APPENDIX-2
WATER AND WASTEWATER SURVEY

CONTENTS

APPENDIX-2
WATER/WASTEWATER SURVEY

A2.1 OBJECTIVES

A water quality survey was conducted by the JICA Study Team. The main objectives of the survey are as follows:

- Grasping the current conditions of water quality in Santiago region, especially Yaque del Norte River and its tributaries;
- Grasping the operating conditions of sewage treatment plants and industrial factories in and around Santiago city.
- Obtaining basic data for projecting future water quality in Santiago city when the sewerage improvement project is implemented.

A2.2 SAMPLING

A total of sixty-six (66) samples were collected in two events. In each event, thirty-tree (33) samples were taken on March 1 and March 6, 2001 respectively. Sapling locations are as shown in the table below and in Figure A2.1:

- Five (5) sewage treatment plants: [TP1 – TP5]
- Ten (10) points of rivers and channels: [RC1 – RC10]
- Fifteen (15) industrial effluents from industrial factories: [F1 – F15]

Sampling Location for Water Quality Survey

WWTPs			River/Channel		Factory	
TP1	Rafey	Influent	RC1	Antes Toma de Pastor	F1	Embotelladora Dominicana
		Efluent	RC2	Antes Obra Toma de Canal	F2	Hilos A & E
TP2	Cienfuego	Influent	RC3	Despues Descarga Teneria Bermudez	F3	Wash & Finish
TP3	Embrujo	Influent	RC4	Frente Planta Rafey	F4	Sadosa
		Efluent	RC5	Despues Descarga A.N. Rafey	F5	Hoyo De Lima
TP4	Los Salados	Influent	RC6	Arroyo Hondo	F6	Baltimore Dominicana
TP5	Tamboril	Influent	RC7	Arroyo Nibaje	F7	Teneria Bermudez
		Efluent	RC8	Arroyo Gurabo	F8	Destileria Bermudez
			RC9	Arroyo Jacagua	F9	Procesadora De Carnes Checo
			RC10	Diversion channel for irrigation	F10	Acero Del Cibao
					F11	Bojos Leatrher
					F12	E. Leon Jimenez
					F13	Corporacion Industrial Del Norte
					F14	Pasteurizadora Cibao
					F15	Isidro Bordas

A2.3 WATER QUALITY PARAMETERS

The following thirty-three (33) parameters were analyzed considering the characteristics of samples.

(1) Water temperature, (2) pH, (3) Electric conductivity, (4) Dissolved oxygen (DO), (5) Biochemical oxygen demand (BOD_5), (6) Chemical oxygen demand (COD_{Cr}), (7) Suspended solids (SS), (8) Chlorides (Cl^-), (9) Sulfate ($SO4^{2-}$), (10) Ammonia nitrogen (NH_4^--N), (11) Nitrate nitrogen (NO_3^-—N), (12) Nitrite nitrogen (NO_2^-—N), (13) Total nitrogen (T-N), (14) Phosphate phosphorus (PO_4^{3-}), (15) Total phosphorus (T-P), (16) Oil and Grease, (17) Total Coliforms, (18) Total fecal Coliforms, (19) Phenols, (20) Cadmium (Cd), (21) Lead (Pb), (22) Zinc (Zn), (23)Hexavalant chromium ($Cr_{(VI)}$), (24) Total chromium (T-Cr), (25) Arsenic (As), (26) Total mercury(T-Hg), (27) Copper (Cu), (28) Iron (Fe), (29) Cyanide (CN^-), (30) Magnesium (Mg), (31) Linear alkylate sulfonate (LAS), (32) Organochloric compounds, and (33) Pesticides

A2.4 METHODS

The following methods were applied for the respective water quality parameter.

Parameter	Method
Dissolved oxygen(DO)	Iodometric Method (4500-O B, APHA, AWWA Std)
Biochemical oxygen demand(BOD_5)	(5210-B, APHA, AWWA Std)
Chemical oxygen demand(COD_{Cr})	Spectrophotometer Method (5220-B, APHA, AWWA Std)
Suspended solis(SS)	(2540-D, APHA, AWWA Std)
Chlorides(Cl^-)	Spectrophotometer Method (4500-Cl^-, APHA, AWWA Std)
Sulfate($SO4^{2-}$)	Spectrophotometer Method (4500-SO_4^{--}, APHA, AWWA Std)
Ammonia nitrogen(NH^{4-}-N)	Spectrophotometer Method (4500-NH_3, APHA, AWWA Std)
Nitrate nitrogen(NO_3^-—N)	Spectrophotometer Method (4500-NO_3^-, APHA, AWWA Std)
Nitrite nitrogen(NO_2^-—N)	Spectrophotometer Method (4500-NO_2^-, APHA, AWWA Std)
Total nitrogen(T-N)	Spectrophotometer Method (4500-N, APHA, AWWA Std)
Phosphate phosphorus(PO_4^{3-})	Spectrophotometer Method (4500-P, APHA, AWWA Std)
Total phosphorus(T-P)	(4500-P-B-5, 4500-PC, APHA, AWWA Std)
Oil and Grease	(2530 C, APHA, AWWA Std)
Total Coliforms	(9221-A, APHA, AWWA Std)
Total fecal Coliforms	(9221-E, APHA, AWWA Std)
Phenols	EPA Method 420.3
Cadmium(Cd)	Atomic absorption method (311B, APHA, AWWA Std)
Lead(Pb)	Atomic absorption method (311B, APHA, AWWA Std)
Zinc(Zn)	Atomic absorption method (311B, APHA, AWWA Std)
Hexavalant chromium(Cr(VI))	EPA Method 218.4
Total chromium(T-Cr)	Atomic absorption method (311B, APHA, AWWA Std)
Arsenic(As)	EPA Method 206.2
Total mercury(T-Hg)	EPA Method 245.1
Copper(Cu)	Atomic absorption method (311B, APHA, AWWA Std)
Iron(Fe)	Atomic absorption method (311B, APHA, AWWA Std)
Cyanide(CN^-)	EPA Method 335.2
Magnesium(Mg)	3111-C
Linear alkylate sulfonate(LAS)	EPA Method 425.1
Organochloric compounds	EPA Method 8021
Pesticides	EPA Method 8081-B/8082A

