer system, nevertheless because the present information system is still in a transitional stage, many staff in the Collection Section are supporting the computer check of arrears. In fact, due to the aforementioned information system problem and shortage of staff and vehicles, visits to customers in arrears are only made where payment has been delayed for more than four months. The customers who can not possibly pay the bill are finally cut off from the water supply.

H8.8 Procurement System

The procurement system functions in order for only necessary materials and supplies to be obtained at most advantageous prices with the quality of the goods being procured. At EMPAGUA, The procedures of procurement are classified into the following categories:

(i) Purchase amount less than Q10,000
When purchase price is less than Q10,000, the purchase request is prepared by each section and submitted to the Division Head. After approval of the Division Head, the request is sent to the Supply Division where the purchasing is effectuated.

(ii) Purchase amount between Q10,000 - Q,300,000
When purchase price probably falls between Q100,000 and Q300,000, the section asks at least three suppliers for the quotation. With these quotations, the purchase request is prepared and submitted to the General Manager Office through the Division Head. After approval of the General Manager, the request is evaluated at the Procurement Committee. There are four permanent committees consisting of a financial staff, an administrative staff and a technical staff: these four committee alter in evaluations from all divisions. After approval of the Committee, purchase request is sent to the Supply Division where the procurement is effectuated. Later the Municipal Council is also informed of the purchase.

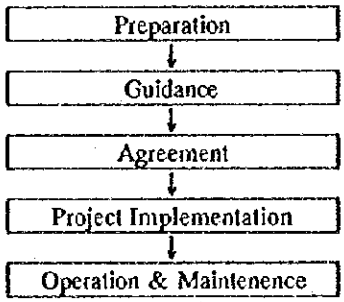
(iii) Purchase amount more than Q300,000
When purchase price probably exceeds Q300,000, the section prepares the base of tenders and submits to the General Manager's Office for approval. After approval, public or limited tender is arranged by the Section. Minimum three suppliers are required to participate in the tender. The tender result is concluded first by the Section, to be later approved by an ad hoc committee consisting of a financial staff, an administrative staff, a technical staff and two other staff. After the Committee's approval of the result, the purchase request is made by the Supply Division. The Municipal Council is later informed of the result.

H9 COMMUNITY PARTICIPATION

Since 1986, the Guatemala Municipality has been encouraging the community participation in provision of infrastructures such as water supply, drainage, paving of sidewalk and street inlet. There are two major types of participation program. The first one, "Foods for Work" is usually applied to settlements in extreme poverty, while the second one, "Assistance to Citizen" is generally practiced in higher income areas where minimum life-line infrastructures have been already provided. Both programs have common objectives which include (i) to provide residents with basic infrastructure; (ii) to save public expenditure for

capital investments; (iii) to enhance community awareness regarding the importance of basic infrastructure; and (iv) to encourage the residents in creating a self-support and team working spirit. Among various infrastructure projects by community participation now in operation, the provision of water supply and drainage system has been directed by EMPAGUA since 1990 on behalf of Guatemala Municipality. About 15 of drainage projects and 15 to 20 water supply projects are annually undertaken. The process of infrastructure provision by each program is characterized as follows:

"Foods for Work" Program



(i) Preparation - Municipality selects target areas to be provided with infrastructure on the basis of present living condition, necessity of infrastructure and income level of the resident.

⇓

(ii) Guidance - Municipality explains the project to the community of target area and asks them to form a resident committee as a representative organization of the community.

⇓

(iii) Agreement - Municipality and resident committee conclude a cooperation agreement in which each party's input and output are stipulated.

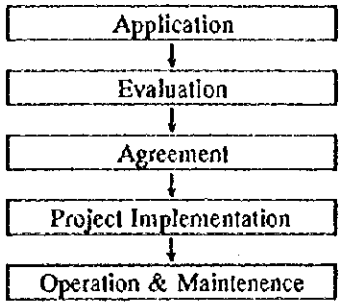
⇓

(iv) Project implementation - In accordance with the agreement, the community mobilizes unskilled laborers who are mostly women and children to help construction works and in exchange, receive basic foods such as cheese and dry milk. Municipality supplies the rest of input to complete the project such as supervision, topographic survey, design, materials and machinery.

⇓

(v) Operation and maintenance - After completion, the infrastructure is operated and maintained by the Municipality.

"Assistance to Citizen" Program



(i) Application - Resident committee which represents a community applies for provision of certain infrastructure to the Municipality.

⇓

(ii) Evaluation - Municipality evaluates the application and decides whether or not the project should be executed.

⇓

(iii) Agreement - Once the project is approved, the Municipality and the resident committee conclude a cooperation agreement in which each party's input are stipulated.

⇓

(iv) Project implementation - In accordance with the agreement, the community mobilizes unskilled laborers which can be either its own residents or subcontracted workers. In case that the community subcontracts outside workers, their salary or subcontracting charges are borne by the community. The community's contribution, however usually covers only a part of the total construction cost. Municipality supplies the rest of input to complete the project such as supervision, topographic survey, design, materials and machinery. The community will not receive anything but benefit from the infrastructure.

⇓

(v) Operation and maintenance - After the completion, the infrastructure is operated and maintained by the Municipality.

The clearest distinction between the two programs lies in the initiative of residents. In principle, "Foods for work" programs are planned by the Municipality, while "Assistance to Citizen" are originated on residents' own initiative. Accordingly, the two programs differ also in residents' receipt of remuneration in exchange for their participation in project. Under the "Food for Work", residents receive an allowance in kind, which is not the case with "Assistance to Citizen."

SUPPORTING REPORT J

SELECTION OF TREATMENT PROCESS

SUPPORTING REPORT J
SELECTION OF TREATMENT PROCESS
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J SELECTION OF TREATMENT PROCESS

J1 INTRODUCTION

Role of wastewater treatment facilities are to improve the wastewater quality before the wastewater is discharged to the public water bodies, and as such located at the end of the wastewater collection system. Sewerage system is incomplete,without wastewater treatment facilities and the role of those facilities are extremely important.

To improve the wastewater quality, many methods, namely wastewater treatment process are available. When selecting any treatment process, various factors need to be considered and out of them most suitable for local conditions (most appropriate technology to local conditions) is the most important.

J2 FACTORS CONSIDERED WHEN SELECTING TREATMENT PROCESS

Following are the factors necessary to be studied when selecting treatment process, they are:

1) Water quantity, quality (influent and effluent) and their variation
2) Quality and quantity of sludge generated
3) Construction cost and O/M cost
4) Personnel necessary for O/M
5) Effect on surrounding environment
6) Topography, geology and climate
7) Treatment processes used at existing facilities and their O/M situation

Out of the factors listed above, for the Study Area the following can be said about 6) and 7). They are;

- The topography is complicated with valleys with steep slopes (ravines), which can be found well within the central part of the town.
- Almost all of the flat area is occupied by town and suitable space for wastewater treatment facilities is very small.
- Therefore, it is unavoidable that the treatment facilities be located on the slopes.
- In other words, locating the treatment facilities on slope implies that potential energy can be utilized positively.
- In the existing facilities, trickling filter process which does not require mechanical energy is being used in many places and even the sludge removal from sedimentation tanks is also by gravity.

- However, O/M of the existing facilities are extremely bad and functions of treatment plants are not achieved at all. (Access roads are in bad condition).
- Climate is mild throughout the year. Temperature variation is low and evaporation rate is almost the same as rainfall.

J3 SELECTION OF ALTERNATIVES FOR TREATMENT PROCESS

J3.1 Conditions And Policies For Selecting Alternatives

1) Planned Sewage Flow Rate

More than one wastewater treatment plant is necessary and their capacity range is from 45,000m^3/d ~ 280,000m^3/d.

2) Planned Sewage Quality

BOD_5 of the influent wastewater is estimated at 280 mg/L (Refer to Water Quality Surveys and Analysis).

3) Effluent Standards

Existing effluent standards for wastewaters are specified in Regulation 60-89 by MPyAS, and that for the municipal wastewaters are shown in Table J-1.

Table J - 1 Maximum Permissible Standards for Municipal Wastewater Discharges

Sample	Settleable Solids, mL/L	BOD_5, mg/L	COD, mg/L
Random Sample	1.0		
Composite sample, 2 hours	1.0	250	500
Composite sample, 24 hours	1.0	200	450

Source : Reglamento 60-89

Out of the parameters shown in Table J-1, standards for settleable solids is the most stringent and can be basically achieved by primary treatment. Therefore, to comply with the existing standards, it is considered that primary treatment is sufficient.

4) Treatment Level and Treatment Process

From 3) above, primary treatment is sufficient to satisfy standards, however for the following reasons secondary treatment is considered.

- In this study, not only clearing the effluent standard at present but also to set the future direction is necessary.

- Of the existing small-scale sewage treatment plants comparibly larger plants have secondary treatment facilities.(However most of them are not functioning).

Depending on the treatment process used, secondary treatment can be divided into middle-levels and high-level treatment. However, in the forthcoming comparisons of secondary treatment, such divisions will not be made.

5) Sludge Treatment Process

Sludge generated from the liquid treatment process will be treated with the precondition that mechanical / electrical facilities are not employed. Based on the climatic conditions in the Study Area, most suitable sludge treatment process is as follows:

Unheated Anaerobic Digestion ----> Sludge Drying Bed

There are a few existing facilities which employs the above process.

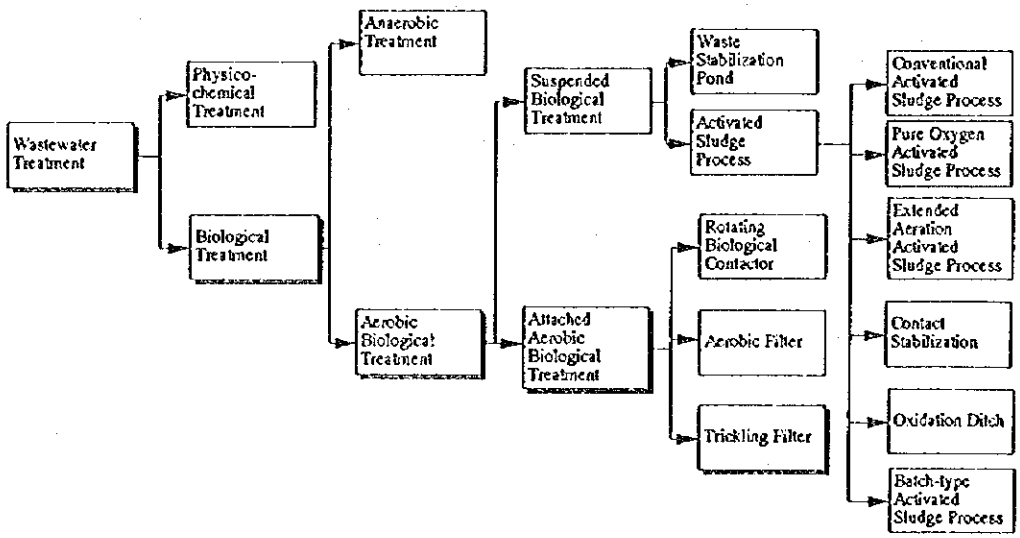
J3.2 Treatment Process Alternatives

Treatment process can be mainly divided into two namely physical treatment and biological treatment. Except when special industrial wastewaters are included, for secondary treatment biological treatment which employs natural purification of microorganisms are selected.

