CHAPTER 4

4. WATER DEMAND PROJECTION IN THE YEAR 2010

4.1 Candidate Municipalities for the Detailed Survey

In order to classify the 96 municipalities in terms of supply shortage, INFOM suggested to tentatively fix the unit water supply amount at 180 liters per capita per day (ℓ/c/d) for the projection of water demand.

According to INFOM's database on existing service amount, 42 municipalities have sufficient water supply sources for the projected population of 2010, as long as the unit service amount is fixed at 180 ℓ/c/d. Therefore, in order to effectively conduct a field survey, these 42 municipalities were eliminated from the long list of 96 municipalities, concentrating the surveys on the remaining 54 municipalities where water shortage is projected.

The underlined 54 municipalities in Table 4.1.1 are the municipalities selected for the detailed survey.

Further, the following 9 municipalities with comparatively sufficient supply sources were excluded from the 54 candidate municipalities. The remaining 45 municipalities became the subjects for the formulation of a water source development plan, under a new assumption of the unit supply service level which was reduced from 180 ℓ/c/d to 106 and 155 ℓ/c/d, as described in the following section.

Gu 10	San Raymundo
Gu 15	Villa Canales
Sa 7	San Bartolomé Milpas Altas
Sa 15	San Antonio Aguas Calientes
Sa 16	Santa Catarina Barahona
So 6	Santa Catarina Ixtahuacán
Qu 11	Concepción Chiquirichapa
Qu 13	Almolonga
Qu 17	Colomba

4.2 Population Projection

The municipal population data shown in Table 4.2.1 was used to forecast the population in 2010, for the evaluation of water source development potential, water demand, and socioeconomic conditions.

The growth rates used to project the future population of the municipalities were estimated on the basis of the 1981 population census data and the population estimates for 1993 and 1994 which were provided by INE, INFOM and the municipalities.

According to the forecast population distribution of the 54 municipalities in 2010, 20 municipalities will have a population exceeding 10,000, 19 between 5,000 and 10,000, and 15 under 5,000 (Table 5.1.1).

4.3 Water Demand Projection

The water demand in the year 2010 was estimated by multiplying the projected population of each municipality by the planned unit supply amount per capita per day by planned area.

The projected population of municipalities is described in Section 4.2 and tabulated in Table 4.2.1.

The planned service level is usually determined based on the existing service level and its grade-up plan. However, the actual water supply service level in the Study Area greatly varies by municipality, ranging from 15 liters per capita per day in San Antonio Palopó (So 12) to 238 ℓ/c/d in Colomba (Qu 17), and no particular criteria has been established by each municipality nor by INFOM. The difference in the existing service level is mainly based on the financial capacity of each municipality and willingness of the inhabitants to pay for operation and maintenance costs, rather than the capacity of the water supply sources. Given these considerations, the following three service level plans were compared and discussed during the first Study Phase:

1) Maintaining, at least, the existing service level of each municipality

2) Fixing the service level uniformly at 180 ℓ/c/d

3) Fixing three to four service levels in accordance with the population scale of the municipalities

Plan 3) was chosen as reasonable, and service level classification was determined based on the criteria below recommended by COPECAS.

Level	Population	House Connection (H.C.) & Public Tap (P.T.)		Average
I	100 - 500	H.C. P.T. 40 ℓ/c/d	 100%	40 ℓ/c/d
II	500 - 2,000	H.C. 100 ℓ/c/d P.T. 40 ℓ/c/d	50% 50%	70 ℓ/c/d
III	2,000 - 10,000	H.C. 150 ℓ/c/d P.T. 40 ℓ/c/d	60% 40%	106 ℓ/c/d
IV	10,000 - 50,000	H.C. 200 ℓ/c/d P.T. 50 ℓ/c/d	70% 40%	155 ℓ/c/d
V	50,000 -	H.C. 225 ℓ/c/d P.T. 50 ℓ/c/d	85% 15%	198 ℓ/c/d

All of the 54 municipalities for the detailed survey, mentioned in the former section, were projected to have a population of between 2,000 and 30,000 and fall under the Level III and IV category of above table, with an average unit service level of 106 ℓ/c/d and 155 ℓ/c/d. The water demand of the 54 municipalities in 2010 was projected and shown in Table 4.3.1.

Table 4.1.1 Candidate Municipality for Detailed Survey (54)

GUATEMALA

No	Municipality
1	Santa Catarina Pinula
2	San Jose Pinula
3	San Jose del Golfo
4	Palencia
5	Chinautla
6	San Pedro Ayampuc
7	Mixco
8	San Pedro Sacatepequez
9	San Juan Sacatepequez
10	San Raymundo
11	Chuarrancho
12	Fraijanes
13	Amatitlan
14	Villa Nueva
15	Villa Canales
16	San Miguel Petapa

CHIMALTENANGO

No	Municipality
1	Chimaltenango
2	San Jose Poaquil
3	San Martin Jilotepeque
4	San Juan Comalapa
5	Santa Apolonia
6	Tecpan Guatemala
7	Patzun
8	San Miguel Pochuta
9	Patzicia
10	Santa Cruz Balanya
11	Acatenango
12	San Pedro Yepocapa
13	San Andres Itzapa
14	Parramos
15	Zaragoza
16	El Tejar

TOTONICAPAN

No	Municipality
1	Totonicapan
2	San Cristobal Totonic.
3	San Francisco el Alto
4	San Andres Xecul
5	Momostenango
6	Santa Maria Chiquimula
7	Santa Lucia la Reforma
8	San Bartolo Aguas Cal.

SACATEPEQUEZ

No	Municipality
1	Antigua Guatemala
2	Jocotenango
3	Pastores
4	Sumpango
5	Sto. Domingo Xenacoj
6	Santiago Sacatepequez
7	San Bartolome M. Altas
8	San Lucas Sacatepequez
9	Santa Lucia M. Altas
10	Magdalena Milpas Altas
11	Santa Maria de Jesus
12	Ciudad Vieja
13	San Miguel Duenas
14	San Juan Alotenango
15	San Antonio Aguas Cal.
16	Santa Catarina Barahona

SOLOLA

No	Municipality
1	Solola
2	San Jose Chacaya
3	Santa Maria Visitacion
4	Santa Lucia Utatlan
5	Nahuala
6	Sta. Catarina Ixtahuacan
7	Santa Clara la Laguna
8	Concepcion
9	San Andres Semetabaj
10	Panajachel
11	Sta. Catarina Palopo
12	San Antonio Palopo
13	San Lucas Toliman
14	Santa Cruz la Laguna
15	San Pablo la Laguna
16	San Marcos la Laguna
17	San Juan la Laguna
18	San Pedro la Laguna
19	Santiago Atitlan

QUETZALTENANGO

No	Municipality
1	Quetzaltenango
2	Salcaja
3	Olintepeque
4	San Carlos Sija
5	Sibilia
6	Cabrican
7	Cajola
8	San Miguel Siguila
9	San Juan Ostuncalco
10	San Mateo
11	Cpcion. Chiquirichapa
12	San M. Sacatepequez
13	Almolonga
14	Cantel
15	Huitan
16	Zunil
17	Colomba
18	San Francisco la Union
19	El Palmar
20	Coatepeque
21	Genova
22	Flores Costa Cuca
23	La Esperanza
24	Palestina

Table 4.2.1 Urban Population Projection and Growth Rates, Municipal City (1)

GUATEMALA

No	Municipality	Population					Growth Rate (%)			
		(Census) 1981	1993	1994	1998	2010	93/81	94/93	98/94	2010/98
1	Santa Catarina Pinula *	4,272	8,030	8,376	9,799	14,134	5.40	4.31	4.00	3.10
2	San Jose Pinula *	5,296	10,743	11,277	13,448	19,970	6.07	4.97	4.50	3.35
3	San Jose del Golfo *	834	1,975	2,070	2,484	4,185	7.45	4.81	4.66	4.44
4	Palencia	3,818	5,608	5,734	6,252	8,019	3.26	2.25	2.19	2.11
5	Chinautla *	2,027	2,135	2,161	2,220	2,438	0.43	0.60	0.68	0.80
6	San Pedro Ayampuc *	3,842	5,561	5,680	6,163	7,770	3.13	2.14	2.06	1.94
7	Mixco *	11,544	19,176	19,800	22,302	29,994	4.32	3.25	3.02	2.50
8	San Pedro Sacatepequez *	5,358	7,512	7,652	8,225	10,140	2.86	1.86	1.82	1.76
9	San Juan Sacatepequez *	6,726	9,825	10,041	10,928	13,948	3.21	2.20	2.14	2.06
10	San Raymundo *	2,519	4,565	4,747	5,543	8,779	5.08	3.99	3.95	3.89
11	Chuarrancho *	4,122	5,519	5,601	5,925	6,927	2.46	1.49	1.41	1.30
12	Fraijanes	3,121	4,697	4,812	5,291	6,978	3.47	2.45	2.40	2.33
13	Amatitlan	20,407	37,177	38,682	44,733	63,778	5.13	4.05	3.70	3.00
14	Villa Nueva *	20,236	35,677	37,432	44,468	65,653	4.84	4.92	4.40	3.30
15	Villa Canales *	3,605	4,745	4,809	5,064	5,866	2.32	1.35	1.30	1.23
16	San Miguel Petapa	3,766	7,484	7,842	9,280	13,701	5.89	4.78	4.30	3.30
	TOTAL (*)	101,493	170,429	176,716	202,125	282,279	4.41	3.69	3.42	2.82

(*) Excluding Guatemala City

SACATEPEQUEZ

No	Municipality	Population					Growth Rate (%)			
		(Census) 1981	1993	1994	1998	2010	93/81	94/93	98/94	2010/98
1	Antigua Guatemala	15,801	20,948	21,033	21,500	23,100	2.38	0.41	0.55	0.60
2	Jocotenango *	6,668	12,179	12,731	14,997	21,885	5.15	4.53	4.18	3.20
3	Pastores	2,996	3,858	3,897	4,044	4,455	2.13	1.01	0.93	0.81
4	Sumpango	9,484	14,008	14,312	15,510	19,258	3.30	2.17	2.03	1.82
5	Sto. Domingo Xenacoj	3,483	5,516	5,664	6,264	8,288	3.91	2.68	2.55	2.36
6	Santiago Sacatepequez	6,522	9,165	9,322	9,933	11,792	2.88	1.71	1.60	1.44
7	San Bartolome M. Altas *	1,970	3,253	3,347	3,725	4,980	4.27	2.89	2.71	2.45
8	San Lucas Sacatepequez	3,825	9,186	9,767	12,054	19,077	7.57	6.32	5.40	3.90
9	Santa Lucia M. Altas *	1,186	3,560	3,738	4,348	7,545	9.09	5.40	5.20	4.70
10	Magdalena Milpas Altas *	2,685	4,310	4,431	4,922	6,580	4.02	2.81	2.66	2.45
11	Santa Maria de Jesus *	8,287	10,971	11,107	11,165	14,890	2.37	1.24	0.13	2.43
12	Ciudad Vieja *	9,435	14,405	14,756	16,161	20,739	3.59	2.44	2.30	2.10
13	San Miguel Duenas	3,147	3,996	4,033	4,162	4,466	2.01	0.93	0.79	0.59
14	San Juan Alotenango	6,761	9,530	9,702	10,367	12,350	2.91	1.80	1.67	1.47
15	San Antonio Aguas Cal. *	3,698	4,852	4,909	5,120	5,702	2.29	1.17	1.06	0.90
16	Santa Catarina Barahona	1,437	2,241	2,295	2,512	3,219	3.77	2.41	2.28	2.09
	TOTAL	87,375	131,968	135,044	146,783	188,327	3.50	2.33	2.11	2.10

Source: 1981, 1993 and 1994 data provided by the National Institute of Statistics (INE), INFOM and the Municipalities
1998 AND 2010, estimated by the Study Team

Table 4.2.1 Urban Population Projection and Growth Rates, Municipal City (2)

CHIMALTENANGO

No	Municipality	Population					Growth Rate (%)			
		(Census) 1981	1993	1994	1998	2010	93/81	94/93	98/94	2010/98
1	Chimaltenango	14,967	24,933	25,682	28,883	37,944	4.34	3.00	2.98	2.30
2	San Jose Poaquil *	2,414	3,784	3,880	4,281	5,704	3.82	2.54	2.49	2.42
3	San Martin Jilotepeque *	6,508	9,086	9,236	9,857	11,968	2.82	1.65	1.64	1.63
4	San Juan Comalapa *	11,362	14,458	14,710	15,760	19,408	2.03	1.74	1.74	1.75
5	Santa Apolonia	1,037	3,949	4,352	5,965	10,835	11.79	10.21	8.20	5.10
6	Tecpan Guatemala	5,977	8,326	8,461	9,026	10,972	2.80	1.62	1.63	1.64
7	Patzun *	9,802	12,613	13,007	14,594	19,398	2.12	3.12	2.92	2.40
8	San Miguel Pochuta	1,597	3,903	4,146	5,126	8,208	7.73	6.23	5.45	4.00
9	Patzicia *	7,628	11,347	11,587	12,596	16,164	3.36	2.12	2.11	2.10
10	Santa Cruz Balanya	2,443	4,480	4,650	5,384	8,268	5.18	3.79	3.73	3.64
11	Acatenango	2,029	3,672	3,807	4,392	6,699	5.07	3.68	3.64	3.58
12	San Pedro Yepocapa	4,030	8,296	8,689	10,283	15,006	6.20	4.74	4.30	3.20
13	San Andres Itzapa	7,968	15,182	15,804	18,276	25,755	5.52	4.10	3.70	2.90
14	Parramos	3,069	5,452	5,645	6,473	9,668	4.91	3.54	3.48	3.40
15	Zaragoza *	4,440	7,578	7,821	8,837	12,024	4.56	3.21	3.10	2.60
16	El Tejar *	3,251	7,123	7,499	9,011	13,617	6.75	5.28	4.70	3.50
	TOTAL	88,522	144,182	148,975	168,744	231,638	4.15	3.32	3.16	2.68

SOLOLA

No	Municipality	Population					Growth Rate (%)			
		(Census) 1981	1993	1994	1998	2010	93/81	94/93	98/94	2010/98
1	Solola *	6,286	14,408	15,254	18,897	30,960	7.16	5.87	5.50	4.20
2	San Jose Chacaya	114	267	272	292	361	7.35	1.87	1.83	1.77
3	Santa Maria Visitacion	745	1,092	1,116	1,209	1,494	3.24	2.20	2.03	1.78
4	Santa Lucia Utatlan *	989	2,071	2,176	2,650	4,773	6.36	5.07	5.05	5.02
5	Nahuala *	2,314	4,076	4,223	4,870	7,494	4.83	3.61	3.63	3.66
6	Sta. Cat. Ixtahuacan *	1,396	2,227	2,289	2,556	3,569	3.97	2.78	2.80	2.82
7	Santa Clara la Laguna *	2,447	4,067	4,194	4,743	6,862	4.32	3.12	3.12	3.13
8	Concepcion	947	1,367	1,394	1,510	1,932	3.11	1.98	2.02	2.08
9	San Andres Semetabaj *	984	1,700	1,760	1,983	2,603	4.66	3.53	3.02	2.29
10	Panajachel	3,403	7,394	7,793	9,383	13,676	6.68	5.40	4.75	3.19
11	Sta. Catarina Palopo *	1,049	1,641	1,684	1,867	2,540	3.80	2.62	2.61	2.60
12	San Antonio Palopo *	1,834	2,418	2,470	2,668	3,243	2.33	2.15	1.94	1.64
13	San Lucas Toliman	6,067	10,647	11,029	12,607	17,891	4.80	3.59	3.40	2.96
14	Santa Cruz la Laguna *	535	697	706	737	812	2.23	1.29	1.09	0.81
15	San Pablo la Laguna *	2,811	5,652	5,918	6,990	10,189	5.99	4.71	4.25	3.19
16	San Marcos la Laguna *	927	1,348	1,375	1,496	1,972	3.17	2.00	2.14	2.33
17	San Juan la Laguna *	2,068	3,732	3,875	4,496	6,965	5.04	3.83	3.78	3.72
18	San Pedro la Laguna	5,597	8,428	8,624	9,462	12,543	3.47	2.33	2.35	2.38
19	Santiago Atitlan	14,152	22,090	22,668	24,992	32,071	3.78	2.62	2.47	2.10
	TOTAL	54,665	95,322	98,820	113,409	161,951	4.74	3.67	3.50	3.01