APHA: American Public Health Association
AWWA: American Water Works Association
EPA: Environmental Protection Agency of America

A2.5 SURVEY RESULTS

The survey results are summarized in Table A2.2. As for the toxic substances, heavy metals, organochlorine compounds and pesticides, no significant concentrations were detected in the river waters. The results indicate that the water contamination of Yaque del Norte River is caused mainly by organic matters.

A2.6 SUMMARY OF WATER QUALITY IN THE STUDY AREA

The table below summarizes the CORAASAN's monitored data and the results of the water quality survey conducted by the Study Team. The figures shown in the table are expressed in average value of CORAASAN's data and the results of the water quality survey.

Average Values of Water Pollution Indicators at River Water in Santiago City
(Average value of Year of 2000 and 2001)

Monitoring Point		RC1	RC2	RC3	RC4	RC5	RC6	RC7	RC8	RC9	RC10
BOD_5	[mg/L]	2.8	5.7	31	32	26	43	22	39	79	6
COD_{Cr}	[mg/L]	21	22	90	105	108	73	65	72	202	23
SS	[mg/L]	113	159	125	386	385	165	142	218	210	214
Electric Conductivity	[μS/cm]	141	186	486	532	564	457	844	1,018	1,362	225
NH_4-N	[mg/L]	0.08	0.25	1.90	1.50	1.97	2.0	5.5	3.7	8.5	0.3
NO_3-N	[mg/L]	1.1	1.3	0.9	1.0	1.9	1.9	2.3	1.3	2.0	2.5
NO_2-N	[mg/L]	0.006	0.013	0.025	0.035	0.072	0.058	0.057	0.038	0.019	0.020
T-N	[mg/L]	0.56	4.4	7.6	24	7.6	5.3	51.9	10.5	14.9	13.0
T-P	[mg/L]	0.82	0.57	1.32	1.90	0.18	2.66	0.60	1.82	1.55	0.89
DO	[mg/L]	6.6	6.7	2.3	2.0	2.1	5.2	3.6	1.6	1.2	7.9

(Source: CORAASAN, JICA Study Team)

The water quality at RC1, which is located at the uppermost stream of Yaque del Norte River in the Study Area, shows relatively good water quality conditions (BOD5: 2.8 mg/L, DO: 6.6mg/L). This water could be suitable for irrigation purposes and potable water supply with full treatment.

It reveals that the water is polluted from upstream to downstream (from RC1 to RC5), for example, the concentrations of BOD_5 and electric conductivity increased and but DO decreased toward downstream. It is also confirmed that the water quality from the monitoring station RC3 to RC5 becomes worse after receiving water polluted from tributary rivers and water courses (from RC6 to RC9).

TableA2.1 Sampling Program for Water Quality Survey(Summary)

	Location No.	Sampling Location/Point (Note1)		Sampling Team (Note2)	Mar.1st (Thu.)	Mar. 6 (Tue)	No. of Sample Total
WTP	TP1	Rafey	Influent	A	TP11IN	TP12IN	2
			Effluent	A	TP11OUT	TP12OUT	2
	TP2	Cienfuegos	Influent	A	TP21IN	TP22IN	2
	TP3	El Embrujo	Influent	B	TP31IN	TP32IN	2
			Effluent	B	TP31OUT	TP32OUT	2
	TP4	Los Salados	Influent	A	TP41IN	TP42IN	2
	TP5	Tamboril	Influent	B	TP51IN	TP52IN	2
			Effluent	B	TP51OUT	TP52OUT	2
	Number of Samples Collected (WTP Sub-Total)				**8**	**8**	**16**
River and Channels	RC1	Antes Toma de Pastor		B	RC11	RC12	2
	RC2	Antes Obra Toma de Canal		C	RC21	RC22	2
	RC3	Despues Descarga Teneria Bermudez		C	RC31	RC32	2
	RC4	Frente Planta Rafey		A	RC41	RC42	2
	RC5	Despues Descarga A. N. Rafey		A	RC51	RC52	2
	RC6	Arroyo Hondo		B	RC61	RC62	2
	RC7	Nibaje		C	RC71	RC72	2
	RC8	Gurabo		C	RC81	RC82	2
	RC9	Jacagua		C	RC91	RC92	2
	RC10	Diversion channel for irrigatiuon		C	RC101	RC102	2
	Number of Samples Collected (Rivers & Channel Sub-Total)				**10**	**10**	**20**
Industrial Effluent	F1	Embotelladora Dominicana		E	F11	F12	2
	F2	Hilos A & E		D	F21	F22	2
	F3	Wash & Finish		D	F31	F32	2
	F4	Sadosa		E	F41	F42	2
	F5	Hoyo De Lima		D	F51	F52	2
	F6	Baltimore Dominicana		E	F61	F62	2
	F7	Teneria Bermudez		D	F71	F72, F73	3
	F8	Destileria Bermudez		D	F81	-	1
	F9	Procesadora De Carnes Checo		E	F91	F92	2
	F10	Acero Del Cibao		E	F101	F102	2
	F11	Bojos Leather		F	F111	F112	2
	F12	E. Leon Jimenez		F	F121	F122	2
	F13	Corporacion Industrial Del Norte		F	F131	F132	2
	F14	Pasteurizadora Cibao		F	F141	F142	2
	F15	Isidro Bordas		F	F151	F152	2
	Number of Samples Collected (Industrial Effluent Sub-Total)				**15**	**15**	**30**
Tota Number of Samples Collected					**33**	**33**	**66**

