CHAPTER 9
FUNDAMENTALS OF PLANNING FRAMEWORK

9.1 TARGET YEAR FOR PLANNING

To carry out the master planning for the improvement of an economically viable sewerage 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.

The Master Plan should, therefore, be compatible with sound projections of population increase, development programs, water consumption, income growth, and other national and local socio-economic factors affecting the future of the Study Area. The base year for future projections of planning framework is set in the year 2000, because almost all data available during the master plan study phase is that of the year 2000 with some exceptional cases.

9.2 SEWERAGE DISTRICTS

9.2.1 SEWERAGE PLANNING AREA

The boundaries of the Study Area were selected after the study on available maps, reports, growth projections, administrative boundaries, and existing sewerage system, and were confirmed by frequent discussions with the personnel of CRASAAN, municipalities and other concerned agencies. Site inspections have further highlighted significant urban, industrial and natural features.

The limits of the Study Area (Master Plan Area) are:

- On the north by Los Salados WWTP (19 °30' N and 70 ° 45' E);
- On the south to 19° 25' N down to El Papayo and Arroyo Hondo housing development areas;
- On the west by La Herradura near the Insituto Superior De Agricultura (ISA), and at the north west up to Cienfuegos WWTP site;
- To the east stretches as far as Sabaneta de Las Palomas and Pontezuela Arriba; and
- Licey and Tamboril Municipalities.

The Master Plan Area covers a total of 11,450 ha. urban districts, comprising municipalities of Santiago, Tamboril and Licey, as illustrated in Figures 9.1, 9.2 and 9.3. The Area was selected to encompass all feasible wastewater collection areas consistent with topography, existing and probable future population concentrations and distributions, and present and future housing development districts.

The Master Plan Area covers the densely populated urban districts in Santiago, Licey and Tamboril Cities, wherein the required branch, lateral, main, and interceptor sewers, and WWTPs should be implemented by stages up to the year 2015

It should be noted that the area limits of the Study Area were selected not necessarily with regard to the administrative district boundaries so as to develop the regional sewerage service areas for the purpose of effective pollution abatement.

9.2.2 SEWERAGE DISTRICTS

The whole sewerage master plan area is divided into eight independent Sewerage Districts, six Districts in Santiago City, and one each in Tamboril and Licey Cities. The division has been elaborated taking into account the present socioeconomic situations, topographic conditions,

trends of future sewer and urban development programs. Area of each District is shown in the following:

Sewerage District Areas **Unit: ha**

Santiago							Tamboril	Licey
Rafey	Cienfuegos	Los Salados	Embrujo	Zona Sur	Herradura	Sub total		
6,700	540	380	590	600	1,150	9,960	600	890

9.3 POPULATION

9.3.1 POPULATION IN THE SEWERAGE PLANNING AREA (STUDY AREA)

As explained in Chapter 2, populations of three municipalities in the Study Area are projected as follows:

Populations in Municipalities

Municipalities	2000	2005	2010	2015
Santigago	582,600	655,900	738,400	831,400
Tamboril	46,000	51,800	58,400	65,700
Licey	21,100	24,300	27,900	32,000
Total	649,700	732,000	824,700	929,100

Note) Figures above are rounded.

The populations in the sewerage planning area (Study Area) are estimated based on the population densities. The present population densities in the area are analyzed based on the water supply data of CORAASAN and categorized into four groups: high, medium high, medium low and low density. The future population densities are fixed taking into account the saturated populations and urban developing conditions in each district.

The population densities in each municipality in 2000 and 2015 are shown in the table below. The intermediate year between 2005 and 2010 could be calculated by linear regression relation.

Population Density in the Study Area

Population	Santiago		Tamboril		Licey	
Density Level	2000	2015	2000	2015	2000	2015
High	120	180	190	200	-	-
Medium-High	85	130	-	-	50	80
Medium-Low	65	89.43	8.98	35.5	-	-
Low	25	30	-	-	0.68	8.77

Source: JICA Study Team

Area by Population Density Category **Unit:ha**

Population Density Category	Santiago	Tamboril	Licey
High	400	110	-
Medium-High	1,090	-	160
Medium-Low	4,720	490	-
Low	3,750	-	730
Total	9,960	600	890

Source: JICA Study Team

The populations in each municipality at every five years up to 2015 are:

Population in the Sewerage Planning Area (Study Area)

Municipalities	Area (ha)	2000	2005	2010	2015
Santiago	9,960	517,600	596,700	671,900	748,300
Tamboril	600	25,300	30,700	35,100	39,400
Licey	890	8,500	11,800	15,600	19,200
Total	11,450	551,400	639,200	722,600	806,900

Source: JICA Study Team

9.3.2 SEWER SERVICE POPULATION

The percentage of the population inhabiting within the Study Area to that within the administrative area for both at present and in future is fixed at 90% for Santiago, but for Tamboril and Licey the percentages are estimated to increase from 55% to 60% and 40% to 60%, respectively.

The population distributions calculated by the Sewerage District and the year are as summarized in the following table:

Population Distribution in Sewerage Districts (2000 to 2015)

Sewerage District	Area (ha)	District Population (persons)			
		2000	2005	2010	2015
1. Santiago					
Rafey	6,700	358,400	413,300	465,500	518,800
Cienfuegos	540	35,900	42,000	48,100	54,000
Los Salados	380	22,800	26,600	30,400	34,000
Embrujo	590	28,800	33,100	37,300	41,500
Zona Sur	600	32,500	37,700	42,800	47,700
Herradura.	1,150	39,200	44,000	47,800	52,300
Sub-total	9,960	517,600	596,700	671,900	748,300
2. Tamboril	600	25,300	30,700	35,100	39,400
3. Licey	890	8,500	11,800	15,600	19,200
Total	11,450	551,400	639,200	722,600	806,900

Source: JICA Study Team

It is prudent to consider that the residents would not occupy the whole sewerage districts by 2015. Because in some isolated areas population would be so scares that the piped sewers construction would not be economically/technically justifiable, hence rely their waste disposal on such on-site waste disposal systems as aqua-privies and septic tanks.