Generally, biological treatment can be either aerobic or anaerobic.However, anaerobic treatment is rarely used in large-scale treatment plants for secondary treatment and the design criteria, with little experience in actual facilities are not well established.

For the reasons stated above, aerobic biological treatment is generally used. Microorganisms can be kept either suspended or attached. In attached process, media is used where microorganisms attach and grow as a biofilm. The above classification and representative aerobic biological treatment processes are shown in Fig. J-1. Considering the treatment process shown in Fig. J-1 and those in Section J2 and J3.1, alternatives for secondary treatment are as shown below (Table J-2).

Fig. J - 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 Classification of Aerobic Wastewater Treatment Processes

Table J - 2 Treatment Process Alternatives for Secondary Treatment

Treatment Process	Reason for Selection
High-Rate Trickling Filter	Potential energy can be utilized and experience of existing facilities in theStudy Area.
Oxidation Ditch	Existing facilities in the Study Area.
Aerated Lagoon	Suitability to topography and climatic conditions.
Conventional Activated Sludge	Smaller facility area requirement and better effluent quality.

Source : Study Team

J4 COMPARISON OF ALTERNATIVES

J4.1 Treatment Process

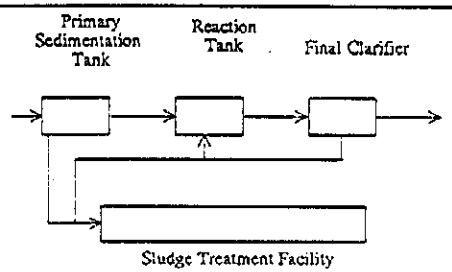
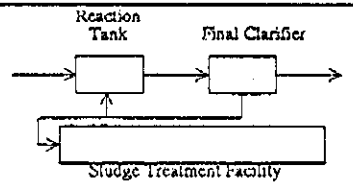
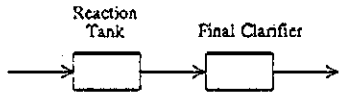
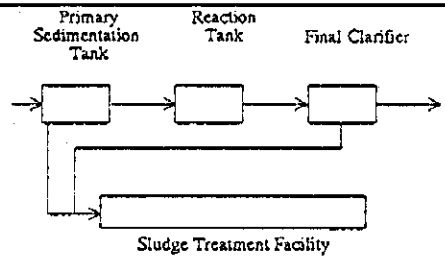
Tables J - 3 and J - 4 show the comparison of selected alternatives. Based on the comparison in the these tables and the reasons shown below, Trickling Filter Process is selected for secondary treatment. The reasons are;

1) Available lands for wastewater treatment facilities are sloped and trickling filter process is suitable for utilizing potential energy. Thus external energy input will not be necessary.
2) Therefore, O/M cost consist of mainly labor cost and will be economical than the other alternatives. This is extremely important for Guatemala for the sustainability of the facilities.
3) Trickling filter process is being used in existing facilities and local experience and knowledge with existing for this process, are accumulated.
4) O/M requirements on simple day-to-day care and does not have any mechanical parts for maintenance.
5) Sludge generation is relatively low.
6) Though the land area required is higher than that of activated sludge process, it is less than that of other processes.

J 4.2 Distribution In Trickling Filter Process

Distribution in trickling filter process can be devided into rotating distrubution method and fixed distribution method. Taking all consideration, fixed distrubution method is selected. (Refer. Annex JA)

Table J-3 Characteristics of Secondary Treatment Processes

Treatment Process	Schematic of Process	Treatment Concept
Conventional Activated Sludge Process		Wastewater is mixed with activated sludge returned (return sludge) from final clarifier and organic substances are absorbed and assimilated by aerobic microorganisms.
Oxidatation Ditch Process		Wastewater is mixed with activated sludge returned (return sludge) from final clarifier and organic substances are absorbed and assimilated by aerobic microorganisms. However, retention time is long.
Aereated Lagoon Process		During wastewater is retained in the aeration tank, organic substances are oxidized with aerobic microorganisms
High-rate Trickling Filter Process		Wastewater distributed over the bed trickles down the bed, on which microorganisms attach and grow by assimilating waste. When microbial film becomes thicker, they detach from the media and are settled in the final clarifier.

Source : Study Team

Table J-4 Comparison of Secondary Treatment Processes

Parameter	Item	Conventional Activated Sludge Process	Oxidation Ditch Process (OD)	Aerated Lagoon Process	High-Rate Trickling Filter Process
Treatment Flexibility	Against Shock Load	Flow Adjustment Tank Required	Possible to withstand	Good	Possible to withstand
	Against Load Fluctuation	Flow Adjustment Tank Required	Possible to withstand	Good	Good
Operation and Maintenance	Easiness of O/M	Easy	Very Easy	Very Easy	Very Easy
	Control System	Well Established	Established	Established	Established
	Number of Points To Be Checked	Many	Some	Some	A Few
	Need for High Technology	Required	Partly Required	Not Required	Not Required
General Characteristics	Volume of Sludge Generated	High	Low	Low	Comparably Less Volume
	Against Fluctation of Temperature	Somewhat Unstable	Stable	Somewhat Unstable	Somewhat Unstable
	Past Experience (Guatemala	No	Very Few	Very Few	Some
	Influence on Surrounding Environment	Varies Depending on the Surrounding Environmental Condition			
	Possibility of not using mechanical equipment	Impossible	Impossible	Impossible	Possible
	Possibility of not using electrical energy	Impossible	Impossible	Impossible	Possible
Area Required	OD Process as 100	55	100	270	70
Removal Rate	BOD (%)	90	90	70	80
	SS (%)	90	90	70	80
Cost	Construction	Very high	High	Medium	Low (if mechanical equipment is not used)
	O/M	High	High	Medium	Low (if electrical power is not used)

Data Source : Study Team

J 4.3 Number Of Stages And Recirculation

In trickling filter process,generally speaking, recirculationm multiple stages (two stages) or conbination of both are adapted.
In this project, multipule stages (two stages) are selected mainly because of low operation and maintenance cost, and intermediate charifier is settle so as to improve treatment efficiency. (Refer. Annex JB)

J5 CONCLUSION

From the discussion in the preceding sections, wastewater treatment process will be as follows :

(1) Treatment Process
Multiple stages (two stages) with intermediate clarifier is suitable.

(2) Distribution Method
Fixed distribution method is selected.

(3) Removal Rates
The following are the removal rates of BOD and SS adopted in Trickling Filter Process. (Refer Annex JC)

Table J-5 Removal Rates for High-rate Trickling Filter Process

Parameter	Removal Rate (%)			
	Primary Treatment	Secondary Treatment		Overall
	PST	TF(I) IC+(I)	TF(II) FC+(II)	
BOD_5	35	50/68	38/80	80
SS	55	56/80		80

Note: 1. Removal rate A/B indicates removal rate in the individual facility (A) and the overall removal rate (B) including the facility.
2. Detailed discussion is included in Supporting Report J, Annex JB.

Source : Study Team

ANNEX JA Notes on Wastewater Distribution in Trickling Filter Process

Rotating and fixed methods are used for distributing wastewater to the media and trickling filter process. Characteristics and comparison of the two are as shown in Table JA-1.

Table JA-1 Characteristics and Comparison of Rotating and Fixed Wastewater Distribution Method for Trickling Filters

Item	Rotating Method	Fixed method
Trusting Power	Potential Energy of Wastewater	—
Maintenance -mechanical	Maintenance is rarely required for the rotating arm facilities. Mechanical trouble is rare.	Not required (no mechanical equipment)
Maintenance -cleaning	Cleaning of pipes is necessary	Cleaning of pipes is necessary
Uniformity of wastewater distribution	Almost uniform	Distribution is almost less uniform than the rotating method
Land requirement	Based on design loading	Trade-off between non-uniform distribution will result in large land requirement
Experience		
- worldwide	many	few
- domestic	nothing	some
Construction cost	about five percent of WWTP investment cost	about one percent of WWTP investment cost

Considering the comparison stated in Table JA-1, and for the following reasons, rotating distribution method is selected.

- Even if methods are devised to improve the uniformity of distributing wastewater, fixed distribution method cannot reach the level of rotating distribution. It is desirable to avoid this kind of deficiency in the first ever large treatment plant in Guatemala
- Fixed method is disadvantageous in terms of land requirement since the design loading has to be reduced.
- Even though there is no experience in Guatemala in rotating distribution method, distribution method is widely used worldwide and the maintenance is easy.

Annex JB Recirculation and Number of Stages in Trickling Filter Process

Effluent quality of trickling filter process is of medium quality when compared to other secondarytreatment processes. To ensure adequate effluent quality, recirculation, or multiple stages (two stages) or combination of both are employed. For recirculation, pumping is necessary resulting in capital and operating expenditures.

In two-stage trickling filter process, generally at the end of first stage filter a second filter of approximately half-size of the first filter is constructed. To increase treatment efficiency a clairfier may be added in between two filters.

In this Study two-stage trickling filter process with intermediate clarifier is considered appropriate for the following reasons:

- for financial reasons, process which does not require electrical power expenditure is desirable.
- Effluent quality required to comply with the existing standard can easily be attained with primary treatment. In this Masster Plan, secondary treatment is planned, however, setting of target effluent quality standards is not considered in this Study. Therefore, any wastewater treatment process which require high operation and maintenance cost is not suitable.
- By avoiding mechanical equipment, effort required for maintenance of those equipment and skilled manpower will become unnecessary.
- Proposed treatment plant sites are on slopes, and construction of two-stage trickling filter using graivty flow is possible.
- After commercing operation, if recirculation become necessary, it is possible to construct pumping facilities.

Annex JC Removal Rates in Trickling Filter Process.

JC-1 BOD

1) Normas de Diseño de Plantas de Tratamiento de Aguas Residuales 1993.

Removal rates are set as follows:

- in primary sedimentation tank (PST)

  For influent BOD, 100~200 mg/L 33%

  " " 200~300 mg/L 36%

- in trickling filter process . . . . . 50~95%

2) Wastewater Treatment Process and Plant Design, Japan Sewage Works Agency, 1962

Following method is used for calculating removal rate of two-stage trickling filter

Influent BOD Concentration = 280 mg/L

Primary sedimentation tank effluent = 280 x (1-0.35)

= 182 mg/L

(Average removal rate in PST is assumed to be 35% based on average reported in Reference 1)

First-stage trickling filter effluent = 182 x 0.5

= 91 mg/L

Second-stage trickling filter effluent = 91/(R+2)

= 45.5 mg/L (R : Recirculation ratis)

Therefore, overal removal rate = $\frac{280-45.5}{280}$

= 0.84

3) Wastewater Engineering Treatment and Disposal, Metcalf and Eddy, 1991 NRC equation is used for design calculations. In this method, to obtain a required removal rate. BOD loading is determined and the size of the filter bed is decided. Based on the example indicated, It is possible to obtain about 80% removal in terms of BOD.

4) Conclusion

Based on the references 1)~3), overall removal rate in wastewater treatment process employing trickling filter process is set at 80%.