Source: 1981, 1993 and 1994 data provided by the National Institute of Statistics (INE), INFOM and the Municipalities
1998 AND 2010, estimated by the Study Team

Table 4.2.1 Urban Population Projection and Growth Rates, Municipal City (3)

TOTONICAPAN

No	Municipality	Population					Growth Rate (%)			
		(Census) 1981	1993	1994	1998	2010	93/81	94/93	98/94	2010/ 98
1	Totonicapan	7,478	14,400	14,732	16,146	21,294	5.61	2.31	2.32	2.33
2	San Cristobal Totonic.	3,416	6,917	7,088	7,819	10,523	6.06	2.47	2.49	2.51
3	San Francisco el Alto *	3,404	8,892	9,560	11,978	18,740	8.33	7.51	5.80	3.80
4	San Andres Xecul *	2,493	3,654	3,748	4,152	5,663	3.24	2.57	2.59	2.62
5	Momostenango *	6,094	10,061	10,390	11,764	16,740	4.55	3.27	3.15	2.98
6	Santa Maria Chiquimula	1,368	3,218	3,323	3,782	5,593	7.39	3.26	3.28	3.32
7	Santa Lucia la Reforma	410	595	610	672	886	3.15	2.52	2.44	2.33
8	San Bartolo Aguas Cal.	874	1,273	1,305	1,442	1,953	3.18	2.51	2.53	2.56
	TOTAL	25,537	49,010	50,756	57,755	81,392	5.58	3.56	3.28	2.90

QUETZALTENANGO

No	Municipality	Population					Growth Rate (%)			
		(Census) 1981	1993	1994	1998	2010	93/81	94/93	98/94	2010/ 98
1	Quetzaltenango	62,719	98,401	100,983	111,997	152,730	3.82	2.62	2.62	2.62
2	Salcaja	7,426	12,233	12,603	14,102	18,636	4.25	3.02	2.85	2.35
3	Olintepeque *	2,690	3,973	4,058	4,418	5,704	3.30	2.14	2.15	2.15
4	San Carlos Sija *	1,521	3,186	3,264	3,601	4,872	6.36	2.45	2.49	2.55
5	Sibilia	467	1,067	1,101	1,248	1,813	7.13	3.19	3.18	3.16
6	Cabrican	623	1,655	1,727	2,047	3,403	8.48	4.35	4.34	4.33
7	Cajola *	1,540	2,928	3,043	3,480	4,775	5.50	3.93	3.41	2.67
8	San Miguel Siguila	656	1,023	1,049	1,162	1,588	3.77	2.54	2.58	2.64
9	San Juan Ostuncalco	7,124	13,104	13,618	15,687	21,876	5.21	3.92	3.60	2.81
10	San Mateo	1,041	1,960	2,004	2,190	2,859	5.41	2.24	2.25	2.25
11	Cpcion. Chiquirichapa *	2,819	4,906	5,076	5,818	8,762	4.73	3.47	3.47	3.47
12	San M. Sacatepequez *	1,813	3,089	3,191	3,626	5,274	4.54	3.30	3.25	3.17
13	Almolonga *	7,148	10,579	10,808	11,775	15,227	3.32	2.16	2.17	2.17
14	Cantel	2,491	3,316	3,361	3,549	4,190	2.41	1.36	1.37	1.39
15	Huitan *	1,120	1,854	1,911	2,153	3,053	4.29	3.07	3.03	2.95
16	Zunil	4,205	6,500	6,663	7,356	9,898	3.70	2.51	2.51	2.50
17	Colomba *	4,252	6,157	6,316	6,967	9,191	3.13	2.58	2.48	2.34
18	San Francisco la Union *	1,065	1,664	1,707	1,890	2,661	3.79	2.58	2.58	2.56
19	El Palmar	1,968	3,901	4,079	4,870	8,238	5.87	4.56	4.53	4.48
20	Coatepeque	19,307	31,254	32,152	35,768	46,550	4.10	2.87	2.70	2.22
21	Genova *	1,826	3,633	3,800	4,539	7,267	5.90	4.60	4.54	4.00
22	Flores Costa Cuca *	1,839	3,808	3,972	4,662	7,378	6.25	4.31	4.08	3.90
23	La Esperanza	1,595	2,603	2,679	3,010	4,296	4.17	2.92	2.96	3.01
24	Palestina *	1,128	2,954	3,160	4,005	7,192	8.35	6.97	6.10	5.00
	TOTAL	138,383	225,748	232,325	259,919	357,334	4.16	2.91	2.85	2.69

Source: 1981, 1993 and 1994 data provided by the National Institute of Statistics (INE), INFOM and the Municipalities
1998 AND 2010, estimated by the Study Team

Table 4.3.1 Water Demand Projection (1)

GUATEMALA

No.	Municipality	1994				1998				2010			
		Population	Service Level l/c/d	Demand m3/day	Water Shortage m3/day	Population	W. Supply Criteria l/c/d	Demand m3/day	Water Shortage m3/day	Population	W. Supply Criteria l/c/d	Demand m3/day	Water Shortage m3/day
1	Santa Catarina Pinula	8,376	89.09	746	889	9,799	106	1,039	596	14,134	155	2,191	-556
2	San Jose Pinula	11,277	69.81	787	34	13,448	155	2,084	-1,263	19,970	155	3,095	-2,277
3	San Jose del Golfo	2,070	80.65	167	96	2,484	106	263	-1	4,185	106	444	-181
5	Chinautla	2,161	71.43	154	-76	2,220	106	235	-157	2,438	106	258	-180
6	San Pedro Ayampuc	5,680	37.34	212	187	6,163	106	653	-254	7,770	106	824	-424
7	Mixco	19,800	159.55	3,159	-500	22,302	155	3,457	-798	29,994	155	4,649	-1,990
8	San Pedro Sacatepequez	7,652	45.55	349	-129	8,225	106	872	-652	10,140	155	1,572	-1,278
9	San Juan Sacatepequez	10,041	57.16	574	808	10,928	155	1,694	-311	13,948	155	2,162	-780
10	San Raymundo	4,747	52.24	248	706	5,543	106	588	366	8,779	106	931	23
11	Chuarrancho	5,601	57.89	324	157	5,925	106	628	-147	6,927	106	734	-253
14	Villa Nueva	37,432	96.53	3,613	1,246	44,468	155	6,893	-2,034	65,653	198	12,999	-8,140
15	Villa Canales	4,809	121.78	586	8,862	5,064	106	537	8,911	5,865	106	622	8,826

SACATEPEQUEZ

No.	Municipality	1994				1998				2010			
		Population	Service Level l/c/d	Demand m3/day	Water Shortage m3/day	Population	W. Supply Criteria l/c/d	Demand m3/day	Water Shortage m3/day	Population	W. Supply Criteria l/c/d	Demand m3/day	Water Shortage m3/day
2	Jocotenango	12,731	139.76	1,779	-77	14,997	155	2,325	-622	21,885	155	3,392	-1,690
7	San Bartolome M. Altas	3,347	96.94	324	272	3,725	106	395	201	4,980	106	528	68
9	Santa Lucia M. Altas	3,550	41.39	147	199	4,348	106	461	-115	7,545	106	800	-454
10	Magdalena Milpas Altas	4,431	79.05	350	126	4,922	106	522	-46	6,580	106	697	-221
11	Santa Maria de Jesus	11,107	35.43	394	-221	11,165	155	1,731	-1,558	14,890	155	2,308	-1,617
12	Ciudad Vieja	14,756	123.62	1,824	-43	16,161	155	2,505	-724	20,739	155	3,215	-1,434
15	San Antonio Aguas Cal.	4,909	75.23	369	434	5,120	106	543	261	5,702	106	604	199
16	Santa Catarina Barahona	2,295	198.60	456	304	2,512	106	266	493	3,219	106	341	418

Table 4.3.1 Water Demand Projection (2)

CHIMALTENANGO

No.	Municipality	1994				1998				2010			
		Population	Service Level l/c/d	Demand m3/day	Water Shortage m3/day	Population	W. Supply Criteria l/c/d	Demand m3/day	Water Shortage m3/day	Population	W. Supply Criteria l/c/d	Demand m3/day	Water Shortage m3/day
2	San Jose Poaquil	3,880	80.32	312	-46	4,281	106	454	-188	5,704	106	605	-339
3	San Martin Jilotepeque	9,236	116.98	1,080	-216	9,857	106	1,045	-181	11,986	155	1,858	-1,340
4	San Juan Comalapa	14,710	126.24	1,857	-1,347	15,760	155	2,443	-1,933	19,408	155	3,008	-1,954
7	Patzun	13,007	32.51	423	307	14,594	155	2,262	-1,532	19,398	155	3,007	-2,277
9	Patzicia	11,587	24.75	287	516	12,596	155	1,952	-1,150	16,164	155	2,505	-1,703
15	Zaragoza	7,821	59.02	462	575	8,837	106	937	100	12,024	155	1,864	-827
16	El Tejar	7,499	79.05	593	733	9,011	106	955	371	13,617	155	2,111	-784

SOLOLA

No.	Municipality	1994				1998				2010			
		Population	Service Level l/c/d	Demand m3/day	Water Shortage m3/day	Population	W. Supply Criteria l/c/d	Demand m3/day	Water Shortage m3/day	Population	W. Supply Criteria l/c/d	Demand m3/day	Water Shortage m3/day
1	Solola	15,254	113.94	1,738	889	18,897	155	2,929	-302	30,960	155	4,799	-2,172
4	Santa Lucia Utatlan	2,176	39.22	85	77	2,650	106	281	-118	4,773	106	506	-344
5	Nahuala	4,223	61.33	259	41	4,870	106	516	-216	7,494	106	794	-495
6	Sta. Catarina Ixtahuacan	2,289	141.41	324	306	2,556	106	271	359	3,569	106	378	252
7	Santa Clara la Laguna	4,194	69.28	291	-21	4,743	106	503	-233	6,862	106	727	-458
9	San Andres Semetabaj	1,760	66.60	117	-35	1,983	70	139	-57	2,603	106	276	-194
11	Sta. Catarina Palopo	1,684	111.21	187	37	1,867	70	131	94	2,540	106	269	-45
12	San Antonio Palopo	2,470	15.01	37	-1	2,668	106	283	-247	3,243	106	344	-307
14	Santa Cruz la Laguna	706	63.74	45	-4	737	70	52	-10	812	70	57	-15
15	San Pablo la Laguna	5,918	25.69	152	-118	6,990	106	741	-707	10,189	155	1,579	-1,546
16	San Marcos la Laguna	1,375	58.96	81	-27	1,496	70	105	-51	1,972	70	138	-84
17	San Juan la Laguna	3,875	65.30	253	-39	4,496	106	477	-262	6,965	106	738	-524

Table 4.3.1 Water Demand Projection (3)

TOTONICAPAN

No.	Municipality	1994				1998				2010			
		Population	Service Level l/c/d	Demand m3/day	Water Shortage m3/day	Population	W. Supply Criteria l/c/d	Demand m3/day	Water Shortage m3/day	Population	W. Supply Criteria l/c/d	Demand m3/day	Water Shortage m3/day
3	San Francisco el Alto	9,560	75.00	717	-138	11,978	155	1,857	-1,278	18,740	155	2,905	-2,326
4	San Andres Xecul	3,748	51.18	192	7	4,152	106	440	-241	5,663	106	600	-402
5	Momostenango	10,390	68.58	713	-73	11,764	155	1,823	-1,183	16,740	155	2,595	-1,955

QUETZALTENANGO

No.	Municipality	1994				1998				2010			
		Population	Service Level l/c/d	Demand m3/day	Water Shortage m3/day	Population	W. Supply Criteria l/c/d	Demand m3/day	Water Shortage m3/day	Population	W. Supply Criteria l/c/d	Demand m3/day	Water Shortage m3/day
3	Olintepeque	4,058	91.04	369	193	4,418	106	468	94	5,704	106	605	-43
4	San Carlos Sija	3,264	100.00	326	-84	3,601	106	382	-140	4,872	106	516	-275
7	Cajola	3,043	79.94	243	-84	3,480	106	369	-210	4,775	106	506	-347
11	Cpcion. Chiquirichapa	5,076	73.38	372	627	5,818	106	617	383	8,762	106	929	71
12	San M. Sacatepequez	3,191	88.10	281	-9	3,626	106	384	-112	5,274	106	559	-287
13	Almolonga	10,808	151.73	1,640	2,017	11,775	155	1,825	1,831	15,227	155	2,360	1,296
15	Huitan	1,911	68.01	130	-51	2,153	106	228	-150	3,053	106	324	-245
17	Colomba	6,316	237.61	1,501	0	6,967	106	739	762	9,191	106	974	527
18	San Francisco la Union	1,707	27.94	48	-22	1,890	70	132	-107	2,561	106	271	-271
21	Genova	3,800	54.20	206	61	4,539	106	481	-214	7,267	106	770	-770
22	Flores Costa Cuca	3,972	51.05	203	152	4,662	106	494	-140	7,378	106	782	-427
24	Palestina	3,160	67.71	214	386	4,005	106	425	176	7,192	106	762	-162

CHAPTER 5

5. CATEGORIZATION OF THE CANDIDATE MUNICIPALITIES

5.1 Criteria and Procedure for Categorization

5.1.1 Final Selection of the Candidate Municipalities for the Detailed Survey

As stated in Chapter 4, 51 municipalities were eliminated because they were viewed to have sufficient supply sources until 2010. Among the remaining 45 municipalities, the following 10 municipalities were excluded from the detailed Study, due to various reasons such as internal strife, lack of interest in groundwater development or because of other on-going or planned projects like Xayá-Pixcayá Project, EMPAGUA Project and others.

Gu 5	Chinautla	Sa 2	Jocotenango
Gu 7	Mixco	Sa 10	Magdalena Milpas Altas
Gu 14	Villa Nueva	Sa 12	Ciudad Vieja
Ch 15	Zaragoza	To 4	San Andres Xecul
Ch 16	El Tejar	Qu 12	San Martín Sacatepéquez

The final number of candidate municipalities for the detailed survey and the planning of water source development strategy was determined to be 35.

5.1.2 Criteria for Categorization

The following factors are assessed for the categorization of the candidate municipalities.

(1) Socioeconomic conditions

(a) Ability to pay/willingness to pay O/M costs

The actual water supply service level in the municipalities varies widely, from a minimum of 15 ℓ/c/d to a maximum of 238 ℓ/c/d, mainly due to financial problems. In many of the municipalities, budget shortage makes it difficult to develop new supply sources, even though the development potential is not low. Also, the inhabitants of some of the municipalities prefer the existing service level at low payment, rather than improved services at higher O/M cost.

Therefore, socioeconomic condition was determined as one of the most important factors in establishing the criteria for categorization. The classification of the municipalities was made based on the results of the interview survey.