The percentage of unsewered area to the whole sewerage district area differs depending on various factors such as the stage of sewer construction, extent of development programs, and socioeconomic conditions peculiar to the district.

The percentage of the sewered population (covered ratio) in each district by stage has been estimated assuming that such coverage percentage will increase at the rate of 2 to 5 percent a year, reaching from 50 to 90 percents by 2015. The coverage ratios vary due to the change of urban development or socioeconomic situations, and as such may be subject to adjustment from time to time in the future when more census and socioeconomic data are available.

The sewered ratio and service population in each Sewerage District by years are estimated as shown in the following table.

Upon completion of the entire sewerage improvement program by 2015, most of the wastewaters from the sewer service area would be intercepted, thereby approximately 733,400 residents would have access to the public sewerage system.

Sewer Service Ratios and Populations by Districts and Year

Sewerage District	Sewer Service Ratio and Population							
	2000		2005		2010		2015	
I. Santiago								
Rafey	0.70	251,800	0.76	313,700	0.85	394,800	0.95	493,000
Cienfuegos	0.67	23,900	0.74	30,900	0.80	38,300	0.87	46,800
Los Salados	0.70	16,000	0.77	20,500	0.83	25,200	0.90	30,600
Embrujo	0.72	20,600	0.78	25,700	0.84	31,200	0.89	36,800
Zona Sur	0.74	24,000	0.83	31,200	0.90	38,700	0.99	47,100
La Herradura	0.09	3,600	0.29	12,900	0.50	24,000	0.71	37,000
Sub-total	0.66	339,900	0.73	434,900	0.82	552,200	0.92	691,300
II. Tamboril	0.42	10,500	0.54	16,500	0.67	23,500	0.82	32,500
III.Licey	0.00	0	0.00	0	0.30	4,700	0.50	9,600
Total	0.64	350,400	0.71	451,400	0.80	580,400	0.91	733,400

Source: JICA Study Team.

9.4 DOMESTIC WASTEWATER QUANTITIES AND QUALITIES

9.4.1 GENERAL

Under the water quality surveys conducted in March 2001at the major points of wastewater outlets and rivers. The domestic wastewater qualities and quantities are then estimated based on the survey results and available data mainly with regard to the water supply system.

9.4.2 DOMESTIC WASTEWATER QUANTITIES

(1) Per Capita Domestic Wastewater Generation

CORAASAN's data on the domestic water consumption rates as of December 31, 2000, including those of metered and non-metered, indicate that an average of 133,378m^3/day water was distributed to 107,304 households. According to the metered water supply data, the average per capita domestic water consumption rates ranged from the lowest 118 lpcd in Tamboril to the highest 226 lpcd in Santiago, with an overall average per capita rate of 189 lpcd.

When the water consumptions include such non-industrial wastewaters as commercial and institutional waters, then the average per capita non-industrial water consumption rates could range from the lowest 128 lpcd in Tamboril to the highest 284 lpcd in Santiago, with an overall average per capita consumption rate of 247 lpcd. The whole per capita water consumption rates thus estimated are shown in the following table.

Water Consumption Rates of Metered Consumers (as of December 2000)

Zone No./Service Office	Domestic Water Consumption (m^3/day)	Number of households	*Number of Consumers (persons)	Per Capita Domestic Water Consumption (lpcd)	Non-industrial Water Consumption (m^3/day)	Per Capita Non-Industrial Water Consumption (lpcd)
1. Santiago	41,930	37,090	203,995	206	57,988	284
4. Gurabo	8,177	6,592	36,256	226	9,500	262
5. Punal	4,213	5,970	32,835	128	4,619	141
7. Cienfuegos	8,191	7,715	42,433	193	11,803	278
8. Bella Vista	5,506	5,212	28,666	192	6,618	231
9. Los Reyes	5,699	5,722	31,471	181	7,132	227
Sub-total	73,715	68,301	375,656	196	97,660	260
3. Licey	6,021	6,227	34,249	176	7,345	214
6. Tamboril	3,833	5,906	32,483	118	4,160	128
Total	83,569	80,434	442,388	189	109,165	247

Source: CORASSAN, breakdowns were made by the Study Team.
Note : *)5.5 persons/household is assumed based on CORAASAN data. Per capita consumption =Metered consumption/metered users.

Although the wastewater generation rates should be based on actual flow data from selected typical residential areas, persuasive data are lacking to determine the exact ratio. In view of this, the per capita wastewater generation rates were estimated based on the per capita water consumptions, assuming the average wastewater generation ratio of 75 percent. The per capita Domestic wastewater generation rates by year are shown in the table below:

Per Capita Domestic Wastewater Generation Rates by Year (lpcd)

Categories	2000	2005	2010	2015
Per Capita Water Consumption	260	273	287	300
Per Capita Wastewater Generation	195	205	215	225

Note: Calculated based on the data by CORAASAN.

The non-industrial wastewater, comprising domestic, commercial and institutional wastewater but excluding wastewater from hospitals, is termed as the domestic wastewater.

(2) Infiltration and Inflow (I/I)

Because of defective sewer joints, broken or cracked sewer pipes and manholes, and incorrectly connected stormwater drainage pipes to sanitary sewers, a significant amount of undesirable infiltrates and surface water inflows to the sewers are unavoidable. The average infiltration and inflow (I/I) into sewers generally range between 10 to 15 percent of the dry weather wastewater flows, 0.15 m^3/d (mm/km), or 50 to 100 lpcd.

The geographic conditions prevailing in the Santiago Region is that the dry clay strata cover most of the areas, with low groundwater elevations, which are dense and hard soils of relatively low permeability. Such conditions and climatic conditions suggest that the groundwater infiltration appears to be of rather low side.

In view of such conditions, a fixed I/I rate of 25 lpcd is considered to be of a reasonable assumption, and this fixed rate will be added to all the wastewater flowing conditions.

(3) Design Per Capita Domestic Wastewater Flow Rates

For the sewerage system hydraulic analysis, flow variations during a day have been assumed based on the data obtained from the existing water supply and from wastewater systems elsewhere under similar conditions.