Removal rate in PST is 35% and removal rate in first-stage trickling filter is set at 50%.

For second stage trickling filter, removal rater is assumed such that the overall removal rate is 80%.

JC-2 SS

In Reference 1) SS removal rate in PST and PST + TF(overall) are reported as follows:

- PST

  For influent BOD 100~200 mg/L 53%

For influent BOD 200~300 mg/L..... 60%

- For both (PST + TF) ..... 50~92%

Other references on SS removal suitable for this purpose is not available. For high-rate trickling filter process with intermediate clarifier, considering that sedimentation is done twice, the overall removal rate is calculated as follows:

Overall SS removal rate = 0.6 + (1-0.6) x 0.53

= 0.81

This value is between the range of 50~92% From the above, overall removal SS rate in PST + TF is considered as 80%. Removal rate in the primary sedimentation tank is set at 55%.

JC-3 Summary

Based on the discussion in JC-1 and JC-2, removal rate of BOD and SS are as shown in Table JC-1.

Table JC-1 Removal Rates for High-rate Trickling Filter Process

Parameter	Removal Rate (%)			
	Primary Treatment	Secondary Treatment		Overall
	PST	TF(I) IC+(I)	TF(II) FC+(II)	
BOD_5	35	50/68	38/80	80
SS	55	56/80		80

Note: 1. Removal rate A/B indicates removal rate in the individual facility (A) and the overall removal rate (B) including the facility.

2. Detailed discussion is included in Supporting Report J, Annex JB.

Source : Study Team

SUPPORTING REPORT K

POLLUTANT LOAD ESTIMATION

SUPPORTING REPORT K
POLLUTANT LOAD GENERATION
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K POLLUTANT LOAD GENERATION

K1 INTRODUCTION

In this Supporting Report, estimates of pollutant load generation for the existing condition, (1995), and in the target year, (2015), are made based on the information available. All of the estimates are for dry weather flows and storm water pollutant load is not estimated. The major objective of this exercise is to arrange and classify existing information by drainage sub-basins, so that it can be used as a wastewater management tool. Since there are many deficiencies in the available data, it is proposed that a continuous effort be made to verify / renew information to make a better representation. The methodology used for estimation is discussed indicating the assumptions made.

K2 METHODOLOGY

Basic information necessary for estimating pollutant load comprises:

- Physical information, (topography, land use, population, drainage basin, discharge locations etc.),
- Unit pollutant load generation,
- Variations of the above,

In Sections K2.1 and K2.2, water consumption rate / wastewater generation and unit pollutant load generation are discussed considering the water quality survey results and other references. In Section K3 physical information for each of the sub-basins is presented together with wastewater discharges.

K2.1 Water Consumption and Wastewater Generation

Water consumption can be estimated from the sum of meter readings or by deducting system losses, (leakage, etc.), from the total water production. The former method is used here to estimate water consumption.

Table K-1 shows the average quantity of water billed by zone for 1994.

Table K-1 Average Quantity of Water Billed by Zone in 1994 (except November)

Zone	Water Consumed, m^3/month		
	Estimated	Real	Total
1	167,058	311,736	478,794
2	36,086	103,072	139,158
3	71,878	137,389	209,266
4	98,951	33,010	131,961
5	77,989	248,957	326,947
6	191,235	365,596	556,831
7	175,336	466,269	641,605
8	21,439	75,438	96,878
9	42,439	81,196	123,634
10	59,364	102,600	161,964
11	91,109	306,433	397,542
12	195,426	531,122	726,548
13	67,199	140,762	207,961
14	31,596	108,887	140,482
15	25,920	129,716	155,637
16	25,365	29,474	54,838
17	39,447	132,678	172,124
18	171,528	327,469	499,007
19	37,315	79,323	116,638
Total	1,626,689	3,711,126	5,337,816

Note: 1 Estimated means water consumed was estimated when the water meter was not working.

2 Real data is from water meter readings

Using population data from the 1994 census which recorded a population of 822,587 in Guatemala City, and estimates of the ratio of population distribution between zones made in 1995 (INE), the population of Zones 1 to 25 is estimated.

Table K-2 shows per capita water consumption for each zone in 1994. Maximum per capita consumption is 1,222 lpcd in Zone 4 while the minimum was 103 lpcd in Zone 18. Average water consumption in Zone 1 to 19 was 233 lpcd.

Zones 17 and 18 lie outside of the Central Region and the unit per capita consumption excluding these zones is 268 lpcd. This includes domestic, institutional and commercial water consumption.

Table K-2 Estimated Water Consumption by Zone in 1994

Zone	Population		Monthly Water Consumption in 1994 m3/month	Average Per Capita Consumption lpcd	Ratio to Average Water Consumption
	1995	1994			
1	79,000	57,000	478,794	280	1.18
2	21,000	15,000	139,158	309	1.30
3	56,000	40,000	209,266	174	0.73
4	5,000	3,600	131,961	1,222	5.15
5	94,000	68,000	326,947	160	0.68
6	82,000	59,000	556,831	314	1.32
7	170,000	123,000	641,605	174	0.73
8	27,000	19,000	96,878	170	0.72
9	7,000	5,000	123,634	824	3.48
10	24,000	17,000	161,964	318	1.34
11	52,000	38,000	397,542	349	1.47
12	86,000	62,000	726,548	391	1.65
13	28,000	20,000	207,961	347	1.46
14	18,000	13,000	140,482	360	1.52
15	16,000	12,000	155,637	432	1.82
16	8,000	5,800	54,838	315	1.33
17	12,000	9,000	172,124	637	2.69
18	223,000	161,087	499,007	103	0.43
19	32,000	23,000	116,638	169	0.71
22	86,000	62,000			
24	8,000	5,800			
25	6,000	4,300			
Total	1,140,000	822,587	5,337,815		
Total of Zones 1~19	1,047,000	755,487	5,337,815	237	
Total of Zones 1~16 and 19	805,000	580,400	4,666,684	268	

Note : Zone 17 and 18 are in East 1 Region .

Zones 1~16 and 19 are in Central Region.

Source : Study Team

In the Central Region, urbanization will continue and, by the year 2015, the gross per capita water consumption is expected to have increased by 10% to 295 lpcd. From past trends, it is clear that difficulties in finding new water resources for the increasing population will limit the per capita consumption.

Table K-3 shows the breakdown of water consumption in 2015 in terms of domestic and institutional/commercial consumption.

Table K-3 Unit Water Consumption in the Year 2015

Area	Domestic	Institutional/ Commercial	Gross Average Per Capita Water Consumption lpcd
Central Guatemala & Mixco	200	95	295
Others	200	20	220

Source : Study Team

Institutional / Commercial activity is low in other municipalities compared to Central Guatemala and Mixco. For other areas institutional/commercial water consumption is assumed to be 20 lpcd.

Table K-4 shows the monthly variation of water consumption in 1994. The ratio of the maximum monthly water consumption to the average monthly consumption is 1.084 therefore the ratio of the maximum daily flowrate to the daily average flowrate is set at 1.1.

Table K-4 Monthly Variation of Water Consumption in 1994 for Guatemala City

Month	Water Consumed, m³/month			Ratio of Monthly Total to Average
	Estimated	Real	Total	
Jan	1,551,653	3,609,497	5,161,150	0.967
Feb	1,656,877	3,498,934	5,155,811	0.966
Mar	1,659,206	3,341,960	5,001,166	0.937
Apr	1,694,658	3,961,484	5,656,142	1.060
May	1,645,085	3,597,688	5,242,773	0.982
Jun	1,588,784	3,768,175	5,356,959	1.004
Jul	1,589,571	3,897,859	5,487,430	1.028
Aug	1,587,067	3,718,891	5,305,958	0.994
Sep	1,788,985	3,999,760	5,788,745	1.084
Oct	1,544,199	3,788,420	5,332,619	0.999
Nov	-	-	-	-
Dec	1,587,498	3,639,721	5,227,219	0.979
Average	1,626,689	3,711,126	5,337,816	1.000

Source : Study Team

The volume of wastewater generated is assumed to be equal to the volume of water consumed.

K2.2 Wastewater Quality

Wastewater quality is estimated considering the following:

- Unit pollutant loads reported in the literature, (including that used in IDB Master Plan, 1976),
- Water quality survey results of Las Vacas River immediately upstream and downstream of Gran Collector discharge,
- *Unit pollutant load estimated for domestic sources.*

Unit pollutant loads reported in the literature are as shown in Table K-5. below.

Table K-5 Unit Pollutant Loads Reported in the Literature

Source	Unit Pollutant Load, gpcd			
	BOD	SS	T-N	T-P
Design Guidelines for Sewerage, Japan Sewage Works Agency, 1994	57	43	12	1.2
Joukasou* System for Treatment of Domestic Wastewater,1994	40~50	-	10~12	1.2~1.5
Imhoff. Germany	54	-	13.9	2.3
IDB Master Plan, 1976.	54	-	-	-

Note : * Joukasou, (literally meaning purifying tank), is a compact treatment unit developed in Japan for treatment of household and small community wastewater.

Source : Study Team

From the above, the average per capita BOD load is set at 56 gpcd. The estimated per capita BOD load for domestic sources ranged from 15 gcpd for low-income colony to 53 gpcd for the high-income colony as described in Table E-19 of Supporting Report E.

Assuming domestic water consumption to be 200 lpcd and a unit per capita BOD load of 56 gpcd, average wastewater concentration will be 280 mg/L. This concentration is reasonable considering the following:

1) As discussed in Chapter 4, Section 4.1, the average daytime BOD concentrations of Gran Collector were 277 and 242 mg/L; SS concentrations averaged 264 and 318 mg/L.
   Assuming that the ratio of daytime flow to the total daily flow varies between 0.7 and 0.5, average BOD (or SS) concentrations are estimated. The average BOD concentration is 215 mg/L with a standard deviation of 51 mg/L while that for SS averages 241 mg/L and has a standard deviation of 60 mg/L. Considering the sum of the average and standard deviation for design, the resulting concentrations of BOD and SS are 266 and 301 mg/L respectively.
2) Similarly, for the four collectors and drainage channels which discharge wastewater, the average BOD concentration was 172 mg/L with a standard deviation of 104 mg/L, (total 276 mg/L), and SS concentrations were 136 mg/L and 110 mg/L, (total of 246 mg/L).

Per Capita SS load is also assumed to be uniform and its concentration is also set at 280 mg/L. Further it is also assumed that the increase in per capita generation of pollutant load up to the year 2015 will be proportional to the increase in water consumption. In other words, the wastewater concentration is assumed to remain at 280 mg/L in terms of BOD and SS while the per capita pollutant load increases.

Table K-6 shows the total per capita pollutant load generation, including that of institutional/commercial origin, in the year 2015.