(Note1): See attached Map

(Note2): Formation of Sampling Team

Team	Number of Persons(including driver)	Team	Number of Persons(including driver)
A	2	E	2
B	2	F	2
C	2	G (Flow Rate Measuring Team)	2
D	2		

TableA2.2 Results of Water Quality Survey (1/6)

Sampling Date: March 1st, 2001

				Temperature		pH	Electric Conductivity	DO	BOD_5	COD_{Cr}	SS	Cl^-	$SO4^{2-}$	NH_4^+-N	NO_3-N	NO_2-N	T-N	PO_4^{3-}P	T-P
				Ambient	Water														
				[℃]		-	[μS/cm]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]
WTP	TP1	Rafey	Influent	29	28	6.83	618	-	128	356	165	59.2	140	10.3	2.0	0.010	27.5	8.1	1.71
			Effluent	29	28	6.50	449	-	2	7	143	38.9	88	0.3	2.5	0.008	1.4	3.7	1.69
	TP2	Cienfuegos	Influent	26	25	6.35	1,554	-	125	310	270	194.2	580	12.6	1.3	0.011	24.2	9.1	0.84
	TP3	El Embrujo	Influent	24	26	6.44	641	-	137	305	187	33.4	200	13.7	1.4	0.020	39.8	14.1	45.34
			Effluent	24	25	6.98	627	-	25	88	224	36.0	170	9.4	0.3	0.011	16.2	7.9	3.29
	TP4	Los Salado	Influent	28	28	6.46	680	-	181	424	117	52.7	160	3.5	2.5	0.025	41.8	12.9	1.88
	TP5	Tamboril	Influent	23	27	6.75	2,370	-	667	3,700	475	82.8	440	32.5	7.0	0.078	7.3	16.6	40.87
			Effluent	23	27	6.85	1,240	-	113	449	193	130.2	260	0.3	5.0	0.015	48.6	3.6	2.80
River and Channels	RC1	Antes Toma de Pastor		28	24	6.26	149	8	2	10	93	6.9	2	0.0	4.4	0.006	0.96	0.45	1.31
	RC2	Antes Obra Toma de Canal		25	23	6.52	193	8	4	8	37	11.8	150	0.4	4.6	0.009	7.9	2.6	0.75
	RC3	Despues Descarga Teneria Bermudez		25	23	5.94	722	ND	267	1,895	106	62.7	4	4.0	1.5	0.037	1.7	1.8	2.06
	RC4	Frente Planta Rafey		28	28	6.31	748	ND	43	121	103	67.0	170	3.8	0.8	0.016	40.0	4.6	1.88
	RC5	Despues Descarga A. N. Rafey		28	28	6.66	732	ND	17	112	172	61.9	82	3.7	4.7	0.064	4.3	3.0	0.22
	RC6	Arroyo Hondo		24	23	6.90	1,363	6	63	158	101	21.4	80	1.7	4.7	0.082	4.9	4.5	4.55
	RC7	Nibaje		24	23	6.69	827	5	39	114	77	56.9	165	4.6	4.4	0.043	14.8	3.4	0.41
	RC8	Gurabo		24	24	6.71	1,121	ND	43	128	142	105.1	195	4.3	4.4	0.023	7.0	3.9	1.60
	RC9	Jacagua		27	24	6.88	1,567	ND	88	140	165	158.1	510	8.9	4.5	0.023	14.4	5.2	2.04
	RC10	Diversion channel for irrigatiuon		23	23	6.99	194	8	4	11	225	10.2	10	0.3	4.6	0.030	25.2	0.7	1.33
Industrial Effluent	F1	Embotelladora Dominicana		27	30	7.21	259	-	333	2,100	371	14.5	10	1.4	0.2	0.011	2.0	0.2	2.40
	F2	Hilos A & E		26	26	6.00	815	-	20	126	1,116	185.0	20	1.4	0.2	0.014	6.5	0.1	1.33
	F3	Wash & Finish		27	47	5.80	193	-	26	113	469	12.0	50	12.6	0.4	0.082	28.5	0.8	1.01
	F4	Sadosa		25	25	6.72	736	-	4	45	131	71.3	460	0.9	2.6	0.098	1.1	1.7	0.16
	F5	Hoyo De Lima		32	29	5.82	736	-	46	212	153	1,980	210	1.4	0.3	0.061	8.0	9.1	32.34
	F6	Baltimore Dominicana		32	35	4.32	4,400	-	331	3,280	339	546.0	80	7.0	2.1	0.084	62.1	12.8	0.06
	F7	Teneria Bermudez		27	28	6.83	4,040	-	280	979	244	37.8	950	25.0	4.0	0.080	70.5	1.2	3.06
	F8	Destileria Bermudez		26	32	5.16	2,520	-	2,700	7,210	224	321.0	540	84.5	14.0	0.230	6.2	0.2	6.07
	F9	Procesadora De Carnes Checo		30	27	6.63	2,300	-	160	610	279	600.0	70	73.5	5.0	0.080	109.8	16.9	5.78
	F10	Acero Del Cibao		29	27	2.43	2,110	-	27	59	713	1,080	30	33.5	1.2	0.020	40.4	10.0	3.24
	F11	Bojos Leather		30	25	6.51	4,060	-	37	184	6,526	280.0	80	12.3	1.1	0.575	25.1	3.9	1.44
	F12	E. Leon Jimenez		24	26	6.71	834	-	294	723	151	370.0	80	42.5	3.4	0.155	41.0	10.1	2.02
	F13	Corporacion Industrial Del Norte		20	25	6.39	2,770	-	510	628	120	280.0	800	24.5	6.0	0.140	137.6	10.0	3.03
	F14	Pasteurizadora Cibao		29	22	6.76	781	-	30	878	162	201.0	80	24.4	2.6	0.070	57.6	15.6	17.54
	F15	Isidro Bordas		25	28	5.36	756	-	20	1,295	82	210.0	30	4.1	1.9	0.038	11.2	8.6	2.09