The ratio of the maximum to average daily wastewater flows is selected to be 1.2, on account of the water use patterns in the water supply system, and the prevailing climatic conditions in the region. The peak flow rate (maximum hourly flow rate) for any one-day, which is to be used for the hydraulic computations of sewers, conduits and other pipelines, is determined in the same manner to be 1.5 times the maximum daily wastewater flow rate.

The per capita domestic wastewater design flows under varied conditions can be summarized as:

i) Average daily per capita wastewater generation; 0.75 x water consumption (lpcd)
ii) Average daily per capita wastewater flow; i) + 25 lpcd
iii) Maximum daily per capita wastewater flow; i) x 1.2 + 25 lpcd.
iv) Maximum hourly per capita wastewater flow; i) x 1.2 x 1.5 + 25 lpcd

The per capita domestic wastewater flows by year are tabulated below:

Per Capita Domestic Wastewater Flow Rates by Year (lpcd)

Categories	2000	2005	2010	2015
1. Per Capita Water Consumption	260	273	287	300
2. Per Capita Wastewater Generation	195	205	215	225
3. Infiltration/Inflow	25	25	25	25
4. Average Daily Per Capita Flow	220	230	240	250
5. Maximum Daily Per Capita Flow	260	270	285	300
6. Maximum Hourly Per Capita Flow	380	400	415	430

Note: Calculated based on the data by CORAASAN.

(4) Domestic Wastewater Design Flow by Year/Sewerage District

Total domestic wastewater flow rates estimated by the sewerage district and year are shown in the table below:

Domestic Wastewater Flows by District and Year (m^3/day)

Districts	2000	2005	2010	2015
1. **Average Daily Flows**				
Rafey	55,400	72,160	94,760	123,250
Cienfuegos	5,260	7,110	9,200	11,700
Los Salados	3,520	4,720	6,050	7,650
Embrujo	4,540	5,920	7,490	9,200
Zona Sur	5,280	7,180	9,290	11,780
Herradura	800	2,970	5,760	9,250
Subtotal	74,800	100,060	132,550	172,830
Tamboril	2,310	3,800	5,640	8,100
Licey	0	0	1,130	2,400
Total of Average Daily Flows	77,110	103,860	139,320	183,330
2. **Maximum Daily Flows**				
Rafey	65,470	84,700	112,520	147,900
Cienfuegos	6,220	8,350	10,920	14,040
Los Salados	4,160	5,540	7,190	9,180
Embrujo	5,360	6,940	8,900	11,040
Zona Sur	6,240	8,430	11,030	14,130
Herradura	940	3,490	6,840	11,100
Subtotal	88,390	117,450	157,400	207,390
Tamboril	2,730	4,460	6,700	9,720
Licey	0	0	1,340	2,880
Total of maximum daily flows	91,120	121,910	165,440	219,990
3.**Maximum Hourly Flows**				
Rafey	95,690	125,480	163,850	211,990
Cienfuegos	9,090	12,360	15,900	20,130
Los Salados	6,080	8,200	10,460	13,160
Embrujo	7,830	10,280	12,950	15,830
Zona Sur	9,120	12,480	16,070	20,260
Herradura	1,370	5,160	9,960	15,910
Subtotal	129,180	173,960	229,190	297,280
Tamboril	3,990	6,600	9,760	13,940
Licey	0	0	1,960	4,130
Total of maximum hourly flows	133,170	180,560	240,910	315,350

Note: Calculated by the Study Team

9.4.3 DOMESTIC WASTEWATER QUALITIES

The domestic wastewater pollutant loads are estimated assuming a condition that after the year 2000 all the wastewaters are collected through the sanitary sewers. The influent wastewater qualities to the existing WWTPs were surveyed generally by composite samples under the water quality survey.

The water quality survey results are summarized in the table below.

The per capita pollutant loads are estimated for the average per capita domestic wastewater generation rate of 200lpcd. As compared the above pollutant loads with those obtained elsewhere in Japan, BOD values appear to be rather low side whereas SS are higher. The high pollutant contents in the influent to Tamboril WWTP can be explained that occasional inflows of the wastewater from slaughter houses or agriculture lands.

WWTPs Influent Qualities Average values of two samples (mg/l)

Parameter	BOD_5	SS	T-N	T-P
Rafey	120	171	30.2	2.5
Cienfuegos	138	236	24.3	1.1
Embrujo	105	154	31.6	—
Los Salados	137	138	41.4	2.5
Tamboril	628	559	—	—
Average	125	175	31.2	2.0
Maximum	138	236	41.4	2.5
Per capita wastewater (lpcd)	200lpcd			
Per capita waste loads(g/cap/day)	25	35	6.2	0.4
Maximum per capita waste loads (g/cap/day)	28	47	8.3	0.5

Note: Values indicated by '—' are excluded from the calculation of average values

For the sewerage system planning, the following per capita pollutant loads of domestic wastewater are used in this Study:

Per Capita Pollutant Loads for Domestic Wastewater by year

Pollutant Loads	2000	2005	2010	2015
BOD5 (kg/day)	30	33	37	40
SS (kg/day)	35	40	45	50
T-N (kg/day)	7	8	8	9
T-P (kg/day)	0.4	0.5	0.5	0.6

The estimated pollutant loads generated from the sewer served populations up to 2015 are summarized in Table in Appendix-10 of the Supporting Report.

9.5 INDUSTRIAL WASTEWATER

9.5.1 CONDITIONS FOR PROJECTION OF INDUSTRIAL POLLUTANT LOADS

(1) Increase Rate of Generated Industrial Wastewater

In general, the industrial wastewater volume generated in factories is regarded to be nearly in proportion to the industrial production amount. According to the industrial statistics collected under the Study, the growth rate of manufacturing industry sector in the Dominican Republic had ranged from 9 to 15 % annually in the period of 1990 to 1999. In terms of future prospective in the industrial sector, however, reliable data on the prediction of the industrial production toward 2015 are not available.

Meanwhile, the Survey [1)] undertaken by the IDB predicted based on the result of the consultation with CORAASAN that the industrial water supply quantity in Santiago City would increase annually at 6 to 10 % between 2000 and 2005, 2.4 to 5.2 % between 2006 and 2010, and 2.4 % between 2011 and 2015. This prediction is based on the annual population growth rate of 2.4 % in the Study Area and intensive development will take place in the areas where water supply service is insufficient at present.