Requests for new water source development and the willingness to pay as well as their ability to pay were categorized as:

a: high level
b: relatively high level
c: low level

(b) Projected population scale in the year 2010

The larger the population the bigger is the impact expected from the improvement of the water supply service. Moreover, the unit cost for operation and maintenance shared per person becomes comparatively smaller, if the population is large. Therefore, population scale is an important factor for categorization (Table 5.1.1).

Projected population of the municipality is:

A: more than 10,000
B: 10,000 - 5,000
C: less than 5,000

(2) Projected water shortage condition in the year 2010

Since the water shortage condition is the most important factor in the categorization of the candidate municipalities, the following criteria on water shortage condition was established based on the results of the water demand projection (Table 5.1.2).

Presumed supply shortage in the year 2010 is:

A: more than 100 ℓ/c/d
B: 50 - 100 ℓ/c/d
C: less than 50 ℓ/c/d

(3) Water source development potential

As described in detail in "Chapter 6", the existing surface water and spring water sources in the 35 municipalities wil be replaced or supplemented by groundwater in the future. Therefore, the following criteria was established to determine water source development potential, based on the results of the hydrogeological field survey in Phase I of the Study (Tables 7.2.2 and 7.2.3).

A: High potential for groundwater development

B: Relatively high potential for groundwater development

C: Low potential for groundwater development, but shallow aquifer development may be possible by constructing shallow dug wells.

5.1.3 Procedure for Categorization

The following procedure was applied for categorization and classification, and for the priority assignment to the 35 municipalities.

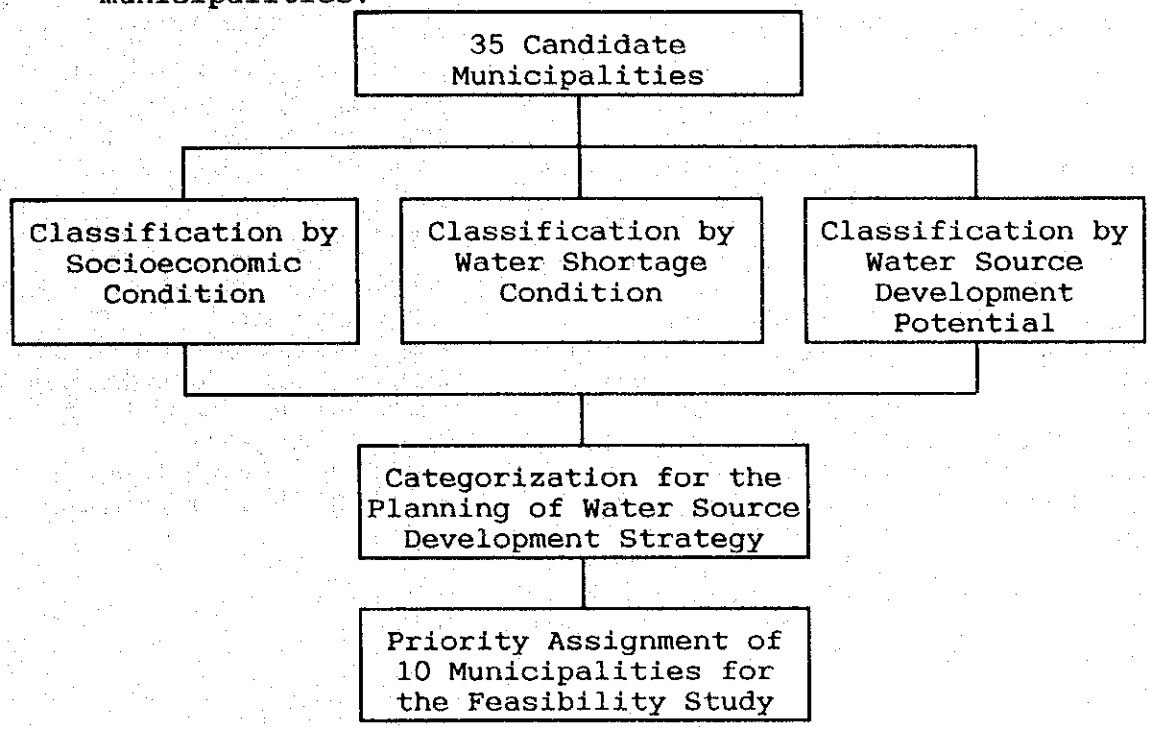


Table 5.1.1 Population Categorization (2010)

A (More than 10,000)			B (5,000 - 10,000)			C (Less than 5,000)		
No.	Municipality	Popul.	No.	Municipality	Popul.	No.	Municipality	Popul.
Gu14	Villa Nueva	65,653	Qu17	Colomba	9,191	Sa 7	San Bartolome M. Altas	4,980
So 1	Solola	30,960	Gu10	San Raymundo	8,779	Qu 4	San Carlos Sija	4,872
Gu 7	Mixco	29,994	Qu11	Cpcion. Chiquirichapa	8,762	Qu 7	Cajola	4,775
Sa 2	Jocotenango	21,885	Gu 6	San Pedro Ayampuc	7,770	So 4	Santa Lucia Utatlan	4,773
Sa12	Ciudad Vieja	20,739	Sa 9	Santa Lucia M. Altas	7,545	Gu 3	San Jose del Golfo	4,185
Gu 2	San Jose Pinula	19,970	So 5	Nahuala	7,494	So 6	Sta.Catarina Ixtahuacan	3,569
Ch 4	San Juan Comalapa	19,408	Qu22	Flores Costa Cuca	7,378	So12	San Antonio Palopo	3,243
Ch 7	Patzun	19,398	Qu21	Genova	7,267	Sa16	Santa Catarina Barahona	3,219
To 3	San Francisco el Alto	18,740	Qu24	Palestina	7,192	Qu15	Huitan	3,053
To 5	Momostenango	16,740	So17	San Juan la Laguna	6,965	So 9	San Andres Semetabaj	2,603
Ch 9	Patzicia	16,164	Gu11	Chuarrancho	6,927	Qu18	San Francisco la Union	2,561
Qu13	Almolonga	15,227	So 7	Santa Clara la Laguna	6,862	So11	Sta. Catarina Palopo	2,540
Sa11	Santa Maria de Jesus	14,890	Sa10	Magdalena Milpas Altas	6,580	Gu 5	Chinautla	2,438
Gu 1	Santa Catarina Pinula	14,134	Gu15	Villa Canales	5,865	So16	San Marcos la Laguna	1,972
Gu 9	San Juan Sacatepequez	13,948	Ch 2	San Jose Poaquil	5,704	So14	Santa Cruz la Laguna	812
Ch16	El Tejar	13,617	Qu 3	Olintepeque	5,704			
Ch15	Zaragoza	12,024	Sa15	San Antonio Aguas Cal.	5,702			
Ch 3	San Martin Jilotepeque	11,986	To 4	San Andres Xecul	5,663			
So15	San Pablo la Laguna	10,189	Qu12	San M. Sacatepequez	5,274			
Gu 8	San Pedro Sacatepequez	10,140						

Table 5.1.2 Water Shortage Condition (2010)

A (More than -100 l/c/d)			B (-100 ~ -50 l/c/d)			C (Less than -50 l/c/d)		
No.	Municipality	Water Shortage l/c/d	No.	Municipality	Water Shortage l/c/d	No.	Municipality	Water Shortage l/c/d
So15	San Pablo la Laguna	-151.69	So12	San Antonio Palopo	-94.81	Gu 3	San Jose del Golfo	-43.24
Gu 8	San Pedro Sacatepeque	-126.01	Qu15	Huitan	-80.25	So16	San Marcos la Laguna	-42.83
To 3	San Francisco el Alto	-124.11	So17	San Juan la Laguna	-75.24	Gu 1	Santa Catarina Pinula	-39.31
Ch 7	Patzun	-117.36	So 9	San Andres Semetabaj	-74.47	Gu11	Chuarrancho	-36.59
To 5	Momostenango	-116.77	Qu 7	Cajola	-72.71	Qu24	Palestina	-22.57
Gu 2	San Jose Pinula	-114.04	So 4	Santa Lucia Utatlan	-71.97	So14	Santa Cruz la Laguna	-18.93
Ch 3	San Martin Jilotepequ	-111.78	So 1	Solola	-70.16	So11	Sta. Catarina Palopo	-17.56
Sa11	Santa Maria de Jesus	-108.59	So 7	Santa Clara la Laguna	-66.72	Qu 3	Olintepeque	-7.47
Qu21	Genova	-106.00	So 5	Nahuala	-65.99			
Qu18	San Francisco la Unio	-106.00	Sa 9	Santa Lucia M. Altas	-60.19			
Ch 9	Patzicia	-105.34	Ch 2	San Jose Poaquil	-59.35			
Ch 4	San Juan Comalapa	-100.69	Qu22	Flores Costa Cuca	-57.94			
			Qu 4	San Carlos Sija	-56.34			
			Gu 9	San Juan Sacatepequez	-55.89			
			Gu 6	San Pedro Ayampuc	-54.63			

5.2 Classification by Socioeconomic Features

Table 5.2.1 shows the classification of the candidate municipalities (35) by projected population scale in 2010: A (more than 10,000), B (10,000 to 5,000) and C (less than 5,000). According to this table, the 35 municipalities were classified as follows.

A (30,960 - 10,140)	13 municipalities
B (7,770 - 5,704)	11 municipalities
C (4,872 - 812)	11 municipalities

Table 5.2.2 shows the classification of the candidate municipalities (35) by the two socioeconomic factors; (1) intensity of desire for new water source development and willingness to pay for increased O-M cost; (2) projected population scale.

Out of the 35 candidate municipalities, 20 of the municipalities were classified as not having strong desire for new water source development and not intensely willing to pay for increased O-M cost, while 15 municipalities were classified as having strong desire for new source development. The latter group is mostly made up of municipalities where supply shortage is severe, as shown in Tables 5.2.3 and 5.3.1.

Table 5.2.1 Population Categorization (2010)

	No.	Municipality	2010				
			Popu-lation	ℓ/c/d	Demand m3/day	Water	
						m3/day	ℓ/c/d
*	So 1	Sololá	30,960	155	4,799	-2,172	-70.16
*	Gu 2	San José Pinula	19,970	155	3,095	-2,277	-144.04
*	Ch 4	San Juan Comalapa	19,408	155	3,008	-1,954	-100.69
	Ch 7	Patzun	19,398	155	3,007	-2,277	-117.36
	To 3	San Francisco el Alto	18,740	155	2,905	-2,326	-124.11
*	To 5	Momostenango	16,740	155	2,595	-1,955	-116.77
	Ch 9	Patzicía	16,164	155	2,505	-1,703	-105.34
*	Sa 11	Santa María de Jesús	14,890	155	2,308	-1,617	-108.59
	Gu 1	Santa Catarina Pinula	14,134	155	2,191	-556	-39.31
	Gu 9	San Juan Sacatepéquez	13,948	155	2,162	-780	-55.89
*	Ch 3	San Martín Jilotepeque	11,986	155	1,858	-1,340	-111.78
	So 15	San Pablo la Laguna	10,189	155	1,579	-1,546	-151.69
*	Gu 8	San Pedro Sacatepéquez	10,140	155	1,572	-1,278	-126.01
	Gu 6	San Pedro Ayampuc	7,770	106	824	-424	-54.63
	Sa 9	Santa Lucía M. Altas	7,545	106	800	-454	-60.19
	So 5	Nahuala	7,494	106	794	-495	-65.99
	Qu 22	Flores Costa Cuca	7,378	106	782	-427	-57.94
*	Qu 21	Génova	7,267	106	770	-770	-106.00
	Qu 24	Palestina	7,192	106	762	-162	-22.57
	So 17	San Juan la Laguna	6,965	106	738	-524	-75.24
	Gu 11	Chuarrancho	6,927	106	734	-253	-36.59
	So 7	Santa Clara la Laguna	6,862	106	727	-458	-66.72
	Ch 2	San José Poaquil	5,704	106	605	-339	-59.35
	Qu 3	Olintepeque	5,704	106	605	-43	-7.47
	Qu 4	San Carlos Sija	4,872	106	516	-275	-56.34
	Qu 7	Cajola	4,775	106	506	-347	-72.71
*	So 4	Santa Lucía Utatlán	4,773	106	506	-344	-71.97
	Gu 3	San José del Golfo	4,185	106	444	-181	-43.24
	So 12	San Antonio Palopó	3,243	106	344	-307	-94.81
	Qu 15	Huítan	3,053	106	324	-245	-80.25
	So 9	San Andres Semetabaj	2,603	106	276	-194	-74.47
*	Qu 18	San Francisco la Unión	2,561	106	271	-271	-106.00
	So 11	Santa Catarina Palopó	2,540	106	269	0.3	0.13
	So 16	San Marcos la Laguna	1,972	70	138	-84	-42.83
	So 14	Santa Cruz la Laguna	812	70	57	-15	-18.93

Table 5.2.2 Municipality Categorization by Willingness-to-Pay and Population Scale

Request for NWSD/Willingness to Pay O/M Costs

	A	B	C
A	Gu 2 San José Pinula Gu 8 San Pedro Sacatepéquez Sa 11 Santa María de Jesús So 1 Sololá To 5 Momostenango	Ch 3 San Martín Jilotepéque Ch 4 San Juan Comalapa	Gu 1 Santa Catarina Pinula Gu 9 San Juan Sacatepéquez Ch 9 Patzicía Ch 7 Patzún So 15 San Pablo La Laguna To 3 San Francisco el Alto
B		So 5 Nahuala Qu 21 Génova Qu 22 Flores Costa Cuca	Gu 6 San Pedro Ayampuc Gu 11 Chuarrancho Sa 9 Santa Lucía M. Altas Ch 2 San José Poaquil So 7 Santa Clara la Laguna So 17 San Juan la Laguna Qu 3 Olitepéque Qu 24 Palestina
C	Qu 18 San Francisco la Unión	Gu 3 San José del Golfo So 4 Santa Lucía Utatlán Qu 4 San Carlos Sija Qu 7 Cajola	So 9 San Andres Semetabaj So 11 Sta. Catarina Palopo So 12 San Antonio Palopo So 14 Santa Cruz la Laguna So 16 San Marcos la Laguna Qu 15 Huitan

Table 5.2.3 Municipality Categorization by Willingness-to-Pay and Water Shortage Condition

Request for NWSD/Willingness to Pay O/M Costs

	A	B	C
A	Gu 2 San José Pinula To 5 Momostenango Sa 11 Santa María de Jesús Gu 8 San Pedro Sacatepéquez Qu 18 San Francisco la Unión	Qu 21 Genóva Ch 3 San Martín Jilotepeque Ch 4 San Juan Comalapa	To 3 San Francisco el Alto Ch 7 Patzún Ch 9 Patzicía So 15 San Pablo la Laguna
B	So 1 Sololá	So 5 Nahuala So 4 Santa Lucía Utatlán Qu 4 San Carlos Sija Qu 7 Cajola Qu 15 Huitan Qu 22 Flores Costa Cuca	Gu 6 San Pedro Ayampuc Ch 2 San José Poaquil Gu 9 San Juan Sacatepéquez So 7 Santa Clara la Laguna Sa 9 Santa Lucía M. Altas So 9 San Antonio Palopó So 17 San Juan la Laguna

C		Gu 3 San José del Golfo	Gu 11 Chuarrancho Gu 1 Santa Catarina Pinula So 11 Sta. Catarina Palopó So 14 Santa Cruz la Laguna So 16 San Marcos la Laguna Qu 3 Olintepeque Qu 24 Palestina

5.3 Classification by Water Shortage Condition

Table 5.3.1 shows the classification of the candidate municipalities (35) by projected water shortage condition in 2010; A (more than 100 ℓ/c/d), B (50 - 100 ℓ/c/d) and C (less than 50 ℓ/c/d). The 35 municipalities are classified as follows.