(Source: JICA Study Team)

TableA2.2 Results of Water Quality Survey (2/6)

Sampling Date: March 1st, 2001

				Oil & Grease	Phenols	Cd	Pb	Zn	Cr(VI)	Total-Cr	As	Total-Hg	Cu	Fe	Mg	CN-	Total Coliforms	Total FecalColiforms	
				[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	10^3NPM/100ml	10^3NPM/100ml	
WTP	TP1	Rafey	Influent	13		<0.01	<0.12	0.07		<0.03			<0.14	0.40	25.6		1,600,000	1,600,000	
			Effluent	2.5		<0.01	<0.12	0.08		<0.03			<0.14	0.20	25.7		200	200	
	TP2	Cienfuegos	Influent	10		<0.01	<0.12	0.08		<0.03			<0.14	0.28	25.7		130,000	130,000	
	TP3	El Embruj	Influent	14		<0.01	<0.12	0.07		<0.03			<0.14	0.28	25.6		80,000	80,000	
			Effluent	2.1		<0.01	<0.12	0.06		<0.03			<0.14	0.21	26.6		50,000	50,000	
	TP4	Los Salado	Influent	7.5		<0.01	<0.12	0.07		<0.03			<0.14	0.27	25.5		500,000	500,000	
	TP5	Tamboril	Influent	41		<0.01	<0.12	0.01		<0.03			<0.14	0.21	25.5		5,000	5,000	
			Effluent	6.0		<0.01	<0.12	0.01		<0.03			<0.14	0.29	10.6		8,000	8,000	
River and Channels	RC1	Antes Toma de Pastor		6.1		<0.01	<0.12	0.07		<0.03			<0.14	0.20	12.5		20	20	
	RC2	Antes Obra Toma de Canal		0.4		<0.01	<0.12	0.08		<0.03			<0.14	0.20	12.5		500	110	
	RC3	Despues Descarga Teneria Bermudez		2.4		<0.01	<0.12	0.07		<0.03			<0.14	0.28	12.5		17,000	6,000	
	RC4	Frente Planta Rafey		2.8		<0.01	<0.12	0.07		<0.03			<0.14	0.27	12.5		50,000	30,000	
	RC5	Despues Descarga A. N. Rafey		2.8		<0.01	<0.12	0.07		<0.03			<0.14	0.41	12.4		70,000	50,000	
	RC6	Arroyo Hondo		2.4		<0.01	<0.12	0.07		<0.03			<0.14	0.20	10.8		9,000	5,000	
	RC7	Nibaje		2.8		<0.01	<0.12	0.07		<0.03			<0.14	0.15	10.7		1,300	1,300	
	RC8	Gurabo		1.6		<0.01	<0.12	0.07		<0.03			<0.14	0.25	10.6		17,000	17,000	
	RC9	Jacagua		2.8		<0.01	<0.12	0.07		<0.03			<0.14	0.22	10.8		50,000	50,000	
	RC1	Diversion channel for irrigatiuon		2.9		<0.01	<0.12	0.07		<0.03			<0.14	0.23	25.7		2,000	0	
Industrial Effluent	F1	Embotelladora Dominicana		6.5		<0.01	<0.12	0.08		<0.03			<0.14	1.30	25.6				
	F2	Hilos A & E		4.2		<0.01	<0.12	0.11		<0.03			<0.14	1.78	25.6				
	F3	Wash & Finish		19.0		<0.01	<0.12	0.09		<0.03			<0.14	0.46	25.8				
	F4	Sadosa		2.8		<0.01	<0.12	0.07		<0.03			<0.14	0.12	25.7				
	F5	Hoyo De Lima		1.6		<0.01	<0.12	0.06		<0.03			0.15	0.41	25.7				
	F6	Baltimore Dominicana		248		<0.01	<0.12	0.19		<0.03			0.16	3.99	12.7				
	F7	Teneria Bermudez		5.6		<0.01	<0.12	0.07		<0.03			0.19	0.23	12.7				
	F8	Destileria Bermudez		3.3		<0.01	<0.12	0.08		<0.03			0.20	2.47	12.6				
	F9	Procesadora De Carnes Checo		8.0		<0.01	<0.12	0.09		<0.03			0.20	0.23	12.4				
	F10	Acero Del Cibao		4.7		<0.01	40.0	38.0		<0.03			0.23	94.2	12.4				
	F11	Bojos Leather		5.6		<0.01	<0.12	0.08		<0.03			0.20	0.20	10.7				
	F12	E. Leon Jimenez		13.0		<0.01	<0.12	0.08		<0.03			<0.14	0.33	10.6				
	F13	Corporacion Industrial Del Norte		67		<0.01	<0.12	0.07		<0.03			<0.14	0.24	10.7				
	F14	Pasteurizadora Cibao		8.9		<0.01	<0.12	0.07		<0.03			<0.14	1.04	10.7				
	F15	Isidro Bordas		5.2		0.01	<0.12	0.08		<0.03			<0.14	1.61	10.6				