Table K-6 Per Capita Pollutant Load Generation in 2015 (including that of Institutional / Commercial Origin)

Area	Wastewater Generation, lpcd			Unit Pollutant Load Generated, BOD or SS, gpcd		
	Domestic	Institutional Commercial	Total	Domestic	Institutional Commercial	Total
Central Guatemala and Mixco	200	95	295	56	26.6	82.6
Others	200	20	220	56	5.6	61.6

Source : Study Team

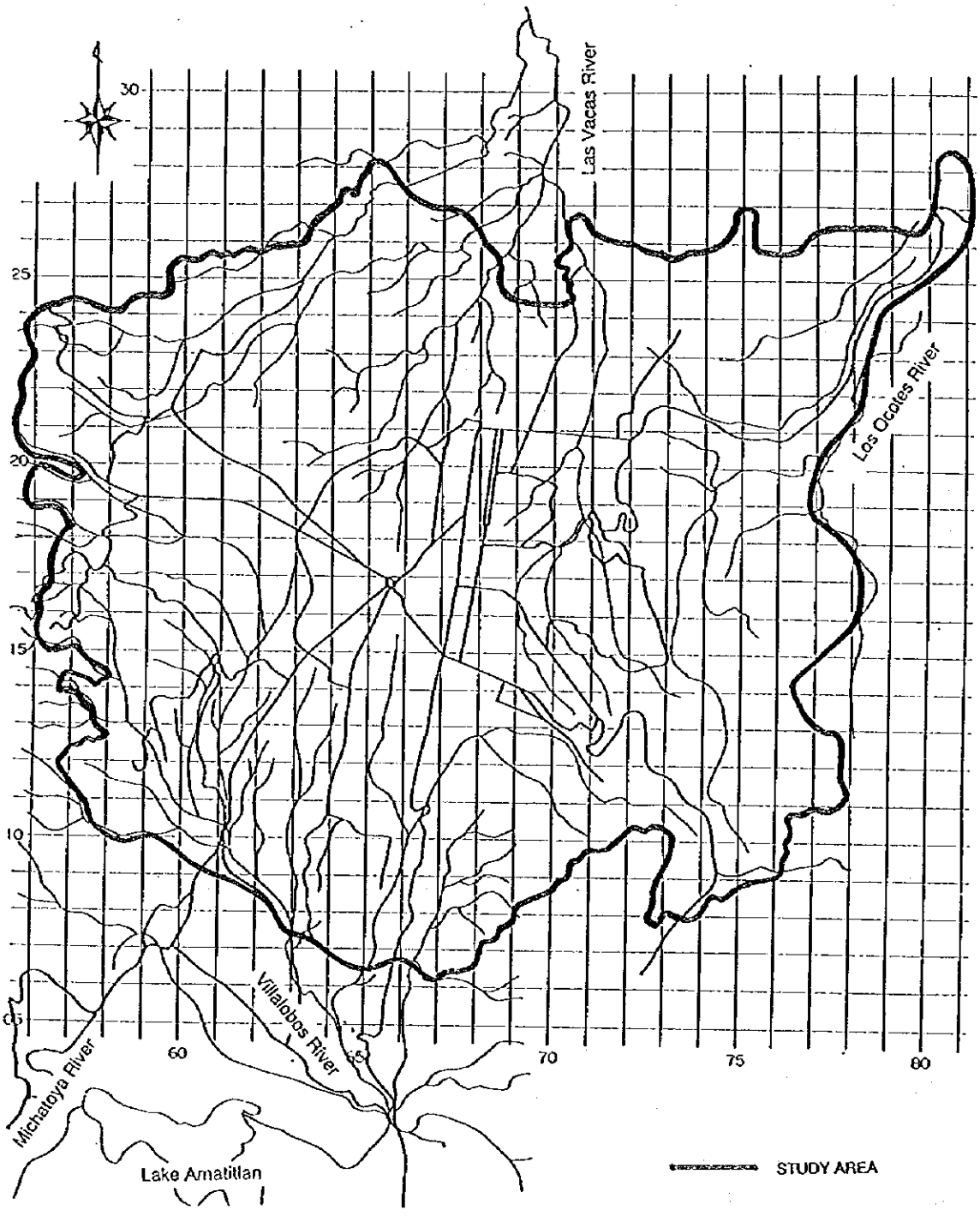
K3 WASTEWATER DISCHARGES BY DRAINAGE BASIN

Figures K-1, K-2 and K-3 show the rivers in the Motagua River Basin and Lake Amatitlan Basin. Only those within the Study Area are considered for further analysis.

K3.1 Existing Wastewater Discharges by Drainage Basin

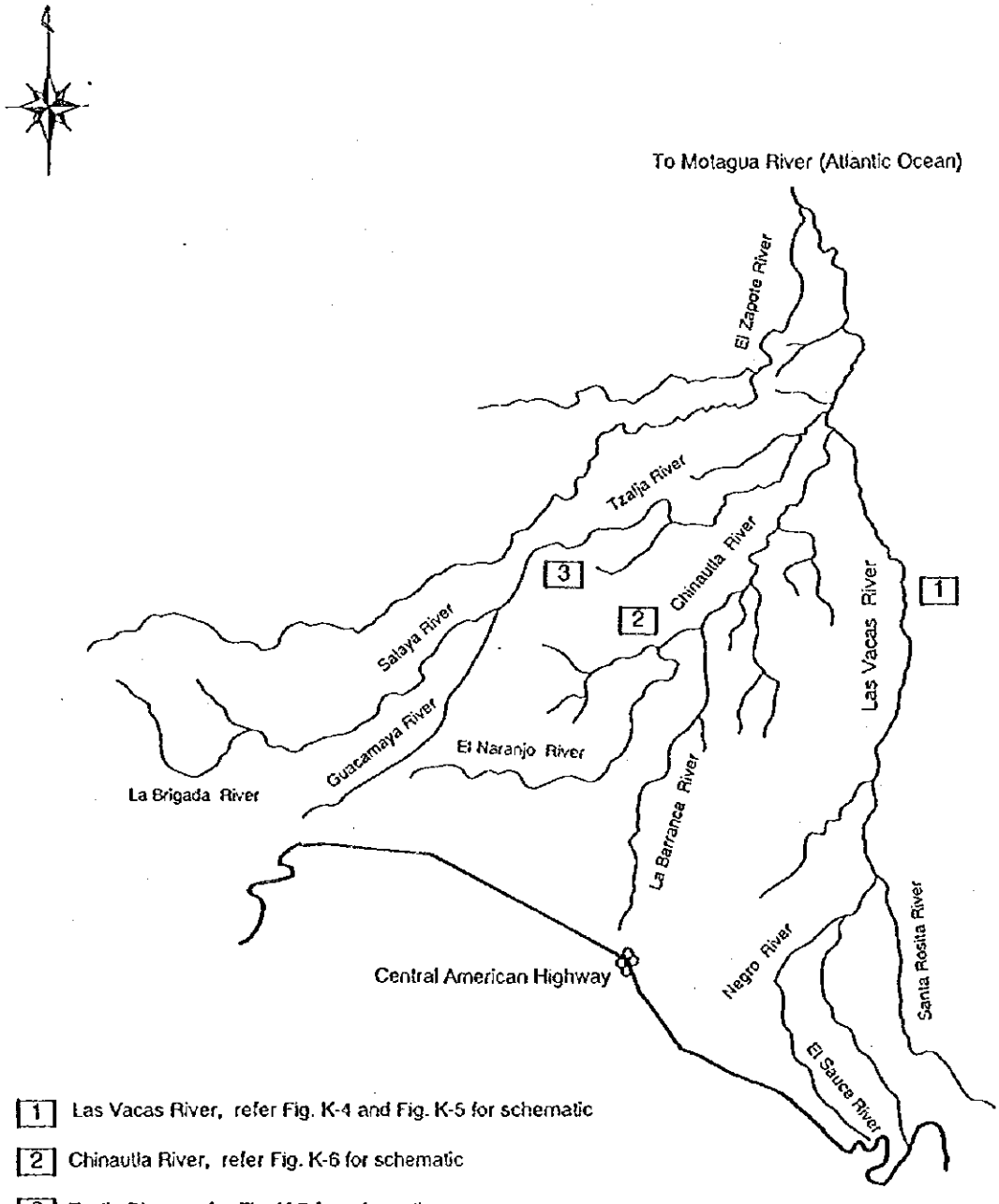
Table K-7 shows the number of known wastewater discharges in the Study Area according to drainage basins. Motagua River basin has 41 separate and 37 combined sewer discharges which include Gran Collector sewer discharging downstream of Belice Bridge. Lake Amatitlan Basin has fewer separate sewer discharges, (24), and a similar number, (35), of combined sewer discharges. This data is taken mainly from one of the Study Reports conducted for EMPAGUA. Wastewater discharges from El Zapote River in the Motagua

Fig. K - 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 PRINCIPAL RIVERS IN THE STUDY AREA

Fig. K - 2



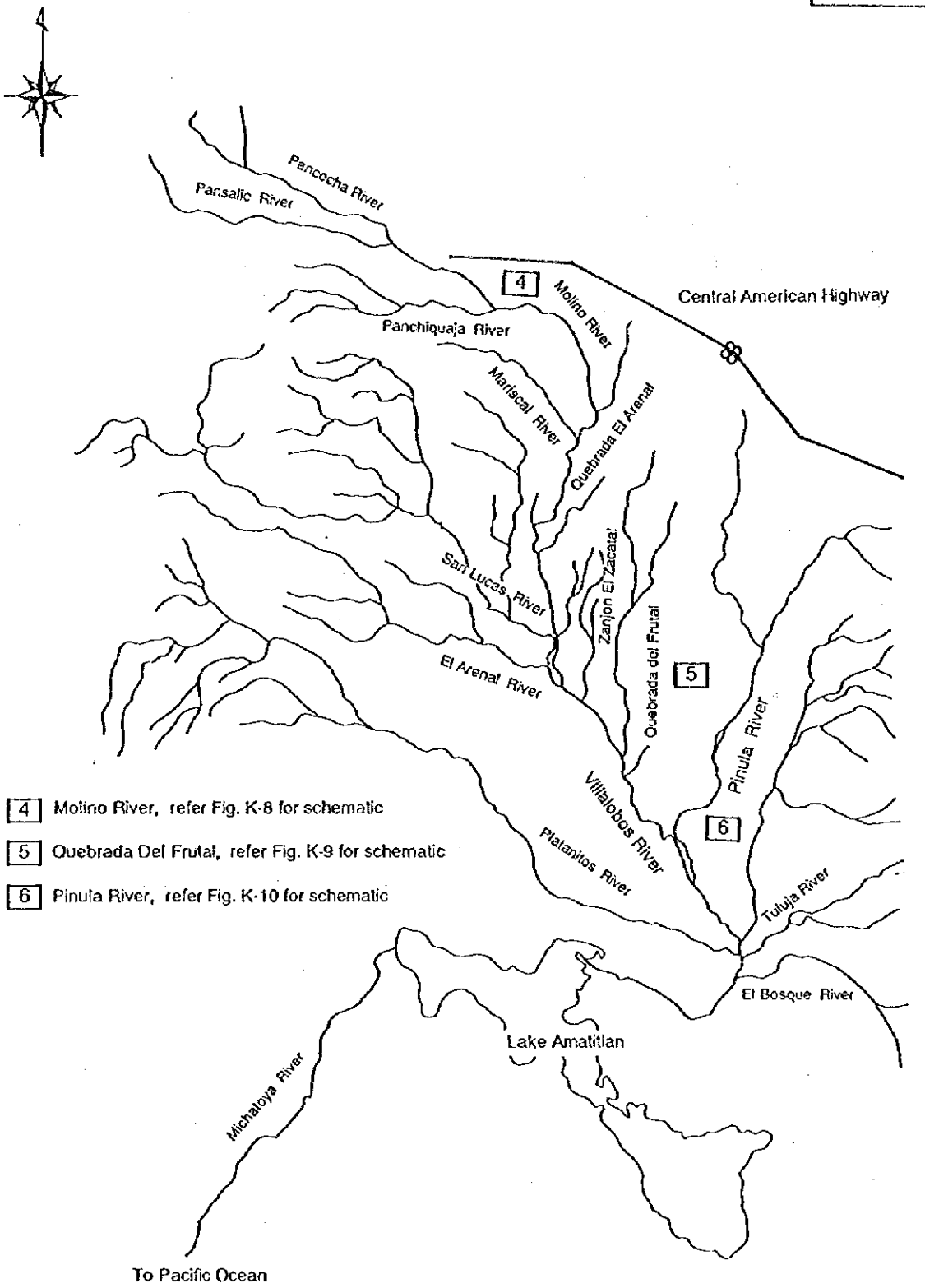
[1] Las Vacas River, refer Fig. K-4 and Fig. K-5 for schematic

[2] Chinautla River, refer Fig. K-6 for schematic

[3] Tzalja River, refer Fig. K-7 for schematic

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 RIVERS IN THE MOTAGUA BASIN

Fig. K - 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 RIVERS IN THE LAKE AMATITLAN BASIN

River Basin, and Las Minas River, Platanitos River (Sucio River), El Molino River and El Bosque River in the Lake Amatitlan Basin are not known.