A (151.69 - 100.69 ℓ/c/d) 12 municipalities
B (54.63 - 94.81 ℓ/c/d) 15 municipalities
C (0.13 - 43.24 ℓ/c/d) 8 municipalities

Out of the 12 municipalities which are classified under group A, the 2 municipalities of Patzun and Patzicía will have sufficient water supply capacity until 2010, as long as the existing water service level, be it satisfactory or otherwise, is maintained.

The 2 municipalities of San Pablo la Laguna and San Francisco el Alto are situated in the areas where spring and groundwater development are hydrogeologically difficult. These four municipalities were not highly prioritized, taking various factors into consideration, even though supply shortage was evident.

Table 5.3.1 Water Shortage Categorization (2010)

	No.	Municipality	2010				
			Popu-lation	ℓ/c/d	Demand m3/day	Water Shortage	
						m3/day	ℓ/c/d
	So 15	San Pablo la Laguna	10,189	155	1,579	-1,546	-151.69
*	Gu 8	San Pedro Sacatepéquez	10,140	155	1,572	-1,278	-126.01
	To 3	San Francisco el Alto	18,740	155	2,905	-2,326	-124.11
	Ch 7	Patzún	19,398	155	3,007	-2,277	-117.36
*	To 5	Momostenango	16,740	155	2,595	-1,955	-116.77
*	Gu 2	San José Pinula	19,970	155	3,095	-2,277	-114.04
*	Ch 3	San Martín Jilotepeque	11,986	155	1,858	-1,340	-111.78
*	Sa 11	Santa María de Jesús	14,890	155	2,308	-1,617	-108.59
*	Qu 18	San Francisco la Unión	2,561	106	271	-271	-106.00
*	Qu 21	Génova	7,267	106	770	-770	-106.00
	Ch 9	Patzicía	16,164	155	2,505	-1,703	-105.34
*	Ch 4	San Juan Comalapa	19,408	155	3,008	-1,954	-100.69
	So 12	San Antonio Palopó	3,243	106	344	-307	-94.81
	Qu 15	Huítan	3,053	106	324	-245	-80.25
	So 17	San Juan la Laguna	6,965	106	738	-524	-75.24
	So 9	San Andres Semetabaj	2,603	106	276	-194	-74.47
	Qu 4	Cajola	4,775	106	506	-347	-72.71
*	So 4	Santa Lucía Utatlán	4,773	106	506	-344	-71.97
*	So 1	Sololá	30,960	155	4,799	-2,172	-70.16
	So 7	Santa Clara la Laguna	6,862	106	727	-458	-66.72
	So 5	Nahuala	7,494	106	794	-495	-65.99
	Sa 9	Santa Lucía M. Altas	7,545	106	800	-454	-60.19
	Ch 2	San José Poaquil	5,704	106	605	-339	-59.35
	Qu 22	Flores Costa Cuca	7,378	106	782	-427	-57.94
	Qu 4	San Carlos Sija	4,872	106	516	-275	-56.34
	Gu 9	San Juan Sacatepéquez	13,948	155	2,162	-780	-55.89
	Gu 6	San Pedro Ayampuc	7,770	106	824	-424	-54.63
	Gu 3	San José del Golfo	4,185	106	444	-181	-43.24
	So 16	San Marcos la Laguna	1,972	70	138	-84	-42.83
	Gu 1	Santa Catarina Pinula	14,134	155	2,191	-556	-39.31
	Gu 11	Chuarrancho	6,927	106	734	-253	-36.59
	Qu 24	Palestina	7,192	106	762	-162	-22.57
	So 14	Santa Cruz la Laguna	812	70	57	-15	-18.93
	Qu 3	Olintepeque	5,704	106	605	-43	-7.47
	So 11	Sta. Catarina Palopó	2,540	106	269	0.3	0.13

5.4 Classification by Water Source Development Potential

The water source development potential of the 35 municipalities are hydrogeologically classified into the following 3 groups:

Group I:

The following 5 municipalities are classified as a group with high groundwater development potential.

Gu 1	Santa Catarina Pinula	Gu 9	San Juan Sacatepéquez
Ch 3	San Martín Jilotepeque	Qu 3	Olintepeque
		Qu 7	Cajola

Group II:

The following 18 municipalities are classified as a group with relatively high groundwater development potential.

Gu 2	San José Pinula	Ch 2	San José Poaquil
Gu 3	San José del Golfo	Ch 4	San Juan Comalapam
Gu 6	San Pedro Ayampuc	Ch 7	Patzún
Gu 5	San Pedro Sacatepéquez	Qu 4	San Carlos Sija
Sa 11	Santa María de Jesús	Qu 18	San Francisco la Unión
Ch 9	Patzíca	Qu 22	Flores Costa Cuca
So 1	Sololá	Qu 24	Palestina
So 4	Santa Lucía Utatlán	Qu 21	Génova
So 5	Nahuala		
To 5	Momostenango		

Group III:

The following 12 municipalities are classified as a group with low groundwater development potential by deep well construction, but has probable potential for shallow aquifer development except for the 2 municipalities of Chuarrancho (Gu 11) and San Antonio Palopo (So 12):

So 7	Santa Clara la Laguna	So 9	San Andres Semetabaj
So 12	San Antonio Palopo*	So 11	Santa Catarina Palopó
So 14	Santa Cruz la Laguna	To 3	San Francisco el Alto
So 15	San Pablo la Laguna	Qu 15	Huitan
So 16	San Marcos la Laguna	Sa 9	Santa Lucía M. Altas
So 17	San Juan la Laguna	Gu 11	Chuarrancho*

* Chuarrancho (Gu 11) uses surface water, but INFOM recommends a water supply plan by groundwater development in the municipal area of San Raymundo, about 12 kilometers southwest of Chuarrancho

* San Antonio Palopó (So 12) uses spring water, and a new spring source has been developed by INSIVUMEH about 5 kilometers east of the municipality.

5.5 Categorization for the Planning of Water Source Development Strategy

Based on the above classification and the present situation of existing water sources, the following categorization was made to prepare the water source development strategy:

Group A: Surface water utilization

Although surface water pollution is becoming progressive in the Study Area, the river water of the following 5 municipalities is kept comparatively clean. Although the development of additional surface water sources is not possible in the future, river water in these places can still be used effectively by adopting anti-pollution measures.

Gu 11	Chuarrancho	Gu 4	San Carlos Sija
Ch 2	San José Poaquil	Gu 7	Cajola
So 5	Nahuala		

Group B: Spring water utilization

Spring water is the most important and economical water supply source in the Study Area. Thirty of the 35 candidate municipalities use spring water as public water supply sources, 21 of which are entirely dependent on it. Since the springs in the Study Area have been almost fully exploited, the additional development of springs will be very difficult in the future. A rare exception, however, is the new spring source recently developed in San Antonio Palopo by INSIVUMEH.

Group C: Shallow aquifer development

The 10 municipalities which have relatively high potential for shallow aquifer development by dug well construction are categorized under this group.

Group D: Groundwater development

Twenty-four of the municipalities are categorized in this group and classified into the following 3 sub-groups in consideration of socioeconomic, water shortage and water source development conditions.

- Class I, 6 municipalities with relatively high groundwater development potential and with desire for new water source development.

Gu 2	San José Pinula	So 1	Sololá
Gu 8	San Pedro Sacatepéquez	To 5	Momostenango
Gu 18	San Francisco la Unión	Sa 11	Santa María de Jesús

- Class II, 9 municipalities with relatively high groundwater development potential but not so strong

desire for new source development.

Gu 3	San José del Golfo	Qu 4	San Carlos Sija
Ch 3	San Martín Jilotepeque	Qu 7	Cajolá
Ch 4	San Juan Comalapa	Qu 21	Génova
So 4	Santa Lucía Utatlán	Qu 22	Flores Costa Cuca
So 5	Nahuala		

- Class III, 9 municipalities with relatively high groundwater development potential and sufficient water supply capacity until 2010 as long as the existing service level is maintained. Therefore, requests for new water source development are not very high.

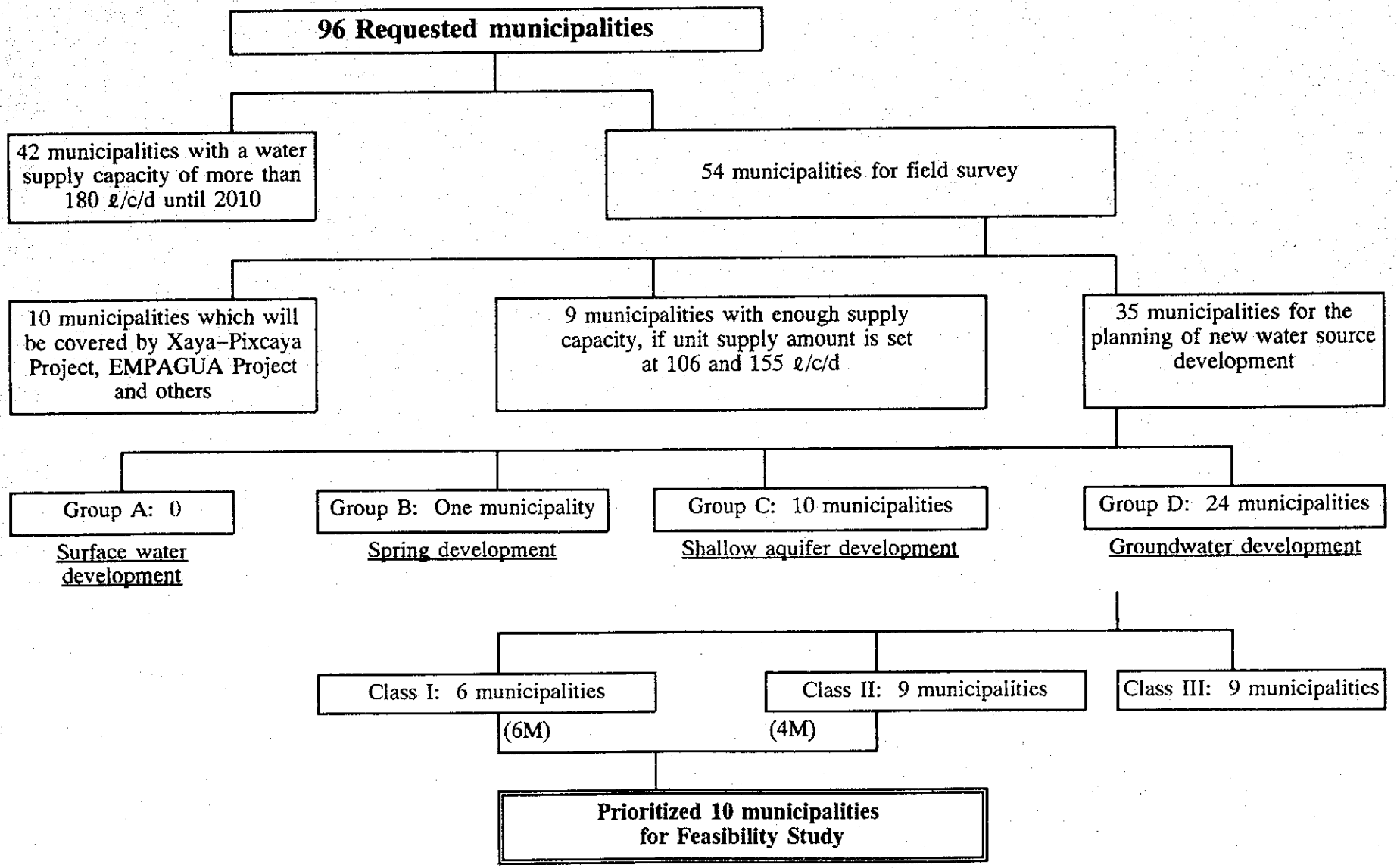
Gu 1	Santa Catarina Pinula	Ch 2	San José Poaquil
Gu 6	San Pedro Ayampuc	Ch 7	Patzún
Gu 9	San Juan Sacatepéquez	Ch 9	Patzicía
Gu 11	Chuarrancho	Qu 3	Olintepeque
		Qu 24	Palestina

5.6 Priority Assignment of 10 Municipalities for the Feasibility Study

Out of the 15 municipalities classified into Class I and Class II of Group D in the former section, the Study Team and INFOM decided to carry out a feasibility study on the following 10 municipalities:

Gu 2	San José Pinula	So 1	Sololá
Gu 8	San Pedro Sacatepéquez	So 4	Santa Lucía Utatlán
Sa 11	Santa María de Jesús	To 5	Momostenango
Ch 3	San Martín Jilotepeque	Qu 18	San Francisco la Unión
Ch 4	San Juan Comalapa	Qu 21	Génova

The final results of the "Categorization of Candidate Municipalities" are summarized in the following chart.


96 Requested municipalities
42 municipalities with a water supply capacity of more than 180 ℓ/c/d until 2010
54 municipalities for field survey
10 municipalities which will be covered by Xaya-Pixcaya Project, EMPAGUA Project and others
9 municipalities with enough supply capacity, if unit supply amount is set at 106 and 155 ℓ/c/d
35 municipalities for the planning of new water source development
Group A: 0
Surface water development
Group B: One municipality
Spring development
Group C: 10 municipalities
Shallow aquifer development
Group D: 24 municipalities
Groundwater development
Class I: 6 municipalities
(6M)
Class II: 9 municipalities
(4M)
Class III: 9 municipalities
Prioritized 10 municipalities for Feasibility Study

CHAPTER 6

6. WATER SOURCE DEVELOPMENT STRATEGY BY CATEGORIZATION

The basic strategies for water source development recommended by INFOM are summarized below.

(a) Spring and river water which can be conveyed to the storage tank by natural flow are given first priority.

(b) Spring and river water pumped up from lower areas and conveyed by booster pump are given second priority.

(c) Groundwater pumping by tube well construction is third priority.

This strategy was determined based on the economic aspect of the operation and maintenance of facilities. The shallow dug wells are considered for places unsuitable for deep wells.

6.1 Surface Water Utilization

The rivers and streams flowing through or near the municipalities are tertiary or smaller tributaries. The flow in the dry season normally becomes very small and is generally seriously polluted with sewage or waste, making the utilization of river water as supply source for the majority of the area increasingly difficult.

However, the following areas where river water is comparatively clean are still dependent on surface water:

(a) Domestic use (drinking, bathing and washing)

- Chuarrancho (Gu): (conveyed by booster pump)
- San José Poaquil (Ch): (conveyed by natural flow)

(b) Domestic use (limited to bathing and washing)

- Nahuala (So)
- San Carlos Sija (Qu)
- Cajola (Qu)

The area around the municipality of Chuarrancho is composed of metamorphic rocks and classified as a "difficult area" for groundwater development. In addition, the area has unstable river flow and deteriorating water quality making the prospect of increasing river water intake activities in the future seem difficult.

Since any type of water source development is hopeless in this area, development should be carried out in other areas, such as San Raymundo, about 12 kilometers southwest of Chuarrancho (Fig. 7.2.1(1)), where the groundwater development potential is high, to acquire the supply source for service expansion.

The municipality of San José Poaquil is heavily dependent on surface water for domestic and agricultural use. Groundwater development is recommended as the municipality's future water supply however, because the contamination of surface water in the area is worsening.

Although the surface water utilized by the municipalities of Nahuala, San Carlos Sija and Cajola has enough quantity even in the dry season, it will no longer be used for drinking, as surface water contamination is worsening in these areas.