(Source: JICA Study Team)

TableA2.2 Results of Water Quality Survey (3/6)

Sampling Date: March 6, 2001

				Temperature Ambient [℃]	Temperature Water [℃]	pH -	Electric Conductivity [μS/cm]	DO [mg/L]	BOD_5 [mg/L]	COD_{Cr} [mg/L]	SS [mg/L]	Cl^- [mg/L]	$SO4^{2-}$ [mg/L]	NH_4^+-N [mg/L]	NO_3-N [mg/L]	NO_2-N [mg/L]	T-N [mg/L]	PO_4^{2-}P [mg/L]	T-P [mg/L]
WTP	TP1	Rafey	Influent	26	27	6.57	1,470	-	113	306	177	188.5	390	21.3	0.9	0.014	32.8	10.9	3.34
			Effluent	22	26	6.62	1,589	-	38	128	100	205.5	410	18.8	0.9	0.022	2.0	10.1	2.15
	TP2	Cienfuegos	Influent	23	26	6.70	605	-	150	353	201	63.0	118	2.4	1.1	0.032	24.3	10.2	1.36
	TP3	El Embruj	Influent	25	22	6.20	644	-	73	271	121	63.0	180	17.7	0.9	0.017	23.3	12.0	2.24
			Effluent	25	22	5.98	592	-	27	66	86	38.5	140	9.8	0.2	0.010	15.1	7.6	1.95
	TP4	Los Salado	Influent	22	26	6.54	684	-	92	291	158	54.5	135	26.2	0.5	0.013	41.0	13.3	3.03
	TP5	Tamboril	Influent	25	26	6.32	2,820	-	588	2,940	642	56.5	400	83.5	5.5	0.050	133.4	39.8	5.64
			Effluent	25	23	6.57	1,352	-	108	386	114	147.5	175	31.8	3.7	0.045	55.7	13.2	3.18
River and Channels	RC1	Antes Toma de Pastor		24	22	6.08	135	8.2	2	8	162	14.5	2	0.2	0.1	0.010	0.15	0.35	0.32
	RC2	Antes Obra Toma de Canal		24	24	5.98	200	8.4	1.5	4	235	19.0	21	0.4	0.3	0.012	0.88	4.2	0.38
	RC3	Despues Descarga Teneria Bermudez		24	23	5.96	675	ND	25	140	140	52.5	125	4.4	0.2	0.015	13.4	4.0	0.57
	RC4	Frente Planta Rafey		23	25	6.22	748	3.0	15	82	981	62.5	145	5.0	0.6	0.019	8.7	7.8	1.92
	RC5	Despues Descarga A. N. Rafey		23	25	6.18	714	3.4	14	40	634	67.5	142	3.4	0.8	0.090	10.9	4.5	0.13
	RC6	Arroyo Hondo		24	21	6.23	500	5.5	20	90	213	39.0	68	6.0	0.9	0.085	5.7	3.7	0.76
	RC7	Nibaje		24	23	6.15	820	5.7	13	31	170	66.0	175	5.3	0.2	0.023	89.0	4.5	0.78
	RC8	Gurabo		25	24	6.28	1,111	ND	8	22	251	110.0	210	10.4	0.2	0.011	14.0	4.5	2.04
	RC9	Jacagua		26	25	6.49	1,017	ND	18	163	228	225.0	390	10.0	0.5	0.013	15.4	7.0	1.05
	RC10	Diversion channel for irrigatiuon		26	24	6.72	256	7.7	7	35	202	20.0	25	0.35	0.3	0.010	0.83	0.8	0.44
Industrial Effluent	F1	Embotelladora Dominicana		28	27	5.82	242	-	825	7,900	244	22.0	6	1.7	0.6	0.018	7.3	3.9	44.26
	F2	Hilos A & E		29	25	5.59	843	-	39	155	174	176.5	43	4.9	0.1	0.018	10.2	0.1	1.82
	F3	Wash & Finish		28	38	10.54	2,120	-	39	1,845	142	75.5	0	9.6	0.8	0.030	89.0	6.3	59.58
	F4	Sadosa		27	25	6.68	132	-	13	90	98	21.0	5	1.8	4.3	0.100	1.3	6.0	0.31
	F5	Hoyo De Lima		27	26	5.61	686	-	13	38	22,848	200	170	1.5	1.1	0.220	61.4	5.5	7.46
	F6	Baltimore Dominicana		26	24	4.44	4,800	-	1,400	2,290	667	866.0	88	8.2	0.9	0.082	79.4	20.4	2.55
	F7	Teneria Bermudez(WWTP IN)		26	28	5.08	4,760	-	994	3,080	428	756.0	725	46.5	2.2	0.070	80.6	17.2	4.66
	F7	Teneria Bermudez(WWTP OUT)		26	28	4.04	5,640	-	250	1,660	499	794.0	290	64.0	5.6	0.050	36.4	1.6	1.83
	F9	Procesadora De Carnes Checo		28	26	6.55	2,380	-	80	526	338	793.0	0	69.0	2.6	0.700	86.0	6.3	5.38
	F10	Acero Del Cibao		22	25	2.38	2,610	-	5	32	112	639	3	38.3	2.0	0.050	41.3	1.1	2.32
	F11	Bojos Leather		28	26	6.72	4,600	-	63	192	371	112.5	116	22.8	0.7	0.020	57.5	4.9	0.39
	F12	E. Leon Jimenez		22	27	6.51	882	-	263	758	124	73.0	26	55.0	2.7	0.065	127.8	15.4	2.42
	F13	Corporacion Industrial Del Norte		24	32	6.24	2,980	-	556	3,640	152	541.0	850	0.8	9.0	0.100	36.3	32.0	5.12
	F14	Pasteurizadora Cibao		22	25	5.67	697	-	80	1,485	189	294.5	2	24.3	2.5	0.060	55.7	56.8	7.18
	F15	Isidro Bordas		24	28	5.91	1,169	-	71	1,552	170	35.5	0	2.0	2.0	0.080	10.5	17.8	3.02