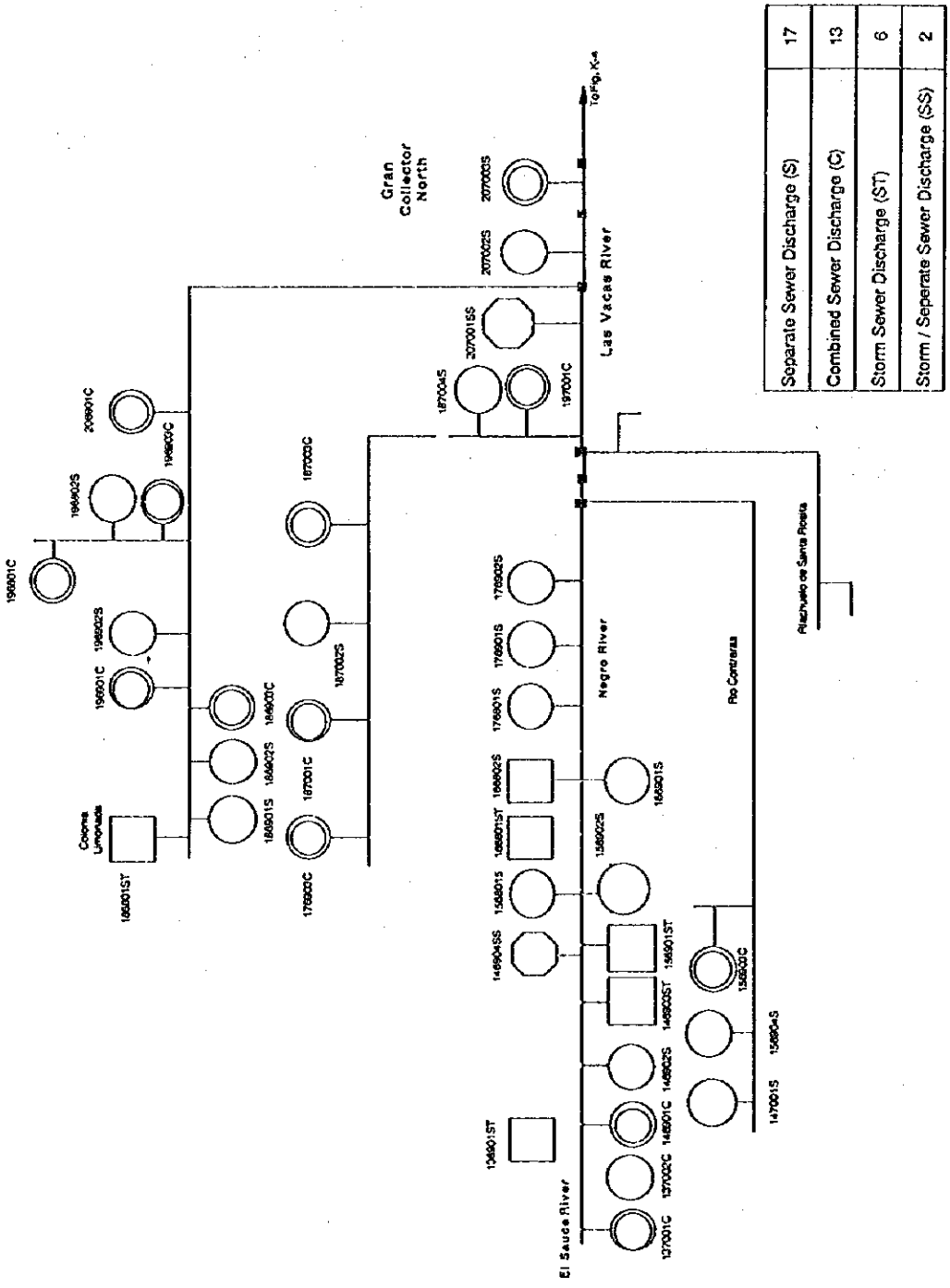
The locations of the known discharges are plotted on a 1:15,000 scale map and are numbered using six digits followed by an alphabetical code. The first four digits are the coordinates of latitude and longitude, the last two digits are a serial number allocated for each discharge within a 1 km square working towards the north and east. The alphabetical code indicates the type of sewer, i.e. whether separate, (S), combined, (C), or storm sewer, (ST).

Figures K-4, K-5, K-6, K-7, K-8, K-9 and K-10 show, in schematic form, the discharges for the sub-basins together with water supply intakes and small-scale sewage treatment works discharges. Water supply intakes are located along Pinula River (Fig. K-10) and La Brigada-Salaya-Tzalja River (Fig. K-7).

For the collector sewer discharges shown in Figures K-4 through K-10, the drainage area and population were estimated from the drawings and are shown in Figures K-11 and K-12. The total areas discharging through collectors in Central Region and North 1 Region are 779 ha and 38 ha respectively and the corresponding populations are 85,300 and 3,000, (in 1995), excluding the catchment covered by Gran Collector. The area covered by Gran Collector is 5,945 ha and the population served is 582,200, (in 1995).

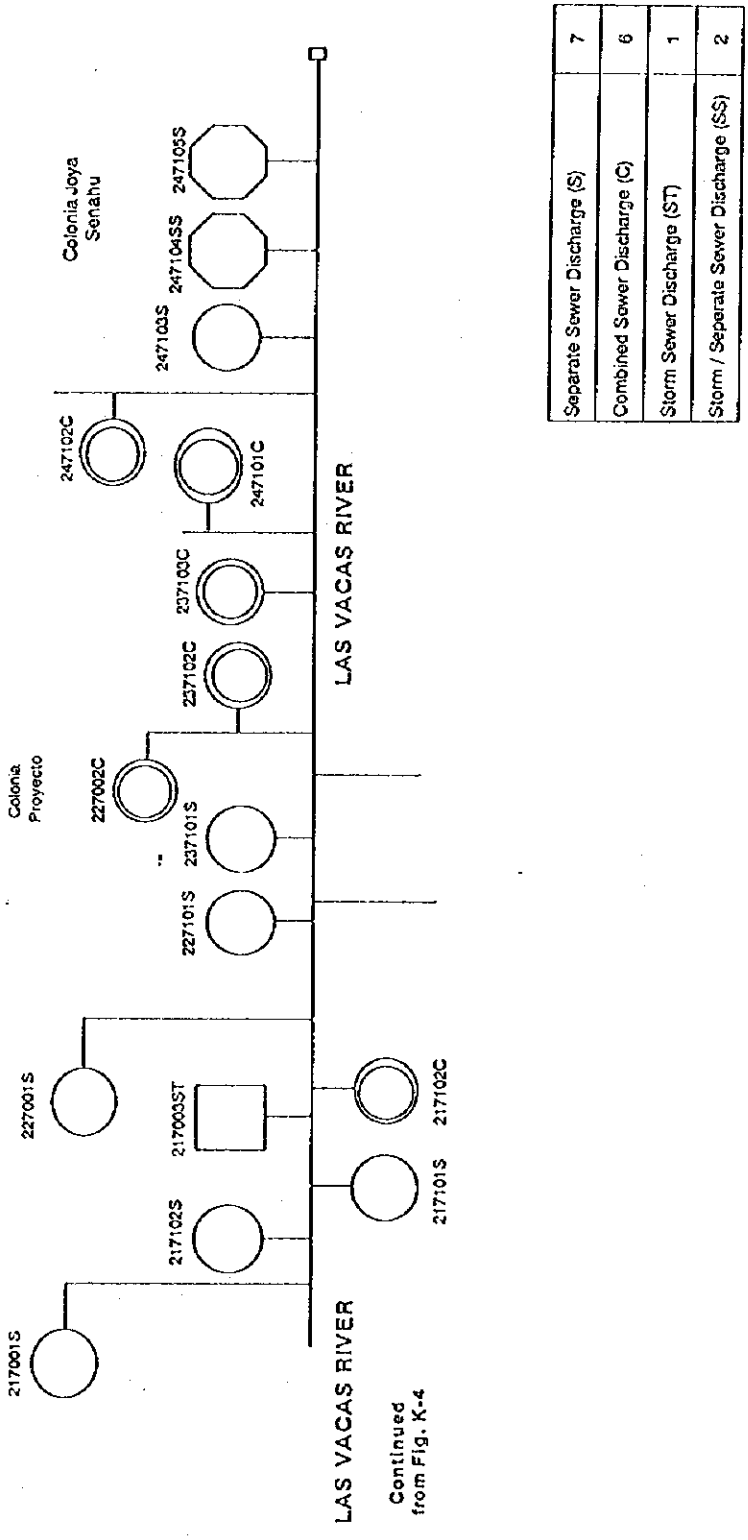
For the Villalobos River, the sewered area is smaller compared to the Las Vacas River. At this stage, a total area of 374 ha and a population of 35,000 persons is known to discharge through collectors.