Taking the study results of the above projects into account, the following annual increase rates for wastewater generations are applied to this study:

[1)] : Report on "Integrated Project of Reform of Potable Water and Sanitation in the Dominican Republic", IDB, August 1998.

- 2000 to 2005: 8.0 %
- 2006 to 2010: 5.0 %
- 2011 to 2015: 3.0 %

This increase rates appear to be naturally dependable on the trend of the national economy in the Dominican Republic, especially on the industrial sector. Hence, the above-assumed increase rates are to be reviewed in the course of the project implementation.

(2) Land Use Plan for Industrial Use

At present, no land use plan, showing the industrial areas in the Study Area, has been established. Therefore, it is assumed in this Study that the industrial wastewater flow in the future would increase in the 17 zones defined in the previous Section at the proportional rate to the current flows.

9.5.2 INDUSTRIAL POLLUTANT LOADS IN FUTURE

The calculations indicate that the total industrial wastewater generated in the Study Area will gradually increase and will reach at 44,407 m^3/d in 2015, as shown in the following:

Predicted Industrial Wastewater Flows

2000 (Present)	2005	2010	2015
20,427 m^3/d	29,014 m^3/d	38,306 m^3/d	44,407 m^3/d

The following table shows the projection results toward the target year of 2015, including the generated and the discharged pollutant loads. The discharged pollutant loads in the future were computed on the condition that generated pollutant loads would be partly treated by existing treatment facilities in the range of the existing treatment capacity. In the target year, the equivalent population of generated and discharged BOD loads will reach nearly 464,000 people (about 63 % of sewered population) and nearly 408,000 people (about 56 % of sewered population), respectively.

Figure 9.4 shows the results of the projection of industrial pollutant loads in the "Without Case". The BOD load discharged from industries of the whole of the Study Area will increase from 6,282 kg/d in 2000 to 16,306 kg/d (160 % up) in 2015, unless the development of industrial wastewater treatment facilities is implemented. Table 5.1 and Table 5.2 shows generated industrial BOD loads (before treatment by existing facilities) and discharged loads (after treatment by existing facilities, in the "Without Case") from 2000 to 2015, respectively.

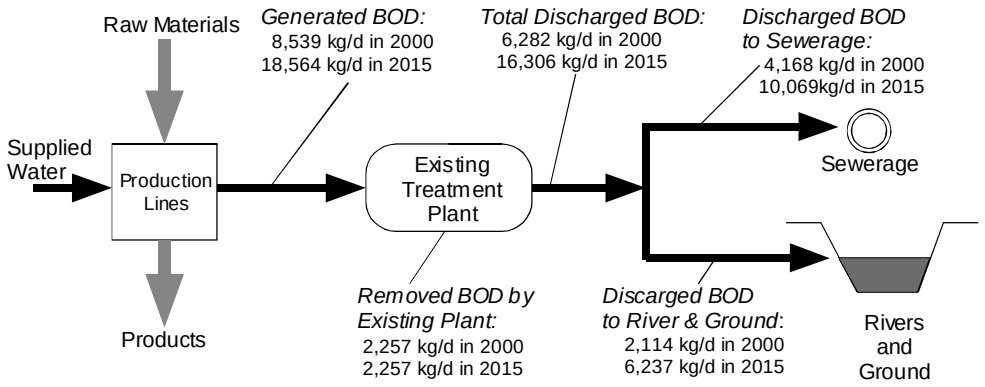
Projection of Generated and Discharged Industrial Pollutant Loads

Year	Generated Loads		Discharged Loads	
	BOD (kg/d)	SS (kg/d)	BOD (kg/d)	SS (kg/d)
2000	8,539	10,984	6,282	5,704
2005	12,547	16,139	10,290	10,859
2010	16,013	20,598	13,754	15,317
2015	18,564	23,879	16,305	18,598
	(BOD equivalent to 464,100 people in 2015)		(BOD equivalent to 407,600 people in 2015)	

Note: The per-capita BOD rate is assumed to be 40 g/d in 2015.

As shown in the following schematic that BOD of 10,069 kg/d (128 % up for 2000) would inflow to the sewerage system and 6,237 kg/d (195 % up for 2000) to rivers and ground by 2015. This clearly indicates that the water bodies in the Study Area would significant be affected by the increasing industrial pollutant loads towards 2015, if no appropriate industrial wastewater control measures were taken.

Industrial Pollution Load Balance in Without Case



Note: This figure shows the overall balance of BOD load in the "Without Case" in the whole Study Area.

9.5.3 INDUSTRIAL WASTEWATER DISCHARGE STANDARDS TO SEWERS

In the Section 5.2 of new Norm defines the industrial wastewater discharge quality standards. In view of the Norm and the results of examination based on the above requirements above, the following discharge standards are to be applied, which are basically the same as the new Norm:

Industrial Wastewater Discharge Standards to Sewers

No.	Item	Unit	Effluent Standard
1	Temperature	℃	below 40
2	pH	—	6 to 9
3	BOD_5	mg/L	350
4	SS	mg/L	400
5	Iodine Consumption	mg/L	220
6	Fat & Oil	mg/L	20
7	Nitrogen (T-N)	mg/L	40
8	Phosphorus (T-P)	mg/L	10

In the above table, the limit of iodine consumption be additionally set, based on the experience in Japan. If the industrial wastewater discharge qualities exceed the permissible limits of the standards, factories are required to install proper treatment facilities at their own responsibility, to comply with the discharge standards.

9.5.4 WASTEWATER DISCHARGED TO PUBLIC SEWERAGE SYSTEM

(1) Discharge to Sewerage

There are two destinations for the industrial wastewater discharge; the discharge into public sewerage after a necessary pre-treatment, and the discharge to river or ground after a complete treatment. As discussed in Chapter 12, it is proposed that industrial wastewater be primarily collected and treated by the public sewerage system.

The criteria to be practically applied for selecting discharge destination will be as follows:

1) Factories in FZIEs

As a rule, the wastewater from the factories in FZIEs, without having central treatment facilities, will be led to sewers.