6.2 Spring Water Utilization

Thirty out of the 35 candidate municipalities use spring water as public water supply source. There are also many springs, either used privately or jointly by a community, for domestic and agricultural purposes.

The total number of spring water sources for public supply in 30 municipalities is 90, and the average discharge is about 1.84 l/sec. Out of the 90 springs, the water from 78 is conveyed to the storage tank by natural flow, while water from the remaining 12 is conveyed to the distribution tank by booster pump.

The following 21 municipalities are entirely dependent on spring water mainly for domestic purposes.

Patzún (Ch):	3 springs (16.90 ℓ/sec)*
Pazticía (Ch):	3 springs (18.15 ℓ/sec)*
Sololá (So):	2 springs (30.40 ℓ/sec)
Santa Lucía Utatlán (So):	4 springs (1.88 ℓ/sec)
Nahuala (So):	3 springs (3.47 ℓ/sec)
San Andres Semetabaj (So):	8 springs (0.95 ℓ/sec)
Santa Catarina Palopó (So):	2 springs (3.13 ℓ/sec)
San Antonio Palopó (So):	3 springs (0.42 ℓ/sec)
Santa Cruz la Laguna (So):	4 springs (0.80 ℓ/sec)
San Pablo la Laguna (So):	3 springs (0.39 ℓ/sec)
San Marcos la Laguna (So):	1 spring (0.62 ℓ/sec)
San Juan la Laguna (So):	2 springs (4.15 ℓ/sec)
Santa Clara la Laguna (So):	5 springs (3.12 ℓ/sec)
San Francisco el Alto (To):	8 springs (6.70 ℓ/sec.)
Momostenango (To):	2 springs (14.20 ℓ/sec.)
San Carlos Sija (Qu):	3 springs (2.8 ℓ/sec.)
Cajola (Qu):	6 springs (1.84 ℓ/sec.)
Huitan (Qu):	2 springs (0.91 ℓ/sec.)
San Francisco la Unión (Qu):	1 spring (0.59 ℓ/sec.)*
Génova (Qu):	7 springs (3.03 ℓ/sec.)
Flores Costa Cuca (Qu):	1 spring (2.20 ℓ/sec.)

* Conveyed by booster pump to distribution tank

As mentioned above, spring water has been the most

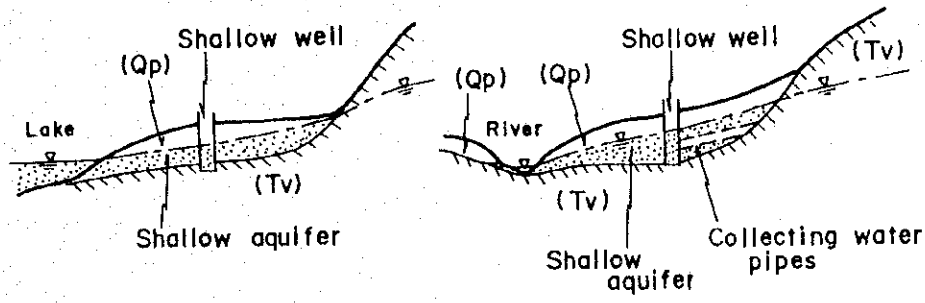
important and economic water supply source in the "Central Plateau Area", and has been almost fully exploited by the inhabitants for a long time. With population growth, these springs will not be able to meet the water demand, except for San Antonio Palopó where a new spring source was recently developed by INSIVUMEH about 5 kilometers east of the municipality.

The remaining 20 municipalities, which are entirely dependent on spring water, are places where groundwater should be developed as a supplemental supply source, either by shallow well or deep well construction.

6.3 Shallow Aquifer Development

In municipalities with relatively small water demand in 2010 and where deep well construction is physically difficult due to poor hydrogeological condition or poor accessibility for drilling equipment, the development of shallow aquifers of alluvial deposits (Qa) and pumice sediments (Qp) is recommended.

This shallow aquifer development will be attained by the construction of dug wells shown below. The detailed design is shown in the Supporting Report.



A type B type

The municipalities classified in this category are as follows.

- Santa Catarina Palopó (So):	A Type
- Santa Cruz la Laguna (So):	A Type
- San Pablo la Laguna (So):	A Type
- San Marcos la Laguna (So):	A Type
- San Juan la Laguna (So):	A Type
- Santa Clala la Laguna (So):	B Type
- San Andres Semetabaj (So):	B Type
- San Francisco el Alto (To):	B Type
- Huitan (Qu):	B Type
- San Carlos Sija (Qu)*:	B Type
- San Francisco la Unión*:	B Type

* Deep aquifer development may also be possible by

construction of a deep tube well.

6.4 Groundwater Development

Based on the "Categorization of the Candidate Municipalities", and with the exclusion of the prioritized 10 municipalities for the Feasibility Study, the municipalities for groundwater development by deep well construction are summarized in Table 6.4.1. The groundwater development strategies for these 10 prioritized municipalities are described in "Chapter 7 (7.3.2)" based on the test drilling and pumping test results, and water balance analysis.

As shown in Table 6.4.1, five of the municipalities are classified under Group D - Class I, while 10 municipalities are classified under Group D - Class II.

Electrical resistivity soundings were conducted during Phase I of the Study, and recommendable drilling sites and depth were examined in the 5 municipalities in Group D - Class II. Test drilling was not carried out however.

Table 6.4.1 Groundwater Development Strategy (1)

Municipality (Classification)	Estimated Water Supply Shortage (ℓ/sec)	Estimated Conditions of Target Aquifer for G/W Development (Tv)	Presumable Potential of Water Production from One Well (ℓ/sec)	G/W Development Plan	
				Number of Wells	Drilling Length (m)
Gu 3 San José del Golfo (Group D – Class I)	2.10	Pyroclastic rocks with lava flow and weathered granitic rocks (Tv)	6.0	1	150
So 6 Nahualá (Group D – Class I)	5.73	Pyroclastic rocks with lava flow (Tv)	6.0	1	200
Qu 4 San Carlos Sija (Group D – Class I)	3.18	Fractured andesitic lava flow (Tv)	7.5	1	200
Qu 7 Cajola (Group D – Class I)	4.02	Pumice sediments (Qp) and fractured andesitic lava low (Tv)	7.5	1	200
Qu 22 Flores Costa Cuca (Group D – Class I)	4.95	Pyroclastic & volcanic mud flow (Qv)	9.0	1	180
Gu 1 Santa Catarina Pinula (Group D – Class II)	6.44	Pumice sediments (Qp) and pyroclastic rocks with lava flow (Tv)	10.0	1	200
Gu 6 San Pedro Ayampuc (Group D – Class II)	4.91	Pyroclastic rocks with fractured lava flow (Tv)	5.0	1	200
Gu 9 San Juan Sacatepéquez (Group D – Class II)	9.03	Fractured andesitic lava flow (Tv)	12.0	1	200

Table 6.4.1 Groundwater Development Strategy (2)

Municipality (Classification)	Estimated Water Supply Shortage (ℓ/sec)	Estimated Conditions of Target Aquifer for G/W Development (Tv)	Presumable Potential of Water Production from One Well (ℓ/sec)	G/W Development Plan	
				Number of Wells	Drilling Length (m)
Gu 11 Chuarrancho (Group D – Class II)	2.93	Pumice sediments (Qp), fractured lava flow (Tv) and weathered granitic rocks in San Raymundo	10.0	1	200
Sa 9 Santa Lucía M. Altas (Group D – Class II)	5.26	Pyroclastic rocks with fractured lava flow (Tv)	6.0	1	200
Ch 2 San José Poaquil (Group D – Class II)	3.93	Pyroclastic rocks with fractured lava flow (Tv) and fractured limestone	6.0 – 30.0	1	200
Ch 7 Patzún (Group D – Class II)	26.36	Pyroclastic rocks with lava flow and clastic sediments (Tv)	10.0	3	600 (200m x 3)
Ch 9 Patzicía (Group D – Class II)	19.71	Pumice sediments (Qp) and Pyroclastic rocks with lava flow and clastic sediments (Tv)	10.0	2	400 (200m x 2)
Qu 3 Olintepeque (Group D – Class II)	0.50	Pumice sediments (Qp) and fractured lava flow (Tv)	10.0	1	200
Qu 24 Palestina (Group D – Class II)	1.88	Pyroclastic rocks with fractured lava flow	13.0	1	200

CHAPTER 7

7. SURVEYS FOR GROUNDWATER DEVELOPMENT

7.1 Hydrology

The objective of the hydrological survey is to evaluate groundwater potential based on water balance calculation in the Study Area.

The rainfall and river discharge records obtained by INSIVUMEH, and other reports on the Study Area, were reviewed and analyzed.

The field survey covered all of the 54 municipalities selected for the detailed survey, except for the few places which could not be visited.

7.1.1 Rainfall

The principal meteorological stations in the Study Area are distributed as shown in Fig. 7.1.1. The number of operating stations have decreased since the 1980s, and the latest "Datos Meteorológicos de las Cabeceras Departamentales" published by INSIVUMEH in 1992 only shows 16 stations in 6 Departments.

The general features of the 16 stations are shown in Table 7.1.1. The station with the lowest elevation is Potrero station at 1,120 m above sea level, and the highest is Labor Ovalle Station at 2,380 m.

Rainy season is generally from May to October and the monthly rainfall peaks in June and September. As a typical example, San Martín Jilotepeque Station has 1,200 mm of average annual rainfall in the 1928-1989 period. The largest monthly rainfall is 263 mm in September, and the second largest is 253 mm in July. The collected monthly rainfall records are attached in the Data Book.

Annual isohyet was made using the average annual rainfall of these stations and other stations shown in Fig. 7.1.1. Observation periods were different for each station. Taking this into consideration, it was concluded that annual rainfall did not significantly vary based on the medium term annual rainfall figures obtained from INSIVUMEH, San Jeronimo and Labor Ovalle stations as shown in Fig. 7.1.2.

As indicated by the isohyet lines, a heavy rainfall zone is located in the southern skirts of the Central Plateau, at around 1,000 - 2,000 m elevation. This phenomenon is explained by the fact that humid air from the Pacific Ocean rises up the mountain slopes, and the rain clouds, caused by the resulting change in pressure, bring about heavy precipitation in limited areas.

Because of deficiencies in the meteorological observation

network, it is difficult to estimate the precise rainfall distribution in the entire municipalities concerned. With complicated topographic undulations, the annual rainfall data also varies with elevation and the micro climatic conditions of each station.

In order to conduct water balance analysis in the target municipalities, the annual rainfall records of the neighboring meteorological station of each municipality were selected and used as shown in Table 7.1.2.

7.1.2 River System and Discharge

(1) Surface Water

- River and River Basin

The territory of Guatemala is divided into three principal river basins: the Pacific Ocean, the Caribbean Sea, and Gulf of Mexico.

Most of the rivers in the Study Area are in the Pacific Ocean basin, flowing southward from their source in the Central Plateau Area.

The following table shows the river basins in the Study Area.

Code of Watershed	Principal Rivers / Lakes	Remarks
1.3	Río Naranjo	Pacific Ocean
1.4	Río Ocosito	Pacific Ocean
1.5	Río Samala	Pacific Ocean
1.6	Río Icon	Pacific Ocean
1.7	Río Nahualate	Pacific Ocean
1.8	Lago de Atitlán	Pacific Ocean
1.9	Río Madre Vieja	Pacific Ocean
1.10	Río Coyolate	Pacific Ocean
1.12	Río Achiguate	Pacific Ocean
1.13	Río María Linda (Laguna de Amatitlán)	Pacific Ocean
2.2	Río Motagua	Caribbean Sea
3.1	Río Cuilco	Gulf of Mexico
3.7	Río Chixoy o Negro	Gulf of Mexico

The target rivers to be reviewed in the Study Area are secondary, tertiary or smaller tributaries with very small flow in the dry season.

Fig. 7.1.3 shows the location of the gauging stations, where river discharge observations were conducted by INSIVUMEH. Many gauging stations were installed in the 1960s to carry out periodical observations. Unfortunately, however, most of these stations were closed in the 1980s.

- Lakes

Lakes Atitlán and Amatitlán are the principal lakes in the Study Area. Lake Amatitlán is situated south of Guatemala City and has a surface area of around 84 km^2. Sewage drained from the surrounding municipalities flows directly into the lake, thereby contaminating the lake water. As a countermeasure, the Government has been planning the construction of lake water treatment plants.

Lake Atitlán is situated in Sololá Department and is an important natural resource for tourism. The surface area is about 125 km^2 with a total catchment area of 548 km^2. Since this lake has no outflowing rivers, all sediments and materials flowing in from the basin accumulate in it. Therefore, the treatment of waste water is vital for this lake. The lake water level record in 1948 - 1976 is attached in the Data Book.

(2) River Discharge Analysis

As only a few river discharge observations have been conducted in the Study Area in recent years, the records from the 1960s to the 1980s were reviewed in order to understand the general river condition.

The following table shows the general features of the principal gauge stations which have been installed in the Study Area (details are shown in Table 7.1.3) or in adjacent areas.

Station	River	Catchment Area (km2)	Elevation (m.a.s.l.)
Cantel	Samala	701.0	2,454
S.C. Ixtahuacán	Nahualate	144.7	1,670
Jaibal	Quiscab	146.5	1,550
Panajachel	Panajachel	51.7	1,600
Alotenango	Guacalate	328.5	1,350

Table 7.1.4 summarizes the average monthly discharge in the Study Area. The peak discharge occurs in September-October and the minimum discharge in February - March. These months and the values for the lowest and peak discharges correspond to monthly rainfall variation.

The discharge values at the Cantel and Candelaria stations are shown in Fig. 7.1.4. The catchment area of the Cantel Station is about 700 km^2, while Candelaria has about 850 km^2, 1.2 times the size of Cantel. However, the annual discharge of Candelaria is almost twice as much as that of Cantel. This is explained by the fact that a part of the catchment area of the Candelaria station is covered by a heavy rainfall zone with an annual average of 3,000 mm. From this point, it is clear that even the base flow, which is regarded as groundwater recharge, directly reflects the amount of annual rainfall if the hydrogeological structure corresponds with the river basin.

Fig. 7.1.5 shows the specific discharge at stations in the Study Area: Cantel, Nahualate, Jaibal, Alotenango, and Panajachel stations. These stations are located downstream of the concerned municipalities, and the discharge records were observed in different years. Therefore, these discharge data only generalize river condition.

The peak discharge in the rainy season is around 35 - 45 $\ell/s/km^2$ at S.C. Ixtahuacán, Jaibal, and Alotenango stations, and 15 - 20 $\ell/s/km^2$ at Panajachel and Cantel Stations. Two peaks, in June - July and another in October were observed at Jaibal and Panajachel stations. The difference in the maximum and minimum discharges at Cantel and Panajachel stations is smaller than that of other stations. The discharge decreases from November to May. The values remain nearly constant from February to May, at about 7 $\ell/s/km^2$ at Naualate and Jaibal stations and 4 - 5 $\ell/s/km^2$ in other stations.

Table 7.1.5 shows the runoff calculation of these rivers. Runoff coefficients are 30 - 50% in the Jaibal and Panajachel Stations, 12 - 28% in the Cantel and Candelaria Stations, and 10 - 18% in Alotenango Station.

In the case of the Jaibal and Panajachel Stations, a high proportion of rainfall in the upper reaches of the catchment area infiltrates into the ground. The basement, composed of compact & massive welded tuff, is deep beneath the ground upstream and shallow downstream, and outcrops at Sololá. Jaibal Station is located in the lower part, thereby showing high flow values. In comparison with these, the runoff coefficient of other stations are relatively low, because their catchment areas are covered by highly permeable materials and because the water that infiltrates these areas recharge the rivers downstream.