Fig. K - 4



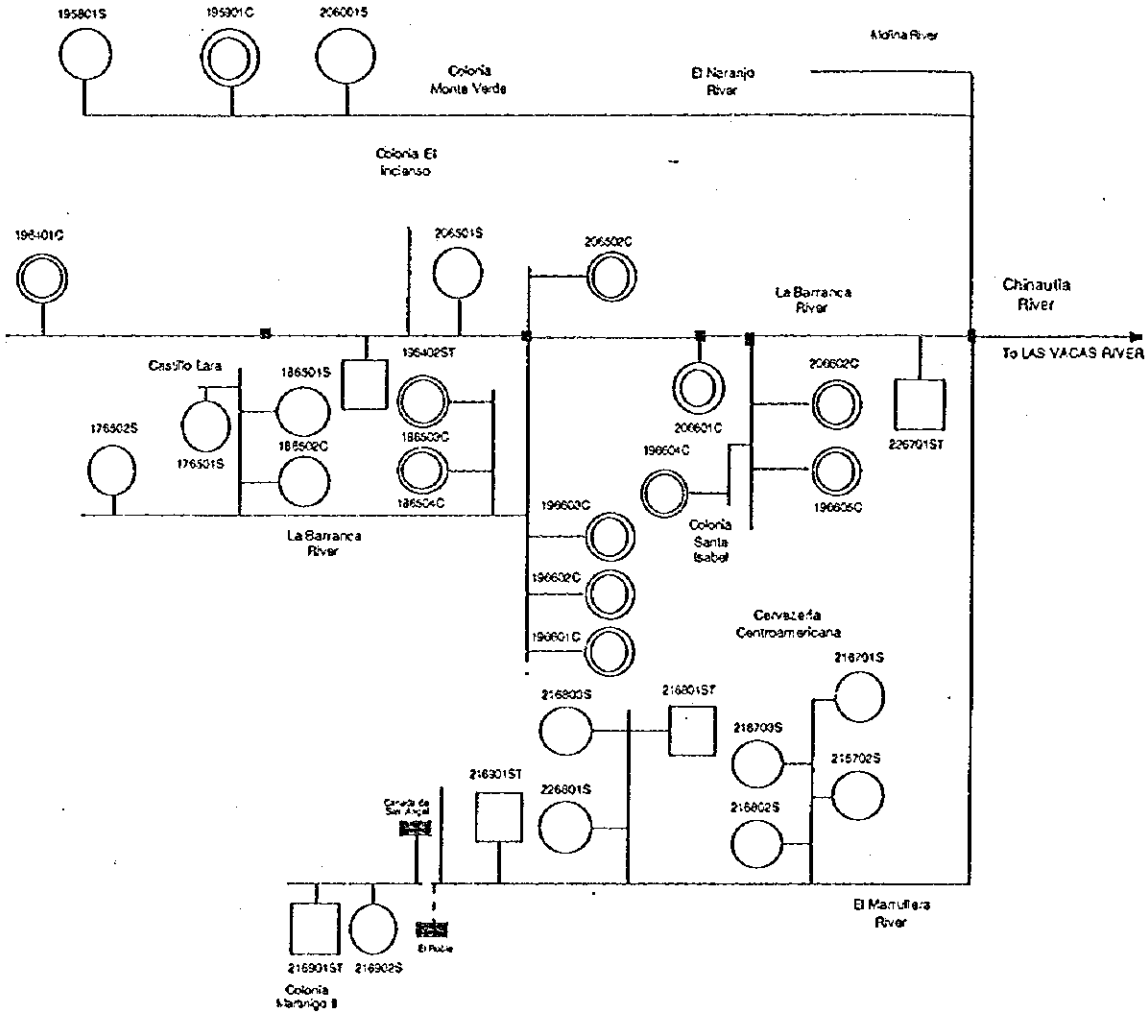
THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE SCHEMATIC OF DISCHARGES TO LAS VACAS RIVER 1 / 2

Fig. K - 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 SCHEMATIC OF DISCHARGES TO LAS VACAS RIVER 2 / 2

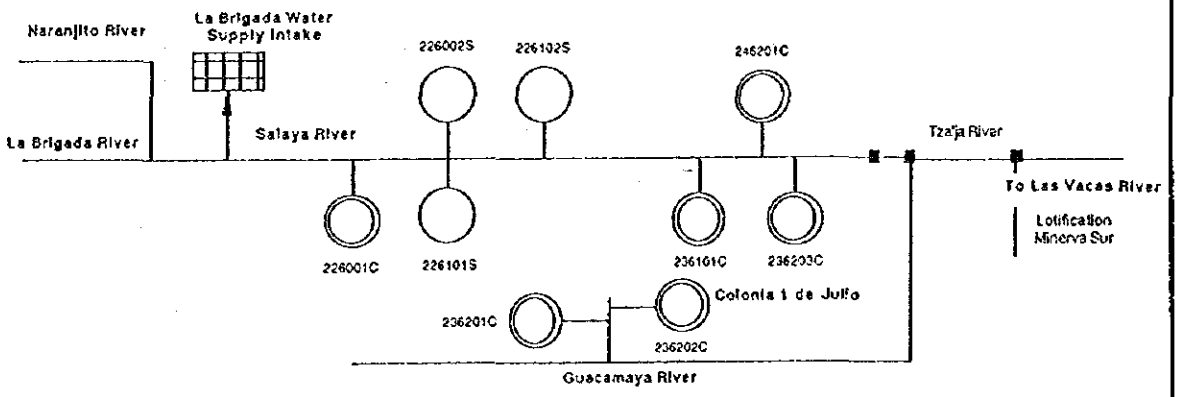
Fig. K - 6



Separate Sewer Discharge (S)	14
Combined Sewer Discharge (C)	12
Storm Sewer Discharge (ST)	5
Storm / Seperate Sewer Discharge (SS)	-

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 SCHEMATIC OF DISCHARGES TO CHINAUTLA RIVER

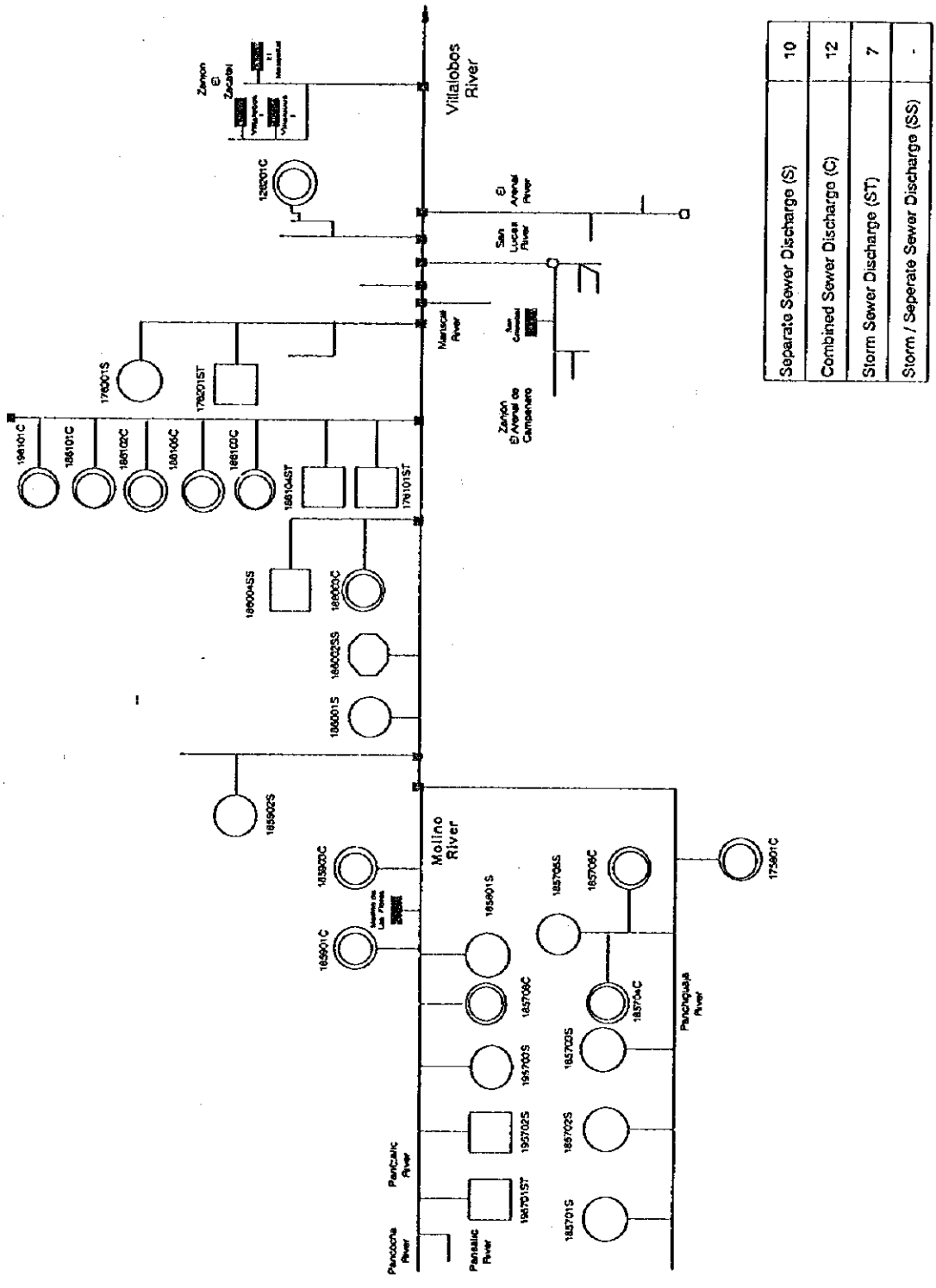
Fig. K - 7



Separate Sewer Discharge (S)	3
Combined Sewer Discharge (C)	6
Storm Sewer Discharge (ST)	-
Storm / Seperate Sewer Discharge (SS)	-

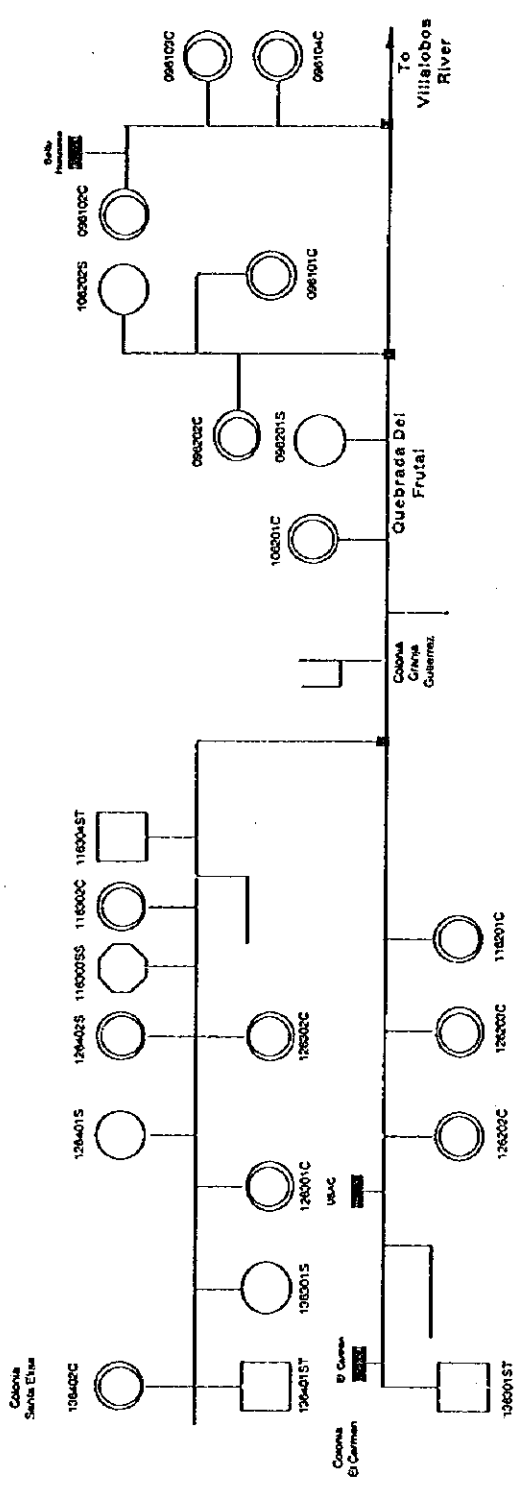
THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE SCHEMATIC OF DISCHARGES TO TZALJA RIVER