2) Factories in Sewerage District

The wastewaters from factories outside FZIEs, where the public sewerage system is readily accessible, are to be discharged to the sewerage system. In such a case, factories' own treatment facilities may be used as a pre-treatment system before discharging to sewers.

3) Factories in Unsewered Areas

Factories in unsewered area, but already connected to their own conveyance system, may continue the discharge into such sewers as an exceptional case.

4) Industrial Wastewater Discharge Quantities to Public Sewers by District

The industrial wastewater quantities inflowing to each sewerage district by year are summarized below:

Industrial Wastewater Discharge to Sewer by District and Year (m^3/day)

Flow Type/ District	2000	2005	2010	2015
1. **Average/maximum daily flow**				
Rafey	10,240	15,050	19,210	22,270
Cienfuegos	480	710	910	1,050
Los Salados	390	570	720	840
Embrujo	0	0	0	0
Zona Sur	30	40	50	60
Herradura	310	460	580	680
Subtotal	11,450	16,830	21,470	24,900.
Tamboril	170	250	320	370
Licey	0	0	250	290
Total of average/max. daily flows	11,620	17,080	22,040	25,560
2. **Maximum hourly flow**				
Rafey	20,490	30,100	38,410	44,530
Cienfuegos	960	1,420	1,810	2,100
Los Salados	770	1,130	1,440	1,670
Embrujo	0	0	0	0
Zona Sur	60	80	100	120
Herradura	620	920	1,170	1,350
Subtotal	22,900	33,650	42,930	49,770
Tamboril	340	500	640	740
Licey	0	0	500	580
Total of maximum hourly flows	23,240	34,150	44,070	51,090

Note: 1) Estimated by the Study Team.
2) Wastewater flows in Licey District in 2000 and 2005 are assumed to be zero because the sewer construction is not planned yet.

(2) Pollutant Loads of Industrial Wastewater Discharged to Public Sewers

As shown in the following table, a total of about 25,500 m^3/d industrial wastewaters from 140 factories within the eight Sewerage Districts are considered to inflow to the sewers by 2015.

Industrial Wastewater Pollutant Loads Discharge to Sewers in 2015

Items		Pollutant Loads	
Industrial Wastewater Flow	(m^3/d)	25,538	
Generated Loads	(kg/d)	15,384 (BOD)	11,826 (SS)
Discharged Loads to Sewerage	(kg/d)	5,862	6,090

Note: This table shows the planning conditions for all the factories to discharge wastewater into sewerage.

Table in Appendix-10 of the Supporting Report shows the industrial wastewater pollutant loads to be discharged to the sewerage by the Sewerage District, after the pre-testament in factories where necessary.

9.6 OVERALL DESIGN FLOWS AND QUALITIES

9.6.1 OVERALL DESIGN FLOWS

From the foregoing discussions, the overall wastewater inflows to the sewerage system by the Sewerage District and years are estimated, including domestic, commercial, institutional and industrial wastewaters from 2000 through 2015:

Total Wastewater Inflows by District and Year

Flow Type/ District	2000	2005	2010	2015
1. **Average daily wastewater flow**				
Rafey	65,640	87,210	113,970	145,520
Cienfuegos	5,740	7,820	10,110	12,750
Los Salados	3,910	5,290	6,770	8,490
Embrujo	4,540	5,920	7,490	9,200
Zona Sur	5,310	7,220	9,340	11,840
La Herradura	1,110	3,430	6,340	9,930
Subtotal	86,250	116,890	154,020	197,730
Tamboril	2,480	4,050	5,960	8,470
Licey	0	0	1,380	2,690
Total of average daily flows	88,730	120,940	161,360	208,890
2. **Maximum daily wastewater flow**				
Rafey	75,710	99,750	131,730	170,170
Cienfuegos	6,700	9,060	11,830	15,090
Los Salados	4,550	6,110	7,910	10,020
Embrujo	5,360	6,940	8,900	11,040
Zona Sur	6,270	8,470	11,080	14,190
La Herradura	1,250	3,950	7,420	11,780
Subtotal	99,840	134,280	178,870	232,290
Tamboril	2,900	4,710	7,020	10,090
Licey	0	0	1,590	3,170
Total of maximum daily flows	102,740	138,990	187,480	245,550
3. **Maximum hourly flows**				
Rafey	116,180	155,580	202,260	256,520
Cienfuegos	10,050	13,780	17,710	22,230
Los Salados	6,850	9,330	11,900	14,830
Embrujo	7,830	10,280	12,950	15,830
Zona Sur	9,180	12,560	16,170	20,380
La Herradura	1,990	6,080	11,130	17,260
Subtotal	152,080	207,610	272,120	347,050
Tamboril	4,330	7,100	10,400	14,680
Licey	0	0	2,460	4,710
Total of maximum hourly flows	156,410	214,710	284,980	366,440

Note: Calculated by the Study Team.

9.6.2 QUALITIES OF WASTEWATERS INFLOWING TO SEWERAGE SYSTEM

The overall wastewater pollutant concentrations and loads inflowing to each of the WWTPs by year are estimated, and are summarized in the following table:

Estimated Overall Wastewater Loads to Sewerage System

District	Av. Inflow	BOD_5		SS		T-N		T-P	
	(m^3/d)	(mg/L)	(kg/d)	(mg/L)	(kg/d)	(mg/L)	(kg/d)	(mg/L)	(kg/d)
I. Year 2000									
1. Rafey	65,640	151	9,891	169	11,114	32	2,076	2.6	170
2. Cienfuegos	5,740	142	815	172	987	32	182	2.3	13
3. Los Salados	3,910	145	568	167	652	32	127	2.3	9
4. Embrujo	4,540	136	618	159	721	32	144	1.8	8
5. Zona Sur	5,310	137	725	159	845	32	169	1.9	10
6. La Herradura	1,110	155	172	155	172	32	36	2.7	3
7. Tamboril	2,480	151	375	176	436	32	80	2.4	6
8. Licey	0	0	0	0	0	0	0	0	0
Total	88,730	148	13,164		14,927	32	2,814	2.5	219
II. Year 2005									
1. Rafey	87,210	158	13,791	184	16,016	34	2,970	3.0	259
2. Cienfuegos	7,820	149	1,165	186	1,456	35	270	2.7	21
3. Los Salados	5,290	152	806	181	955	35	187	2.8	15
4. Embrujo	5,920	143	848	174	1,028	35	206	1.8	13
5. Zona Sur	7,220	144	1,038	174	1,255	35	252	1.9	16
6. La Herradura	3,430	154	528	180	618	35	120	2.7	10
7. Tamboril	4,050	156	633	182	760	35	141	2.4	11
8. Licey	0	0	0	0	0	0	0	0	0
Total		156	18,809	188	22,088	34	4,146	2.9	345
III. Year 2010									
1. Rafey	113,970	167	19,001	195	22,227	33	3,746	2.9	329
2. Cienfuegos	10,110	158	1,602	198	2,005	33	335	2.5	25
3. Los Salados	6,770	162	1,097	193	1,306	34	231	2.8	19
4. Embrujo	7,490	154	1,154	187	1,404	33	250	2.1	16
5. Zona Sur	9,340	154	1,442	187	1,751	33	312	2.0	19
6. La Herradura	6,340	161	1,023	192	1,217	34	214	2.5	16
7. Tamboril	5,960	165	982	199	1,186	33	199	2.5	15
48. Licey	1,380	164	227	197	272	34	47	2.9	4
Total	161,360	164	26,528	194	31,368	33	5,334	2.7	443
IV. Year 2015									
1. Rafey	145,520	171	24,814	205	29,823	35	5,119	3.1	448
2. Cienfuegos	12,750	164	2,086	209	2,666	36	454	2.7	35
3. Los Salados	8,490	167	1,415	204	1,729	36	308	2.9	25
4. Embrujo	9,200	160	1,472	200	1,840	36	331	2.4	22
5. Zona Sur	11,840	160	1,896	200	2,365	36	426	2.4	28
6. La Herradura	9,930	165	1,639	203	2,013	36	359	2.7	27
7. Tamboril	8,470	169	1,426	209	1,768	36	305	2.7	23
8. Licey	2,690	166	446	204	550	36	96	3.0	8
Total	208,890	168	35,194	205	42,754	35	7,398	2.9	616

Note: Estimated by the Study Team.

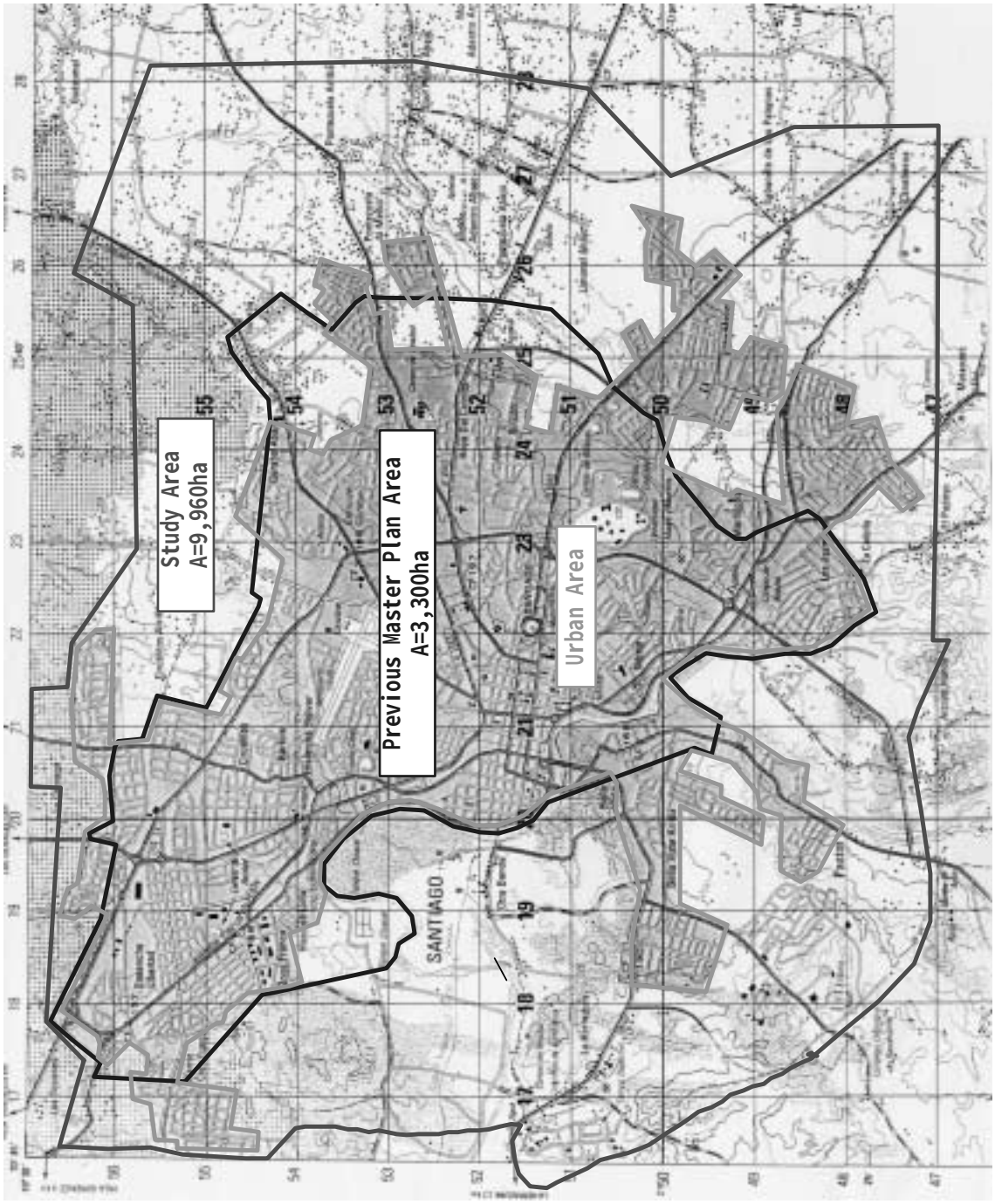
9.7 REQUIRED LEVEL OF WASTEWATER TREATMENT

As previously mentioned in Section 3.6 of Chapter 3, the new water quality standards "Norma de calidad del augua y control de descargas, AG-CC-01, June 2001" define the permissible qualities of the municipal wastewater discharge to the region's public waters, and discharge wastewater qualities to the public owned sewer systems.