(Source: JICA Study Team)

TableA2.2 Results of Water Quality Survey (4/6)

Sampling Date: March 6, 2001

				Oil & Grease	Phenols	Cd	Pb	Zn	Cr(VI)	Total-Cr	As	Total-Hg	Cu	Fe	Total Coliforms	Total FecalColiforms	CN-	Mg	LAS
				[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	10^3NPM/100ml	10^3NPM/100ml	[mg/L]	[mg/L]	[mg/L]
WTP	TP1	Rafey	Influent	93	0.018	<0.01	<0.12	0.09	<0.05	<0.03	<0.01	<0.002	<0.14	0.55	500,000	500,000	<0.02	55.0	4.80
			Effluent	14		<0.01	<0.12	0.07		<0.03			<0.14	0.46	30,000	30,000		57.5	
	TP2	Cienfuegos	Influent	31	<0.005	<0.01	<0.12	0.07	<0.05	<0.03	<0.01	<0.002	<0.14	0.28	30,000	30,000	<0.02	55.0	1.34
	TP3	El Embruj	Influent	94		<0.01	<0.12	0.06		<0.03			<0.14	0.50	500,000	300,000		55.5	5.94
			Effluent	53		<0.01	<0.12	0.05		<0.03			<0.14	0.47	5,000	3,000		55.5	
	TP4	Los Salado	Influent	30	0.015	<0.01	<0.12	0.07	<0.05	<0.03	<0.01	<0.002	<0.14	0.51	300,000	300,000	<0.02	55.0	1.57
	TP5	Tamboril	Influent	234		<0.01	<0.12	0.11		<0.03			<0.14	0.76	60,000	60,000		55.0	6.90
			Effluent	19		<0.01	<0.12	0.07		<0.03			<0.14	0.71	2,000	2,000		55.0	
River and Channels	RC1	Antes Toma de Pastor		38	<0.005	<0.01	<0.12	0.05	<0.05	<0.03	<0.01	<0.002	<0.14	0.42	70	40	<0.02	47.0	0.16
	RC2	Antes Obra Toma de Canal		107		<0.01	<0.12	0.05		<0.03			<0.14	0.61	300	230		46.5	
	RC3	Despues Descarga Teneria Bermudez		25		<0.01	<0.12	0.06		<0.03			<0.14	0.53	17,000	13,000		56.0	
	RC4	Frente Planta Rafey		85		<0.01	<0.12	0.07		<0.03			<0.14	0.75	13,000	13,000		56.0	
	RC5	Despues Descarga A. N. Rafey		10	<0.005	<0.01	<0.12	0.06	<0.05	<0.03	<0.01	<0.002	<0.14	0.54	500,000	500,000	<0.02	47.5	0.27
	RC6	Arroyo Hondo		89		<0.01	<0.12	0.06		<0.03			<0.14	0.48	330	330		47.5	0.58
	RC7	Nibaje		80	0.085	<0.01	<0.12	0.06	<0.05	<0.03	<0.01	<0.002	<0.14	0.62	13,000	13,000	<0.02	47.0	0.58
	RC8	Gurabo		120	<0.005	<0.01	<0.12	0.07	<0.05	<0.03	<0.01	<0.002	<0.14	0.70	11,000	11,000	<0.02	3.1	1.04
	RC9	Jacagua		13	<0.005	<0.01	<0.12	0.07	<0.05	<0.03	<0.01	<0.002	<0.14	0.56	170,000	170,000	<0.02	47.0	1.67
	RC1	Diversion channel for irrigatiuon		57	<0.005	<0.01	<0.12	0.05	<0.05	<0.03	<0.01	<0.002	<0.14	0.66	5,000	5,000	<0.02	47.5	1.56
Industrial Effluent	F1	Embotelladora Dominicana		40		<0.01	<0.12	0.08		<0.03			<0.14	1.97				4.9	
	F2	Hilos A & E		8		<0.01	<0.12	0.07		<0.03			<0.14	0.73				10.7	
	F3	Wash & Finish		82		<0.01	<0.12	0.09		<0.03			<0.14	0.80				10.6	
	F4	Sadosa		110		<0.01	<0.12	0.13		<0.03			<0.14	0.51				10.5	
	F5	Hoyo De Lima		74		<0.01	<0.12	0.04		<0.03			<0.14	0.94				10.5	
	F6	Baltimore Dominicana		153		<0.01	<0.12	0.21		<0.03			<0.14	2.93				10.6	
	F7	Teneria Bermudez(WWTP IN)		71		<0.01	<0.12	0.16		<0.03			<0.14	0.70				10.5	
	F7	Teneria Bermudez(WWTP OUT)		120		<0.01	<0.12	0.16		<0.03			0.34	1.39				10.5	
	F9	Procesadora De Carnes Checo		139		<0.01	<0.12	0.07		<0.03			<0.14	0.82				54.5	
	F10	Acero Del Cibao		81		<0.01	<0.12	16.0		<0.03			<0.14	84.2				54.5	
	F11	Bojos Leather		57		<0.01	<0.12	0.06		<0.03			<0.14	0.35				54.5	
	F12	E. Leon Jimenez		61		<0.01	<0.12	0.09		<0.03			<0.14	1.90				155.0	
	F13	Corporacion Industrial Del Norte		175		<0.01	<0.12	0.10		<0.03			<0.14	0.55				55.5	
	F14	Pasteurizadora Cibao		63		<0.01	<0.12	0.14		<0.03			<0.14	0.47				55.0	
	F15	Isidro Bordas		86		<0.01	<0.12	0.10		<0.03			<0.14	1.47				55.0	