Fig. K - 8



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 SCHEMATIC OF DISCHARGES TO MOLINO RIVER

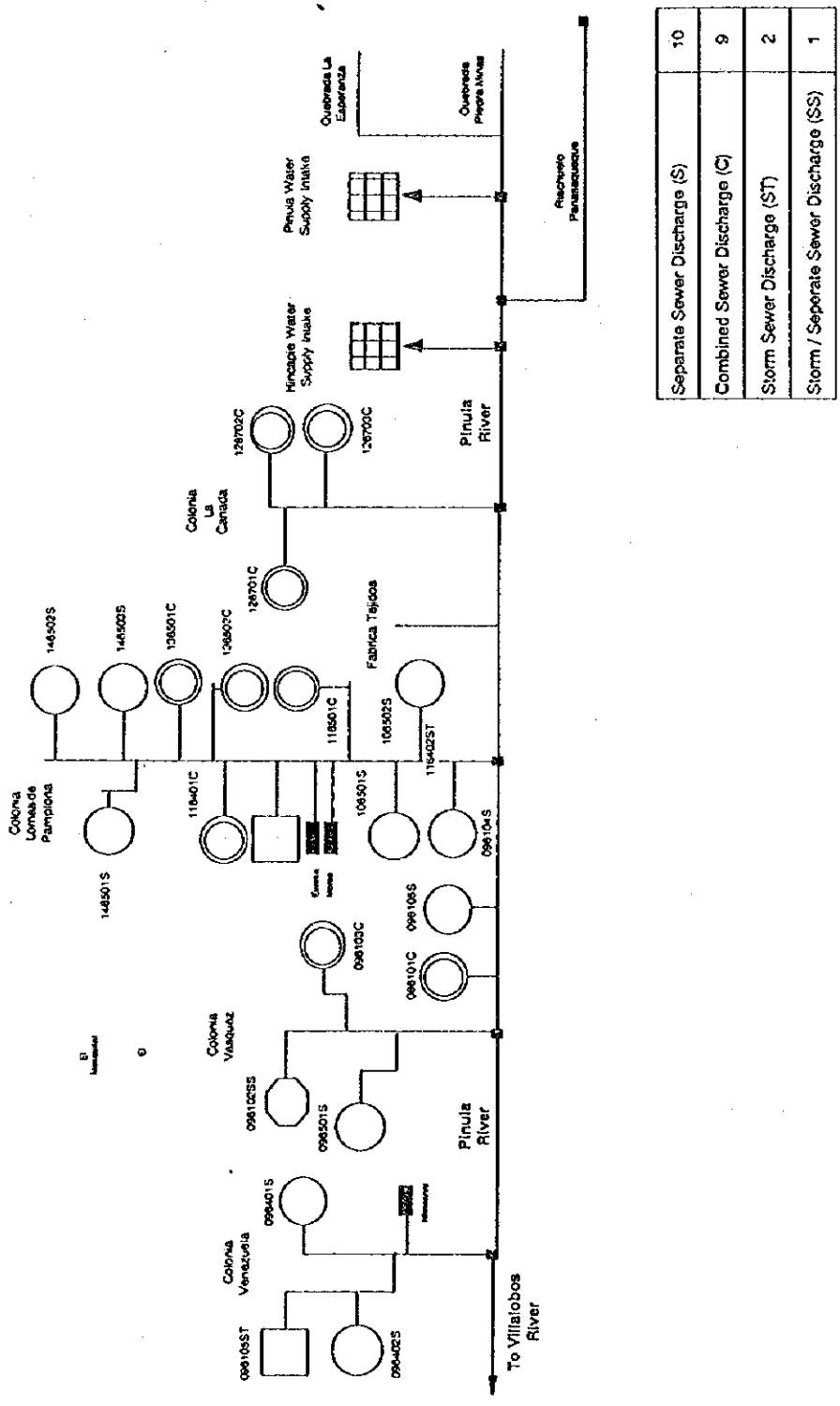
Fig. K - 9



Separate Sewer Discharge (S)	4
Combined Sewor Discharge (C)	14
Storm Sewer Discharge (ST)	3
Storm / Seperate Sewer Discharge (SS)	1

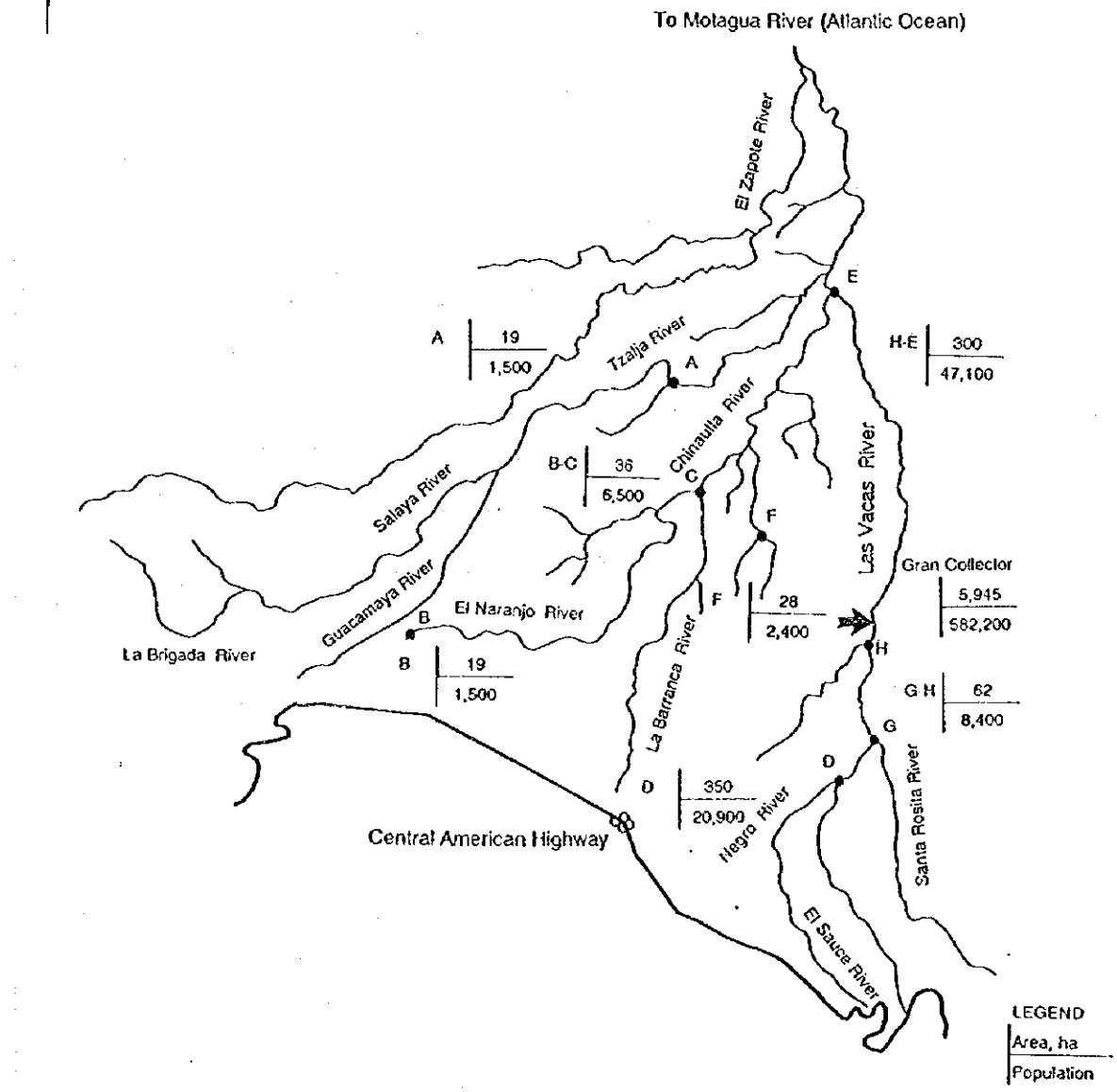
THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE SCHEMATIC OF DISCHARGES TO QUEBRADA DEL FRUTAL

Fig. K - 10



THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA	TITLE SCHEMATIC OF DISCHARGES TO PINULA RIVER
	JAPAN INTERNATIONAL COOPERATION AGENCY	

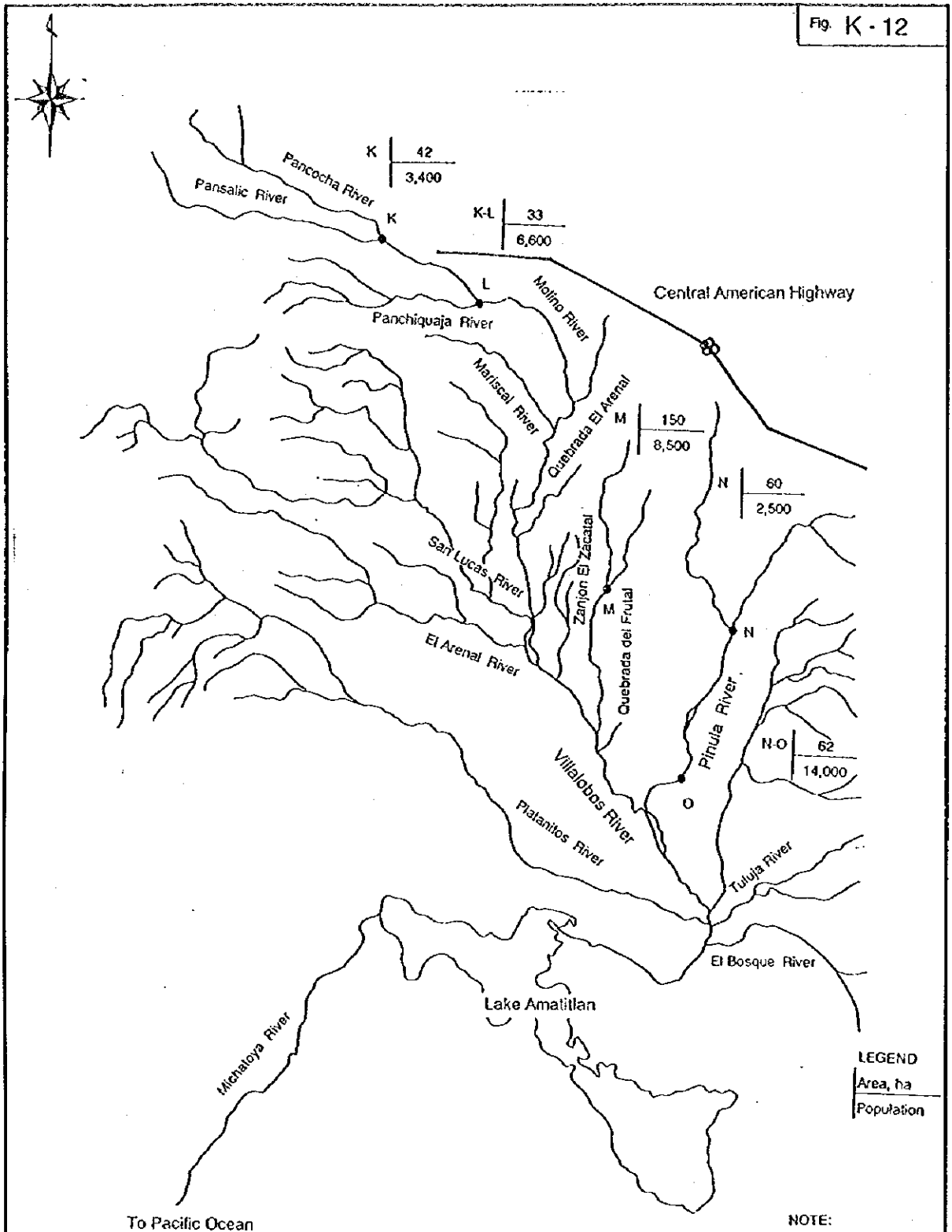
Fig. K - 11



NOTE:
Only known discharges are shown.