The required minimum permissible qualities of WWTPs effluents to the public surface waters are those achievable by the biological secondary treatment processes, preferably by the activated sludge process or its modifications.

Because the existing Rafey and other WWTPs are either of the conventional activated sludge or other secondary processes (except such small WWTPs as La Loteria, Tohmen and P.U.C.M.M., which are treating the wastewater by means of Imhoff tank or oxidation pond systems), the existing plants are capable of clearing the standard limits if the facilities are rehabilitated or expanded.

The newly planned WWTPs for the Zona Sur, La Herradura, and Licey Districts, the most desirable secondary treatment process that can clear the standards is to be selected based upon economic and engineering studies.

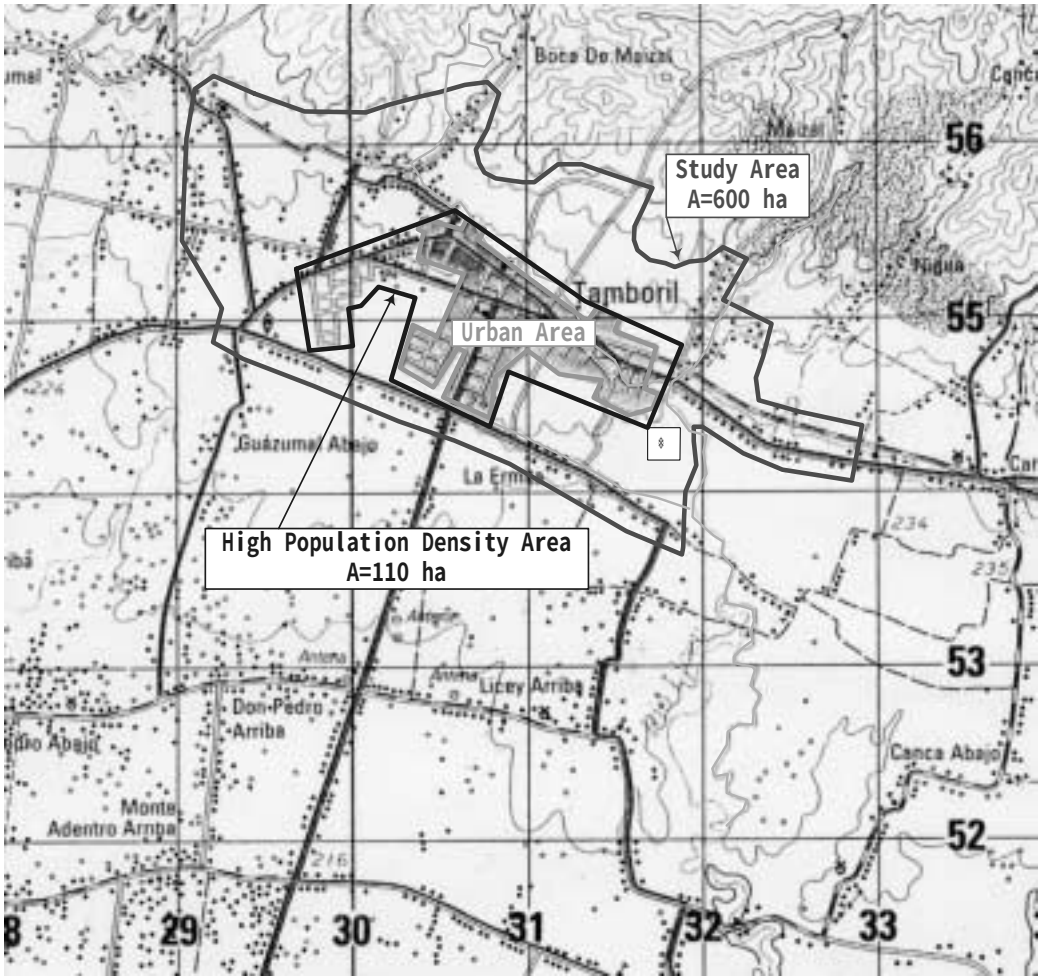


THE STUDY ON THE IMPROVEMENT OF SEWERAGE SYSTEM AND ENVIRONMENT IN THE CITY OF SANTIAGO

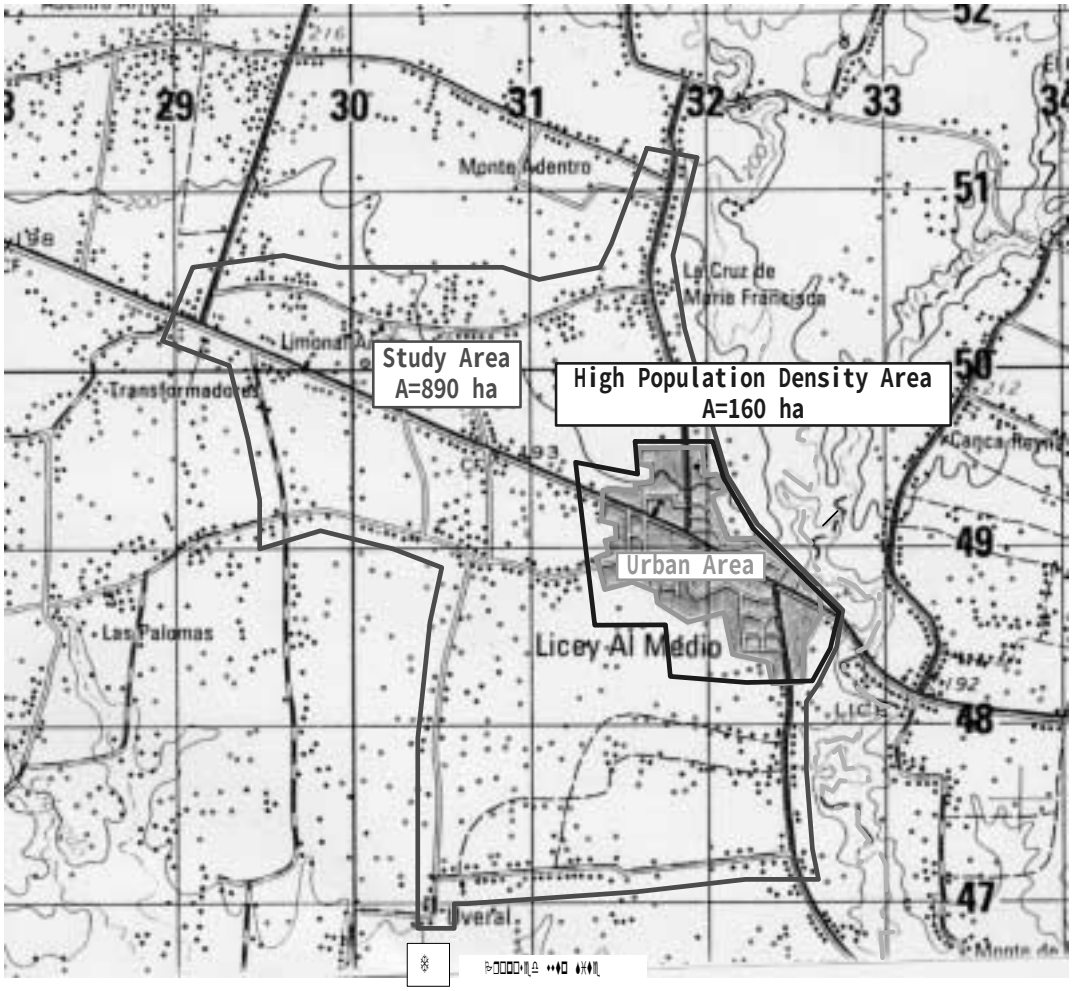
JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 9.1