Most of the concerned municipalities belong to the latter condition. The rainfall infiltrates into the grounds of

highly elevated areas, and spring out to form small streams in the Study Area.

(3) Field Observation and Spot Measurement

Hydrological field surveys were conducted in April - May and August - November 1994, in order to grasp the general condition of the river basins.

Except for some municipalities like San Raymundo and the southern part of Quetzaltenango, the surrounding lands of the majority of the municipalities have been excessively cultivated for agricultural use, resulting in the reduction of recharge and increase in erosion.

Spot measurements were conducted at the points considered useful to evaluate river basin capacity. Table 7.1.6 summarizes the results of discharge by rivers. These results do not include the amount of water taken in the upper reaches for drinking and irrigation purposes.

The specific discharge in April - May at most of the points is very small. One reason is that the groundwater level is lower than the river bed in the dry season due to the geological condition of the area. For example, the discharges at Jaibal and Panajachel, where measurement points are covered by alluvium deposits, are 2.9 $\ell/s/km^2$ and less than 5.1 $\ell/s/km^2$, respectively.

Discharge measurement in the rainy season was conducted in the selected 10 municipalities, in August and November 1994. The discharge in the rainy season was 2 to 6 times bigger than the amount in the dry season.

For the river basins of San Jose Poaquil, Cajolá and Nahuala, the survey focused on the possibility of spring water use. These municipalities were selected from those entirely dependent on spring water for domestic use, and have larger catchment areas.

The following points were noted from the existing field conditions.

- Many small communities exist in the upper reaches and their drinking and domestic water is taken from springs or streams. The population of these communities has been increasing in recent years.

- Land owners in downstream Cajolá have the right to use spring water within their property, while communities obtain the right to use spring water in the upper reaches.

- Springs and streams are used as sources for domestic and irrigation purposes. Domestic waste water and drainage water from the agricultural lands, possibly containing residue of fertilizers and insecticides, flow back into

the river system.

- Most of the water for San José Poaquil is taken from the river stream and some from spring water. The amount in the dry season is almost half of that in the rainy season.

- The river basins of San José Poaquil and Cajolá no longer have enough surface water to meet the demands of these municipalities. For Naualá, new surface water sources will be considered around the "Paquix" area.

7.1.3 Spring Flow

Table 7.1.7 shows results obtained from research on water sources conducted by INFOM in 1987 and the JICA Study Team in 1994. According to this table, the water source has been converted from spring water to a combination of spring and well in the Departments of Guatemala, Sacatepéquez and Chimaltenango.

The municipalities in Sololá Department only use spring water at present. The municipalities in Totonicapán and Quetzaltenango Departments depend extensively on springs when compared with other Departments.

Fig. 7.1.6 shows the distribution of the springs and discharge amount. Small springs tend to decline in number, while larger springs, like those in Sololá, Almolonga and San Juan Comalapa, have been developed in the past 7 years.

7.1.4 Groundwater Level and Monitoring Facilities

Automatic rainfall recorders and groundwater level recorders were installed at the wells of 3 municipalities, San José Pinula, San Pedro Sacatepéquez and Comalapa.

The groundwater level at the existing well in San José Pinula has been periodically measured by use of handy water level meter from June, 1994. This well was drilled by the municipal government, to a depth of 213 m, but was abandoned because of its small productivity of 0.76 l/sec.

The automatic water level recorder was installed at this well and a continuous record has been taken since November 16, 1994. Groundwater level was around 31.6 m below ground surface from June to September. The water level has been rising since October.

Table 7.1.1 List of Meteorological Stations

No.	Station	Regist.	Eleva.	Lat.	Long.	Municipality	Departament
1	SAN MARTIN JILOTEPEQUE	31101	1800	14.46.43	90.47.19	SAN MARTIN JILOTEPEQUE	CHIMALTENANGO
2	STA. CRUZ BALANYA	31401	2080	14.41.12	90.54.55	STA. CRUZ BALANYA	CHIMALTENANGO
3	INSIVUMEH	60100	1502	14.35.11	90.31.58	GUATEMALA	GUATEMALA
4	FLORINDA	60117	1470	14.38.12	90.29.35	GUATEMALA	GUATEMALA
5	OJO DE AGUA	60124	1260	14.31.50	90.33.28	SAN MIGUEL PETAPA	GUATEMALA
6	JARDIN MIL FLORES	60203	1189	14.28.12	90.37.45	AMATITLAN	GUATEMALA
7	LA SOLEDADO	60903	1650	14.30.10	90.23.50	SAN JOSE PINULA	GUATEMALA
8	SAN PEDRO AYAMPUC	61201	1200	14.46.35	90.27.17	SAN PEDRO AYAMPUC	GUATEMALA
9	CHILLANI	61304	1400	14.43.20	90.32.10	SAN PEDRO SACATEPEQUEZ	GUATEMALA
10	POTRERO	61606	1120	14.21.11	90.31.40	VILLA CANALES	GUATEMALA
11	LABOR OVALLE	131401	2380	14.52.12	91.30.50	OLINTEPEQUE	QUEZALTENANGO
12	LA SUIZA CONTENTA	161101	2105	14.37.08	90.39.40	CIUDAD VIEJA	SACATEPEQUEZ
13	SANTA MARIA DE JESUS	161501	2065	15.29.34	90.42.34	SANTA MARIA DE JESUS	SACATEPEQUEZ
14	EL CAPITAN	191005	1562	14.38.35	91.08.26	SAN LUCAS TOLIMAN	SOLOLA
15	SANTIAGO ATITLAN	191904	1580	14.37.54	91.13.53	SANTIAGO ATITLAN	SOLOLA
16	SANTA LUCIA LA REFORMA	210701	1840	15.07.57	91.14.38	SANTA LUCIA LA REFORMA	TOTONICAPAN

Table 7.1.2 Estimated Annual Rainfall

No.	Department	Municipality	A.RAIN (mm)	No.	Department	Municipality	A.RAIN (mm)
1	Guatemala	Chinautla	1135	28	Solola	Solola	1081
2		Chuarrancho	1063	29		Nahuala	1341
3		Mixco	1197	30		San Andres Semetabaj	1010
4		San Jose del Golfo	1063	31		San Antonio Palopo	1010
5		San Jose Pinula	1650	32		San Juan la Laguna	1010
6		San Juan Sacatepequez	1032	33		San Marcos la Laguna	1010
7		San Raymundo	1122	34		San Pablo la Laguna	1010
8		Santa Catarina Pinula	1342	35		Santa Catarina Ixtahuacan	1341
9		Villa Canales	1524	36		Santa Catarina Palopo	1010
10		Villa Nueva	1213	37		Santa Clara la Laguna	1010
11		San Pedro Ayampuc	1063	38		Santa Cruz la Laguna	1010
12		San Pedro Sacatepequez	1032	39		Santa Lucia Utatlan	1341
13	Sacatepequez	Ciudad Vieja	992	40	Totonicapan	Momostenango	1341
14		Jocotenango	1031	41		San Andres Xecul	843
15		Magdalena Milpas Altas	1031	42		San Francisco el Alto	1341
16		San Antonio Aguas C.	992				
17		San Bartolome M. Altas	1031	43	Quetzaltenango	Almolonga	1594
18		Santa Lucia M. Altas	1031	44		Colomba	3423
19		Santa Maria de Jesus	1229	45		Concepcion Chiquirichapa	2100
20		Santa Catarina Barahona	992	46		Cajola	1057
21	Chimaltenango	Comalapa	1414	47		Flores Costa Cuca	3640
22		El Tejar	1234	48		Genova	3640
23		Patzicia	1283	49		Huitan	936
24		Patzun	1283	50		Olintepeque	843
25		San Jose Poaquil	1272	51		Palestina de los Altos	1027
26		San Martin Jilotepeque	1272	52		San Carlos Sija	1027
27		Zaragoza	1283	53		San Francisco la Union	843
				54		San M. Sacatepequez	2100

Table 7.1.3 List of Gauge Staions

No.	Station	Regist.	River	No.	Catchment Area	C.A. (km2)	Eleva. (m)	Lat.	Long.	Municipality	Departament
1	COATEPEQUE	1030102	NARANJO	1.03	NARANJO	501	291	14.43.05	91.52.25	COATEPEQUE	QUETZALTENANGO
2	CABALLO BLANCO	1040101	OCOSITO	1.04	OCOSITO	462	48	14.29.57	91.51.03	RETALHULEU	RETALHULEU
3	CANTEL	1050102	SAMALA	1.05	SAMALA	701	2454	14.48.33	91.27.03	CANTEL	QUETZALTENANGO
4	CANDELARIA	1050101	SAMALA	1.05	SAMALA	861	720	14.39.04	91.33.55	EL PALMAR	QUETZALTENANGO
5	PAQUIB	1070102	YATZA	1.07	NAHUALATE	38	1679	14.40.56	91.19.42	SAN JUAN LA LAGUNA	SOLOLA
6	S. C. IXTAHUACAN	1070101	NAHUALATE	1.07	NAHUALATE	145	1670	14.46.08	91.21.20	S. C. IXTAHUACAN	SOLOLA
7	SAN MIGUEL MOCA	1070103	NAHAULATE	1.07	NAHAULATE	620	176	14.27.32	91.22.27	SAN JOSE EL IDOLO	SUCHITEPEQEZ
8	JAIBAL	1080301	QUISCAB	1.08	LAGO ATITLAN	147	1550	14.45.00	91.11.00	SOLOLA	SOLOLA
9	PANAJACHEL	-	PANAJACHEL	1.08	LAGO ATITLAN	52	1600	14.45.30	91.08.30	PANAJACHEL	SOLOLA
10	CONCEPCION POTRERO	1080201	PANAJACHEL	1.08	LAGO ATITLAN	38	1889	14.47.30	91.08.25	CONCEPCION	SOLOLA
11	ALOTENANGO	1120301	GUACALATE	1.12	ACHIGUATE	329	1350	14.28.56	90.53.26	ALOTENANGO	SACATEPEQUEZ
12	PANAJAX	2020109	LOS PLATANOS	2.02	MOTAGUA	1503	408	14.52.12	90.23.54	SANARATE	EL PROGRESO

Table 7.1.4 Average Monthly Rainfall

STATION	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
SAN MARTIN JILOTEPEQUE	69-'89	3	6	17	25	111	258	203	198	263	151	32	5	1273
STA. CRUZ BALANYA	72-'89	2	5	17	21	111	197	140	148	203	108	17	3	970
INSIVUMEH	28-'89	3	4	9	20	126	250	192	184	248	134	21	7	1197
FLORINDA	67-'89	6	6	13	28	147	276	186	218	284	120	24	5	1310
OJO DE AGUA	73-'84	4	14	13	21	107	223	175	175	244	102	15	2	1094
JARDIN MIL FLORES	67-'89	3	1	5	23	90	192	133	190	209	61	16	3	924
LA SOLEDAD	68-'89	8	7	5	40	163	318	248	248	324	205	59	17	1639
SAN PEDRO AYAMPUC	69-'89	4	5	17	25	105	231	151	164	211	119	25	6	1063
CHILLANI	58-'89	2	7	13	35	125	26	194	181	290	121	23	17	1032
POTRERO	67-'83	0	2	10	37	120	268	226	223	369	221	41	7	1524
LABOR OVALLE	53-'89	1	8	12	32	119	151	98	128	198	74	19	4	843
LA SUIZA CONTENTA	10-'89	3	7	13	18	124	200	141	181	219	63	17	7	992
SANTA MARIA DE JESUS	72-'89	8	3	4	32	128	317	159	195	254	111	15	3	1229
EL CAPITAN	70-'89	2	10	17	29	118	226	124	156	231	80	17	3	1012
SANTIAGO ATITLAN	70-'89	3	16	31	47	122	211	103	146	217	82	29	5	1010
SANTA LUCIA LA REFORMA	77-'89	2	5	11	48	101	216	122	143	213	58	15	7	939

Table 7.1.5 Run off Calculation

River Basin	Station	River Basin (km)	Year	Q (m3/sec)	Q x 1,000,000 (m3/year)	R (mm/year)	R x 1,000,000 (m3)	Q/R
Lago de Atitlan	Jaibal	147	66-67	2.412	76.1	1454	213.0	35.7
		147	66-68	1.804	56.9	763	111.8	50.9
	Panajachel	52	66-67	0.752	23.7	1454	75.1	31.6
Rio Samala	Cantel	701	77-78	4.94	155.8	932	653.3	23.8
		701	80-81	4.169	131.5	967	677.9	19.4
		701	81-82	6.822	215.1	1425	998.9	21.5
		701	82-83	4.592	144.8	1692	1186.1	12.2
		701	83-84	4.516	142.4	1316	922.5	15.4
		701	84-85	5.843	184.3	1325	928.8	19.8
	Candelaria	849	82-83	9.167	289.1	1692	1437.3	20.1
		849	83-84	8.734	275.4	1316	1117.9	24.6
		849	85-86	10.36	326.7	1332	1131.5	28.9
Rio Antiquate	Alotenango	329	73-74	1.29	40.7	1294	425.1	9.6
		329	74-75	1.53	48.3	961	315.7	15.3
		329	75-76	1.74	54.9	944	310.1	17.7
		329	76-77	1.24	39.1	868	285.1	13.7
		329	77-78	1.01	31.9	720	236.5	13.5
		329	78-79	1.25	39.4	900	295.7	13.3
		329	79-80	1.305	41.2	1165	382.7	10.8
		329	81-82	1.211	38.2	1104	362.7	10.5
		329	83-84	1.063	33.5	949	311.7	10.8
		329	84-85	1.329	41.9	1034	339.7	12.3
		329	85-86	1.137	35.9	1062	348.9	10.3

Table 7.1.6 Results of Discharge Measurement

No.	Department	Municipality	River	C.A.	Dry Season		Rainy Season	
					Q	S.D.	Q	S.D.
4	Guatemala	San Jose del Golfo	Queb. Agua Zarca	5.13	0	0.00	1.23	0.24
5		San Jose Pinula	Q. Las Anonas	5.65	45.7	8.09	107.84	19.09
			Rio El Bijague	20	26.2	1.31	9.64	0.48
			Rio El Pinula		6.6		20.62	
6		San Juan Sacatepequez	Rio Rastunya	4.62	1.2	0.26		
			Rio Santiago	12.94	4	0.31	205.4	15.87
			Rio Paxot		0.23			
12		San Pedro Sacatepequez	Rio El Miragro	3.4	3	0.88	18.2	5.35
			Rio El Miragro	5.16	34.75	6.73	205.4	39.81
21	Chimaltenango	Comalapa	Rio Piscaya	17.98	59	3.28		0.00
			Rio Coloya	12.42	99	7.97	139.77	11.25
26		San Martin Jilotepeque	Rio Frio	4.79	3	0.63	180	37.58
			Rio Cucuya	3.98	3	0.75	190.19	47.79
28	Solola	Solola	Rio Quiscab	135.2	390	2.88	1146	8.48
			Rio Quiscab	146.5	180	1.23	30.86	0.21
			Rio Cojolya	5.89	12	2.04	2.49	0.42
			Rio Rio Buenaventura	5.82	30	5.15	16.18	2.78
			Rio Panajachel	51.65	262	5.07	167.7	3.25
29		Nahuala	Rio Guatchojojcje	15.32	202	13.19	719	46.93
			Rio Nahualate	24.56	150	6.11	448	18.24
30		Santa Lucia Utatlan	Rio Flores	3.95	5	1.27		0.00
			Rio Pugualtui	35.3	104	2.95		0.00
			Rio Pamacha	4.2	25	5.95	104	24.76
			Rio Pamacha	5.89	33	5.60	84.5	14.35
52	Quezaltenango	San Carlos Sija	Rio Caquixa o Samala	53.6	22	0.41	1350	25.19
53		San Francisco la Union	Riachuelo Chinataren	6.46	15	2.32	272	42.11
54		San M. Sacatepequez	Rio Talcana	6.21	13	2.09		0.00