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 AND CATCHMENT AREA FOR DISCHARGES TO MOTAGUA BASIN

Fig. K - 12



NOTE:
Only known discharges are shown.

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 AND CATCHMENT AREA FOR DISCHARGES TO LAKE AMATITLAN BASIN

Table K-7 Number of Wastewater Discharges in the Study Area According to Drainage Basin

Basin	River	Type and Number of Discharges				
		Separate	Combined	Storm Sewer	Dual Storm/ Sepa-rate	Total
Motagua River Basin	Las Vacas River	24	19	7	4	54
	Chinautla River (-Naranjo River)	14	12	5		34
	La Brigada-Salaya-Tzalja River	3	6			9
	El Zapote River	U	U	U	U	-
	Sub-Total	41	37	12		97
Lake Amatitlan Basin	Molino River	10	12	7		29
	Quebrada Del Frutal	4	14	3	1	22
	Pinula River	10	9	2	1	22
	Las Minas River	U	U	U	U	-
	Sucio River (-Platanitos River)	U	U	U	U	-
	El Molino River	U	U	U	U	-
	El Bosque River	U	U	U	U	-
	Sub-Total	24	35	12	2	73
Total		68	72	24	2	170

Note : U means unknown.

This table does not show all the discharges in the Study Area as there is limited information available.

Source : Investigacion de las Descargs de Aguas Residuales y Pluviales en la Ciudad de Guatemala, Rudy Fernando Morales Mancilla, EMPAGUA and Study Team

Based on the water quality survey results, pollutant loads were estimated and are shown in Table K-8 for the Las Vacas River, (upstream and downstream of Gran Collector), Villalobos River, Pinula River and Molino River. Due to the many assumptions already made to estimate this data, no further attempt is made to calculate the annual pollutant load. It is recommended that further studies be made to obtain basic data for pollutant load estimation.

Table K-8 Pollutant Loads Estimated for Las Vacas River near Gran Collector Outfall, and Villalobos River and its Tributaries

Parameter	Las Vacas River (near Gran Collector Outfall)				Villalobos River and Tributaries					
	Upstream of Outfall		Downstream of Outfall		Villalobos River Mouth (near Maya Crops)		Pinula River (Puente Villa Hermosa)		Molino River (Puente Villalobos)	
Daytime Load.(approximate 7:30~16:00)										
BOD, kg	468.7	742.6	7,137.0	7,332.8	3,057.3	1,388.1	1,428.6	1,163.5	632.0	192.1
COD, kg	596.4	1,057.6	9,094.4	9,293.4	6,090.8	1,889.9	1,924.5	1,883.4	867.2	428.4
SS, kg	1,011.4	1,941.2	9,233.5	19,230.8	31,626.8	6,504.3	5,825.2	4,363.3	1,475.0	165.1
T-N, kg	25.23	33.32	1,533.62	632.02	693.66	407.18	288.59	298.99	107.68	134.30
T-P, kg	27.48	36.64	221.80	206.74	166.93	69.66	20.97	31.39	14.97	11.18
Daily Load(Daytime Load/Total Load = 0.5)										
BOD, kg/d	938	1,485	14,274	14,666	6,115	2,776	2,857	2,327	1,264	384
COD, kg/d	1,193	2,115	18,189	18,587	12,182	3,780	3,849	3,767	1,734	857
SS, kg/d	2,023	3,882	18,467	38,462	63,254	13,009	11,650	8,727	2,950	330
T-N, kg/d	50.5	66.6	3,067.2	1,264.0	1,387.3	814.4	577.2	598.0	215.4	268.6
T-P, kg/d	55.0	73.3	443.6	413.5	333.9	139.3	41.9	62.8	29.9	22.4
Daily Load(Daytime Load/Total Load = 0.6)										
BOD, kg/d	781	1,238	11,895	12,221	5,096	2,313	2,381	1,939	1,053	320
COD, kg/d	994	1,763	15,157	15,489	10,151	3,150	3,207	3,139	1,445	714
SS, kg/d	1,686	3,235	15,389	32,051	52,711	10,841	9,709	7,272	2,458	275
T-N, kg/d	42.1	55.5	2,556.0	1,053.4	1,156.1	678.6	481.0	498.3	179.5	223.83
T-P, kg/d	45.8	61.1	369.7	344.6	278.2	116.1	35.0	52.3	24.9	18.63

Note : Day-time loads means the load during approximately 7:30~16:00

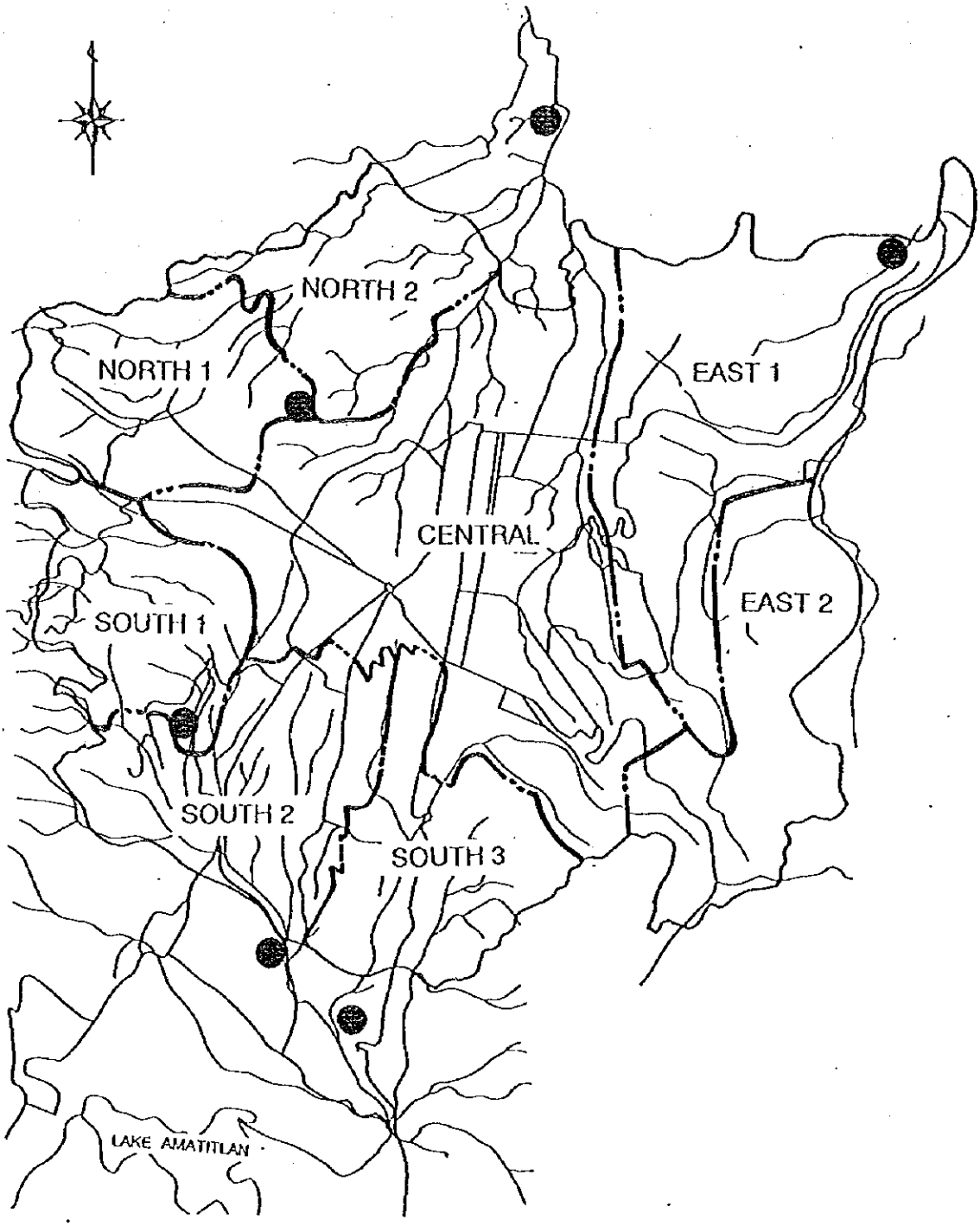
Source : Study Team

At the completion of implementation of the Master Plan, wastewater discharges will only be through sewers. Existing separate and combined sewer discharges will be connected to the planned collector sewers. Figure K-13 shows the location of proposed wastewater treatment plant discharges in the year 2015.

K4 POLLUTANT LOAD GENERATION

Pollutant load generated and removed at wastewater treatment plants and at the sanitation treatment facilities when the implementation of Master Plan is completed for all Regions is shown in Table K-9.

Fig. K - 13



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 PROPOSED WASTEWATER TREATMENT PLANT SITES

Table K - 9 Pollutant Load (BOD) When Master Plan is Completed

Region	Population		Pollutant Load, ton BOD/d					Receiving Water Body for WWTP Discharges
			Generated	Removed			Discharged	
	Sewerage	Sanitation		WWTP	Sanitation	Total		
Central	751,800	109,600	72.54	53.26	4.48	57.74	14.80	Las Vacas River
North 1	379,100	12,900	25.59	19.91	0.53	20.44	5.15	El Naranjo River
North 2	0	150,000	8.17	0.00	6.13	6.13	2.04	
South 1	277,500	2,500	18.06	14.34	0.11	14.45	3.61	Zanjon El Arenal de Campanero (Molino River)
South 2	183,600	8,000	14.71	11.42	0.33	11.75	2.96	VIllalobos River
South 3	275,400	3,600	18.56	14.69	0.15	14.84	3.72	Pinula River / Villalobos River
East 1	500,800	20,200	34.81	26.97	0.83	27.80	7.01	Purgatorio River
East 2	0	40,000	2.18	0.00	1.64	1.64	0.54	
Total	2,368,200	346,800	194.62	140.59	14.20	154.79	39.83	

Note : WWTP is Wastewater Treatment Plant

Source : Study Team