(Source: JICA Study Team)

TableA2.2 Results of Water Quality Survey (5/6)

Sampling Date: March 6, 2001

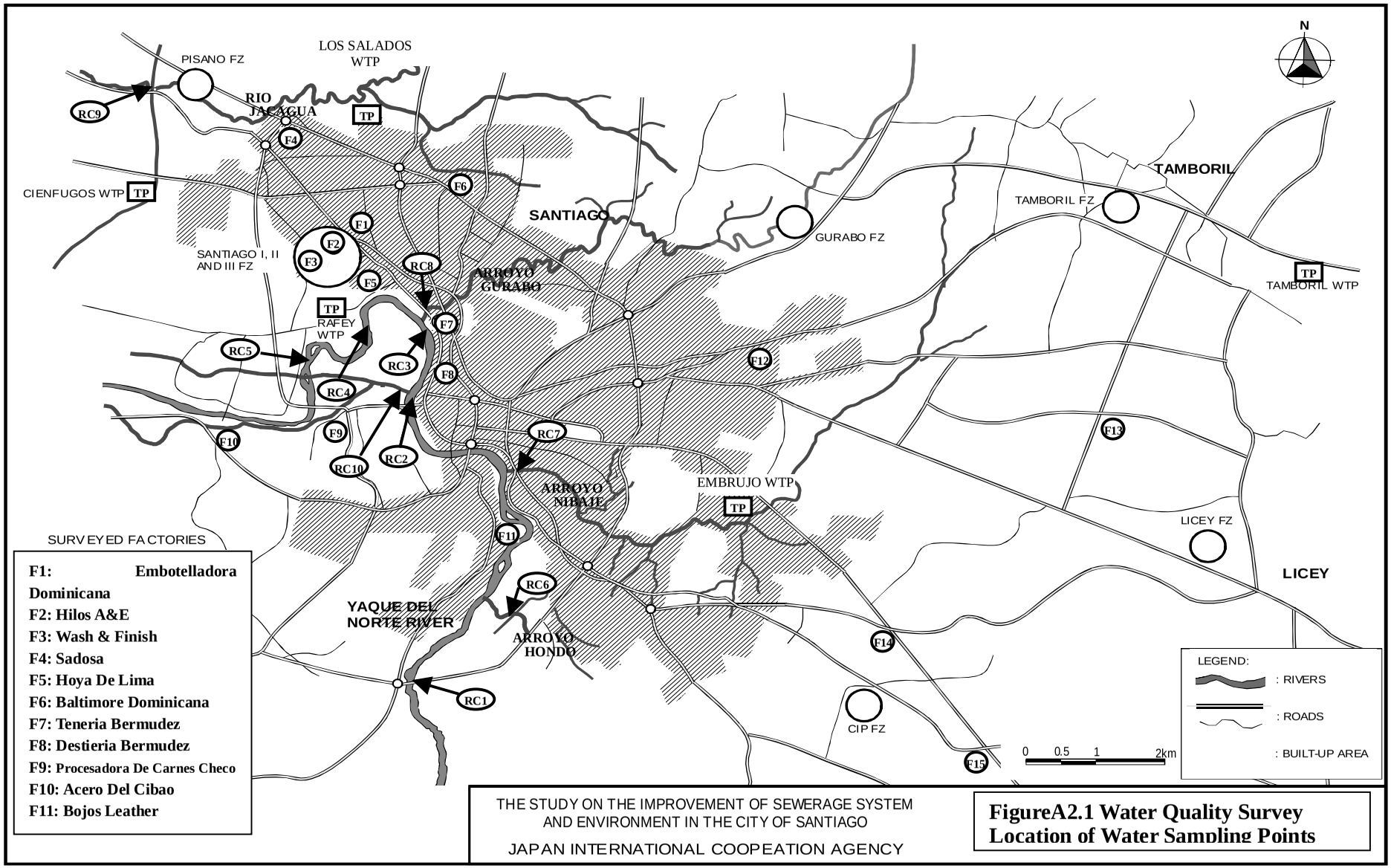
				Organochlorine Compounds																
				CCl_4	C_6H_6	CH_2CHCl	$C_2H_4Cl_2$	1,2-$C_2H_4Cl_2$	C_2HCl_3	1,1-$C_2H_4Cl_2$	$C_2H_2Cl_4$	1,1,1-$C_2H_3Cl_3$	1,3-C3H6Cl_2	CH_2Cl_2	1,1,2-$C_2H_3Cl_3$	1,2 Dichloroethane	1,1 Dichloroethane		
				[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[mg/L]		
WTP	TP1	Rafey	Influent	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		
			Effluent																
	TP2	Cienfuegos	Influent	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		
	TP3	El Embruj	Influent																
			Effluent																
	TP4	Los Salado	Influent	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		
	TP5	Tamboril	Influent																
			Effluent																
River and Channels	RC1	Antes Toma de Pastor		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		
	RC2	Antes Obra Toma de Canal																	
	RC3	Despues Descarga Teneria Bermudez																	
	RC4	Frente Planta Rafey																	
	RC5	Despues Descarga A. N. Rafey		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		
	RC6	Arroyo Hondo																	
	RC7	Nibaje																	
	RC8	Gurabo																	
	RC9	Jacagua																	
	RC1	Diversion channel for irrigatiuon		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		
Industrial Effluent	F1	Embotelladora Dominicana																	
	F2	Hilos A & E		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		
	F3	Wash & Finish		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01		
	F4	Sadosa																	
	F5	Hoyo De Lima																	
	F6	Baltimore Dominicana																	
	F7	Teneria Bermudez(WWTP IN)																	
	F7	Teneria Bermudez(WWTP OUT)																	
	F9	Procesadora De Carnes Checo																	
	F10	Acero Del Cibao																	
	F11	Bojos Leather																	
	F12	E. Leon Jimenez																	
	F13	Corporacion Industrial Del Norte																	
	F14	Pasteurizadora Cibao																	
	F15	Isidro Bordas																	