*** Legend

C.A. : Catchment Area (km2)

Q : Discharge (l/sec)

S.D. : Specific Discharge (l/s/km2)

Table 7.1.7 (1) Condition of the Spring Sources in 1987 & 1994

No.	Municipality	INFOM Record in 1987				JICA Study in 1994			
		Type	No.	Q (l/s)	Q/No. (l/s/pc)	Type	No.	Q (l/s)	Q/No. (l/s/pc)
	Dept.: Guatemala								
1	Chinautla	NG1	3	2.6	0.87	N2,P1	2	0.05	0.03
2	Chuarrancho	NB	1	1	1.00	N1,RB1	1	0.01	0.01
3	Mixco	NG4,PB4	4	8.6	2.15	N9,P4	9	5.79	0.64
4	San Jose del Golfo	NG2,PB1	2	0.96	0.48	N1,P2	1	0.31	0.31
5	San Jose Pinula	NG2	2	9.8	4.90	P4	-		
6	San Juan Sacatepequez	NG2,PB1,RG2	3	2.8	0.93	N3,P5	3	10	3.33
7	San Raymundo	PB2,RGT1	-			P2	-		
8	Santa Catarina Pinula	NG2,PB1,RG3	2	1.1	0.55	N2,P2	2	8.67	4.34
9	Villa Canales	NB1,PB1	2	5.2	2.60	N1,P3	1	45	45.00
10	Villa Nueva	NG3,PB4,RGT1	with Rio			N1,P6	1	4.98	4.98
11	San Pedro Ayampuc	NG1,PB1	1	0.6	0.60	N2,P2	2	2.03	1.02
12	San Pedro Sacatepequez	NG2,PB1	2	4.5	2.25	N3,P1	3	4.24	1.41
	Total		22	37.16			25	81.08	
	Av.			1.69				3.24	
	Dept.: Sacatepequez								
13	Ciudad Vieja	NG1,PB2	1	1.5	1.50	N1,P3	1	0.55	0.55
14	Jocotenango	NG1,PB3	1	7.6	7.60	N1,P3	1		0.00
15	Magdalena Milpas Altas	NG6	7	3.8	0.54	N4,P1	4	0.81	0.20
16	San Antonio Aguas C.	NG5	5	11.9	2.38	N4,P1	3	8.45	2.82
17	San Bartolome M. Altas	NG2,PB1	2	2.4	1.20	N2,P2	2	0.4	0.20
18	Santa Lucia M. Altas	PB1	-			P2	2	8	4.00
19	Santa Maria de Jesus	NG3,PB1	3	1.6	0.53	N2,P1	2	1.5	0.75
20	Santa Catarina Barahona	NG4	4	25.1	6.28	N4	4	25.12	6.28
	Total		23	53.9			19	44.83	
	Av.			2.34				2.36	
	Dept.: Chimaltenango								
21	Comalapa	NG11	3	7.8	2.60	NB2,P1	2	34	17.00
22	El Tejar	NG2,PB2	2	1.3	0.65	P3	-		
23	Patzicia	NG3,NB2,RG1	5	0.23	0.05	NB3	3	8.58	2.86
24	Patzun	NG3,NB1	4	10.8	2.70	NB3	3	16.9	5.63
25	San Jose Poaquil	NG1,RGT1	1	0	0.00	N2,R1	2	0.93	0.47
26	San Martin Jilotepeque	NG4,PB1,RG1	5	1.73	0.35	N3,P1	3	8.87	2.96
27	Zaragoza	NG8	6	14.6	2.43	N5,P1	5	10.42	2.08
	Total		26	36.46			18	79.7	
	Av.			1.40				4.43	

Table 7.1.7 (2) Condition of the Spring Sources in 1987 & 1994

No.	Municipality	INFOM Record in 1987				JICA Study in 1994			
		Type	No.	Q (l/s)	Q/No. (l/s/pc)	Type	No.	Q (l/s)	Q/No. (l/s/pc)
	Dept.: Solola								
28	Solola	NG2	3	5.9	1.97	N2	2	30.4	15.20
29	Nahuala	NG2	2	9.9	4.95	N3	3	30.47	10.16
30	San Andres Semetabaj	NG2	2	?	0.00	N8	8	0.95	0.12
31	San Antonio Palopo	NG3	6	1	0.17	N1	1	0.42	0.42
32	San Juan la Laguna	NG1	2	2.5	1.25	-			
33	San Marcos la Laguna	NG1	1	0.62	0.62	-			
34	San Pablo la Laguna	NG2,RG1	3	0.4	0.13	-			
35	Santa Catarina Ixtahuac	NG2	2	1.2	0.60	N3	3	7.29	2.43
36	Santa Catarina Palopo	NG2	4	1.2	0.30	-			
37	Santa Clara la Laguna	NG5	5	3.1	0.62	-			
38	Santa Cruz la Laguna	NG3	4	0.8	0.20	-			
39	Santa Lucia Utatlan	LG1	6	0.06	0.01	N4	4	1.88	0.47
	Total		40	26.68			21	71.41	
	Av.			0.67				3.40	
	Dept.: Totonicapan								
40	Momostenango	NG2	2	5.6	2.80	NG2	2	14.2	7.10
41	San Andres Xecul	NG2	2	2.4	1.20	N1,P1	1	2.3	2.30
42	San Francisco el Alto	NG5	3	5.8	1.93	N8	8		
	Total		7	13.8	1.97		3	16.5	
	Av.			1.97				5.50	
	Dept.: Quezaltenango								
43	Almolonga	NG4	4	7.17	1.79	N1,P3	1	23.87	23.87
44	Colomba	NG2	2	17.3	8.65	N2	2	17.31	8.66
45	Concepcion Chiquirichap	NG2	5	8.8	1.76		2	11.57	5.79
46	Cajola	NG4	5	2.1	0.42	N7	7	2.2	0.31
47	Flores Costa Cuca	NG2	2	3.7	1.85	N1,P1	1	2.25	2.25
48	Genova	NG1	1	4.3	4.30	N7	7	3.03	0.43
49	Huitan	NG2	2	1.8	0.90	N2	2	0.91	0.46
50	Olientepeque	NG6,PB1	6	1.5	0.25	N1,P1	1	0.94	0.94
51	Palestina de los Altos	NG1	2	4.5	2.25	P1	1	13.89	13.89
52	San Carlos Sija	NG2	2	4.5	2.25	N3	3	2.8	0.93
53	San Francisco la Union	NB1	1	0.25	0.25	NB1	1	0.59	0.59
54	San M. Sacatepequez	NG2	2	4.8	2.40	N2	2	3.15	1.58
	Total		34	60.72			30	82.51	
	Av.			1.79				2.75	

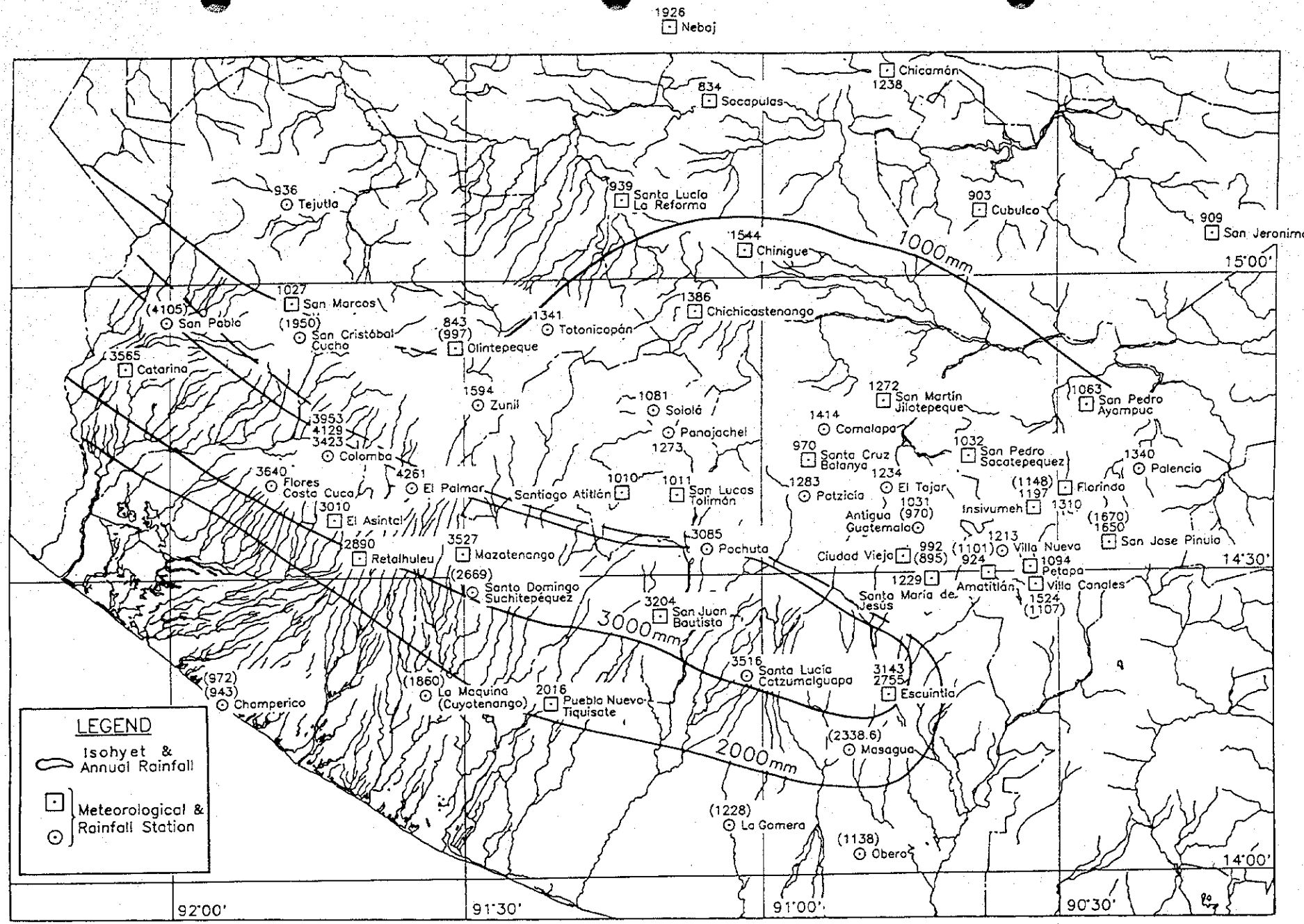
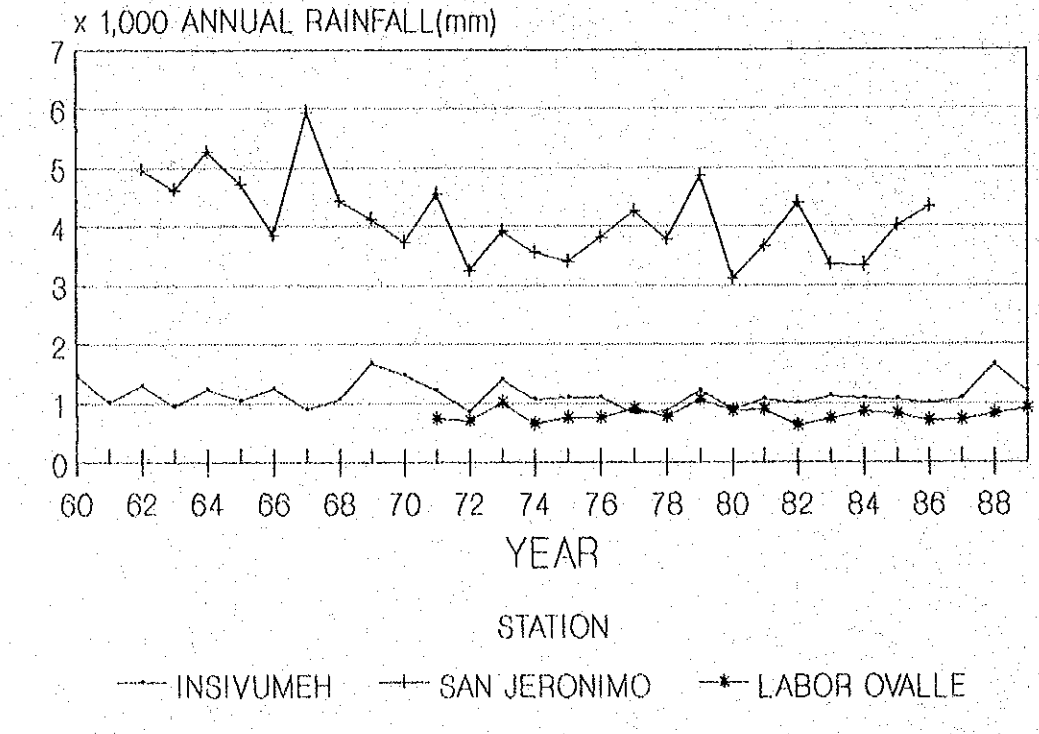