Study Area of Santiago



THE STUDY ON THE IMPROVEMENT OF SEWERAGE SYSTEM AND ENVIRONMENT IN THE CITY OF SANTIAGO	Figure 9.2. Study Area of Tamboril
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY ON THE IMPROVEMENT OF SEWERAGE SYSTEM AND ENVIRONMENT IN THE CITY OF SANTIAGO	Figure 9.3 Study Area of Licey
JAPAN INTERNATIONAL COOPERATION AGENCY	

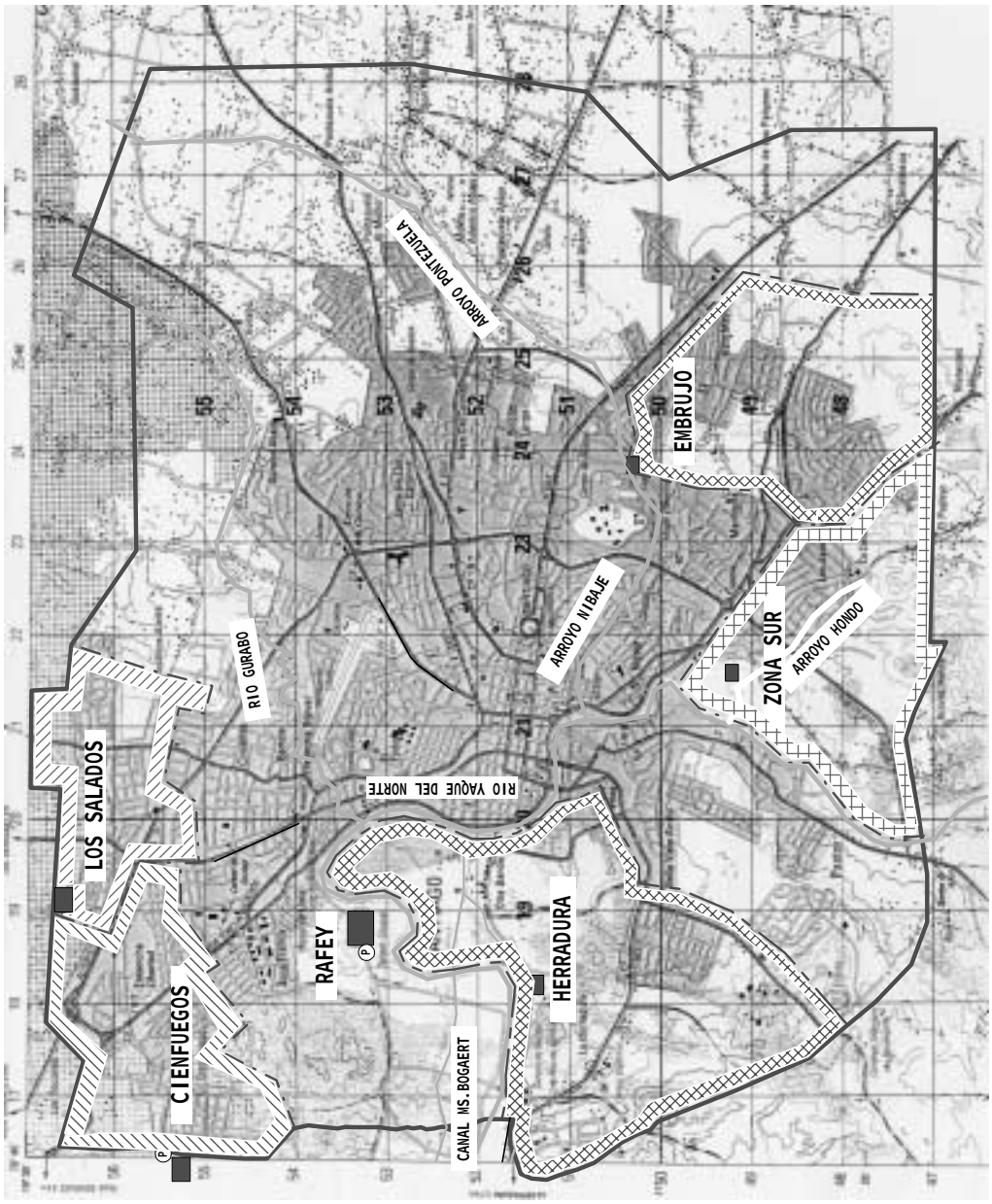


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Figure 9.4

Santiago Sewerage District