TableA2.2 Results of Water Quality Survey (6/6)

Sampling Date: March 6, 2001

				Pesticides																	
				Aldrin	Alpha-BHC	Beta-BHC	Gamma-BHC	Delta-BHC	Chlorodane	4,4-DDT	4,4-DDD	Dieldrin	Endosulfan I	Endosulfan II	Endosulfan Sulfate	Endrin	Endrin Aldehyde	Heptachlor	Heptachlor Epoxide	4,4-DDE	Toxaphene
				[μg/L]	[μg/L]	[μg/L]	[μg/L]	[μg/L]	[μg/L]	[μg/L]	[μg/L]	[μg/L]	[μg/L]	[μg/L]	[μg/L]	[μg/L]	[μg/L]	[μg/L]	[μg/L]	[μg/L]	[μg/L]	[μg/L]
WTP	TP1	Rafey	Influent																		
			Effluent																		
	TP2	Cienfuegos	Influent																		
	TP3	El Embruj	Influent																		
			Effluent																		
	TP4	Los Salado	Influent																		
	TP5	Tamboril	Influent																		
			Effluent																		
River and Channels	RC1	Antes Toma de Pastor		<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14
	RC2	Antes Obra Toma de Canal																			
	RC3	Despues Descarga Teneria Bermudez																			
	RC4	Frente Planta Rafey																			
	RC5	Despues Descarga A. N. Rafey		<0.14	<0.11	<0.12	<0.09	<0.11	<0.05	<0.10	<0.13	<0.06	<0.14	<0.06	<0.11	<0.07	<0.42	<0.09	<0.07	<0.13	<50
	RC6	Arroyo Hondo																			
	RC7	Nibaje																			
	RC8	Gurabo																			
	RC9	Jacagua																			
	RC10	Diversion channel for irrigatiuon		<0.14	<0.11	<0.12	<0.09	<0.11	<0.05	<0.10	<0.13	<0.06	<0.14	<0.06	<0.11	<0.07	<0.42	<0.09	<0.07	<0.13	<50
Industrial Effluent	F1	Embotelladora																			
	F2	Hilos A & E																			
	F3	Wash & Finish																			
	F4	Sadosa																			
	F5	Hoyo De Lima																			
	F6	Baltimore Dominicana																			
	F7	Teneria Bermudez(WWTP IN)																			
	F7	Teneria Bermudez(WWTP OUT)																			
	F9	Procesadora De Carnes Checo																			
	F10	Acero Del Cibao																			
	F11	Bojos Leather																			
	F12	E. Leon Jimenez																			
	F13	Corporacion Industrial Del Norte																			
	F14	Pasteurizadora Cibao																			
	F15	Isidro Bordas																			

(Source: JICA Study Team)



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

JAPAN INTERNATIONAL COOPEATION AGENCY

FigureA2.1 Water Quality Survey Location of Water Sampling Points