Fig. 7.1.1 Isohyet-Meteorological & Rainfall Stations



INSIVUMEH, San Jeronimo, Labor Ovalle

Fig. 7.1.2 Annual Rainfall in the 1960-1989 Period

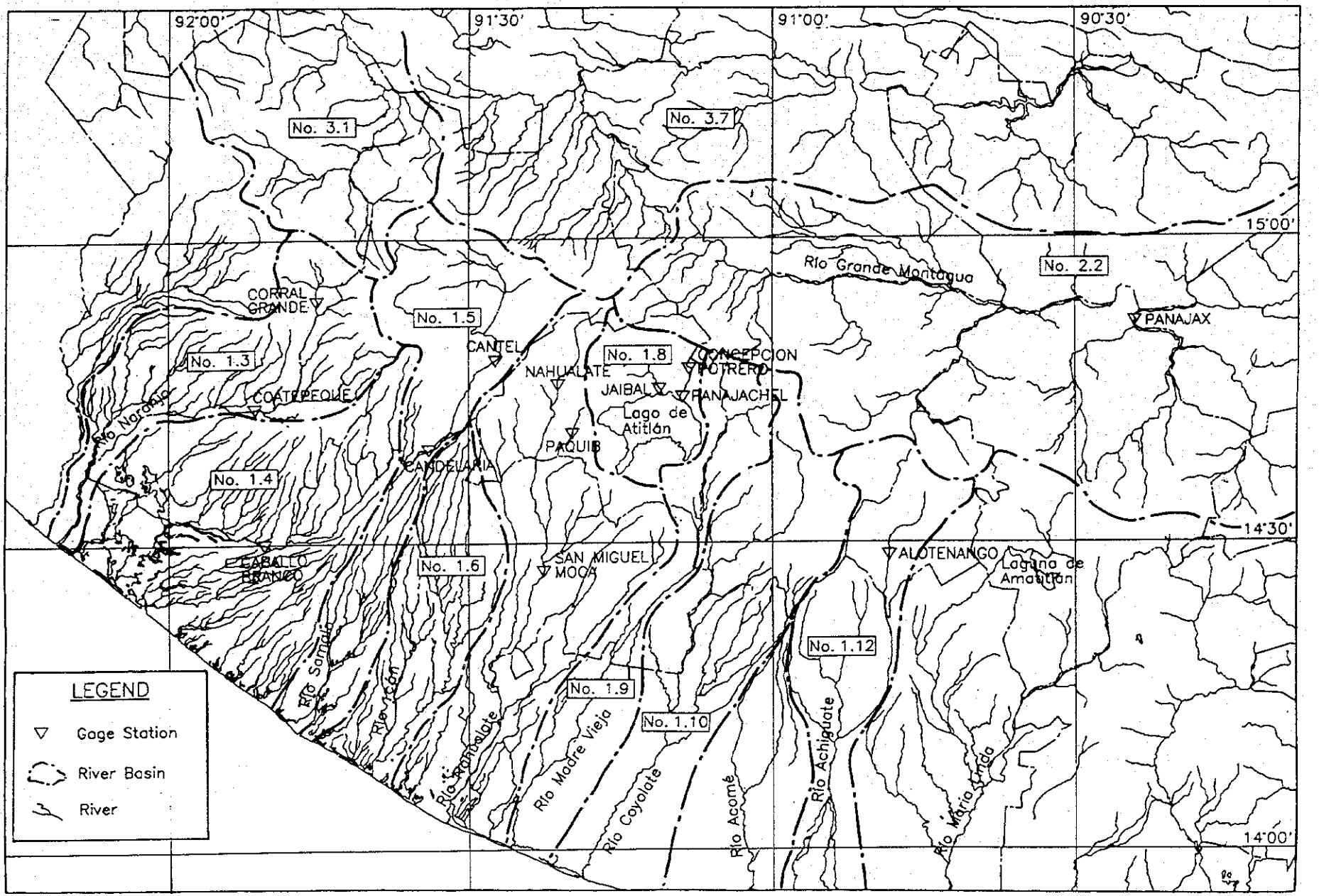


Fig. 7.1.3 Gauge Station

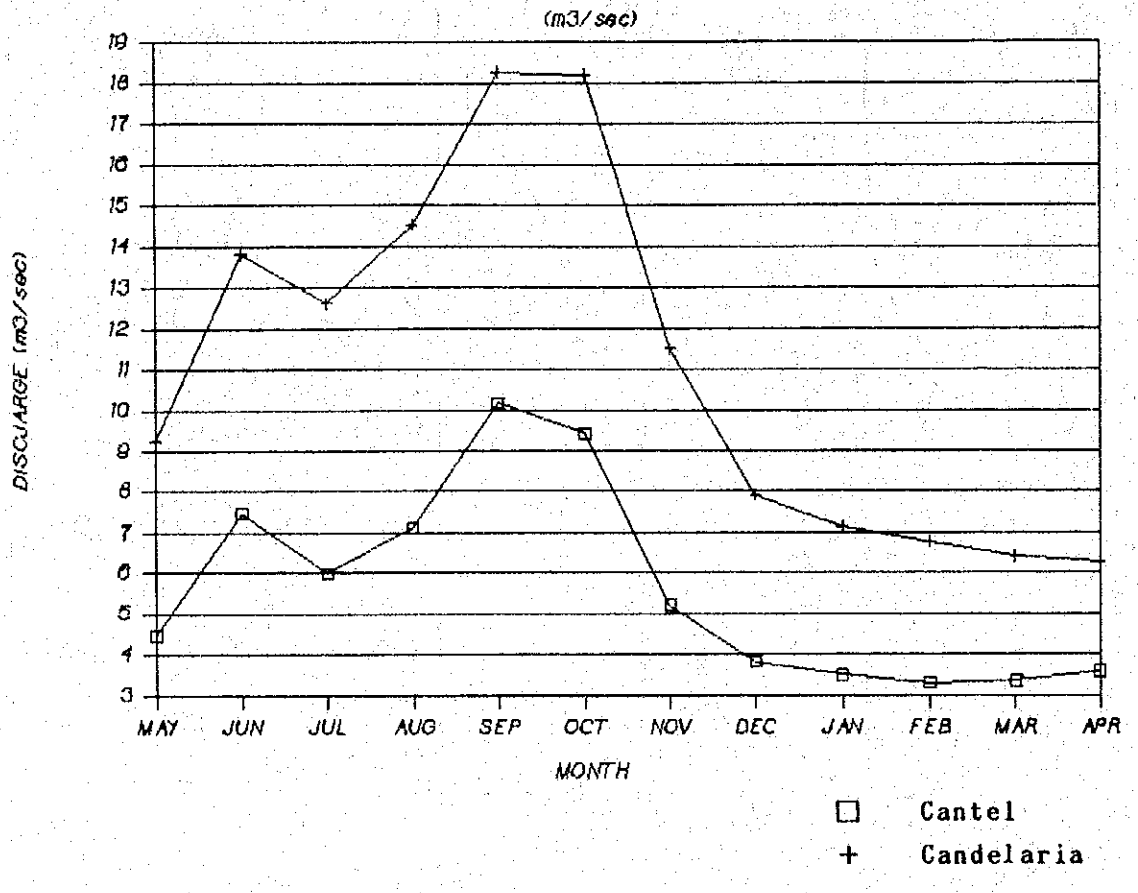


Fig. 7.1.4 Monthly Discharge in Cantel & Candelaria Stations

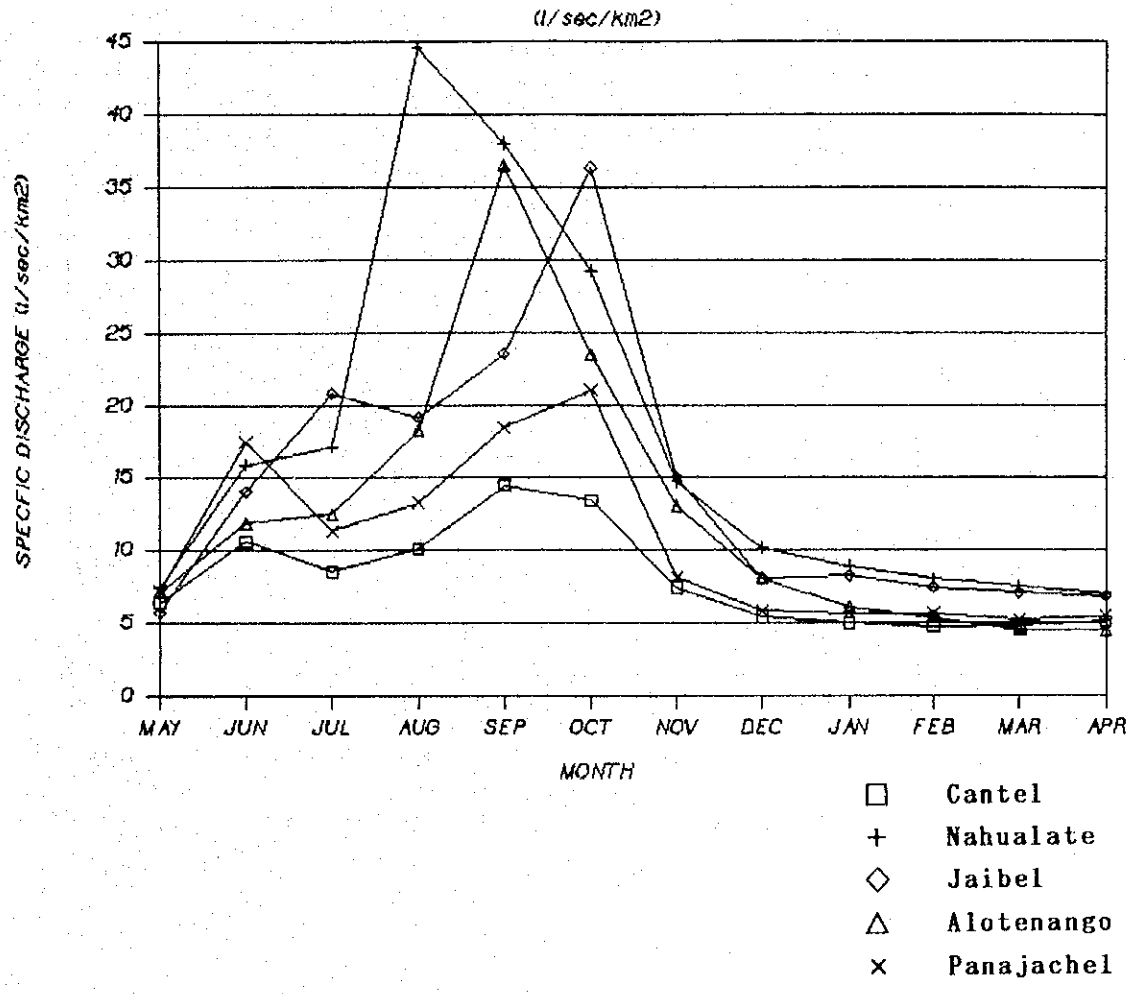


Fig. 7.1.5 Specific Discharge in 5 Stations

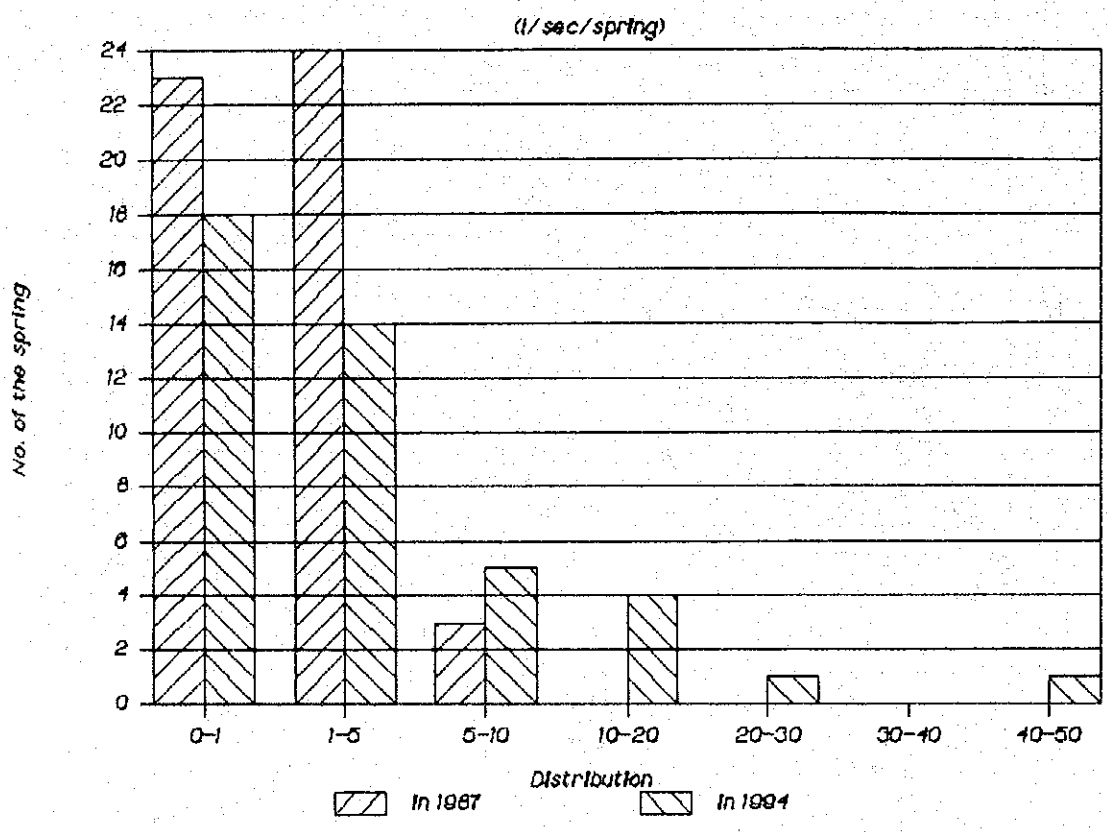


Fig. 7.1.6 Distribution of the Spring Source & its Discharge

7.2 Hydrogeology

7.2.1 General Hydrogeological Feature of the Study Area

The groundwater bearing layers of the Study Area are generally classified into the upper aquifer and the lower aquifer. The upper aquifer is composed principally of Quaternary volcanic rocks, such as Pleistocene pumice sediments, Holocene lava flows, and, in some places, alluvial deposits. The lower aquifer consists basically of latitic to dacitic welded tuffs and locally fractured andesitic to basaltic lava flows of the Tertiary. However, whereabouts of this lower aquifer is not well known. Accordingly, well drilling activities were very limited. It is, therefore, very important to properly locate drilling sites based on careful and detailed hydrogeological investigations.

Hydrogeologically, the basement group consisting of metamorphic rocks, Cretaceous series and intrusive rocks is a groundwater basin. However, sheared or fractured limestone of the Cretaceous series is regarded as local aquifer similar to the lower aquifer of the Tertiary volcanic.

The Study Area is divided into 9 main intramountain basins nearly corresponding with the groundwater basins. These groundwater basins are classified into the following three types, based on topographic and geological features:

Graben Type

- Rio las Vacas-Lago Amatitlan basin (Guatemala Valley)

Compound Type of Local Grabens

- Rio Platanos Basin (Guatemala)
- Rio Samala Basin (Quetzaltenango)
- Rio Aguacapa Basin (Guatemala)
- Rio Pixcayá Basin (Chimaltenango-Guatemala)

River Basin Type

- Rio Chixoy o Negro Basin (Totonicapán)
- Rio Coyolate Basin (Sacatepéquez)
- Rio Guacalate Basin (Sacatepéquez)
- Lago Atitlán Basin (Sololá)

Of the above mentioned groundwater basins, the upper aquifers of Río las Vacas-Lago Amatitlán, Río Samala and Río Guacalate basins are relatively well developed.

Although existing well records are insufficient for the review and analyses of aquifer characteristics, they are roughly summarized in Table 7.2.1 (the original well records are shown in the well inventory of the Supporting Report).

The thickness of the upper aquifer consisting of Pleistocene volcanic material (Qp) varies from several meters at the edge to some 250 m at the central portion of the groundwater basin with highly diversified lithological features. Since the water level of this aquifer shows large seasonal variation, this aquifer is classified as "unconfined". The yielding capacity of this aquifer at various locations is shown below.

Basin	Production range per well (1/sec)	Average Production per well (1/sec)
Rio Las Vacas/Lago Amatitlán	1.58 - 22.67	14.23
Rio Samala	3.15 - 68.81	20.86
Rio Guacalate	3.78 - 17.70	9.84

In contrast with the upper aquifer, the lower aquifer of the Tertiary volcanic, including highly fractured limestone of the Cretaceous series, is relatively unknown, and the number of previously drilled wells down to the lower aquifer is very few. Moreover, the existing well records do not differentiate the geological formation of upper and lower aquifers.

The table below, arranged by INFOM in 1987, shows the average production of existing water sources by Department. The wells with a larger than average production in Quetzaltenango and Guatemala Departments mostly pump water up from the upper aquifer, and some of the wells with rather smaller production in the other 3 Departments take in water from the lower aquifer.

Department	Spring			Groundwater		
	No.	Q(ℓ/s)	Q/N(ℓ/s)	No.	Q(ℓ/s)	Q/N(ℓ/s)
Quetzaltenango	54	369.47	6.84	30	578.48	19.28
Totonicapán	18	42.88	2.38	3	19.06	6.35
Sololá	41	74.04	1.81	-	-	-
Chimaltenango	50	253.58	5.07	3	19.65	6.55
Sacatepéquez	35	125.53	3.48	14	153.58	10.97
Guatemala	24	75.47	3.14	21	278.59	13.26

Even though the number of wells drilled down to the lower aquifer is limited, past records led to the conclusion that the development of the lower aquifer is somehow difficult.

However, test drilling activities conducted in this Study